Bangladesh Electricity Transition: A Diverse, Secure and Deflationary Way Forward

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Tim Buckley, Director of Energy Finance Studies, Australasia, IEEFA

Simon Nicholas, Energy Finance Analyst, IEEFA

Sara Jane Ahmed, Energy Finance Analyst, IEEFA

Executive Summary

This Report Finds that Domestic Solar Energy and Imported Electricity are a Commercially Viable Alternative Preferable to Imported Thermal Power in Bangladesh

IEEFA has undertaken a detailed review of the Bangladesh electricity sector. A critical component underpinning Bangladesh's successful economic growth to date, expanded supply of electricity is proving to be a key constraint to sustainable economic growth.

IEEFA has modelled Bangladesh's likely strong electricity demand growth and then mapped out an electricity generation investment plan utilising the latest technology and cost analyses. This plan would build capacity whilst enhancing energy security via a bias toward a more diverse, predominately domestic generation profile. Combining increased electricity imports from India and Bhutan, a clear government policy driving energy efficiency and expanded solar energy options, this plan offers a cost competitive, sustainable solution.

Key Findings

With a growing gas supply crisis, Bangladesh has an excessive dependence on gas-fired power generation, which currently accounts for 62% of total electricity capacity.

Fossil fuel subsidies and electricity-sector losses are an entrenched and growing drag on economic growth in Bangladesh. These range from a domestic price cap on gas, diesel and oil import subsidies; long-dated tax holidays for new power generation investments; and unfunded losses on electricity distribution that saw the Bangladesh Power Development Board (BPDB) report net losses of a cumulative US$4bn in the last five years.

Bangladesh's plan to double fossil fuel generation capacity to 24 gigawatts (GW) by 2021 currently focuses on building heavily Export Credit Agency (ECA) and development assistance-subsidised thermal power generation almost entirely reliant on imported coal, diesel, oil and liquid natural gas (LNG). This plan would instil a long term dependence on fossil fuel imports (rising to 60-70% of capacity), bringing a destabilising drag to the current account deficit, eroding the currency, and importing inflation. The 2016 Bangladesh Power System Master Plan will note the higher energy security risk of relying on fossil fuel imports as well as the exposure of the energy system to imported fossil fuel price increases of the type currently being experienced by the Indian imported coal-fired power generation through higher coal prices.

IEEFA has modelled a cost-effective, more sustainable and faster-to-implement alternative electricity plan for the coming decade. The key ingredients would enhance grid efficiency and energy efficiency, build a fivefold increase in grid capacity for imported electricity from India and Bhutan, and set an ambitious energy program for solar power in all of its forms. An associated but much more incremental build of oil, imported coal and LNG generation still provides ample generation diversification and overall sector capacity growth. Under this plan, only 18% of generation capacity would be dependent on fuel imports, with a further 9% coming from electricity imports from India and Bhutan.

In the last few years increased cooperation and economic development has seen India and Bangladesh jointly commission two international grid connections with a combined capacity of 600 megawatts (MW). Plans are well underway for a fivefold increase in grid capacity for imported electricity from India and Bhutan. These plans would serve to boost diversity of electricity system supply and take advantage of India's new surplus of mine-mouth Indian coal-fired power generation and growing, cost-competitive solar energy capacity. Bangladesh also plans to jointly build, own and source competitively-priced hydroelectricity from Bhutan.

Bangladesh has the world's largest and most successful base of solar home systems (SHS), installed on some 4.5 million off-grid residences. This base demonstrates what a clear government renewables policy can achieve in Bangladesh. There is scope to accelerate this program and significantly expand the size of individual units to cost effectively and rapidly deliver on the government program of electricity for all by 2021.

The success of this solar program also has proven the cost effectiveness of smart solar system development. IEEFA sees an enormous opportunity for Bangladesh to replicate the long-term vision of the Modi government of India in pursuing a solar-driven electricity sector transformation. One of India's leading solar PV developers, Adani, has recently demonstrated strong interest in the Bangladesh market by submitting proposals for 320MW of utility-scale solar power plants. Bangladesh has recently joined the International Solar Alliance, an initiative which aims to encourage collaboration between members which also includes India.

Bangladesh should immediately target a 1GW annual utility-scale solar installation program that would see 10GW of cumulative capacity operational by 2024/25. As has been demonstrated in countries as diverse as India, Dubai, Mexico, Chile, Brazil, Australia and Morocco, the dramatic deflationary nature of gigawatt-scale solar has surpassed all expectations. Unsubsidised utility-scale solar reverse auction tenders have been completed at successively lower electricity tariffs as low as US$64/megawatt hour (MWh) in India, US$24/MWh in UAE, US$29/MWh in Chile and US$33/MWh in Mexico in 2016. Previous predictions of how much suitable, non-agricultural land is available for solar power development in Bangladesh are likely to have been too low.

The trend of reducing auction tenders for solar PV in India can be repeated in Bangladesh. Once scale has been achieved, tenders equivalent to US$70-US$75/MWh should be achievable, and should reduce 5-10% annually. This compares favourably to IEEFA's calculated cost of US$93/MWh for new, imported coal-fired generation.

There is significant scope for distributed residential rooftop solar in urban areas, as well as on commercial and industrial (C&I) buildings, avoiding the complexities and costs of land requirement for any utility-scale electricity generation. Distributed, off-grid bioenergy plus solar hybrid for water irrigation pumps and telecom towers systems all show significant promise.

IEEFA also models in the development of cost-competitive concentrated solar power (CSP) with storage early next decade to provide increased peaking electricity capacity.

IEEFA's analysis of wind and hydro resources suggests little if any scope for large-scale cost-competitive development in these technologies in Bangladesh. Incremental investment is possible and would serve to add domestic diversity of supply.

What is also clear is that Bangladesh needs to re-evaluate its exceptionally grand but entirely subsidised plans for ever more imported thermal power capacity. While headlines

over the last few years report 21GW of imported coal-fired power capacity, 8GW of domestic coal-fired power, 7GW of new gas-fired capacity, 1.1GW of oil/diesel and 2.4GW of nuclear capacity, the reality is that few of these projects have moved beyond non-binding Memorandums of Understandings (MoU). Civil society resistance to the cumulative compulsory land acquisition orders and loss of biodiversity, plus increased water, air and particulate pollution (and associated public health costs) mean most of these projects fail on any independently assessed cost-benefit economic analysis. Far better would be ECA financing supporting domestic utility-scale solar.

Conclusion:

Bangladesh can look forward to a continued period of strong economic growth and development. The electricity sector should play a critically important role underpinning sustainable development. IEEFA's electricity system model shows that a cost-effective long-term investment program that prioritizes renewable energy, grid and energy efficiency, and increased electricity imports from India and Bhutan would best serve the country in terms of energy security in comparison to heavy reliance on fossil fuel imports, and would deliver a significantly larger, long-term cost-competitive energy supply. A robust government endorsement of a transformational US$15-20bn investment program in renewables, smart grid and energy efficiency by 2024/25 is likely to find strong international financial system support to develop long-term deflationary energy supply.

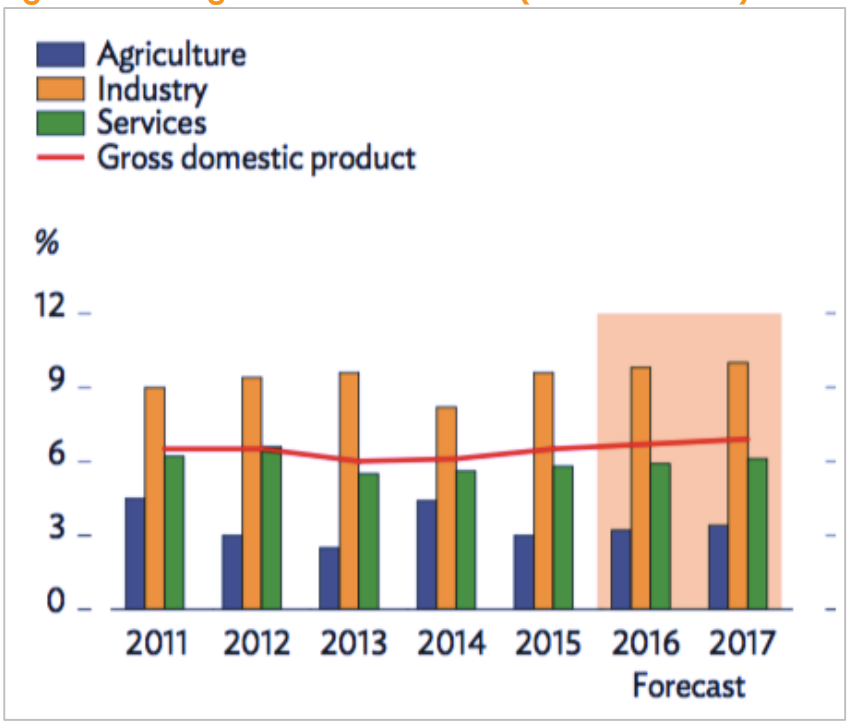
1.0 The Economy of Bangladesh

Bangladesh has an estimated 161 million people,[1] making it the ninth largest country in the world by population. By area, it is ranked 92nd globally, which means it is one of the most densely populated countries.[2] Although the growth rate of the population has slowed in recent years, the labour force is growing rapidly. Improving the labour force participation will be a key driver of economic growth into the future.

The Bangladeshi economy, identified by Goldman Sachs as one of the "Next Eleven" economies globally,[3] reported a healthy Gross Domestic Product (GDP) growth rate of 6.3% from 2010-11 to 2014-15 – refer Figure 1.1. In 2014-15, GDP growth was 6.6%, and the Asian Development Bank (ADB) estimates that growth will accelerate to a very robust 6.7% in 2015-16 and 6.9% in 2016-17. The sustained economic expansion has resulted in increased demand for infrastructure to support continued growth in industry and in services such as telecommunications, transport and energy.

Bangladesh's economy is transitioning away from its historic reliance on the agriculture sector, with the industrial sector set to grow at 9-10% annually while service sector growth is forecast at a still robust 6% annually. This increasing share of the economy by the Industrial sector has implications for the electricity sector, as the energy intensity of growth is likely to remain well above the rate of real GDP growth (we discuss the implications of this in Section 4.0). In terms of GDP per capita, the country is ranked 178th in the world.[4]

Figure 1.1: Bangladesh: GDP Growth (FY2011-FY2017)

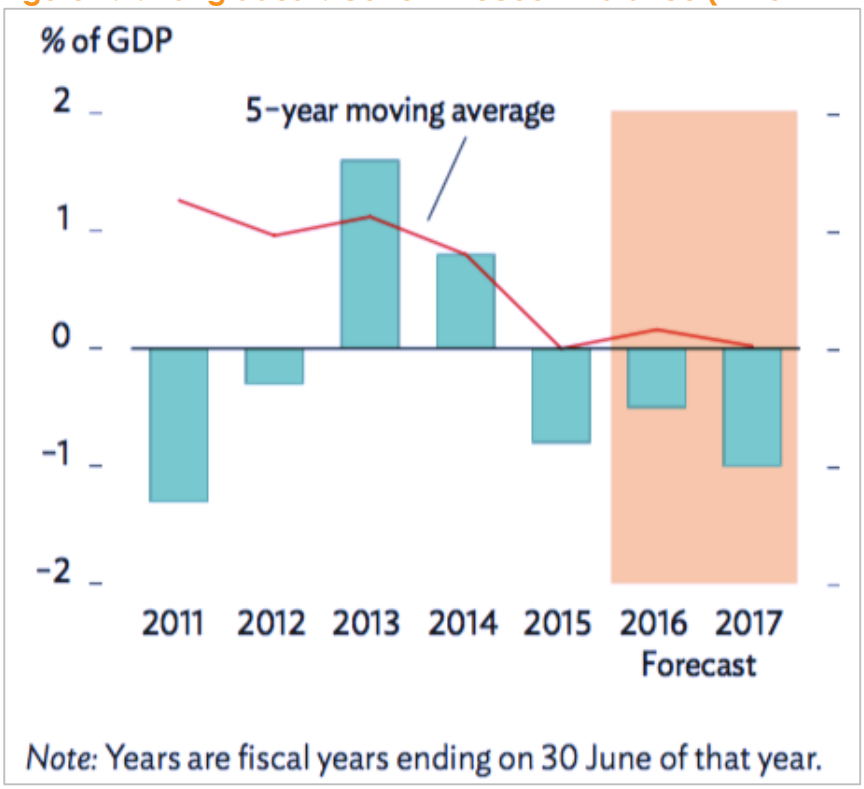


Source: Bangladesh Bureau of Statistics, Asian Development Bank

[1] World Bank Country Data - Bangladesh
[2] http://statisticstimes.com/population/countries-by-population-density.php
[3] http://www.bloomberg.com/news/articles/2012-08-07/goldman-sachs-s-mist-topping-brics-as-smaller-markets-outperform
[4] https://www.cia.gov/library/publications/resources/the-world-factbook/rankorder/2004rank.html

Bangladesh moved into a current account deficit in 2014-15, and the Asian Development Bank forecasts this deficit to widen into 2016/17. Increasing reliance on fossil fuel imports (oil, diesel, LNG and coal) over the forecast period would further undermine the current account and recent currency stability, particularly if foreign worker remittances weaken – refer Figure 1.2.

Figure 1.2: Bangladesh: Current Account Balance (FY2011-FY2017)



Source: Bangladesh Bureau of Statistics, Asia Development Bank

Over the past five years, Bangladesh has witnessed a stable currency regime, with the Bangladeshi Taka (Tk) depreciating 1.3% per annum against the U.S. dollar, notwithstanding inflation running at 5-6% annually.[5]

The government's credit rating has remained stable, with Standard and Poor's rating the country's government debt at BB- with a stable outlook since April 2010.[6] The favourable factors for the country are its relative political stability, its strong projected economic growth of 6% annually, and expectation for continuing strong garment export growth as Bangladesh continues to take market share from competing nations like Pakistan. However, high inflation, a high budget deficit, debts exceeding reserves, civil unrest over compulsory land acquisitions, access to fresh water and rising environmental damage from industrialisation, plus rising competition in the international garment industry, are key risks to the fiscal stability of Bangladesh.[7]

The country's budget deficit increased to 4.7% of GDP in 2014-15, up from 4.0% in 2013-14 and 3.6% in 2012-13.[8] If this budget deficit as a percentage of GDP increases further, it

[5] http://www.xe.com/currencycharts/?from=USD&to=BDT&view=10Y
[6] http://www.tradingeconomics.com/bangladesh/rating
[7] http://www.euromoney.com/Article/3358334/The-worlds-10-riskiest-sovereigns.html?single=true
[8] http://www.tradingeconomics.com/bangladesh/government-budget

may lead to a stress in the government's bond rating. As a result, the government may be forced to reduce its expenditures, like those that currently support electricity system losses. In 2012, the country faced a financial crunch due to a shortage of foreign exchange. The government's excessive borrowing was one of the reasons for this issue.[9]

Current average government interest rates in the Bangladeshi financial system are 10.9%,[10] private sector lending rates are 12-13%, with both rates reflecting consumer inflation rates of 7-8% annually over the past five years. Progressively building out renewable energy capacity would introduce a long-term deflationary benefit to help address this inflation issue (note Indian solar tariffs are fixed in nominal terms for the 25-year duration (declining ~5% annually in real terms).

Figure 1.3: Bangladesh: Key Statistics (2015)

Population (million)	161.0
GDP (US$ billion)	195.1
GDP per capita (US$)	1,211.7
GDP Growth (2015)	6.6%
GDP Growth (2011-2015)	6.3%
Current account balance 30 June 2015 (US$ billion)	-1.60
Current account balance 30 June 2015 (% of GDP)	-0.8%
Inflation (2015)	6.2%
Average government lending rate	10.9%
Surface area (Sq km)	130,170
Population density (people/Sq km)	1,237
Net Foreign Direct Investment (US$ million)	-3,330
Ease of doing business index (1=most business-friendly regulations)	174
Taka/USD exchange rate (15 September 2016)	78.4
Currency Depreciation v US$ (2011-2016 p.a.)	1.3%
Credit Rating (Standard & Poor's)	BB- (Stable)

Source: World Bank, Asian Development Bank, Bangladesh Bank

The nation aspires to become a middle-income country by 2021. To achieve this target, GDP growth will need to reach 7.5-8% p.a. along with increased public and private investment. Key challenges for the country include management of urban growth, industrialisation, and climate-change adaptation. Unfunded and growing fossil fuel subsidies (across gas, diesel and electricity distribution) and infrastructure deficits will also need to be tackled.

Bangladesh has the potential to become an even greater exporter of labour-intensive manufacturing, filling in markets vacated by the maturing Chinese economy. Adopting a long-term, clear energy strategy to transition the electricity sector toward a significantly larger, more diverse, domestic-based and lower-emissions-profile generation capacity would build energy security, enhance the nation's international reputation whilst serving to protect the environment and develop industries of the future. Renewable energy, smart grids and energy efficiency opportunities are increasingly cost competitive and deflationary.

[9] https://www.timesofassam.com/international/bangladesh-selling-sovereign-bond-to-cope-with-financial-crisis/
[10] https://www.bb.org.bd/econdata/bb_nsdp.php

Figure 1.4: Map of Bangladesh.

Source: United Nations

2.0 Bangladesh's Electricity System

2.1 Electricity Generation and Consumption Trends

Bangladesh has increased its electricity generation by 145% since 2004 to 60.5 Terawatt hours (TWh) in 2015 (refer Figure 2.1 below). Energy consumed has also increased, but at a slightly faster rate due to a trend of declining Transmission and Distribution (T&D) losses over the same period. Total installed and operating generation capacity has more than doubled in the six years to August 2016 to 12.8GW (including 600MW of electricity imports from India).

Electricity consumption has grown by an average 9.7% annually through 11 years to 2015, facilitating Bangladesh's exceptional GDP growth of over 6% annually in recent years. Even with population growth of 1.2% annually, the economy has still seen a growth in per capita electricity consumption of 8.4% annually as rural electrification has continued to be a priority for the Bangladeshi government.

One key statistic from an electricity system planning perspective: energy intensity of economic growth. Electricity consumption has risen by 1.56 times the rate of GDP growth over this timeframe, reflective of ongoing industrialisation, as discussed in Section 1.0. In IEEFA's projections for the Bangladesh electricity sector, we model a moderation of this ratio to a still-challenging 1.2 times over the next decade (refer Section 4.0).

Figure 2.1 – Bangladesh Generation and Consumption Trends 2004-2015

Bangladesh Electricity System	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2004-2015 Average
Electricity Generation (TWh)	24.7	26.4	29.5	31.0	34.2	37.2	40.8	44.2	48.6	53.0	55.6	60.5	
Electric power distribution losses (% of output)	21.2%	20.0%	19.1%	16.6%	14.4%	13.6%	13.1%	13.1%	12.2%	12.0%	11.9%	11.2%	
Electricity Consumption (TWh)	19.4	21.2	23.9	25.9	29.3	32.1	35.4	38.4	42.7	46.7	49.0	53.8	
Growth in electricity consumption		8.8%	13.0%	8.2%	13.2%	9.7%	10.3%	8.3%	11.1%	9.5%	5.0%	9.7%	9.7%
Per capita consumption (kWh)	138	148	165	176	198	214	234	250	275	297	308	334	8.4%
GDP Growth (%) - World Bank	5.2%	6.5%	6.7%	7.1%	6.0%	5.0%	5.6%	6.5%	6.5%	6.0%	6.1%	6.6%	6.2%
Ratio of Electricity demand to GDP growth		1.35	1.94	1.16	2.20	1.93	1.85	1.28	1.71	1.58	0.82	1.48	1.56

Source: BP World Statistics 2016, World Bank Country Database, BPDB, IEEFA calculations.

Note 1: There is a material discrepancy between the electricity generation figures referenced from BP World Statistics relative to that published by Bangladesh Power Development Board (BPDB). BP World Statistics are 20% above the BPDB estimates of actual electricity generation. In the IEEFA Electricity Model for Bangladesh, we have chosen to base our figures on those cited by BPDB as the likely original data source.

Note 2: The World Bank country statistics[11] include much lower rates of electricity T&D losses than the BPDB over the last decade. For instance, in 2004 the BPDB report distribution losses of 21% whilst the World Bank has a rate of 8% (the later includes both T&D losses). Since 2004 the World Bank has reported increasing losses whilst the BPDB has reported decreasing losses to the point that the two institutions estimates have largely converged to similar rates of loss by 2013. In Figure 2.1 we cite BPDB Annual Report 2014-15 estimates.

[11] http://data.worldbank.org/country/bangladesh

2.2 Bangladesh's Electricity Grid

Transmission and Distribution Loss Trends

Historical distribution losses referenced in Figure 2.1 are sourced from the BPDB Annual Report 2014-15. Distribution loss rates have steadily declined from an unsustainably high 21.2% in 2004 to 11.2% in 2014/15. Note that these figures do not include transmission losses, which totalled 2.74% in 2014-15 (2.72% in 2013-14), taking total T&D losses to 13.9%.

Electricity Supply-Demand Mismatch

Bangladesh's electricity sector has consistently been plagued by a mismatch between demand and supply, owing to gas-availability issues in a virtually single-fuel dependent electricity system (energy security is a key country risk exaggerated by this excessive dependence on subsidised domestic gas) as well as strong demand growth and a resulting insufficient investment in new generating capacity. The latter reflects the government's inability to adhere to and successfully implement a commercially viable, clear, long-term electricity supply plan at a speed sufficient to match demand growth. As discussed in section 5.0, a disproportionate number of projects are announced with little subsequent implementation.

Despite having large gas reserves, Bangladesh has not been able to produce enough gas to meet demand. As per the government-owned Bangladesh Oil, Gas and Mineral Corp. ("Petrobangla"), demand for gas in 2015-16 is estimated to be 3,800 million cubic feet per day (mmcfd). By comparison, the production of gas stood at 2,330mmcfd in January 2014.[12] This demand-supply gap has led to a situation in which power capacity totalling 603MW lacks fuel, resulting in frequent power cuts.[13] A progressive move toward import price parity for gas would incentivise exploration and reduce LNG import needs.

Another reason for interruptions in power supply: a large segment of Bangladesh's installed capacity requires shutdowns for long-term maintenance (at any particular time, this runs at 10% of total installed system capacity), even though this situation has been eased recently by some newer capacity additions.

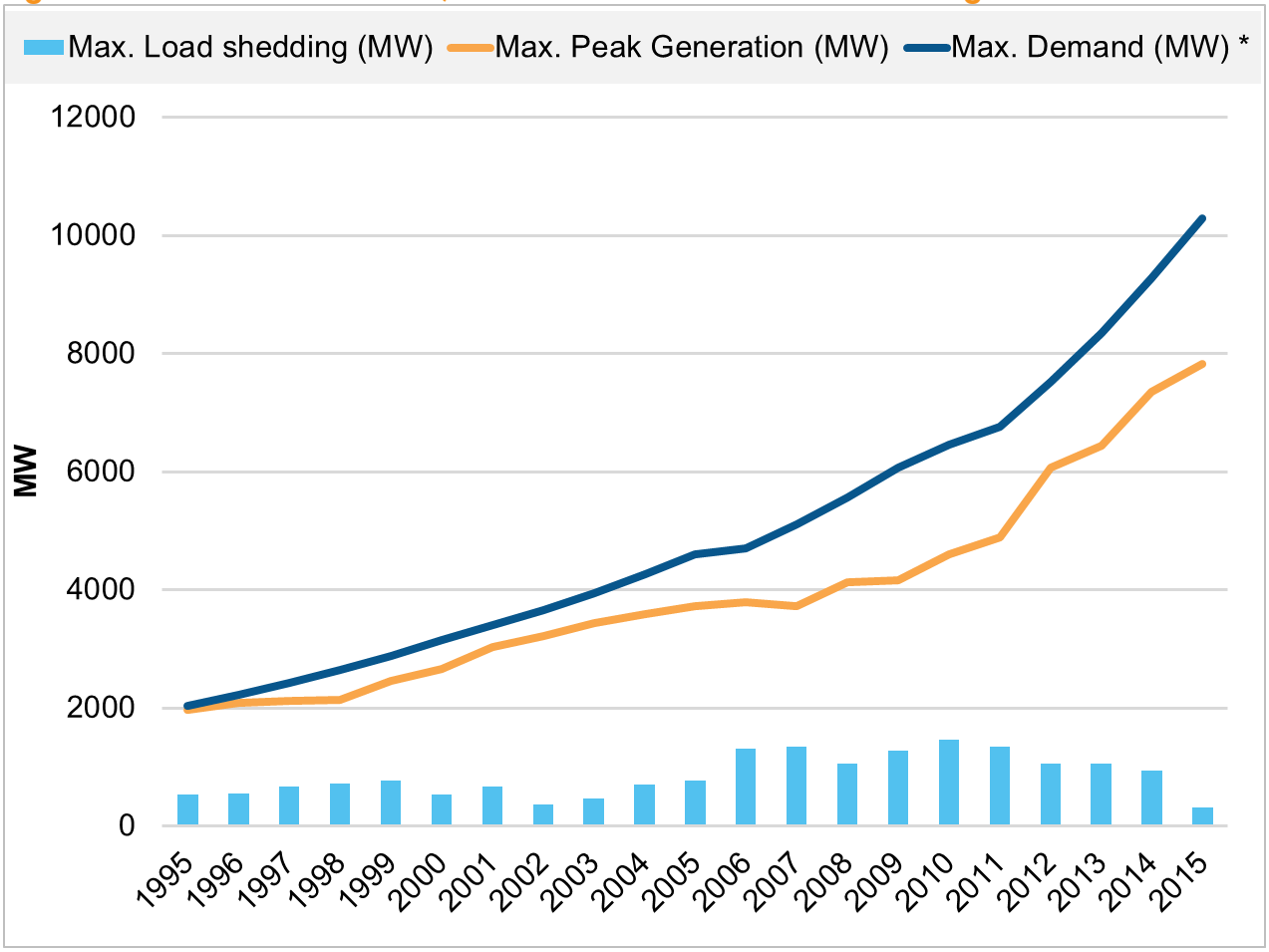
Power-supply issues aside, Bangladesh suffers from power transmission issues, owing to its fragile grid, struggling to both modernise and cope with the continued strong growth in demand for electricity, which reaches about 74% of the population.[14] Bangladesh faced a major blackout due to grid failure in 2014.[15] Since then, grid problems of lesser magnitude have persisted.[16]

Figure 2.7 details the predominance of gas-fired power generation in the Bangladesh electricity system alongside the rising reliance on expensive imported furnace oil and diesel fuels due to growing domestic gas shortages. The lack of diversification is clear, as is the absence of renewable energy. A key conclusion of this report is that Bangladesh's energy security and economic growth prospects would be enhanced significantly by

[12] http://www.petrobangla.org.bd/
[13] http://www.dhakatribune.com/bangladesh/2015/mar/22/load-shedding-wont-improve-year
[14] http://www.bpdb.gov.bd/download/annual_report/
[15] http://www.reuters.com/article/bangladesh-power-failure-idUSL4N0SR0AT20141101
[16] http://www.dhakatribune.com/bangladesh/2015/nov/01/power-grid-vulnerable-ever

adding a diverse range of renewable energy and energy efficiency programs.

Figure 2.2 – Maximum Demand, Peak Generation and Load Shedding



*Maximum demand as per the Bangladesh Power System Master Plan 2010.
Source: Bangladesh Power Development Board 2015 annual report.

Tariff Structures

Under the Bangladesh Energy Regulation Act (2003), the price at which the BPDB sells electricity is meant to cover the expenses incurred by BPDB in operating its power plants and in purchasing power from independent and rental suppliers. The difference between the cost of these electricity purchases and the supply tariff at which BPDB sells is subsidized by the government via a direct budgetary transfer. In FY2014, the government transferred US$800m to BPDB (FY2013: US$584m).[17]

Under the Act, the price paid by distribution companies to the Power Grid Corporation of Bangladesh (PGCB), which manages transmission assets and end-user tariffs, are also set. End-user tariffs vary according to customer type, with incremental block tariffs for domestic users and a single rate for agricultural pumps and street lighting. Small industry and commercial users have flat off-peak and peak rates.

Tariffs are set such that low-use residential and agricultural customers are subsidised by commercial, industrial and high-use residential users. However, such cross-subsidies do not

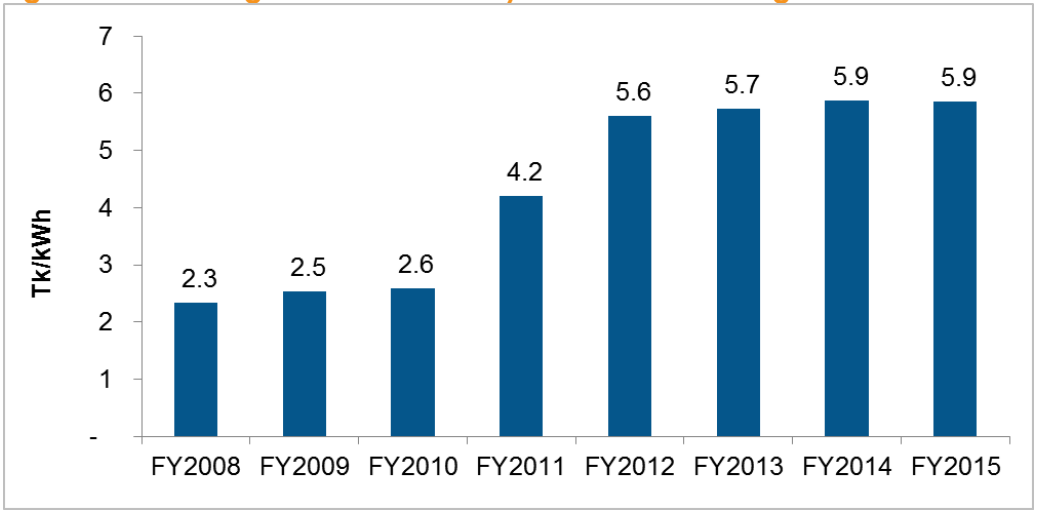
[17] Sustainable & Renewable Energy Development Authority, Investment Plan for Bangladesh, October 2015, p. 30.

cover the losses incurred from selling electricity at prices below the cost of generation. In FY2014 ,the average retail tariff was 16.7% below the delivery cost, and while PGCB recorded an operating profit that year,[18] BPDB's losses increased.

Bangladesh's Electricity System is Undermined by Losses and Subsidies

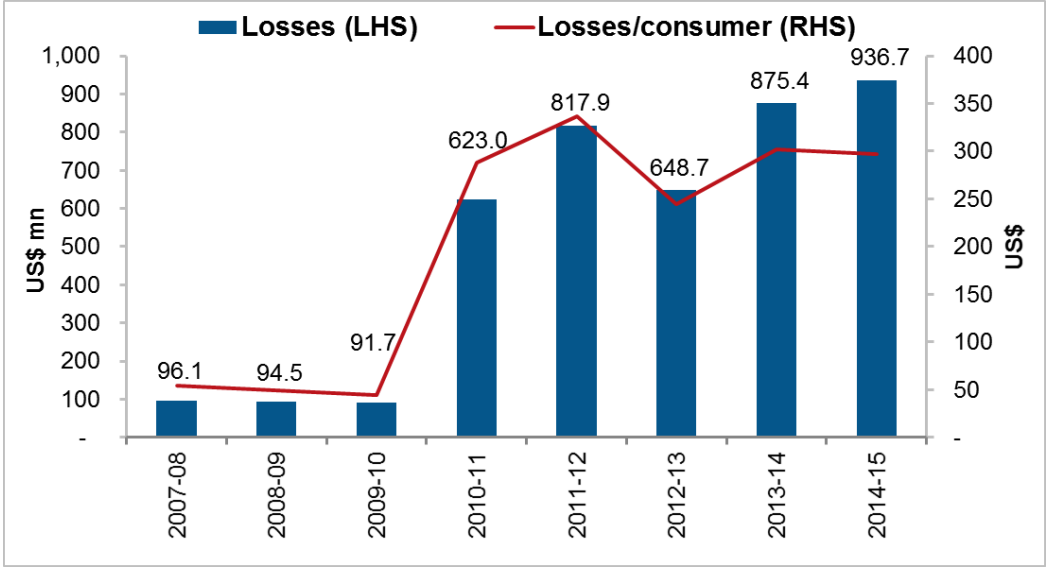
The electricity sector in Bangladesh has seen a steep increase in power generation costs in recent years. Average costs of electricity production have increased at an annualized rate of 17.8%, more than doubling from Tk2.6/kilowatt hour (kWh) (US3.3c/kWh) in 2009-10 to Tk5.9/kWh (US7.5c/kWh) in 2014-15.

Figure 2.3 – Average Cost of Electricity Generation in Bangladesh has Increased Substantially



Source – Bangladesh Power Development Board Annual Reports

Figure 2.4 – Bangladesh Power Development Board Plagued by Continuous Massive Losses



Source – Bangladesh Power Development Board Annual Reports

The rising cost of generation has put pressure on the already troubled Bangladeshi power system and led to the BPDB posting massive losses over 2008-2015. In 2007-08 BPDB lost

[18] Sustainable & Renewable Energy Development Authority, Investment Plan for Bangladesh, October 2015, p. 31.

Tk6.6bn (US$96m), or US$53.9 per customer. Those losses had increased 10-fold by 2014-15, when BPDB lost Tk72.8bn (US$937m), or US$297 on each customer.

These losses reveal how extensively Bangladesh electricity depends on subsidies at multiple levels. This was examined in 2014 by The International Institute for Sustainable Development (IISD):[19]

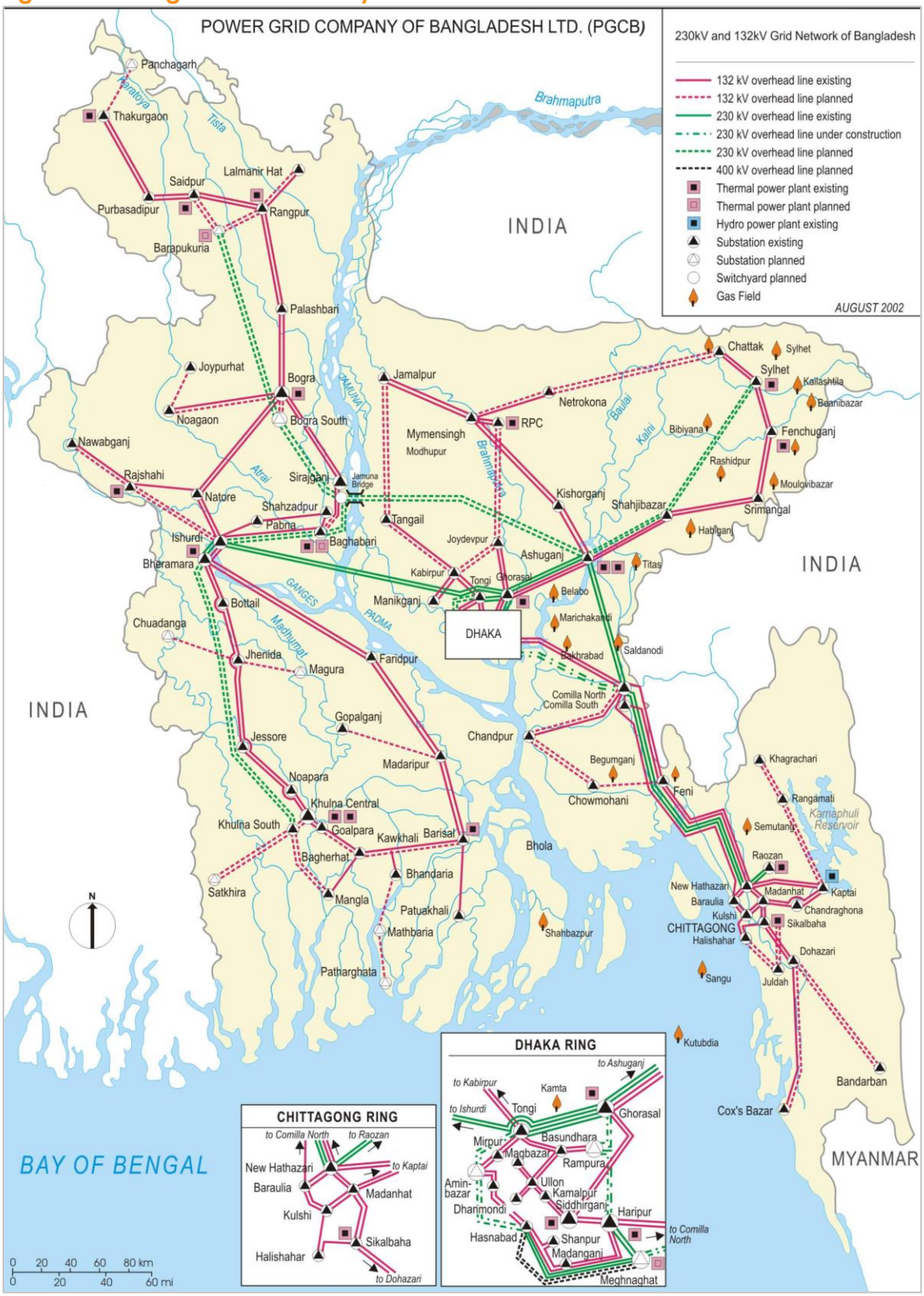
1. All electricity generation input fuels, i.e. gas, furnace oil, diesel and coal, are subsidised;
2. BPDB sells electricity to six distribution companies at lower-than-generation cost;
3. The Bangladesh government provides loans to the BPDB at lower-than-market-rate interest rates in exchange for BPDB selling electricity at lower-than-generation cost;
4. Electricity tariffs for certain consumer segments, especially residential consumers and farmers, are lower than production costs; and
5. Industrial and commercial segments pay higher tariffs to compensate for the losses incurred due to lower-than-cost tariffs paid by residential and agricultural sectors.

These subsidies amounted to nearly 0.9% of GDP in FY2012 as per IISD's estimates. They especially benefit middle-income groups in Bangladesh but fail to benefit many of the poorest people in Bangladesh, who are off the grid entirely and unable to access the country's richly-subsidised electricity. These subsidises, all in all, distort the free market and leave less government resources for development of other important areas of the economy. By artificially keeping retail electricity prices low, the subsidies also act as a barrier to the cost effectiveness of distributed rooftop solar and energy efficiency. The ongoing losses also act as a major obstacle to global financial investment inflows, given the unsustainable nature of the current electricity pricing structure and the inevitability of policy changes. They also create non-bankable counterparty risk.

The Bangladesh grid T&D loss rate was 14% in 2014-15.[20] This high rate of loss in T&D puts significant added financial pressure on any electricity system planning utility scale projects, again highlighting the overall merits of distributed generation alternatives (refer Section 5.0).

[19] http://www.iisd.org/gsi/energy-subsidies-bangladesh-0
[20] Bangladesh Power Development Board Annual Report, 2015

Figure 2.5: Bangladesh Electricity Network



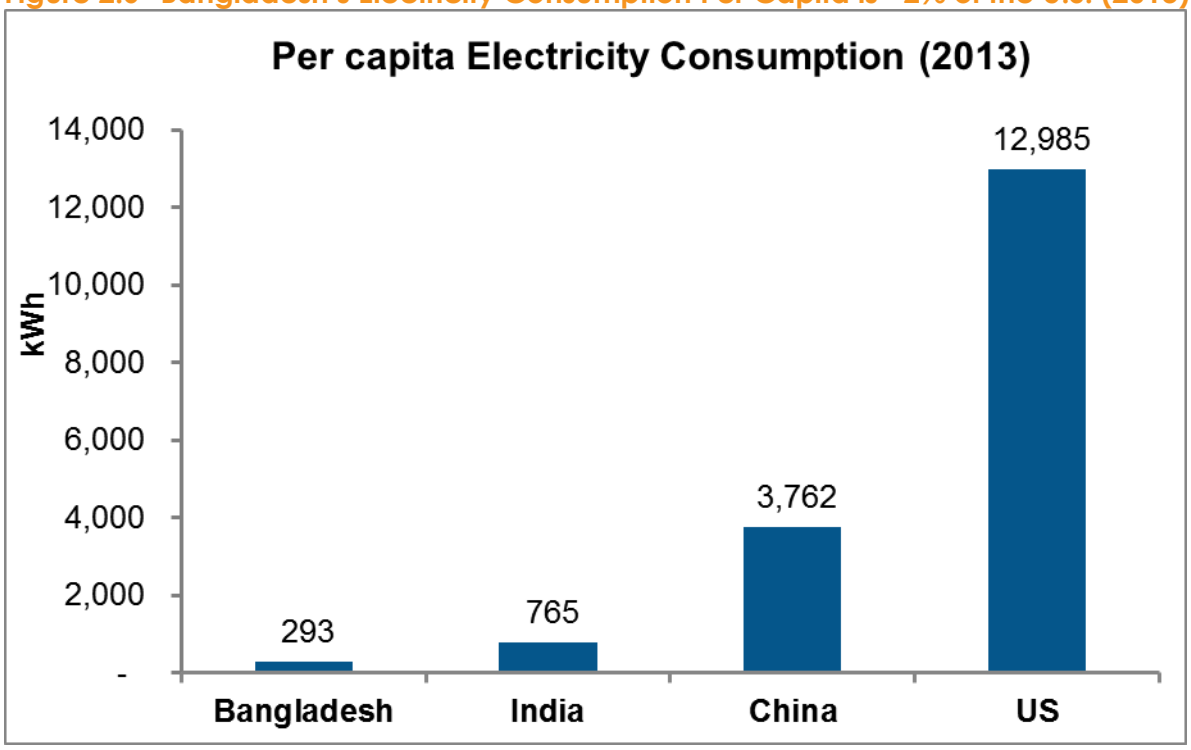
Source: Power Grid Company of Bangladesh

2.3 Electricity Consumption Trends

Growth in electricity consumption has averaged 9.7% per annum over the period 2004 to 2015. This has outpaced Bangladesh's GDP growth (average of 6.2% over the same period) giving a ratio of electricity demand to GDP growth that has averaged 1.56 since 2004 (refer Figure 2.1). Per capita consumption has increased at an average rate of 8.4% per annum but it still remains exceptionally low by world standards.

Bangladesh is ranked 168th globally in the electricity consumption,[21] with annual per capita consumption of 293 kWh in 2013 (Figure 2.6).[22] This is only about 38% of the annual per capita electricity consumption in neighbouring India of 765kWh and it a tiny fraction of per capita consumption in the U.S. and even China.

Figure 2.6- Bangladesh's Electricity Consumption Per Capita is ~2% of the U.S. (2013)



Source: World Bank 2015 Statistics

[21] http://www.indexmundi.com/g/r.aspx?v=81000
[22] http://data.worldbank.org/country/bangladesh

2.4 Generation Mix

Excessive Reliance on Subsidised Domestic Gas

Bangladesh is currently dependent on gas for the majority of its electricity generation. Gas fuels 61.5% of the nation's 13GW generation capacity (Refer Figure 2.7), and in 2015 accounted for 69.5% of electricity production. Given that the "gas supply crisis is deepening,"[23] according to Khaled Mahmood, chairman of BPDB, this creates a major pressure point for Bangladesh's electricity sector. A long-term target for up to 10 LNG import facilities might alleviate volume constraints, but will cause significantly higher wholesale electricity prices as Bangladesh transitions to imported gas price parity.

The other major contributors to the capacity mix are expensive furnace oil and diesel generation (a combined 33.6% of capacity). In comparison, other sources of electricity generation are insignificant at present. Coal-fired power generation comprises only 200MW (1.6% of the total) although the 600MW capacity of electricity imports from India are also currently largely coal-fired (although we note major Indian government efforts to diversify electricity generation to a less emissions-intensive basis by adding significant wind, solar and hydro capacity).

The flat geography of Bangladesh limits the potential for hydro generation, which makes up just 1.9% of capacity. Renewable energy has yet to make a significant impression on the Bangladesh electricity system. The country has the largest off-grid solar energy program in the world, however, with 18 million people (11% of the population) supplied with electricity via the Solar Home System Program (refer Section 5.1), which aims to create 257MW of generation by 2018.[24] Utility-scale solar has yet to make an impact, although a number of initial projects are in the planning stages. Only 2MW of wind capacity is in place. Renewable energy represents a major strategic opportunity for Bangladesh to accelerate investment in sustainable growth sectors.

Figure 2.7: Bangladesh Electricity Generation by Source (August 2016)

Capacity	MW	% of total
Coal	200	1.6%
Gas	7,529	61.5%
Hydro	230	1.9%
Wind	2	0.0%
Utility scale solar	-	0.0%
Distributed rooftop solar	161	1.3%
Furnace Oil	2,627	21.4%
Diesel	1,499	12.2%
Domestic Installed Capacity	12,248	100.0%
Imports - India	600	
Total Generation Capacity	12,848	

Source: Bangladesh Power Development Board

[23] http://ep-bd.com/online/details.php?sec=1&cid=10&id=20674
[24] http://idcol.org/home/solar

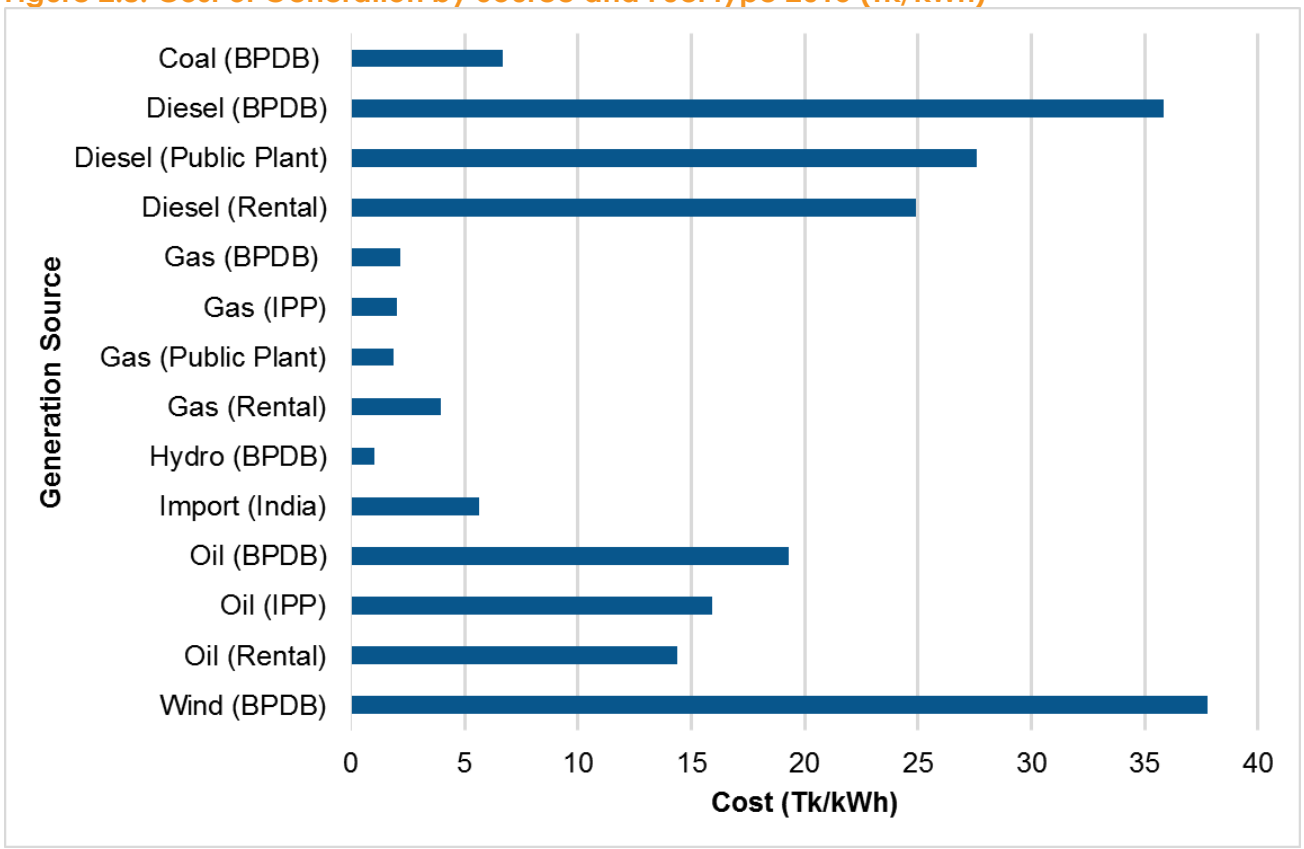
Cost of Generation by Fuel Type

The almost 62% of current capacity fuelled by gas, which, excepting the small amount of hydro capacity (230MW at Tk1.03/kWh), is the cheapest source of electricity generation in Bangladesh, costing as little as Tk1.85/kWh from public power plants (Figure 2.8) due to the artificially low price cap applied to domestic gas.

Bangladesh currently relies on oil and diesel for a third of its generation capacity, which has a much higher cost. The BPDB generates electricity from oil at a cost of Tk19.28/kWh and from diesel at Tk35.84/kWh. Only wind-based generation is more expensive than this at Tk37.76/kWh, in part due to a lack of scale of this renewable source.

The relatively low level of coal-fired generation (including power imports from India) is in the middle of the range, with BPDB generation costing Tk6.7/kWh. But a multitude of constraints relating to biodiversity and water risks, exceptionally high population densities plus resistance to forced community resettlements makes domestic coal expansion an unviable choice.

Figure 2.8: Cost of Generation by Source and Fuel type 2015 (Tk/kWh)



Source: Bangladesh Power Development Board 2014/15

Excessive Reliance on Fossil Fuel Subsidises

The gas-based development of the electricity generating system to date has historically been driven by the domestic availability of natural gas. In March 2015, Bangladesh had 14.3 trillion cubic feet of gas reserves.[25] Ironically, the subsidised pricing of domestic gas has been an immovable obstacle to the incentivising of new on and offshore exploration drilling for new gas reserves.

Since the Modi government was elected in May 2014, India's strong leadership in energy policy has accelerated development and deployment of very cost competitive new energy technologies. A key prerequisite to this electricity sector transformation has been the progressive phase-out of previously entrenched and systematic fossil fuel subsidies and reduction of massive distribution sector losses. Levelling the playing field allows financial markets and corporates to deliver the lowest priced, fully-costed solutions to the energy sector.

India is currently reducing subsidies for kerosene, which is used for lighting and cooking, as rural electrification increases. It seems likely that kerosene subsidies will drop 25% in 2016[26] as use of the fuel falls. This will also lead to decreased air pollution and associated negative health effects.

Bangladesh needs to replicate the successes of India by cutting subsidies and setting a program of accelerated deployment of renewable energy to entrench a deflationary system.

In October 2016, Chevron Corp (US) sought to sell its Bangladesh gas assets for US$2bn, according to published reports.[27] In part reflecting Chevron's own need to repair its balance sheet after the rapid decline in global oil and gas prices, the potential exit from Bangladesh of one of the largest foreign private energy investors in the country is worth noting.

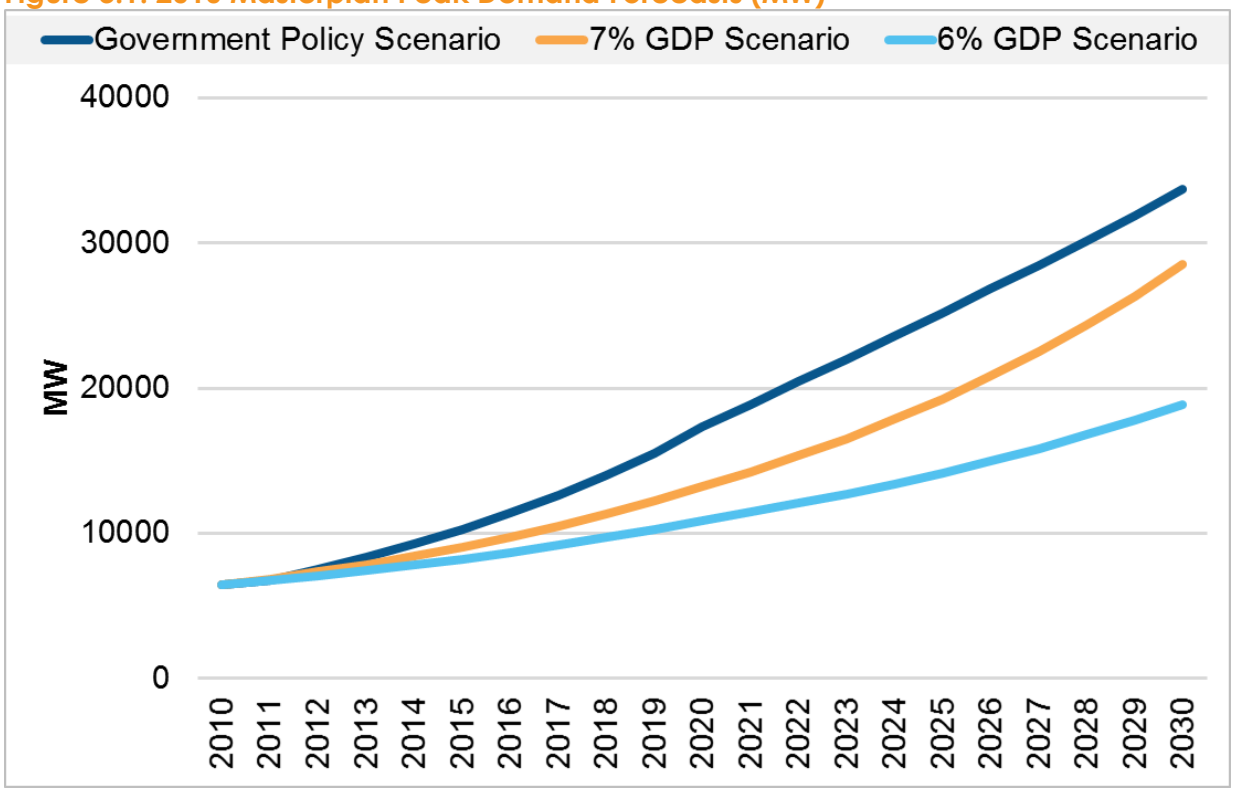
[25] http://bdnews24.com/business/2015/06/15/bangladesh-s-gas-reserves-14.32-trillion-cubic-feet-until-march-bipu
[26] http://economictimes.indiatimes.com/news/economy/policy/kerosene-subsidy-likely-to-decline-by-25-per-cent-this-fiscal-year/articleshow/54819717.cms
[27] http://energy.economictimes.indiatimes.com/news/oil-and-gas/ongc-in-race-for-2bn-chevron-assets-in-bdesh/54846575

3.0 Power System Master Plan

3.1 Plan Overview

To counter the plague of power outages and to support continued economic growth, Bangladesh has adopted a major power-generating-capacity expansion plan. Aims include diversifying Bangladesh's electricity generation from an over-reliance on gas-fired plants that are limited by fuel supply constraints, thereby also improving Bangladesh's energy security.

Figure 3.1: 2010 Masterplan Peak Demand Forecasts (MW)



Source: Bangladesh Power System Masterplan 2010

Under the Power Sector Master Plan formulated in 2010 (PSMP-2010), [28] Bangladesh added 7GW of power generation capacity between 2010 and June 2016. PSMP-2010 envisages plans to add an additional 11.3GW by 2021, as Figure 3.2 details. Actual proposed projects include 7.0GW of additional coal-fired and 5.8GW of gas-fired capacity. PSMP-2010 aims to reduce dependence on gas-based power to 44% by 2021 (down from about 62% today), primarily by adding imported coal-fired power, whose share in the electricity system is projected to rise to 22% by 2021. This is in addition to 2% domestic-coal-fired capacity and 8% capacity imported from India, making for a total of 32% dependence on coal-fired capacity by 2021 (up from about 2% today).

[28] http://www.albd.org/index.php/en/resources/special-reports/1336-powering-bangladesh-s-future-story-of-electricity

Figure 3.2: 2010 Masterplan Peak Demand – Capacity and Annual Additions (GW)

Date	Derated Capacity (GW)	Net additions per annum
June 2009	**4.9**	
Additions: 2009-2010		0.8
June 2010	**5.7**	
Addition: 2010-2016		1.2
June 2016	**12.7**	
Additions: 2016-2021		2.3
June 2021	**24.0**	

NB The 12.7GW of capacity as at June 2016 is net of 595MW of de-rated capacity (i.e. offline long-term).
Source: Bangladesh Power System Masterplan 2010 & BPDB website statistics

In its 2015 Annual Report, the BPDB detailed projects with a combined 17.3GW of new capacity over seven years to 2022. This projection appears to factor in more than 5GW of slippage on the total proposed plan to reach just under 25GW by the same year, particularly as the government has committed to accelerate renewable energy (RE) deployment beyond the 104MW included in the schedule.

The PSMP-2010 strategy has five key objectives:

1. To actively develop domestic resources;
2. To improve energy security by building electricity-generation diversity;
3. To move toward a low-carbon society by introducing modern technology by improving thermal power plant efficiency (by an average of 10% by 2030) and by promoting energy efficiency;
4. To ensure a stable electricity supply through energy-grid enhancements; and
5. To build efficient and effective organizations and capacities.

The PSMP-2010 envisions solar power contributing 5.7% and wind power 4.5% to the electricity system by 2021. Beyond this, the PSMP-2010 recommends a system by 2030 that is 50% coal-based, 25% natural gas-based and that gets about 25% of its power from oil, nuclear and renewable-based power. This plan has seriously adverse energy security issues in terms of reliance on imported supply of fuels.

Power System Master Plan 2016 (PSMP-2016)

The delayed 2015 Power Sector Master Plan is now expected to be released in 2016. Importantly, the new plan is expected to take account of both environmental and energy security concerns when assessing the potential energy mix out to 2041. PSMP-2016 will acknowledge that the Bangladeshi economy would be vulnerable to sudden shortages in fuel supply where the country is heavily dependent on imports for its energy system. Stability of fuel prices are also recognised as an important element of energy security. As such, the plan will assess the economic, environmental and energy security impacts of a range of fossil fuel mix ratio scenarios in the Bangladeshi energy system, focussing on coal

and gas. The plan will highlight that high percentages of coal (55%) versus gas (15%) within the energy system, or vica versa, are sub-optimal as such scenarios are dependent on high levels of imports and hence raise energy security concerns[29].

PSMP-2016 will predict total coal demand of 71 million tonnes per annum (Mtpa) by 2041 with 61Mtpa costing US$4.6bn per annum sourced from coal imports which raises major energy security issues for Bangladesh. The plan will maintain that securing this level of import into Bangladesh will be difficult as coal use across Asia is rising meaning supply will be tight. However, this is based on the historical increase in coal use in the region from 1990 to 2014. It is a mistake to believe that such coal demand increases will continue at this rate going into the future as national clean energy commitments and the fast-decreasing cost of renewable energy are already quickly eroding coal's share of the energy mix in Asia.

The plan will also highlight predicted price increases of coal imports out to 2040 and beyond which is another major risk to an energy system dependent on imports. Much of the forecast is based on outdated International Energy Agency (IEA) scenarios predicting continued coal consumption growth, meaning IEEFA would contend that the forecasts within PSMP-2016 will prove to be inaccurate. Global coal consumption peaked in 2013 and has dropped each year since and will do so again in 2016. However, despite declining global consumption, coal price spikes could still highlight the vulnerability of an imported coal-dependent Bangladeshi energy system. Such a price spike is occurring now with thermal coal prices up over 100% from the beginning of this year. This is a result of supply restrictions emanating from Chinese government policy aimed at controlling the country's transition away from coal rather than any increase in coal demand. The recent price increases have already put pressure on the imported coal electricity generation sector in neighbouring India[30].

The energy security issues arising from dependence on coal imports are also true of LNG. PSMP-2016 is to report that 70% of Bangladesh's gas demand will need to be fulfilled with LNG imports as domestic production declines from 2017.

Recognising the vulnerabilities arising from heavy dependence on fuel imports, PSMP-2016 is to place a high priority on domestic coal production increases. The plan assumes that controversies surrounding coal mining in Bangladesh can be resolved and that open cut operations at sites such as Phulbari can commence and make a meaningful contribution to the countries energy mix. Given the long development delays that have already taken place at Phulbari and the recent press reports that the Bangladesh government is turning away from open cut coal mining[31], this prospect seems unlikely. The prospects for nuclear power development in Bangladesh seem similarly remote: PSMP-2016 will highlight ongoing progress on the deal with the Russian government to build the 2.4GW Ruppor Nuclear Power Plant whilst acknowledging that there are significant public acceptance, regulatory and market risks surrounding nuclear power development. Given nuclear power's long history of cost overruns and delays, the 2023/24 completion dates are likely to prove unachievable.

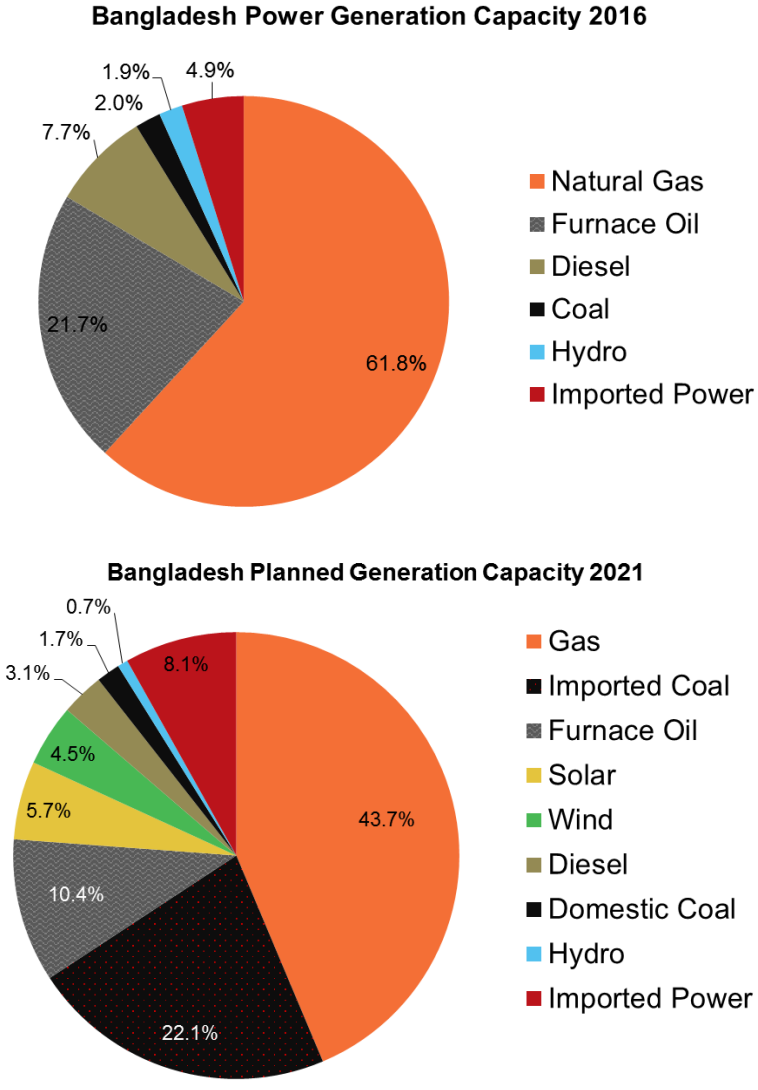
In fact, the report will highlight the fact that 70% of the country's existing power plants were completed 1 to 4 years behind schedule. One of the benefits of solar power technology is that such power plants can be constructed relatively quickly. Within the

[29] Bangladesh Power System Master Plan (Draft) 2016
[30] http://www.business-standard.com/article/pti-stories/high-imported-coal-price-may-hit-power-sector-report-116110700695_1.html
[31] http://energybangla.com/govt-backtracks-on-open-pit-mining-in-barapukuria/

renewables space, PSMP-2016 will make the point that utility-scale investment has been hindered by the absence of a transparent, competitive bidding process. It will also note that finding space for utility-scale solar PV power plants in such a densely populated country is a major issue. A key limiting factor is the fact that government policy prohibits the use of agricultural land for such developments. Countries like Japan, India, Germany and Taiwan are not finding such constraint and IEEFA would strongly contest this likely false assumption.

A 2015 Sustainable & Renewable Energy Development Authority (SREDA) on renewables investment in Bangladesh assumed that only 2% of non-agricultural land would be suitable for solar power development[32]. The report acknowledges that this assumption is conservative; more land is likely to be available for utility-scale solar than acknowledged by this report.

Figure 3.3 – Bangladesh Electricity Generation Capacity Transformation 2016-2021 (MW)[33]



Source: Bangladesh Power Development Board, IEEFA Research

[32] Sustainable & Renewable Energy Development Authority, Scaling Up Renewable Energy in Low Income Countries – Investment Plan for Bangladesh, October 2015, p. 39.
[33] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=150&Itemid=16

3.2 An Emphasis on Renewable Energy Has Been Initiated

In October 2015, the chairman of the Bangladesh Energy Regulatory Commission, A. R Khan, said the government should replicate the renewable energy transformation under way in Germany. Khan projected Bangladesh would have 6GW electricity from solar generation by 2030.[34]

In November 2015, the Bangladesh government announced plans for an aggressive build-out of renewable energy. "We revised our plan earlier this year to target 15% [of electricity] from renewables by 2021, which means 3,100MW," Siddique Zobair, a member of the Sustainable and Renewable Energy Development Authority of Bangladesh (SREDA), said.[35] However, a year has passed and the BPDB's "Power Vision 2021" discussion still fails to mention renewables and instead talks of much greater reliance on imported coal and LNG power generation.

In addition to its recent successes in rooftop solar, the government of Bangladesh has started to focus on grid-connected solar power generation. Bangladesh's 2021 target now includes 1.7GW of solar capacity and 1.3GW of wind, plus some expansion of biomass-based power capacity. Given the potential for solar development and the benefits of solar power, Bangladesh is starting to seriously evaluate solar as an alternative. While this is an encouraging sign, the government still needs to commit to replicating the rapid acceleration of solar investment clearly evident across India. The recent announcement that Bangladesh has joined the International Solar Alliance is a positive step[36].

Seven utility scale solar projects have been initiated in the last two years in Bangladesh, but a very clearly stated top-of-government endorsement is needed to accelerate this potential transformation and to ensure successive tenders have clear timeline delineations and binding long-term offtake agreements from highly credit-worthy counterparties.[37]

Renewables Are a Viable Alternative

Bangladesh clearly needs to diversify and expand its power generation system.

The huge potential for both distributed rooftop and utility scale solar power offer an alternative way to achieve cost-effective expansion of the power generation base while reducing Bangladesh's fuel-price risk and avoiding additional current account deficit and currency pressures. With solar radiation of 4-5kWh per square metre per day, Bangladesh has massive solar potential—enough to generate 380TWh electricity per annum through solar photovoltaic (PV) installations[38], far more than forecast demand well into the future.

Realising just part of this potential would meet Bangladesh's medium-term electricity needs. And while the Bangladesh government has said since 2014 it endorses a succession of utility scale solar projects, almost all of these proposals have seen major contractual and approval delays and all clearly need a Prime Minister-endorsed solar policy to provide transparency, longevity and certainty.[39] Replicating and leveraging off the brilliant progress achieved in solar in neighbouring India would dramatically transform

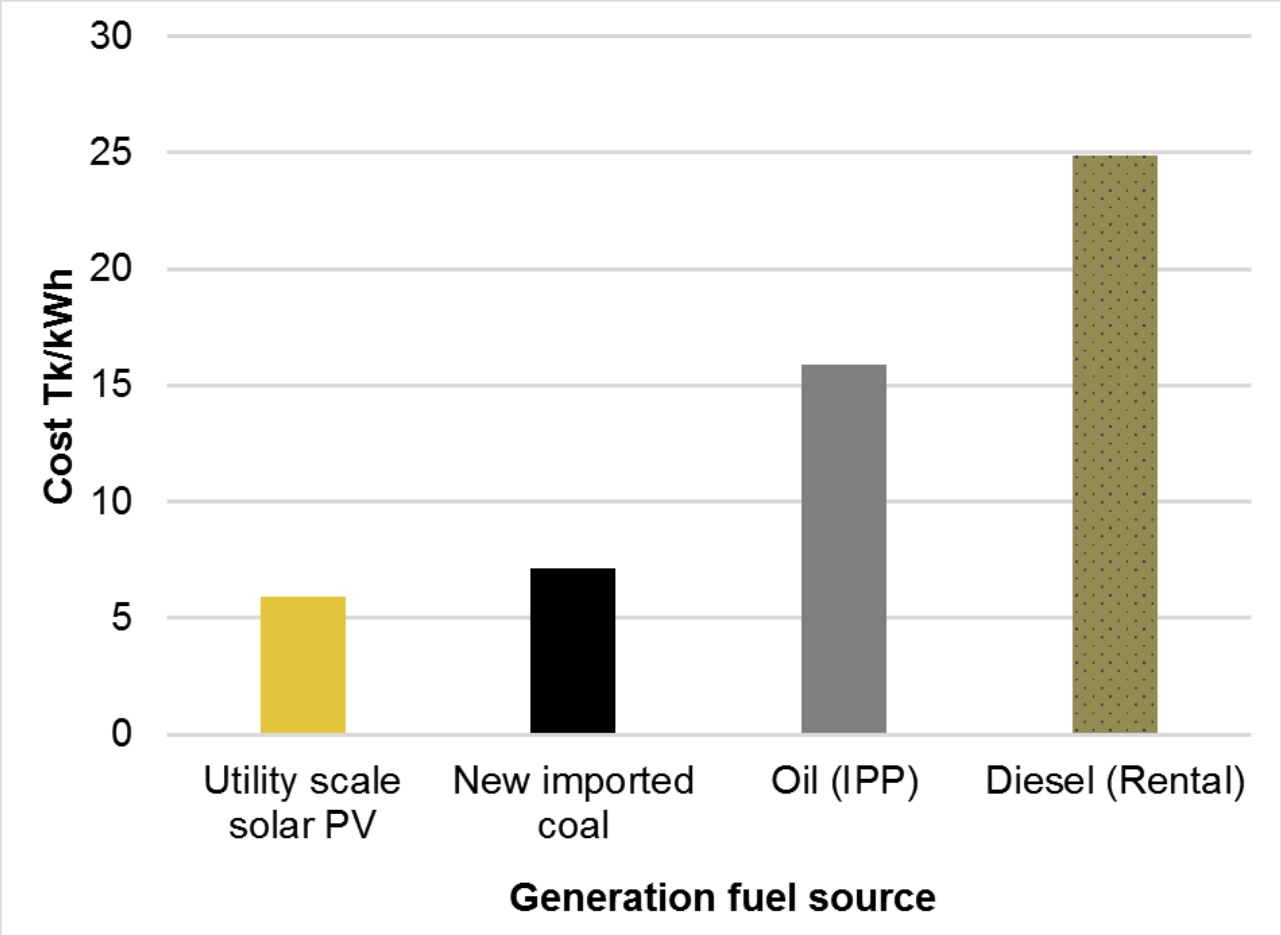
[34] http://ep-bd.com/online/details.php?cid=33&id=19071
[35] http://reneweconomy.com.au/2016/is-dubais-new-record-about-to-set-a-new-normal-for-solar-tariffs-42945
[36] http://energy.economictimes.indiatimes.com/news/renewable/bangladesh-joins-international-solar-alliance/55453469
[37] http://newagebd.net/231208/6-mega-solar-power-projects-hit-snag/
[38] http://en.openei.org/datasets/dataset/solar-resources-by-class-and-country
[39] http://newagebd.net/231208/6-mega-solar-power-projects-hit-snag/

Bangladesh's energy and growth outlook.

Cost of Solar PV Compares Favourably to Imported Coal

In India solar PV is now cheaper than new, imported coal-fired power generation[40]. During 2016, new solar generation tariffs have consistently been priced below Rs4.50-5.00/kWh (around US$0.065-0.070/kWh). Bangladesh is in a good position to benefit from the progress made by the solar PV industry in India and, once enough scale has been reached, Bangladesh should be able to achieve similarly low tariffs for solar if it were to implement its own reverse auction process. Figure 3.4 below compares the cost of solar generation to that of new, imported coal and other fossil fuel generation. Once sufficient scale and learning-by-doing has been achieved, a cost of Tk5.9/kWh (equivalent to Rs5/kWh and around US$0.070-0.075/kWh) has been assumed for solar PV, 10-15% higher than what is currently being achieved in India. IEEFA calculates that the cost of new, imported coal-fired electricity generation would be Tk7.15/kWh (US$0.093/kWh) once a project is fully operational and inclusive of subsidies.

Figure 3.4 – Cost of Utility Scale Solar Vs Cost of Fossil Fuel Generation



Source: IEEFA estimates, Bangladesh Power Development Board.

[40] http://cleantechnica.com/2016/01/22/solar-power-now-cheaper-than-coal-in-india-says-energy-minister/

Limits on Available Land and Lack of Wind / Hydro Favour Solar

A key constraint in Bangladesh electricity-generation development is land availability, be it for coal mining, thermal power generation, utility-scale solar or hydroelectricity. Bangladesh has one of the highest population densities in the world. While utility scale solar projects offer considerable potential, it is imperative that the government targets use of non-arable wastelands via the establishment of Solar Industrial Parks with government-sponsored grid transmission connectivity, as is being pursued in India. The World Bank estimates 59% of Bangladesh's total land is arable, and 11% is forested. With 66% of the population still based in rural areas, this is a key constraint that requires careful management. A 2015 Sustainable & Renewable Energy Development Authority (SREDA) report found that if agricultural land is avoided, space for only 1.4GW of solar power plants is available[41]. However, this report made the assumption that only 2% of non-agricultural land would be suitable for solar power development. In addition, the report makes clear that this 2% figure was used to bring the resultant potential capacity finding in line with current government renewables targets.

IEEFA is of the opinion that the assumption that only 2% of non-agricultural land will be suitable for utility-scale solar power development is too conservative and that more land has the potential for such developments than is currently acknowledged.

Notwithstanding the challenges of limited land, utility scale solar has considerable scope so long as it is pursued with sensible planning policies. If Bangladesh were to set an ambitious target of 10GW of utility solar by 2025, it would require 20,000 hectares of land, or just 0.15% of Bangladesh's 13.2 million total.

Rooftop solar, micro-grids and solar irrigation pumps all have strong potential in Bangladesh.

Renewable Power Can Provide Bangladesh with Both Timely New Power Capacity and Enhanced Energy Security Through Diversification

Bangladesh needs electricity to power its future growth and to meet its current demand shortfall. Coal-fired power plants take the best part of a decade from planning to commissioning. But, solar plants—as India has shown—can be cost effectively commissioned in 12 months and are able to add to electricity supply almost immediately.

Coal projects are prone to delay, especially in Bangladesh. This is evidenced, for example, by the less than expected output from the Barapukuria coal mine and an 11-year delay in development the Phulbari coal mine.

Renewable energy sources provide true energy security to Bangladesh, since they have no raw-material requirement. Plants requiring imported coal, by contrast, expose the Bangladeshi system to both fuel-price as well as exchange-rate risk.

[41] Sustainable & Renewable Energy Development Authority, Scaling Up Renewable Energy in Low Income Countries – Investment Plan for Bangladesh, October 2015, p. 39.

4.0 IEEFA's Electricity Model: FY2015 to FY2025

The Bangladesh electricity system faces dual challenges of building energy security through better diversification of fuel sources and of delivering sustainable and cost competitive capacity expansions of 1-2GW annually over the next decade.

Given that the global electricity sector transformation is now clearly underway (witness recent developments in a collection of such wide-ranging locales as China, India, Brazil, Mexico and Canada), an additional challenge for Bangladesh is to adopt a clear long-term policy framework for an electricity plan that transitions toward a lower emissions-intensive system that cost-effectively expands capacity and production. This transition needs to gradually incorporate and leverage the new technologies rapidly emerging across renewable energy and energy efficiency whilst building system flexibility through a cost competitive smart grid rollout combined with offgrid/micro-grid distributed energy systems capable of adding battery storage as it becomes increasingly cost competitive.

The success of the COP21 Paris Agreement reminds us of the common but differentiated responsibilities of addressing climate change and of Bangladesh's exposure to extreme weather events and the increasing risk of rising sea levels. Bangladesh is a member of the Climate Vulnerable Forum (CVF) and adopted the CVF's 2015 declaration which called for zero global greenhouse gas emissions by mid-century[42]. There is a clear need for global financial institutions like the China Development Bank, JBIC (Japan Bank for International Cooperation), the Green Climate Fund, the Export-Import Bank of the U.S., India's EXIM Bank, plus new AIIB and BRICS institutions to assist in providing long-dated, patient debt and equity capital to accelerate investment in Bangladesh's electricity transition.

IEEFA has developed a country-level electricity-sector model for Bangladesh based on the likely rates of economic and hence electricity system demand growth, combined with assumptions on opportunities for ongoing improvements in energy efficiency and grid-transmission loss rates. From this top-down perspective, IEEFA calculates the likely electricity demand growth over the coming decade to 2024/25.

We then estimate the overall capacity addition requirements across the various fuel and technology options available. We give consideration to the balancing act of evaluating often-competing pressures relating to the:

1. Need for timely total system growth;
2. Long-term cost-competitive supply of electricity;
3. Ongoing current account imposts with follow-on impact on currency devaluation and domestic inflation and hence interest rates;
4. Significant costs of externalities of fossil fuels (e.g. air, particulate and water pollution);
5. Resource and land limitations affecting any new capacity developments, be they fossil fuel or low emission technologies; and

[42] http://www.thecvf.org/web/publications-data/official-documents/cvf-declarations/

6. The need for system diversification.

In summary, we believe Bangladesh could well sustain real economic growth of 7% annually over the next decade. Even with a gradual improvement in grid Aggregate Technical and Commercial (AT&C) loss rates and the accelerated emphasis on energy efficiency, this growth will likely result in a doubling of total system electricity demand to 81TWh by 2024/25. With IEEFA assuming that AT&C loss rates can be reduced from 13.6% in 2014/15 to 11.6% by 2024/25 (a 0.2% annual improvement), 47TWh of additional production will be required this coming decade. With the benefit of significantly diversifying the total electricity system, this requires the trebling of total system capacity from 11.1GW in at the end of 2014/15 to 33.2GW by end-2024/25 – refer Figure 4.1 and 4.2 below.

Figure 4.1: Changes in Bangladesh's Net Electricity Consumption: 2014/15-2024/25

			TWh
Net Electricity consumed in Bangladesh in 2014/15 (TWh)			39.6
Real GDP Growth	7%	pa	-
Electricity to GDP multiplier	1.2	times	-
Electricity Demand Growth	8%	pa	43.1
Energy Efficiency	1%	pa	(7.3)
Growth in gross production AT&C losses			7.6
Reduced grid AT&C losses	0%	pa grid efficiency gain	(2.0)
Net Electricity consumed in Bangladesh in 2024/25 (TWh)			80.9
Electricity consumption growth required (TWh)			41.3
Production growth required (TWh)			46.7

Source: Bangladesh Power Development Board 2015 Annual Report, IEEFA estimates

Economic Growth … 7.0% per annum for the next decade

IEEFA models that Bangladesh can sustain an average rate of real economic growth (gross national product (GDP)) of 7.0% annually over the next decade to 2024/25. While this implies Bangladesh is one of the fastest growing developing countries globally, this is consistent with the International Monetary Fund forecast for 6.9% growth in 2016/17 and only slightly higher than that achieved over the last five years (refer section 1.0).

Electricity to GDP Growth Ratio … 1.2x GDP

IEEFA models that Bangladesh will continue to see near-10% annual growth in its more electricity-intensive industrial sector whilst the agricultural sector will grow in line with recent growth of 3-5% annually and that the consumer/service sectors will grow in line with GDP at 7% p.a. This means the industrial sector continues to gain share of overall GDP over in the next decade as the economy transforms and industrialises. This in turn means the electricity intensity of economic activity is likely to rise over time. Consistent with the trend

evident over the first 12 years of this century in China, we model a 1.2x multiplier i.e. gross electricity demand growth will be 8.4% p.a. relative to 7.0% GDP growth.

Energy Efficiency … 1% per annum improvement

While we model 8.4% p.a. gross electricity demand growth, we also and separately assume that ongoing improvements from energy efficiency initiatives will reduce demand growth by 1.0% annually so net electricity demand growth will be 7.4% annually over the coming decade.

While not a focus of this report, energy efficiency should play an absolutely key role in Bangladesh, reducing the rate of new capacity investment needed, thereby reducing pollution and people-displacement pressures. This should be a key area of government policy focus to incentivise capital investment and to maximise energy productivity.

Behind-the-Meter Generation

IEEFA sees significant inherent grid efficiencies of an increasingly distributed energy load structure, with the importance of this for Bangladesh evident in terms of both constraints on land availability and the heavy increase in grid capacity expansions required this coming decade. As such, distributed electricity generation should continue to play a pivotal and increasing role in Bangladesh's smart-grid development.

Bangladesh already has the highest residential rooftop solar system penetration globally, with an estimated 4.4 million systems in place by June 2016 (refer section 5.1). With regular system-wide brownouts a reoccurring theme and a major constraint to sustained strong economic growth, IEEFA would expect the commercial, retail and industrial sectors to accelerate the uptake of rooftop installations (of 20kW through to 500kW sized systems). This is likely to be driven by A) significant improvements in the commercial viability of battery storage by 2020 and B) the need for BPDB to increase the tariff for sectors of the economy most able to pay i.e. industrial and commercial customers in order to rein in unsustainable distribution sector losses (refer section 2.2).

Bangladesh already has a progressive retail electricity tariff structure where on-grid low-income households receive a heavily subsidised concessional rate. The higher tariff applying to households that are higher electricity users incentivises energy efficiency and rooftop solar (unfortunately this subsidy also acts as a disincentive for poorer households that have lower usage to adopt rooftop solar systems).

AT&C Loss Rate … declining 0.2% p.a. to 11.6% by 2024/25

IEEFA assumes that the BPDB can continue to achieve a gradual reduction (i.e. improvement) in grid Aggregate Technical and Commercial (AT&C) loss rates of 0.2% annually, meaning the loss rate declines from 13.6% in 2014/15 to 11.6% by 2024/25. This loss rate is still double the global average (and triple the world's best, that being 4% as achieved by Germany), but we have not assumed a faster improvement in light of India reporting an average AT&C loss rate of 22-26% annually over the last five years, meaning

there is a real risk that as the electricity grid system trebles in the next decade, AT&C losses could balloon if a strong priority is not assigned to building in grid efficiency measures.

In August 2016, State Minister for Power Nasrul Hamid set a target to bring grid losses down to 11.5%, suggesting there is scope to accelerate relative to our forecast.[43]

Electricity Supply Growth … installed capacity to triple to 33GW by 2024/25

With the assumptions above, net demand for electricity in Bangladesh is forecast to double to 80.9TWh over the decade to 2024/25, rising by 41.3TWh from the 39.6TWh reported in 2014/15. With AT&C losses of 11.6%, in order to deliver an extra 41.3TWh of demand, an additional 46.7TWh of gross electricity production is required.

Figure 4.2 details the sources of increased electricity production by technology type. IEEFA models the tripling in installed capacity in Bangladesh by 2024/25 from 11.1GW to 33.2GW.

IEEFA's electricity generation capacity modelling presumes the Government of Bangladesh sets and then articulates strong support for a new energy policy framework that clearly endorses an electricity system transformation along the lines of that being so effectively implemented in China and more recently by India.

Whether the primary motive is to build energy security through greater diversification, or to limit current account deficit pressures, reduce water stress and particulate pollution or to address long-term systemic risks of climate change, the cost-effective move to a lower emissions-intensive, smart-technology electricity system has a multitude of benefits.

Figure 4.2: Changes in Bangladesh's Gross Electricity Production: 2014/15-2024/25

The Increase in Net Electricity Demand is met by:	TWh	Uplift	Installed Total FY15 (GW)	Installed Total by FY25 (GW)
Utility scale solar	17.5	38%	-	10.0
Rooftop solar - Residential	2.4	5%	0.1	1.6
Rooftop solar - Commercial & Industrial	2.4	5%	-	1.6
Solar irrigation pumps	1.8	4%	-	1.0
Solar thermal addition	0.9	2%	-	0.5
Development of Windfarms	0.5	1%	0.0	0.3
Increase in biomass / Biogas generation	2.1	5%	-	0.6
Increase in large & ROR hydro electricity	0.9	2%	0.2	0.5
New hydro imports from Bhutan	3.5	8%	-	1.0
Electricity imports from India	8.4	18%	0.5	2.1
Increase in LNG/gas-fired electricity	5.2	11%	6.8	8.8
Increase in coal-fired electricity	5.9	13%	0.3	1.5
Increase in diesel/furnace oil-fired electricity	(4.7)	-10%	3.2	3.8
Net expansion in Electricity Production by 2024/25 (TWh)	**46.7**	**100%**	**11.1**	**33.2**

Source: Bangladesh Power Development Board 2015 Annual Report, IEEFA estimates

[43] http://www.observerbd.com/details.php?id=30004

4.1 Capacity and Production Expansion by Fuel Type

We estimate that various forms of solar can deliver half of the incremental production requirement for Bangladesh over the coming decade. This assumes:

1. 10GW of utility scale solar with tracking (an average addition of 1GW annually) that would supply 17.5TWh or 37% of the total system additions;
2. Distributed rooftop solar adding 2.4TWh or 5% from residential installs and another 2.4TWh from commercial and industrial (C&I) installations. Each of these two groups would require 1.6GW of capacity over the coming decade. This looks to be a massive step-up in the context of the entire existing installed rooftop basis evident today (estimated at just 161MW – refer Section 5.1). Australian residential rooftop installs, by way of comparison, have averaged over 800MW annually over the last six years, and Australia has less than one-eighth of the population of Bangladesh, although Australia would have a significantly larger average roof size. Bangladesh would need to add less than 200MW annually to reach 1.6GW of residential solar by 2025.
3. With its significant agricultural-sector and current heavy reliance on subsidised diesel powered irrigation pumps, there is a strong fiscal incentive for Bangladesh to follow India's target to install 26 million solar-powered irrigation pumps. This could replace 1.8TWh of diesel generation, or 4% of total system growth this coming decade (SREDA estimates 545MW of solar pump capacity); and
4. Concentrated Solar Power (CSP) is still cost prohibitive, but with China and South Africa now leveraging Spanish and US investments over the last decade, CSP beyond 2020 should be a cost-competitive source of peaking capacity versus current peaking rental power producers running on imported oil. NTPC have recently announced Asia's first integrated solar thermal project with the involvement of German CSP company Frenell which could mark the beginning of the CSP sector in India. We assume 500MW by 2024/25 generating 0.9TWh or 2% of total system growth.

With very low wind speeds across Bangladesh, the scope for cost-effective wind power development is very limited—we assume just 302MW is installed by 2024/25 relative to the 2MW currently operational today. As such, wind contributes a modelled 0.5TWh or just 1%.

With the agricultural industry remaining a key sector of importance in Bangladesh in terms of economic contribution and as the largest employer, we have factored in a material investment in small-scale applications of distributed and offgrid biomass and bio-gas electricity generation to add 600MW in the coming decade, this should add 2.1TWh of new generation (4% of incremental production needs – refer Section 5.3).

Bangladesh has very limited scope to expand its very minor existing hydro-electricity capacity of just 230MW at Kaptai Hydro Power Station. We assume the addition of 250MW by 2024/25, reflecting both large scale installs plus incremental, distributed mini and micro-hydro systems. This adds an estimated 0.9TWh or 2% of total production growth.

We forecast that electricity imports from domestic coal and solar power plants in India plus hydro from Bhutan can rise to 3.1GW of capacity by 2024/25 relative to 500MW in June 2015. This can provide a collective 12TWh pa (8.4TWh from coal and solar in India plus 3.5TWh from Bhutan hydro); 26% of Bangladesh's increased generation requirement – refer Section 5.4. Although this relies on delivery from foreign countries, it represents much less of an energy security issue than depending on coal and gas imports for the great majority of generation, as is the current plan for Bangladesh.

A 2.0GW increase in gas-fired power generation addition is forecast by 2024/25, adding 5.2TWh or 11% of new production requirements. LNG is assumed to supply half of this.

Coal-fired power capacity is forecast to rise to 1.5GW by 2024/25, from just 250MW at June 2015. This adds 5.9TWh or 13% of the increase required, suggesting that four-fifths of the 7.1GW of BPDB's planned import coal-fired capacity expansions slated to be online by 2022 are surplus to Bangladesh's needs in the coming decade on IEEFA's modelling.

Finally, the IEEFA modelling factors in a marginal increase to 3.8GW in diesel/heavy furnace oil-fired capacity over the coming decade (much of which is already under construction). However, we model a progressively lower utilisation rate that sees actual production from this fuel source decline 4.7TWh as the grid operator favours wider availability of lower cost alternatives. BPDB reports the average cost of diesel fired generation in 2014/15 was Tk24.91-35.84/kWh and heavy furnace oil at Tk14.39-19.28/kWh. We note that other than Japan, no major developed country relies on expensive oil for other than peak generation or back-up needs.

Figure 4.3: Bangladesh's Gross Electricity Capacity and Production: 2014/15-2024/25

Bangladesh Electricity Technology type	2014/15 Capacity MW	2024/25 Capacity MW	2014/15 Capacity %	2024/25 Capacity %	2014/15 Production TWh	2024/25 Production TWh	2014/15 Utilisation Rate %	2024/25 Utilisation Rate %
Utility scale solar	-	10,000	0%	30%	-	17.52	n.a.	20%
Rooftop solar - Residential	125	1,563	1%	5%	0.18	2.46	16%	18%
Rooftop solar - C&I	-	1,563	0%	5%	-	2.46	n.a.	18%
Solar irrigation pumps	-	1,000	0%	3%	-	1.75	n.a.	20%
Solar thermal	-	500	0%	2%	-	0.88	n.a.	20%
Wind energy	2	302	0%	1%	0.00	0.48	n.a.	18%
Biomass / Biogas generation	-	600	0%	2%	-	2.10	n.a.	40%
Large & ROR hydro electricity	230	480	2%	1%	0.57	1.47	28%	35%
Hydro imports from Bhutan	-	1,000	0%	3%	-	3.50	n.a.	40%
Electricity imports from India	500	2,100	4%	6%	3.38	11.83	64%	64%
LNG/gas-fired electricity	6,781	8,783	61%	26%	31.16	36.36	52%	47%
Coal-fired electricity	250	1,500	2%	5%	0.99	6.85	45%	52%
Diesel/foil-fired electricity	3,228	3,828	29%	12%	9.57	4.84	34%	14%
Total Gross Generation	**11,116**	**33,218**	**100%**	**100%**	**45.84**	**92.51**		

Source: Bangladesh Power Development Board 2015 Annual Report, IEEFA estimates

IEEFA's model of the Bangladesh electricity system assumes a heavy prioritisation of more sustainable renewable energy generation. We forecast a trebling of total installed capacity to 33.2GW by 2024/25 (Figure 4.3). Solar in all its technology types represents a combined 14.6GW of 44% of the total capacity (27% of production), ahead of gas-fired capacity of 8.8GW or 26%. The grid's reliance on expensive, imported diesel & furnace oil drops dramatically; while total installed capacity increases to 3.8GW or 12% of the total, a more than halving of utilisation rates is likely over the coming decade. Electricity imports from India and Bhutan play a critical diversification role in grid electricity supply, rising to 3.1GW or 9% of total capacity (17% of production).

With one of the highest population densities in the world (1,237 people per square km), any large-scale energy development is problematic, including utility solar. However, with imports the main alternative, Bangladesh needs to prioritise domestic fuel sources.

5.0 Electricity Generation by Technology Type

In this section we explore some of the opportunities and limitations for renewable energy, electricity imports and fossil fuels in Bangladesh. In order to incentivise and accelerate global investment (and hence job opportunities) in the Bangladesh power sector, IEEFA would recommend a strong policy commitment to deployment of new technologies across the renewable energy spectrum.

5.1 Bangladesh Has Made Significant Progress in Rooftop Solar

Bangladesh has already implemented an aggressive adoption of rooftop residential solar, having possibly the most successful distributed solar program globally. This progress was initiated by the government-owned Infrastructure Development Company Limited (IDCOL), which provided concessional loans, assisted by the World Bank and developmental agencies like GIZ, KfW, ADB, IDB, GPOBA, JICA, USAID and DFID.[44]

Over 4.5 million households had installed Solar Home Systems (SHS) under this fee-for-service program by November 2016.[45] This expansion has been due in large part to Nobel Laureate Professor Muhammad Yunus establishing Grameen Shakti in 1996, a group that promotes and supports renewable energy technologies. This non-government organisation is the leading Bangladesh installer of SHS.[46]

The Solar Home System movement continues to grow. Every month, 60,000-70,000 additional households install rooftop SHS.[47] [48] Figure 5.1 shows that by adding 66,000 SHS monthly to June 2018, and by lifting the average new system size installed to 60W, the program will see 6 million SHS installed with a total capacity reaching 257MW of distributed solar relative to 125MW in June 2015.

Figure 5.1 – Bangladesh Residential Rooftop Distributed Solar Program

Rooftop Solar	Jun-15	Monthly additions	Jun-16	Monthly additions	Jun-18
Household systems	3,700,000	60,000	4,420,000	66,000	6,004,000
Average system size (W)	34	50	37	60	43
Total capacity (kW)	125,800		161,800		256,840
Total capacity (MW)	125		162		257

Source: Bangladesh Power Development Board, IEEFA calculations and forecasts

This world-leading program is providing much-needed electricity-sector diversification and new capacity while avoiding the perennial and multi-decade economic drain of fuel costs for thermal power and grid extensions to remote villages. Given that access to electricity in Bangladesh is calculated by the World Bank at just 60% of the population, and with 66% of the total population being rural, SHS programs dramatically reduce the

[44] http://idcol.org/home/solar
[45] http://www.thefinancialexpress-bd.com/2016/11/16/53213/FBCCI-to-seek-incentives-for-promoting-green-business
[46] http://www.gshakti.org/index.php?option=com_content&view=article&id=190:onemillionshs&catid=47:news-and-media&Itemid=73
[47] http://in.reuters.com/article/bangladesh-solar-idINKBN0KY0O220150125
[48] http://ep-bd.com/online/details.php?cid=31&id=20335

retail price of delivered electricity to the rural poor, acting as an extremely cost effective and timely program to reduce energy poverty and improve health and literacy.

A key consideration in all this is that the average residential rooftop system installed in the U.S. and Australia in 2015 was 4,900W.[49] The current Bangladesh SHS averages only 34W and although there is little prospect of matching the U.S. and Australian average, the scope for significantly larger SHS installations is clear. With the program's scale and collapsing solar module costs, a doubling of the average SHS system would see residential rooftop solar capacity exceed 500MW by June 2018, a timeframe that beats by several years any new fossil fuel project proposal.

A significant side benefit of Bangladesh's off-grid solar program is that an estimated 200,000tpa (tonnes per annum) of kerosene worth about US$180m annually no longer needs to be imported, a change that brings current account and currency benefits, plus reduces the fiscal deficit required to subsidise kerosene use.

There are several areas of significant potential for off-grid solar applications, including replacement of some 1.4 million diesel-fuelled irrigation pumps in Bangladesh, development of micro-grid systems, and progress in the commercial and industrial rooftop solar sector. Refer Annexure III for details.

Major solar progress in Bangladesh has hitherto been off-grid, which makes sense given that rooftop solar has a myriad of advantages:

1. It brings electricity immediately to Bangladeshis who have no access to the centralised grid;
2. It underpins a democratic, easily scalable, distributed energy system;
3. It avoids the massive water usage, pollution, and waste-ash disposal problems that come from thermal power generation;
4. It does not create air and particulate pollution or the associated health costs;
5. It brings speed of implementation, taking less than a day rather than a decade to commission;
6. It can tap into global financial capital flows designated to facilitate emerging-market low-carbon emissions investment, such as from the World Bank's new Climate Investment Fund Clean Technology Fund and the rapidly developing global Green Bond market;
7. It has almost zero operational costs once built, avoiding imported fossil fuel costs and the resulting drain on the nation's current account deficit and resulting exchange rate and inflation pressures; and
8. It avoids land acquisition and resettlement issues.

[49] http://reneweconomy.com.au/2016/australia-5th-in-world-in-small-scale-rooftop-solar-pv-in-2015-2015

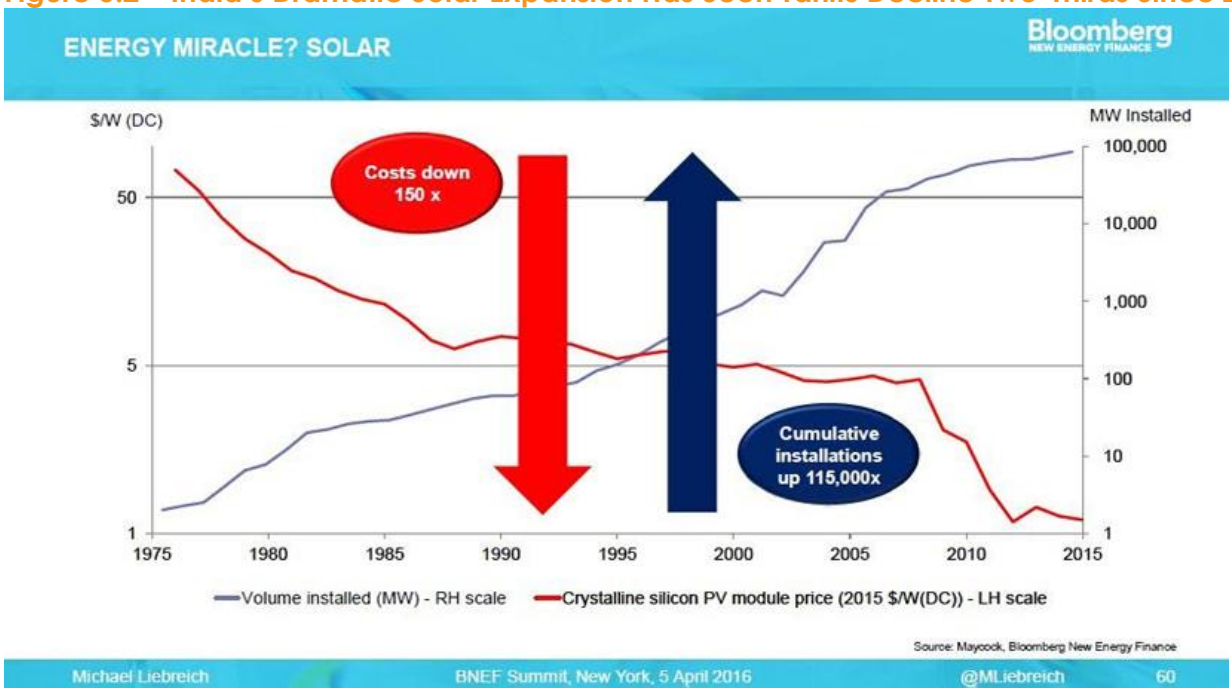
5.2 Gains in Grid-Connected Utility-Scale Solar Power

Bangladesh has started to work on utility-scale renewable projects to meet its green energy targets, which became more ambitious in 2015/16. The government of Bangladesh is beginning to more seriously develop policies to support grid-connected solar power generation, aiming for a target of 1.7GW of solar capacity by 2021 and 6GW by 2030. While Bangladesh has made progress, it can do so much better. IEEFA models a more progressive 1GW p.a. that implies cumulative installs can easily reach 10GW by 2024/25.

In April 2014, the BPDB committed to building the first utility scale solar project in Bangladesh, a 7.5MW plant on 10 hectares at the Kaptai Hydro-electricity facility costing Tk1,930m (US$25m), offering a Tk20/kWh tariff. BPDB reports that commissioning is due December 2016.[50]

In the following two years, nine utility scale solar project proposals have been initiated, with varying levels of progress to date. We detail these individual projects in Annexure IV. A key observation here is that while the initial capital and tariff costs are high, each subsequent proposal benefits from learning by doing, and the deflationary nature of solar capital costs as technologies improve and panel manufacturing costs decline more than 10% p.a. This rapid escalation of solar installs and deflationary cost trend has been well documented by Bloomberg New Energy Finance (Figure 5.2).

Figure 5.2 – India's Dramatic Solar Expansion Has Seen Tariffs Decline Two-Thirds Since 2010



Source: Bloomberg New Energy Finance, April 2016

It is clear that Bangladesh can readily replicate and leverage much of the learning and progress achieved in neighbouring India in terms of how to deliver a successful solar policy that rapidly attracts both global and domestic partners to bring capital, technology and

[50] http://www.dhakatribune.com/bangladesh/2014/apr/09/75mw-solar-plant-supply-power-grid#sthash.Jmq0osbI.dpuf

capacity.[51] This will very quickly drive solar tariffs rapidly down to rates lower than new import-coal-fired and LNG gas-fired power generation. The fact that Bangladesh has recently joined the International Solar Alliance (ISA) means that opportunities for collaboration on solar projects with fellow members such as India are now enhanced[52].

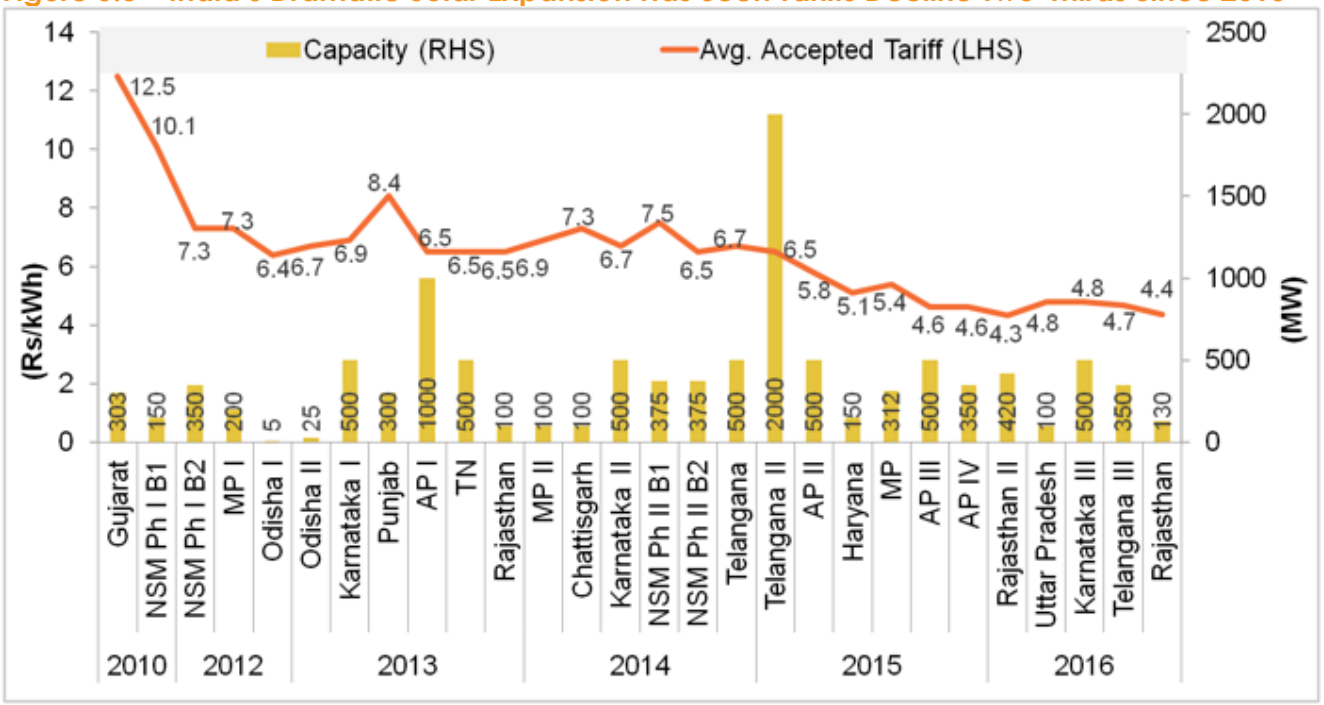
Great Potential in Solar Cost Decline and Expanded Utility-Size Deployment

IEEFA forecasts global installed solar exceeding 65GW globally in 2016, growth of 20% year on year. This continues a trend of double-digit annual growth in installations that is being driven by continuous technology innovation and the benefits of economies of scale. The result is that the cost of solar power is declining rapidly.

In May 2016, bids to develop a 800MW solar power project in Dubai were contracted at a record low solar electricity tariff of US3.0c/kWh (down almost 50% in just 16 months from the previous tender result of US5.8c/kWh).[53] This was trumped by a new record low of US2.42c/kWh in September 2016, almost 20% below the May 2016 result.[54]

This is 75% below the unsubsidised cost of new imported unsubsidised coal-fired power in Bangladesh, the cost of which is estimated at US10-12c/kWh. While the cost of power from the first-of-its-kind 200MW solar plant in Bangladesh was set at a very high US17c/kWh, the evidence is clear that learning by doing in the local context can drive an exceptionally rapid cost decline for subsequent installations, consistent with the global trend.

Figure 5.3 – India's Dramatic Solar Expansion Has Seen Tariffs Decline Two-Thirds Since 2010



Source: IEEFA Research, India's MNRE

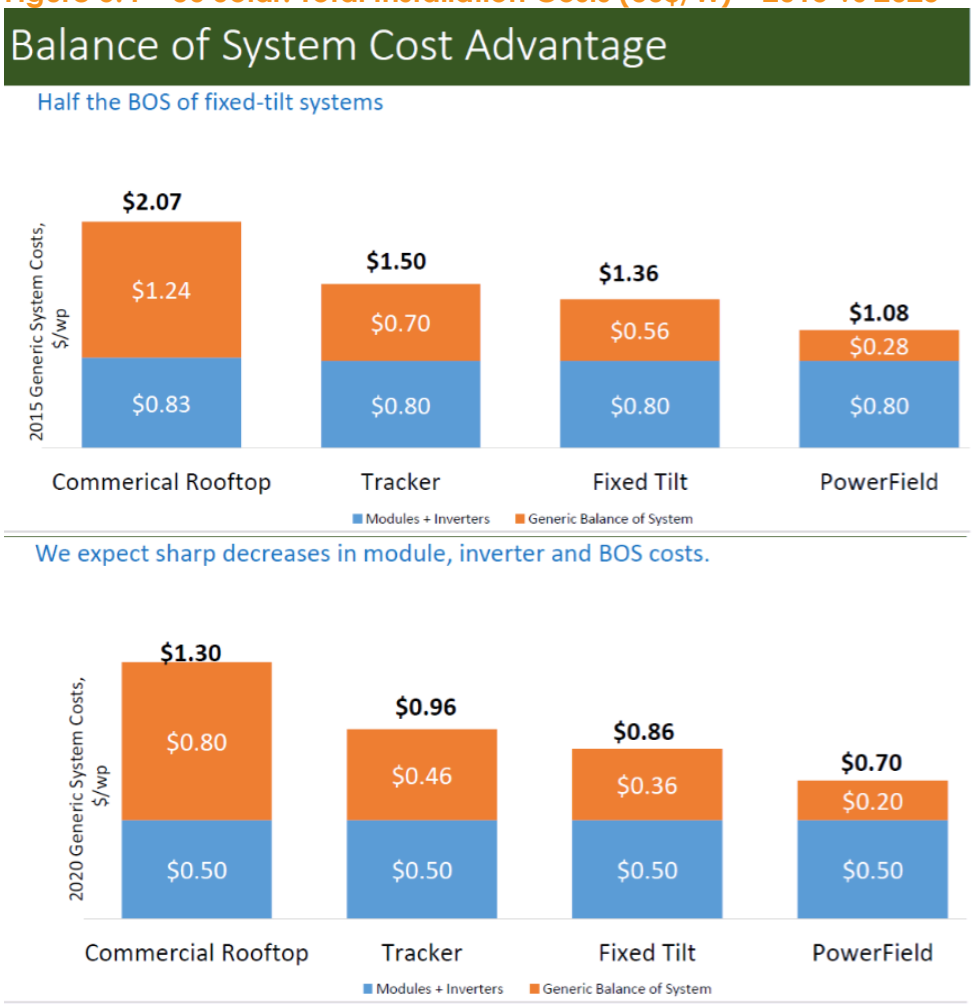
[51] http://bit.ly/2dwmskI
[52] http://energy.economictimes.indiatimes.com/news/renewable/bangladesh-joins-international-solar-alliance/55453469
[53] http://www.bloomberg.com/news/articles/2016-05-01/dubai-s-dewa-gets-5-bids-to-expand-solar-power-complex-in-desert
[54] http://renewables.seenews.com/news/update-abu-dhabi-confirms-usd-24-2-mwh-bid-in-solar-tender-540324

The chairman of Trina Solar in May 2016 forecast solar costs in China falling by 38% to US8c/kWh within four years, making them lower cost than some new domestic coal-fired power.[55] As a mark of just how rapidly solar cost deflation is coming through, in September 2016 China reported a new record low 1GW solar tender at just US7.2c/kWh.[56]

This well-established deflationary trend will be assisted by an expansion in the conversion efficiency from 18% currently to an estimated 20% by the end of this decade. The U.S. Energy Information Administration reports that average U.S conversion efficiencies reached a record high 28% in 2015,[57] showing IEEFA's modelling is very conservative and is likely to underestimate the extent of solar technology improvements available.

In neighbouring India, solar plants were consistently being bid at tariffs of US6-7c/kWh in 2015-16, down more than 20% year on year. IEEFA expects double-digit tariff declines over the balance of this decade, consistent with the projection by First Solar Inc. in May 2016 that system and solar module costs will decline 12% annually to 2020. The magnitude of cost reductions is illustrated in Figure 5.4 with 2015 vs 2020 solar cost estimates for the U.S.

Figure 5.4 – US Solar: Total Installation Costs (US$/W) – 2015 vs 2025



Source: UBS US Utilities Research, PowerField EPC, Sept'2016

[55] http://www.bloomberg.com/news/articles/2016-05-23/china-s-solar-prices-can-fall-38-become-competitive-with-coal
[56] http://www.pv-tech.org/news/chinas-lowest-ever-solar-bids-in-inner-mongolia-reports
[57] https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_6_07_b

Solar tariffs will drop significantly as more capacity is added, as has been shown in India. In fact, current solar tariffs in Bangladesh are reminiscent of India's experience, where solar tariffs were in the range of US28c/kWh in 2010 and since then have declined rapidly, having hit a low of US6.4c/kWh in January 2016.[58] [59] This has occurred on the back of clear intent and an aggressive support policy framework from the Indian government, as well as strong investment interest from both public and private entities, both domestic and international.

Indian Energy Minister Piyush Goyal in January 2016 declared utility scale solar is now lower cost than new coal fired powered capacity.[60] There is every reason to believe Bangladesh can best leverage this solar cost decline by building on India's recent experience with reverse auctions to that consistently seek lower prices and drive down costs. Adani Green Energy, which has recently commissioned the world's largest solar power plant in Tamil Nadu, has already demonstrated interest in developing solar PV in Bangladesh by submitting a proposal to the Bangladesh government for four solar power plants totalling 320MW of capacity[61].

In 2011, State Minister for Power Mohammad Enamul Huq told parliament that the Asian Development Bank was willing to finance a 10-20MW capacity Solar Thermal Power Plant inside the Kaptai Hydro-electric Plant.[62] Solar thermal technology has come a long way in the five years since then, and given the likely development of utility scale solar PV, peak demand management will require Bangladesh to develop storage capacity, including distributed solar with battery systems, hydro and solar thermal. A 10-20MW commercial deployment is a very logical first step for progressive scale-up as needed.

Solar Brings Capital Access to Global Financial Institutions

Given the Indian government's proposed financial support for coal-fired power to provide new electricity capacity development in Bangladesh, it would seem financially and environmentally prudent for the Indian EXIM Bank to transfer its support to solar development programs instead. Such a transfer would both avoid all the negative externalities of coal-fired power generation and allow India to further accelerate its emerging position as a solar-sector world leader – Section 6.0).

IEEFA sees such a transfer as a catalyst that would attract expanded financial support of the Asian Development Bank, the Asian Infrastructure and Investment Bank (AIIB), the Green Climate Fund and the New Development (BRICS) Bank, amongst others, from the rapidly developing global green bond market. It would also likely attract equity capital investments from the World Bank's Climate Investment Fund's Clean Technology Fund, plus international firms like SoftBank of Japan, Enel of Italy, Engie of France, Fortum of Finland and Adani Green Energy of India, to name a few leading candidates.

We note that the World Bank in May 2016 sanctioned a US$625m loan for Indian rooftop solar systems targeting the addition of 400MW of new capacity.[63] The development of the global green bond market has also opened up new access, as illustrated by India's Yes

[58] http://www.thehindubusinessline.com/news/solar-tariffs-fall-to-rs-434/article8123480.ece
[59] http://idcol.org/home/solar_ir
[60] http://cleantechnica.com/2016/01/22/solar-power-now-cheaper-than-coal-in-india-says-energy-minister/
[61] http://www.dhakatribune.com/bangladesh/power-energy/2016/11/06/adani-group-install-solar-power-bd/
[62] http://helioscsp.com/bangladesh-concentrated-solar-energy-plant-on-cards-by-2016/
[63] http://renewables.seenews.com/news/world-bank-sanctions-usd-625m-loan-for-rooftop-solar-in-india-525122

Bank working with the IFC (International Finance Corporation) to bring European pension funds into Indian renewables.[64]

With government commitment and the necessary policies in place, finance for utility solar in Bangladesh is ready.

5.3 Renewable Energy Alternatives – Wind, Hydro & Bioenergy

Wind Energy in Bangladesh Has Potential, Albeit Limited

Several studies are under way to determine whether Bangladesh has commercially viable potential for wind electricity generation, although new data from an online model developed by Imperial College of London and ETH Zürich suggests wind speeds in Bangladesh do not allow for the development of major grid-connected wind parks.[65] Bangladesh does have sites in its coastal areas and offshore islands that could produce wind energy,[66] albeit subject to extreme monsoon weather conditions.

A study included in the Sustainable & Renewable Energy Development Authority's 2015 Investment Plan found suitable sites for 637MW of wind energy. Such sites had a capacity factor range of 20-25% and excluded land prone to flooding or greater than 20km away from a transmission line[67].

Currently, the installed wind capacity in Bangladesh is abysmally low, at around 2MW.[68]

BPDB has set a 2021 target of 1.3GW of wind energy and is now in the process of scoping wind capacity, installing wind monitoring stations in various locations to better estimate Bangladesh's wind potential.[69] The most advanced wind project is a 60MW initiative being developed at Cox's Bazar that BPDB reports is due to enter production in 2017. This joint Danish-American-Bangladesh project is being developed by US-DK Green Energy (BD) at a reported cost of US$120m.[70]

A second 50-200MW wind project is being planned by BPDB at Parky Beach, Chittagong.

A 100MW wind project was announced in 2015 at Feni by the Power Generation Company of Bangladesh (a subsidiary of PPBD).[71]

Bangladesh Plans to Overcome the Limited Scope for Hydro

Bangladesh operates the 230MW Kaptai Hydro Power Station in the hill district of Rangamati, operational since 1962. Published reports indicate the possibly for a 100MW expansion.[72] The BPDB has identified two other sites at Sangu (varyingly reported as 58-140MW scope) and Matamuhuri (20-75MW) for hydropower plants.[73] Beyond this, further

[64] http://www.pv-tech.org/news/yes-bank-to-raise-us50-million-through-green-bond-issuance-with-fmo
[65] https://www.renewables.ninja
[66] http://www.sdnbd.org/wind.htm
[67] Sustainable & Renewable Energy Development Authority, Investment Plan for Bangladesh, October 2015, pp. 43-44
[68] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=26
[69] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=26
[70] http://www.daily-sun.com/post/108464/60MW-wind-turbine-power-by-2017
[71] http://www.egcb.com.bd/welcome/project_details/7
[72] https://www.usaid.gov/bangladesh
[73] http://www.dhakatribune.com/bangladesh/2015/may/20/government-planning-new-hydro-power-company

exploitation of larger hydropower is reported to be limited due to the flat terrain of Bangladesh, as well as to the considerable negative impact on local communities and the heavy seasonality of monsoonal flows.[74]

There is scope for small, distributed mini and micro-hydro systems, variously estimated at 60M to 125MW in aggregate.

Both Bangladesh and India have long considered plans to overcome geographical limitations by investing in hydro power plants in Bhutan – refer Section 5.4.

Biomass Energy Potential in Bangladesh

Since Bangladesh is an agricultural country and rice is one of the main agricultural products, rice husk is abundant in the country. It is reported Bangladesh produces about 6 million tonnes per annum (Mtpa) of rice husk from about 30 million tonnes of paddy – sufficient to power 171-500MW biomass capacity.[75] [76] Rice husk is currently being used for rice parboiling, domestic cooking, poultry and fish feed.

As a measure of the potential for this as a generation source, biomass electricity generation in the US in 2015 was 64TWh, more than the entire electricity system generation of Bangladesh in aggregate.[77]

A 10MW waste to energy project is in planning by the BPDB on the outskirts of Dhaka City.

Biogas Energy Potential in Bangladesh

IDCOL has been implementing a domestic biogas program in Bangladesh since 2006 with support from SNV Netherlands, the state owned German development bank KfW and the World Bank. Biogas plants not only provide gas for cooking purpose but also produce organic fertilizer for the crops and fish ponds. The program also reduces use of biomass fuel for cooking. Till April 2014, IDCOL has financed construction of 33,000 biogas plants across Bangladesh through 24 partner organizations.[78]

The program saves 80,000 tonnes per annum (tpa) of firewood worth US$2m pa and replaces 28,000tpa of chemical fertilizer worth US$20m by producing 200,000tpa of organic fertilizer. The program also reduces the use of 1,000tpa of kerosene. IDCOL plans to install 100,000 biogas plants in Bangladesh by 2018.

Establishment of biogas based electricity plants in poultry farms reduces dependency on fossil fuel use in captive diesel generators. This ensures bio-security and proper litter management in these farms. Moreover, slurry produced in the digesters as by-product is a good bio-fertilizer. According to the Livestock Department, currently in Bangladesh there are 1,500 poultry farms having more than 20,000 bird populations. So, Bangladesh has

[74] http://www.powerdivision.gov.bd/site/page/7cdf7d30-6656-41ec-aa8a-943193f30a61/R--E-Program
[75] https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwisq_Oj0_HMAhWEIKYKHSujA1cQFggbMAA&url=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS1364032110001449&usg=AFQjCNEZpy_bLKgVGIPi4UKJgVCOJIXpBA&sig2=bLQPt5dxCtfh3rGEALQ4qw&bvm=bv.122676328,d.dGY
[76] https://www.unido.org/fileadmin/user_media/Services/Energy_and_Climate_Change/Energy_Efficiency/2007-03_CDM_Workshop_Mexico/
[77] http://www.eia.gov/todayinenergy/detail.cfm?id=26392&src=email
[78] http://idcol.org/home/dbiogas

good potential for biogas based electricity projects. IDCOL has so far financed 5 biogas based power plants, the largest one having a capacity of 400kW in Thakurgaon. IDCOL has a target to finance 450 such projects with an average capacity of 50 kW. The World Bank, KfW, USAID and JICA are providing support to IDCOL for these projects which could add up to an estimated 200MW of biogas electricity capacity.[79]

5.4 Imported Electricity

India

Bangladesh has found it near impossible 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, there is a logic 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 600MW of grid connectivity. BPDB reports 3.38TWh of electricity was imported in 2014/15, reflecting a 65% utilisation rate on this grid connection.

BPDB is working with India to double the capacity of the 500MW Baharampur-Bheramara line (commissioned in September 2013) to 1,000 MW by June 2018 at an estimated project cost of US$180m,[80] with Siemens AG of Germany signed to implement this project in June 2016 and the Asian Development Bank assisting on funding. A second expansion plan involves doubling the new 100MW Tripura-Comilla line capacity (commissioned in March 2016 at a cost of US$26m by Korean contractor GS Engineering and Construction[81]) to 200MW.[82] A second Tripura-Comilla upgrade to 500MW is in BPDB's forecasts for 2021.

Since 2010, Adani Power Ltd has been working on a 1,600MW 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.[83] For more detail, refer Annexure V.

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 the growth of renewables.

[79] http://idcol.org/home/other_re
[80] https://www.pgcb.org.bd/PGCB/?a=user/ongoing_project_details.php&id=58
[81] https://www.pgcb.org.bd/PGCB/?a=pages/latest_news_details.php&id=41
[82] http://www.business-standard.com/article/news-ians/tripura-to-supply-additional-100-mw-power-to-bangladesh-116042300388_1.html
[83] http://www.business-standard.com/article/economy-policy/adani-to-supply-1600-mw-power-to-bangladesh-from-jharkhand-project-116071200589_1.html

Bhutan

Bangladesh has almost no additional hydroelectricity capacity and neighbouring Bhutan is desperately in need of export revenues. As such, in the absence of other cost-competitive alternatives, there is significant logic for Bangladesh to assist Bhutan in funding the development of surplus hydro capacity for importation of cost-competitive electricity into Bangladesh. This would provide scope to improve Bangladesh's energy security through diversification of the sources of electricity generation.

In July 2016, it was reported that a joint investment proposal of Bangladesh, India and Bhutan had progressed for the construction of the US$1.24bn 1,125 MW Dorjilung hydropower project in the Lhuentse district ,with 80-90% of the output being exported from Bhutan across India into Bangladesh.[84] [85]

5.5 Fossil Fuels – Gas, Coal, Diesel and Oil

The Bangladesh government has a multitude of thermal project proposals and non-binding MoUs with a myriad of international and domestic counterparties to treble to 39GW Bangladesh's total installed power generation capacity by 2030. IEEFA strongly contends that most of these are redundant and unlikely to proceed beyond the initial press release.

One report details 21GW of imported coal-fired power plants across 23 approved projects; only five are reported as showing any progress. Another report details plans for 8GW of domestic coal-fired power plants by 2030. Additionally, 7GW of gas-fired plant proposals are at various stages of discussion, again at odds with the deepening gas supply crisis detailed above. BPDB also details 15 proposed diesel or oil-fired power plants variously scheduled for commissioning by 2022.

Included in this total are 9GW of imported-coal and LNG thermal power capacity planned at an entirely new energy hub centred around the Cox's Bazar district on the two islands of Matarbari and Moheshkhali. International MoUs have been announced with India, China, Japan, Korea, Malaysia and Singapore, but progress to date is minimal.

Progress and financing of most of these projects is unclear at best, and IEEFA models that most will remain stranded at the concept stage. Press reports in September 2016 talked of a possible move to ban open-cut coal mining at the one existing mine at Barapukuria in Bangladesh, suggesting little prospect of progress on the 8GW of domestic coal-fired plant proposals. While GCM Resources Plc has since announced the press reports were erroneous,[86] we note no reported progress on these proposals. We summarise these plans and provide an overview of the key proponents of a number of projects in Appendix V.

[84] http://ep-bd.com/online/details.php?cid=31&id=20347
[85] http://www.thedailystar.net/world/south-asia/bangladesh-invest-bhutans-hydropower-sector-1225786
[86] http://otp.investis.com/clients/uk/gcm_resources/rns1/regulatory-story.aspx?cid=1564&newsid=790559

Bangladesh Has Resisted Using Its Domestic Coal Reserves

Bangladesh has coal reserves estimated at 2,000 million tonnes (Mt),[87] of which about 1,000Mt are considered economically viable for mining.[88] However only the Barapukuria mine is operational. It reports reserves of 300Mt and produces 1Mtpa of coal. Barapukuria has produced 7.6Mt to date,[89] well short of a 1998 projection that it would produce 30Mt coal, a typical timetable slippage inherent in coal power.[90]

Owned by the state's Petrobangla (the renamed Bangladesh Oil, Gas & Mineral Corporation), most of the coal from Barapukuria goes to the only operational coal-fired power plant in the country, which has a nameplate capacity of 250MW, albeit with only 200MW operational.[91] The BPDB has a proposal to double capacity by adding a second 275MW unit due for commissioning by June 2018.

Efforts by U.K.-listed GCM Resources Plc to develop another domestic coal deposit in the Dinajpur District of Northwest Bangladesh by way of the 15Mtpa Phulbari Coal project have yielded little progress over several decades. The company reports it has a legally enforceable contract and it has done an Environmental and Social Impact Statement, but remains in limbo as it continues to wait for a government decision.

Press reports from September 2016 suggest debates over a possible Bangladesh government ban on open-cut coal mining because of excessive risks to water and hence agriculture, plus associated risks to loss of biodiversity and subsidence.[92]

Gas & LNG

BPDB's 2015 annual report details 4.9GW of gas-fired power plants due for commissioning by 2022, and a 1.0GW imported LNG proposal due 2020 (presumably by Reliance Power), plus 1.2GW of hybrid gas/diesel plant proposals—a total of 7.1GW of new gas capacity.

IEEFA includes just one-third of this new gas power in its electricity model (section 4.0):

1. We presume that, as with many thermal power plant proposals across Asia, delays and abandonment are more likely than construction, with India experiencing a ratio of six to one against projects going ahead in the last few years. India has seen its development pipeline shrink by 40GW in just the seven months of January to July 2016, while China's pipeline is down an estimated 114GW.[93]
2. Bangladesh's electricity grid is excessively reliant on gas (7.5GW or 61.5% of current installed capacity), which poses an energy security risk.
3. Bangladesh faces chronic gas shortages. Given limited new gas discoveries and depleting gas reserves, and with strong growth in gas demand likely to match industrial sector growth, the situation is deteriorating. Finance Minister Abul Maal Abdul Muhith in August 2016 warned of the need to halt residential customer gas use.[94]

[87] http://www.gcmplc.com/resources and http://www.gcmplc.com/news-announcements
[88] http://en.banglapedia.org/index.php?title=Coal
[89] http://www.bcmcl.org.bd/index.php?page=production_statistics
[90] http://www.thedailystar.net/news-detail-90796
[91] http://www.petrobangla.org.bd/
[92] http://energybangla.com/govt-backtracks-on-open-pit-mining-in-barapukuria/
[93] http://endcoal.org/resources/shrinkingcoal/
[94] http://ep-bd.com/online/details.php?cid=31&id=20469

4. A key reason for strong industrial demand for gas is the excessive, ongoing subsidies. The Gas Sector Master Plan of 2006 proposed trebling domestic gas prices to incentivise exploration, but almost a decade later the domestic gas price in 2015 was reported to still be US$2-3/thousand standard cubic feet (Mscf), or less than half import price parity.[95]
5. To alleviate domestic gas shortages, Bangladesh is proposing two LNG import terminals, but even at current depressed LNG prices, this is a high-cost proposition.[96] Additionally, little progress on LNG facilities has been achieved since this was first proposed in 2010.
6. Finally, IEEFA's modelling suggests that much of this planned expansion is redundant and surplus to Bangladesh needs if the necessary investment in lower all-in-cost renewable energy and electricity import infrastructure is undertaken.

5.6 Nuclear Would Likely Face Decade-Plus Delays

The Bangladesh Atomic Energy Commission (BAEC) is evaluating the scope for nuclear-generated electricity. December 2015 reports indicate that an agreement was signed with Russia's Rosatom to build the 2.4GW Rooppur nuclear power facility for US$12.65bn.[97] The first unit expected to start operations by 2022 and the second by 2023. In June 2016, Russia was reportedly planning US$11.4bn of massively subsidised debt financing here, including through an interest rate cap of 4% and a 10-year interest grace period. We would challenge BAEC on the question of whether the capital cost is fixed or if the people of Bangladesh bear cost and time over-runs.

IEEFA remains extremely sceptical that Bangladesh will see any electricity delivered from nuclear, even by 2030, given the probability of massive capital cost and time blowouts that follow almost every nuclear project globally. The massive government and electricity user subsidies required to underwrite the project risks for nuclear are nothing short of massive, as has been extensively documented with the proposed UK Hinkley Point C project. IEEFA recently reviewed the performance of nuclear in India and found massive underestimation of the complexities, capital costs, performance and decade-long delays, with out-dated Russian technology a key risk.[98]

[95] http://ep-bd.com/online/details.php?cid=10&id=19127
[96] http://in.mobile.reuters.com/article/idINL8N1BY05C
[97] http://www.world-nuclear-news.org/NN-Bangladesh-Russia-ink-12.65-billion-Rooppur-plant-deal-29121501.html
[98] http://ieefa.org/ieefa-study-india-plan-build-12-new-nuclear-reactors-economically-unviable-fraught-risk/

6.0 India as a Neighbour: Strategic Implications

IEEFA notes very positive developments in India-Bangladesh relations this decade, and the resulting improvements in share infrastructure investment and trade, and maritime territorial dispute resolutions.[99] Joint power sector plans could prove very mutually beneficial, leveraging joint policy, technical and financial expertise.

In a strong boost to energy security, India has recently commissioned 600MW of electricity grid connectivity to Bangladesh, with further plans to double this capacity by 2018, and possibly again by 2022

IEEFA views the Rampal project is more an instrument of Indian foreign policy than a commercially viable proposition, progressing only through the promise of tax shields, heavily subsidised financial support and government guarantees.

- The government of India is extending 100% of the project's debt finance through a US$1.6bn loan from the 100% government-owned India EXIM Bank for an estimated 12-year duration. IEEFA estimates the financing subsidy involved at US$988m.
- NTPC (70% owned by the government of India) proposes investing an estimated US$298m for a 50% equity share in Rampal.
- Bharat Heavy Electricals Limited (BHEL), the proposed builder of the power plant, is 63% owned by the Indian government and won the engineering and construction contract on the strength of financial support from the Indian EXIM Bank.

It has also been suggested that beyond the current plan to develop India-Bangladesh rail connectivity,[100] Indian funds are being offered to establish a railway connection as a follow-on development for a Stage II expansion to double capacity from 1.32GW to 2.64GW.[101] Rather than relying on high-energy, low-ash imported thermal coal, this project might end up being used simply as an export destination for low-energy, high-ash coal from Coal India Ltd (80% owned by the government of India).[102]

IEEFA's research indicates that the India EXIM Bank could fulfil its role of promoting Indian exports and international diplomacy through supporting NTPC and BPDB in initiating a renewable-energy program and awarding an EPC contract to install a series of utility-scale solar plants in Bangladesh, initially modest and then stepping up to be larger in size, each at progressively lower PPA tariffs. Such a move would significantly boost India's fledgling solar manufacturing export industry; it would also augur well for the government of India's "Make in India" program and build on India's announcement at COP21 Paris that it will show leadership toward a global solar alliance.[103] Most importantly, for Bangladesh this would provide energy system diversity and greater energy security by adding substantial domestic solar generation capacity. Adani has made a key lead move here. As discussed in Section 5.4, India is very constructively working toward a fivefold lift in Bangladesh electricity grid import capacity from the newly commissioned 600MW capacity.

[99] http://www.thehindu.com/opinion/op-ed/indiabangladesh-land-boundary-agreement-breakthrough-in-ties/article7190811.ece
[100] http://timesofindia.indiatimes.com/business/india-business/Rs-1000-crore-approved-for-India-Bangladesh-rail-link/articleshow/48225940.cms
[101] http://www.daily-sun.com/printversion/details/80614/Installing-rail-line-to-Rampal-PP-for-carrying-coal-sought
[102] http://www.business-standard.com/article/companies/coal-india-hopes-to-win-orders-from-bangladesh-116053000752_1.html
[103] http://www.theguardian.com/environment/2015/nov/30/india-set-to-unveil-global-solar-alliance-of-120-countries-at-paris-climate-summit

7.0 Conclusion

By utilising solar investment options and embracing energy efficiency, Bangladesh has in its grasp a path to a cost competitive, secure and sustainable energy solution that will meet the needs of its economic growth into the future. By taking such a path, the country can avoid a range of unnecessary complications and risks going forward.

Bangladesh is currently excessively dependent on gas-fired electricity generation whilst domestic sources of gas are becoming increasingly unreliable. The country's plan to increase reliance on subsidised coal-fired generation is almost entirely dependent on imported coal and would increase energy security risk. Under the proposed Master Plan 2016, 60%-70% of electricity supply will be dependent on imported electricity or imported fuel. If Bangladesh were to concentrate instead on utility-scale solar development and energy efficiency, complemented by some imported coal-fired power and hydro-electricity, problems with over-reliance on gas and imported coal supply can be minimised. Under IEEFA's proposed plan, only 18% of electricity supply will be dependent on imported fuel, with a further 9% coming from electricity imports from India and Bhutan.

Neighbouring India is currently undergoing a major transformation in its electricity generation sector with a target to produce 40% of electricity from renewable sources (including hydro) by 2030. Solar-powered generation will fulfil a large part of this transformation, and Bangladesh is well placed to benefit from the advances already made in solar financing and engineering on the subcontinent as well as from the deflationary nature of long term solar power purchase agreements. With total solar installation costs declining rapidly, IEEFA recommends BPDB undertake a reverse auction tender process to minimise solar tariffs, pre-register eligible bidders, and include a deposit requirement and a time limit to project completion to enhance rapid implementation.

As rural India is increasingly electrified, off-grid fossil fuel based energy options such as kerosene are being used less and subsidies are being reduced. This is of relevance to Bangladesh where subsidies within the electricity system are unsustainable. Bangladesh already has the largest solar home system programme in the world, and an upscaling of this scheme can drive further rural electrification and decreased reliance on expensive and unhealthy fossil fuel use.

Bangladesh's numerous coal-fired power projects are often bogged down by slow processes that keep most from advancing beyond the announcement of MoU stage. Over-reliance on a large, slow-to-build thermal power programme raises questions as to whether Bangladesh can expand its generation capacity at the rate needed to support sustainable economic growth. By comparison, solar power plants can be much faster to build and commission and are a better option, along with some power imports, for Bangladesh to match its electricity generation capacity with its economic growth intentions.

Given the recent increases in global capital flows into renewable energy infrastructure, a strong government endorsement of a major investment programme in renewable energy and energy efficiency would likely prompt a significant response from the international financial system and allow Bangladesh to benefit from a diverse, secure and deflationary energy supply.

Annexure I

Bangladesh Electricity Sector Growth Forecast

Total Electricity in Bangladesh													
GDP Growth (% per annum)	7.0%												
Electricity Multiplier (x)	1.2												
Grid AT&C losses (%) - reported	13.6%	FY 2015											
Grid AT&C losses (%) - calculation	13.9%	FY 2015											
Year ended June	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	**2022/23**	**2023/24**	**2024/25**
Net Production (TWh)	38.2	42.2	45.8	49.1	52.6	56.4	60.4	64.7	69.4	74.3	79.7	85.4	91.5
Gross Production growth	8.9%	10.4%	8.6%	7.1%	7.2%	7.2%	7.2%	7.2%	7.2%	7.2%	7.2%	7.2%	7.2%
AT&C losses - TWh	5.5	6.0	6.2	6.6	6.9	7.3	7.7	8.1	8.6	9.0	9.5	10.0	10.6
AT&C losses	14.3%	14.1%	13.6%	13.4%	13.2%	13.0%	12.8%	12.6%	12.4%	12.2%	12.0%	11.8%	11.6%
Reduced grid losses		-0.1%	-0.6%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Real GDP Growth (%)	6.0%	6.1%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Electricity multiplier (x)	1.58	0.82	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Electricity growth (%)	9.5%	5.0%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%
Energy efficiency (%)	n.a.	n.a.	n.a.	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
Net demand (TWh)	32.8	36.2	39.6	42.6	45.7	49.1	52.7	56.6	60.8	65.3	70.1	75.3	80.9
Net demand growth (%)		10.6%	9.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%
Ratio of net electricity demand to GDP growth (x)		1.74	1.34	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06

Annexure II

Coal-Fired Power Generation: USC vs. SC

If Bangladesh is to plan for use of imported coal fired power generation, it needs to accept the capital and hence generation costs are higher than many proponents suggest. The electricity will also prove inflationary given exchange rate and coal price variability. Subsidised Export Credit Agency finance often hides much higher capital construction costs, which vary from US$1.0-3.9bn/GW of installed capacity (Figure II.1). By comparison, energy from renewables currently has high up front capital cost, but has a very deflationary impact.

Figure II.1 – Capital Costs for Construction of New Coal Fired Power Plants (US$m)

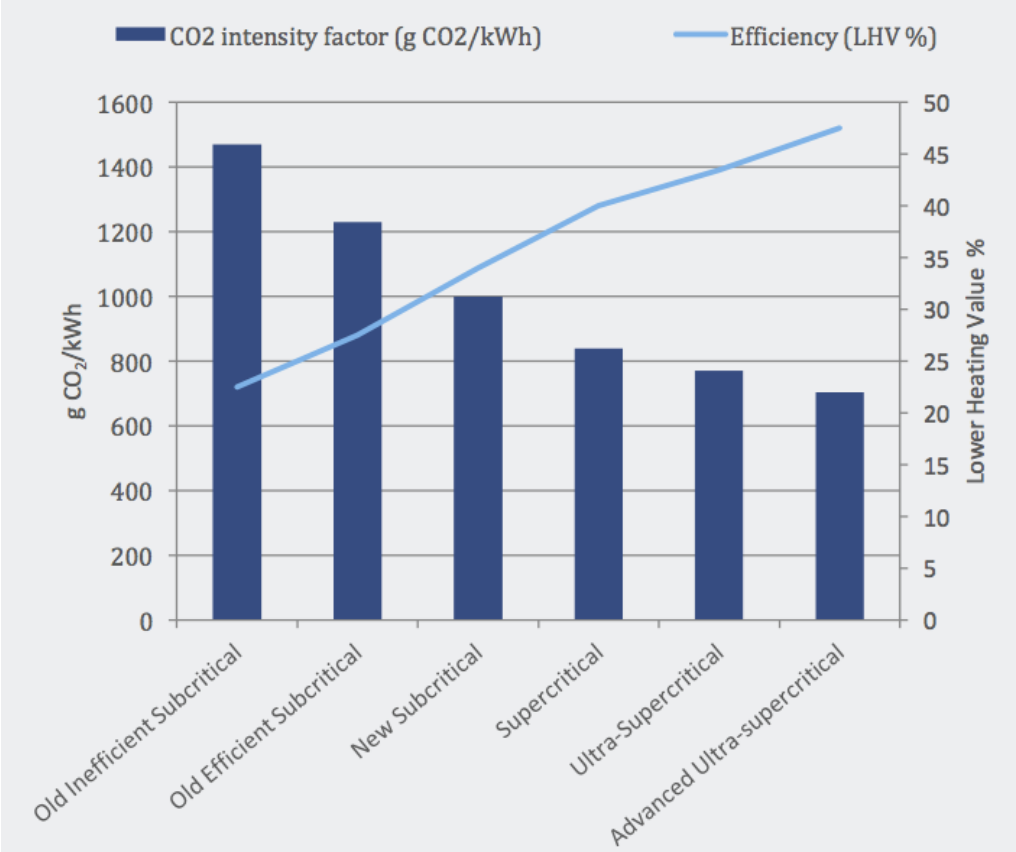
Project	Country	Technology	Technology Supplier	Completion	Capacity (GW)	Cost (US$ bn)	Cost (US$bn/GW)
Manjung Power Plant Unit 4	Malaysia	USC	Alstom (France) and CMC (China)	2015	1.0	1.5	1.5
Manjung Power Plant Unit 5	Malaysia	USC	Alstom (France) and CMC (China)	2017	1.0	1.4	1.4
Tanjung Bin-4	Malaysia	SC	Alstom (France), Mudajaya and Shin Eversendai (Malaysia)	2016	1.0	1.1	1.1
Mae Moh Power Plant	Thailand	USC	Alstom (France) and Marubeni Corp (Japan)	2018	0.6	1.1	1.8
Batang Power Plant	Indonesia	USC	PT Adargo Energy (Indonesia), J-Power Electric Power Development Co Ltd and Itochu Corp (Japan)	2020	2.0	4.0	2.0
Jawa - 7	Indonesia	SC	China Shenhua Energy (China) and PT Pembangkitan Jawa Bali (Indonesia)	2020	2.0	5.0	2.5
Kudgi STPP	India	USC	Doosan Heavy Industries (South Korea) and Toshiba (Japan)	2016-17	2.4	2.3	0.9
Khargone TPP	India	USC	BHEL and Alstom - Bharatforge (France, India)	2019	1.3	1.5	1.1
Bellary TPP	India	SC	Alstom (France) and Siemens (Germany)	2016	0.7	0.7	1.0
Yermarus TPP	India	SC	BHEL (India), Alstom (France) and Siemens (Germany)	2016	1.6	1.4	0.8
Gadarwara TPP	India	SC	BHEL (India)	2017-18	1.6	1.7	1.1
Luz de Atacama	Chile	USC	NA	2021	1.4	4.2	3.0
Matarbari	Bangladesh	USC	NA (Debt funding commitment by Japan International Cooperation Agency)	2023	1.2	4.6	3.8
Rampal	Bangladesh	SC	BHEL	2021	1.3	1.8	1.4

Source: IEEFA Estimates

Discussion of SC Versus USC Technology

If the choice for a new coal fired plant is between a Supercritical (SC) or an Ultra Supercritical (USC) cycle, the latter would provide a few additional percent gain in efficiency as compared to the SC technology - meaning slightly less coal consumed per unit of electricity produced and hence slightly lower CO2 emissions and slightly less ash waste. Regardless of whether SC or USC technology is used, significant reductions of major pollutants can only occur from either SC or USC coal plants by using state-of-the art controls for major pollutants. This means using wet flue gas desulfurization (wet FGD) technology for removal of 98-99% of SO2 emissions; using Selective Catalytic Reduction (SCR) for NOx control to remove 92-95% NOx in addition to Low Nox burner technology in the boiler itself; installation of a baghouse for particulate matter removal (as opposed to electrostatic precipitator (ESP) technology; and the use of additional mercury controls above what might be achieved with the wet FGD alone. While these additional state-of-the art technologies alleviate some of the added environmental risks from coal plants they will come at a materially higher cost of electricity generation than a plant without such technologies. That will make the real unsubsidised cost of electricity from either an SC or an USC coal plant much greater than the cost of generation from solar plants or avoided generation using energy efficiency options.

Figure II.2: Emissions Intensity and Efficiencies of Coal-Fired Power Technologies



Source: IEA, "Energy Technology Perspectives 2013"

Annexure III

Opportunities in Off Grid Solar Power

Bangladesh has significant potential off-grid solar applications beyond rooftop SHS. An ambitious long term policy commitment from Bangladesh's leadership could be a key catalyst to enable rapid implementation, as has been witnessed in neighbouring India.

Solar irrigation pumps: An estimated 1.4 million Bangladesh diesel-fuelled irrigation pumps could instead run on solar. IDCOL targets the installation of 1,550 solar irrigation pumps in 2017. A similar program in India seeks to replace 26 million diesel-fuelled irrigation pumps with solar.[104] The Sustainable and Renewable Energy Development Authority of Bangladesh (SREDA) sees the potential for 150MW of solar irrigation,[105] with the Rahimafrooz Group estimating up to 600MW of capacity potential for solar irrigation. Requiring some US$1.3bn of total capital financing, this suggests IDCOL needs to create a structure that can leverage Bangladesh private banking capacity, possibly via loan guarantees subsequently combined and syndicated, or packaged up into a Green Bond. Analysis of the full cost of end-of-grid connection costs, the high level of AT&C losses and the subsidies on sale of electricity show that solar irrigation pumps and micro grids are an extremely cost effective and rapid solution to energy poverty.[106]

Mini-grids: as part of the government's 500MW solar program, the IDCOL and World Bank target installation of 25MW of electricity from a program to install 50 mini-solar grids, plus solar-diesel hybrid power solutions in the telecom sector for off-grid mobile phone towers. In June 2016 India announced a 500MW mini-grid investment program.

In May 2016, Gamesa unveiled in La Muela municipality, Spain, an applicable new off-grid solution, with a total capacity of over 2MW, combining three power sources—245kW of solar, a 850kW wind turbine and three diesel generators that produce 222kW each—with 500kW of battery storage.[107] The prototype is expected to generate enough power to meet the needs of 400 households and is perfect for micro-grid applications across Bangladesh. Likewise, India continues to pilot new micro-grid schemes.[108]

Industrial and commercial sector rooftop solar: Many multinational firms are committing to be 100% renewable energy self-sufficient, including major chemical and fertilizer firms like Dow.[109] With the right policy support, industrial-commercial expansions can bring international capital to rapidly expand electricity capacity at scale and better manage load distributions. Signs are that this is beginning to occur already. In May 2016, Punjab commissioned one of the world's largest rooftop solar projects. Covering eight rooftops across 82 acres, it involves a US$20m, 11.5MW industrial installation.[110]

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[104] http://spectrum.ieee.org/energywise/green-tech/solar/india-plans-for-26-million-solar-water-pumps
[105] http://www.powerdivision.gov.bd/site/page/7d42b92a-8f64-4778-a0a8-b38c1448620d/500-MW-Solar-Program
[106] http://indianexpress.com/article/india/india-news-india/sustainable-agriculture-a-new-anand-cooperative-model-this-time-in-solar-farming-2807828/
[107] http://www.pv-magazine.com/news/details/beitrag/gamesa-combines-pv--wind--diesel-and-storage-in-off-grid-system_100024549/#ixzz48ggjqPO1
[108] http://www.business-standard.com/article/government-press-release/small-wind-solar-hybrid-system-to-provide-electricty-to-unelectrified-areas-116052500780_1.html
[109] http://reneweconomy.com.au/2016/dow-chemical-puts-more-manufacturing-plants-on-100-renewables-75802
[110] http://mashable.com/2016/05/18/india-worlds-biggest-rooftop-solar-power-plant/#mjp4oUJIFqqy

Annexure IV

Gains in Grid-Connected Utility-Scale Solar Power

In addition to off-grid solar, Bangladesh is now working on utility-scale renewable projects to meet its green energy targets. Again we would consider it critical Bangladesh leadership embrace and loudly support this investment program and set out clear long term and ambitious goals. The use of a succession of reverse tenders with fixed completion dates and performance bonds would serve to accelerate deployment at the lowest cost to consumers.

We would reference Mexico's second solar reverse auction tender completed in September 2016 that catalyzed US$4bn of new investment across 2.9GW of renewable energy projects at a price 30% lower than that bid only six months previously in the March 2016 first round tender. Mexico achieved a near record low of US$34.40/MWh average tariff.[111]

We detail the status of a number of proposed individual solar projects. IEEFA would note that despite the Bangladesh Government commitment to add 1.5GW of renewable energy by 2021, the lack of commitment and drive supporting a clear, long term oriented and aggressive policy framework is clearly holding the solar sector back.

It was reported that as of May 2016, despite seven solar projects receiving the Prime Minister's endorsement, it is reported only one has received a signed BPDB contract. Given rapidly declining total solar installation costs, IEEFA would recommend BPDB undertaking a reverse auction tender process to minimise solar tariffs required, pre-register eligible bidders, put a deposit requirement in and a time limit to project completion to maximise rapid implementation.

In April 2014, the BPDB committed to building the first utility scale solar project in Bangladesh, a 7.5MW plant on 22 acres at the Kaptai Hydro-electricity facility at a cost of Tk1,930m (US$25m), offering a Tk20/kWh tariff. BPDB reports commissioning is due in December 2016.[112]

In November 2014, it was reported that a Chinese consortium, ETERN-CCCE (China)-Hareon, had won a Bangladesh Power Development Board tender to operate as an independent power producer on a BOO (Build, Own, Operate) basis at a tariff of $0.17/KWh or Tk13.18/KWh for a 20- year power purchase agreement (PPA). The consortium was to be awarded a contract for a 30MW solar power plant beside the Dhorola River in Kurigram.[113] [114] Updates on this project have been limited, although the BPDB targets commissioning by March 2017. We note that Hareon Solar Technology Company (one of China's largest solar energy companies), in joint venture with ReNew Power of India, commissioned a 72MW solar project in Andhra Pradesh, India, in May 2016

[111] http://www.gob.mx/cenace/articulos/inversion-de-4-mil-millones-de-dolares-al-concluir-el-proceso-de-la-segunda-subasta-electrica?idiom=es (Spanish)
[112] http://www.dhakatribune.com/bangladesh/2014/apr/09/75mw-solar-plant-supply-power-grid#sthash.Jmq0osbI.dpuf
[113] http://www.dhakatribune.com/bangladesh/2014/nov/30/chinese-firm-get-work-kurigram-30mw-solar-power-plant#sthash.mljI8VqP.dpuf
[114] http://www.observerbd.com/2015/01/16/66835.php

and so remains keen on building its operating profile in this region, if the investment conditions make sense.[115]

In October 2015, SkyPower Global of Canada announced plans to build 2GW of solar capacity over the next five years in Bangladesh with a reported US$4.3bn investment.[116] SkyPower has made a similar announcement in India and progress there has been material.[117] In October 2015, SkyPower entered into a PPA with the government of Madhya Pradesh for 150MW of utility-scale solar power.[118] In February 2016, SkyPower signed a Rs5.17/kWh (US¢7.9/kWh) 200MW solar PPA with the Indian state of Telangana.[119] And in May 2016, SkyPower announced a joint venture proposal with BYD of China to tender for 750MW of solar with battery storage in India.[120] More recently however, there have been no reports of further developments regarding SkyPower's development plans in Bangladesh.

In October 2015, the government of Bangladesh cleared a 200MW solar power project for construction in the Teknaf district by SunEdison Energy Holding (Singapore) at an agreed tariff of US$0.17/kWh.[121] However, the April 2016 bankruptcy of the U.S.-listed parent is likely to delay or even derail this proposal, absent a new financier taking the venture over.

In October 2015, the BPDB agreed to a proposal for a 20MW solar power park in Teknaf near Cox's Bazar. The BPDB signed a 25-year PPA with Joules Power Ltd for buying electricity from the solar park at a rate of $0.14 or Tk10.92 per unit.[122] Final Cabinet approval was received May 2016.

In November 2015, the state Planning Commission approved a 100MW solar project with a tariff of Tk12/kWh on 350 acres at Sonagazi in Feni, at a cost of Tk14.60bn (US$190m) with 70% of the funding to come from the Asian Development Bank via the Climate Change Fund.[123] The project proponent is the Electricity Generation Company of Bangladesh (a subsidiary of BPDB).[124] In September 2016 it was reported that the Planning Commission approved the purchase of land for the project and that invitations for tenders will now be made.[125]

BPDB has asked public-sector power companies to set up equipment for generating electricity from solar and doing feasibility studies. A number of local and foreign private-sector companies were reported in November 2015 to be submitting preliminary proposals to invest in solar power generation, with projects ranging in size from 5-100 MW.[126]

In November 2015, state-owned West Zone Power Distribution Company Ltd (WZPDCL) said it would set up a 10MW solar power plant on Monpura Island in Bhola with

[115] http://en.hareonsolar.com/index.php?c=content&a=show&id=738
[116] http://www.skypower.com/skypower-announces-2-gw-of-solar-energy-projects-in-bangladesh/
[117] http://www.pv-magazine.com/news/details/beitrag/developments-on-over-1-gw-of-new-pv-in-india_100024342/#ixzz478TcP2do
[118] http://www.skypower.com/skypower-signs-power-purchase-agreement-to-deliver-150-megawatts-of-solar-power-to-the-indian-state-of-madhya-pradesh/
[119] http://www.skypower.com/news/skypower-signs-power-purchase-agreement-to-deliver-200-mw-of-solar-energy-projects-to-the-indian-state-of-telangana/
[120] http://www.skypower.com/skypower-enters-into-agreement-with-byd-to-submit-joint-bid-for-750-mw-of-solar-energy-development-in-india/
[121] http://cleantechnica.com/2015/11/26/bangladesh-approves-200-mw-solar-power-project-sunedison/
[122] http://www.dhakatribune.com/business/2015/oct/14/local-bridge-loan-be-allowed-163mw-fenchuganj-plant
[123] http://energynewsbd.com/details.php?id=119#sthash.xzz6MDZ1.dpuf
[124] http://www.egcb.com.bd/welcome/project_details/6
[125] http://www.daily-sun.com/post/167230/Sonagazi-to-have-solar-and-wind-power-plants-
[126] http://www.reuters.com/article/bangladesh-energy-solar-idUSL8N13F16I20151120

commissioning due in 2016.[127] Being an off-grid island means current electricity is Tk35/kWh from the oil-based plant (and being sold for just Tk3.5). The cost will drop by two-thirds with solar at Tk13-14/kWh.

In December 2015, state-owned North-West Power Generation Company Ltd (NWPGCL) announced a US$15m, 7.6 MW solar power plant on 23 acres in Sirajganj for commissioning in 2017.[128] Tenders were called and nine mostly international proposals were submitted by March 2016.[129]

In January 2016, a 50MW solar project at Sathiakhali in Bangladesh by Pacific Consultants Co. Ltd (Japan) was approved to receive "Joint Crediting Mechanism" (JCM) carbon credits from the Japanese Ministry of the Environment.[130]

In March 2016, Haor-Bangla Korea Green Energy Ltd won a US17c / Tk13.5/kWh PPA with BPDB on a 32MW solar farm at Dharmapasha, Sunamgonj,[131] (the US$100m project was proposed June 2015). In August it was reported that Power Point Korea had been selected as contractor, BDPB contracts have been signed and completion is due June 2018.[132]

The BPDB has issued a letter of intent to the sponsor company Intraco CNG Ltd & Juli New Energy Co Ltd (China) for a proposed 30 MW Solar Park Project at Gangachara. The Cabinet Committee on Government Purchase approved the project earlier this year according to a report in March 2016[133].

The North-West Power Generation Company Ltd (NWPGCL) lists the Faridpur 100 MW Solar Power Plant Project as due for commissioning by June 2018.[134]

A joint venture between Bangladeshi conglomerate Beximco and TBEA Xinjiang SunOasis Co. is expected to be awarded a contract to develop a 200MW solar plant in Gaibandha. The government will purchase electricity from the plant for 20 years at Tk12/kWh[135].

A solar project at Goainghat, Sylhet has received Cabinet Committee on Government Purchase approval to sell electricity at Tk 11.12 per kWh. Sun Solar Power Plant Ltd Bangladesh and Iki Shoji Company Ltd of Japan are to commission the 5MW plant[136].

[127] http://www.dhakatribune.com/bangladesh/2015/oct/18/10-megawatt-solar-plant-planned-monpura#sthash.2FCQc2bU.dpuf
[128] http://www.dhakatribune.com/bangladesh/2016/jan/11/76mw-solar-plant-planned-sirajganj-2016
[129] http://www.dhakatribune.com/bangladesh/2016/mar/07/9-tenders-submitted-sirajganj-solar-power-plant
[130] http://techon.nikkeibp.co.jp/atclen/news_en/15mk/011500308/?ST=msbe
[131] http://hkge-bd.com
[132] http://www.dhakatribune.com/bangladesh/2016/08/30/solar-power-plant-planned-sirajganj/
[133] http://www.thedailystar.net/frontpage/six-power-deals-get-go-ahead-792436
[134] http://www.nwpgcl.org.bd/en/future-projects
[135] http://www.bdchronicle.com/detail/news/32/28260
[136] http://bdnews24.com/economy/2016/08/03/bangladesh-greenlights-three-new-power-plants-including-one-of-beximco

Annexure V

Profile of Main Government & Corporate Entities

Bangladesh Power Development Board (BPDB)

BPDB is a statutory body under Bangladesh's Ministry of Power, Energy and Mineral Resources, responsible for managing the Bangladeshi electricity system. The key responsibilities of BPDB are:

i. Generation of electricity through its own plants;

ii. Purchase of electricity from power generators in Bangladesh;

iii. Sale of electricity to Utilities;

iv. Distribution of electricity in Bangladesh; and

v. Preparation and implementation of Generation and Distribution plans

The total installed capacity under BPDB and its subsidiaries in 2014-15 was 5.4GW out of a total system capacity of 10.9GW. The number of customers served was 3.2m. BPDB had total assets of Tk534bn (US$6.8bn) and revenues of Tk212bn (US$2.7bn), while it posted losses of Tk72.8bn (US$0.9bn) in 2014-15.[137]

Power Grid Company of Bangladesh Ltd. (PGCB)

PGCB was formed under the restructuring process of Power Sector in Bangladesh with the objective of bringing about a commercial environment including increased efficiency and accountability.[138] PGCB was incorporated in 1996. It was entrusted with the responsibility to own, operate and progressively expand the national power grid. PGCB is 76.25% owned by BPDB, with the balance of 23.75% held by the general public following a listing in 2006.

Pursuant to a Government decision to transfer transmission assets to PGCB from Bangladesh Power Development Board (BPDB) and Dhaka Electric Supply Authority (DESA), PGCB completed taking over all the transmission assets in 2002. PGCB also manages the importation of the 600MW of electricity imports from India.

PGCB has had to accommodate rapid growth in the overall grid transmission of electricity, facilitating a more than doubling of grid connected electricity generating capacity from 5GW in 2009 to 11.9GW by 2015, The Government target is to double again to 24GW by 2021 and further expand to 40GW by 2030.

We note the key financial support of Asia Development Bank, The World Bank, KfW of Germany, Japan International Cooperation Agency (JICA) & Islamic Development Bank.

[137] http://www.bpdb.gov.bd/download/annual_report/
[138] https://www.pgcb.org.bd/PGCB/?a=user/home.php

North-West Zone Power Generation Company Ltd (NWPGCL)

The state-owned NWPGCL signed the Joint Venture Agreement (JVA) with CMC, China in June 2014 in Beijing, China in presence of the Prime Minister of Bangladesh and her counterpart the Prime Minister of China in order to implement the Payra 1320 MW import coal-fired Power Plant Project by using Ultra Supercritical technology. The Bangladesh-China Power Company (Pvt.) Limited (BCPCL) was constituted in October 2014 as a Joint Venture Company. In March 2016 two Chinese firms – NPEC and CECC – were reported to be the engineering, procurement and construction contractor for the project. Commissioning of the 1,320MW Phase I is due CY2019 at a reported cost of US$2bn.[139] A second 1,320MW Phase II is planned for CY2021.[140] Subsidised financing possibly covering 70% of the total project cost is reportedly likely to be delivered by China Export and Credit Insurance Corporation.

The Coal Power Generation Company Bangladesh Ltd (CPGCBL)

The CPGCBL is a State Owned Enterprise of the Government of Bangladesh, established in September 2011. The main objective of CPGCBL is to generate electricity based on coal. The prime initiative of the Company is to construct a 1.2GW import coal fired power plant at Matarbari Island in the Cox's Bazar District. This project comprises of construction of jetty and coal handling facilities for coal import, coal storage, township development, rural electrification and construction of transmission facilities and road communication.[141]

In December 2015 BPDB announced a new MoU with Sembcorp Utilities of Singapore to build a two phase 1.4GW USC import coal fired power project, also at Matarbari Island in the Cox's Bazar District. Commissioning of the 700MW Phase I is due in December 2021.

S. Alam Group (S. Alam)

S. Alam is a Bangladeshi conglomerate operating a diverse group of businesses including steel, public transport, vegetable oil, sugar, real estate, hotels and power generation.

S. Alam plans to build a 1.3GW import coal-fired power plant at Chittagong for commissioning over 2020/21 and 2021/22. In December 2013, S Alam Group, struck an agreement with SEPCO3 Electric Power Construction Corporation of China to set up a coal-fired power plant in Banshkhali, Bangladesh. The joint venture of S Alam Group, SEPCO3 Electric Power and HTG of China aim to set up the power plant by November 2019 with a reported investment of US$2.4bn of which US$1.75bn will come from Chinese lenders. In April 2016, a least four persons were killed and 30 others injured in the clash between law enforcers and locals in Banshkhali upazila of Chittagong over grievances relating to this project proposal.[142] Other press reports suggest little progress,[143] and BPDB

[139] http://www.coalpost.in/two-chinese-firms-ink-deal-for-payra-power-project-in-bangladesh/
[140] http://www.nwpgcl.org.bd/en/future-projects
[141] http://www.cpgcbl.gov.bd
[142] https://business-humanrights.org/en/bangladesh-4-killed-in-clash-over-setting-up-power-plant-company-denies-involvement
[143] http://archive.dhakatribune.com/bangladesh/2015/oct/16/govts-coal-power-miracle-rocks#sthash.tV5Iol6h.dpuf

said in October 2016 that the project has advanced but is yet to reach financial close.

Orion Group

The Orion Group is one of the leading industrial conglomerates in Bangladesh, led by the Founder Chairman, Mr Mohammad Obaidul Karim (reported to have been jailed in 2007 for misappropriation of Oriental Bank funds[144] and investigated again on a similar charge in 2015[145]). Reporting staff of 18,000, Orion claims it is a Bangladesh market leader in Pharmaceuticals and Cosmetics & Toiletries sectors. Besides these, Orion has focused on Infrastructure Development and Power Generation businesses.

BPDB reports that Orion had plans to build up to five units of imported coal fired power plants at Khulna, Munshiganj, Dhaka and Chittagong all reported to be due for commissioning in 2019/2020. However, there have been press reports that these plans have been awarded on the basis of tariffs that are uncommercial and it is reported Orion has scaled its plans back to only the 565MW near the Sundarbans, but BPDB CEO Khaled Mahmood reports in October 2016 that Orion has been significantly delayed by a protracted environmental approval process.

In April 2016 it was reported that a consortium of the Orion Group and China-based Fujian Zhongde Energy Co Ltd and UAE-based Firstgen Energy FZE have signed a PPA with BPDB to set up a 535MW import coal-fired USC power plant in Munshiganj. According to the agreement, the BPDB will purchase electricity from the plant for the next 25 years at a levelised tariff of Tk5.86 per kWh.[146] Orion anticipates financing participation by US EXIM and Korean EXIM for the first time in Bangladesh, ECA financing tied to the use of equipment from GE of the USA and Doosan of Korea.[147] However, the import coal plant technology and significant civil resistance potentially precludes Orion's access to US EXIM ECA financing.[148]

Summit Power

Summit Power is one of the largest private power plant owners in Bangladesh, operating a 305MW high speed diesel plant at Meghnagat as well as 215MW of furnace oil fired power plants at Madangonj and Khulna. Additionally, Summit commissioned a 341MW gas fired power plant at Bibiana-II in 2015 (80% owned by Summit, 20% by GE US) and is due to commission 165MW of furnace oil power plants at Barisal and Madangonj in 2016.

Bangladesh-China Power Company Ltd – Payra Power

The Bangladesh-China Power Company Limited was constituted in October 2014 as a joint venture company between Bangladesh's NWPGCL and China National Machinery Import & Export Corporation (CMC). In March 2016 two Chinese firms – NPEC and CECC – were

[144] http://bdnews24.com/bangladesh/2007/12/27/orion-chairman-gets-life-in-oriental-bank-scam
[145] http://www.theindependentbd.com/printversion/details/20980
[146] http://archive.dhakatribune.com/bangladesh/2016/apr/22/munshiganj-see-635mw-coal-power-plant#sthash.lQ8Hh03c.dpuf
[147] http://www.orion-group.net/concern/26/60/orion-power-dhaka-ltd
[148] http://www.energycentral.com/news/us-exim-bank-urged-refrain-financing

reported to be the engineering, procurement and construction (EPC) contractor for the project in Kalapara. Commissioning of the 1,320MW USC plant phase I is due CY2019 at a cost of US$2bn. China Export and Credit Insurance Corporation Sinosure was reported as providing the financing for the project.

Bangladesh-India Friendship Power Company Ltd – Rampal

The US$2bn 1.32GW import coal-fired power plant proposal at Rampal is a joint venture with equity split 50:50 between BPDB and NTPC Ltd (NTPC) of India. The heavily subsidized US$1.5bn debt funding for the project is to be extended by the Indian EXIM Bank under an Indian government guarantee, in effect a billion-dollar subsidy. BHEL is to undertake the EPC.

NTPC Ltd of India

NTPC is India's largest electricity generation company, with a total installed capacity of 47.2GW out of India's total electricity generation capacity of 298.0GW.[149] NTPC is a publicly listed company, owned 70% by the Government of India.[150] The company had assets of INR1,971bn (US$29.4bn) and profits of INR103bn (US$1.5bn) in 2015-16.

While over 40GW of capacity is based on coal power,[151] NTPC has undertaken a substantial strategic shift and is now a leading proponent and facilitator of India's renewable energy capacity expansion plans. NTPC has 310MW solar projects commissioned, with plans to add 1GW capacity by 2017[152] and a 10GW in 3 tranches in by 2021.[153] NTPC has also allocated 2.5GW capacity of solar plants under the state specific bundling scheme as part of the Batch II of the Phase II of the National Solar Mission.[154] NTPC has been mandated to procure 15GW of solar projects by 2022, acting as the financially credible counter-party for PPAs which it will on-sell to the Discoms.[155]

NTPC holds a 50% equity stake in the US$2bn 1.32GW Rampal imported coal fired power project adjacent to the Sundarbans. We note the strategic shift by NTPC to target 52% from renewables by 2020[156].

Bharat Heavy Electricals Limited (BHEL)

BHEL is India's leading power plant equipment manufacturer, with 62% of India's coal-based thermal utility installations and power generation equipment installations of over 150GW.[157] Outside the power sector, BHEL also manufactures industrial systems and

[149] http://www.ntpc.co.in/en/media/press-releases/details/record-generation-ntpc-stations-fy-16
[150] http://www.bseindia.com/corporates/shpSecurities.aspx?scripcd=532555&qtrid=89.00
[151] http://www.ntpc.co.in/en/power-generation/coal-based-power-stations
[152] http://www.ntpc.co.in/en/power-generation/renewable-energy-and-distributed-generation
[153] http://www.pv-magazine.com/news/details/beitrag/indian-state-utility-ntpc-given-green-light-for-15-gw-solar-adani aplan_100018354/#axzz494JWxMzb
[154] http://www.bridgetoindia.com/blog/another-day-another-auction-indian-developers-on-a-winning-spree/
[155] http://www.bloomberg.com/news/articles/2016-10-04/india-s-ntpc-to-expand-solar-goal-slow-thermal-power-bnef-says
[156] http://infracircle.vccircle.com/renewable-energy-contribute-52-ntpcs-electricity-generation-capacity-2020/
[157] BHEL Annual Report 2014-15, Page 13

products for a variety of industries. BHEL has contracted 48 supercritical steam generators. BHEL is a publicly listed company, with 63% ownership by the Indian Government.[158] The company posted sales of Rs263bn (US$3.92bn), while posting losses of Rs9.0bn (US$134m) in 2015-16.

While BHEL has focused historically on thermal power generation equipment, it has lately started to invest in solar power installation as well, in accordance with the policy direction of the Indian government.[159] As part of this endeavour, it has recently won an order from NTPC to set up a 50MW solar plant in the Indian state of Madhya Pradesh.[160]

Export Import Bank of India (EXIM Bank)

The India EXIM Bank is owned 100% by the Government of India, was established to finance, facilitate and promote India's international trade and investment. EXIM Bank provides Export and Import credits, as well as loans for exporting units. EXIM Bank had a total loan portfolio of Rs1,025bn (US$15.2bn) in 2015-16, while it made profits of Rs3.2bn (US$47m).

EXIM Bank has backed a bid by BHEL for the supply of equipment to the Rampal plant and is currently in the process of providing the entire debt portion of the capital structure, a stated US$1.6bn.

IEEFA believes that EXIM Bank would better deliver on its mission by supporting NTPC and BPDB in initiating a joint program by awarding BHEL an EPC contract to install a series of solar plants in Bangladesh. Not only would such backing significantly boost India's fledgling solar manufacturing industry, it would augur well for the government's "Make in India" program. EXIM Bank commenced work in the renewable space in 2015 launching its first US$500m green bond.[161]

Adani Power Ltd of India

The Adani Family group of companies is one of the largest coal power conglomerates in India, with four Bombay Stock Exchange listed entities: Adani Power Ltd; Adani Enterprises; Adani Ports & SEZ Ltd; and Adani Transmission Ltd.

In 2010, Adani Power Ltd and BPDB signed an agreement aimed at developing the Godda 1,600MW coal-fired power plant in Jharkhand and supplying the electricity generated to Bangladesh through a dedicated power transmission line. Costing US$2.1bn, power is being offered at Tk6.85/kWh, plus an unquantified capacity charge but as of October 2016 agreement has not been reached. Repeated delays including issues related to water access and issues over Adani's request to waiver or alter the required supply of power to the State[162] saw the project only issued Terms of Reference by an

[158] http://www.bseindia.com/corporates/shpSecurities.aspx?scripcd=500103&qtrid=89.00&Flag=New
[159] http://www.pv-tech.org/news/indias-bhel-told-to-step-up-solar-activity-by-minister-bags-50mw-epc-order
[160] http://economictimes.indiatimes.com/industry/energy/power/bhel-bags-rs-282-crore-order-from-ntpc-for-50mw-solar-plant-in-mp/articleshow/51824345.cms
[161] https://cleantechnica.com/2015/03/31/indian-export-import-bank-issues-countrys-first-dollar-green-bond/
[162] http://www.oneindia.com/ranchi/jharkhand-changed-power-policy-to-help-adani-opposition-2213958.html

Indian expert review panel in August 2016. An Environmental Impact Assessment is the next step.[163]

In June 2015 it was announced that Adani Power Ltd had signed a MoU with BPDB to build a US$2.3bn 1,600MW imported coal fired power plant in Bangladesh as part of a state visit there by the Indian Prime Minister Narendra Modi.[164] In March and again in August 2016 it was reported Adani Power had moved away from its proposal to build in Bangladesh reportedly after it ran into land acquisition issues.

Yet another proposal is a 3,000MW domestic sourced coal fired power plant at Orissa in India with the electricity due to exported to Bangladesh by a dedicated transmission line possibly to likewise be built and owned by Adani Transmission Ltd.[165] [166]

In addition, the Adani group also owns Adani Green Energy Ltd, one of India's largest solar power plant owner / developer and module manufacturers. Adani Green commissioned the world's largest 648MW solar project in Tamil Nadu in 2016, and is due to commission a second 105MW tracker based solar project in Punjab by end 2016, with construction taking less than a single year. With solar electricity costs declining 10-20% annually, and India regularly awarding tenders set on 25 year solar tariffs at Rs4.40-4.80/kWh (fixed with no inflation), the opportunity for Bangladesh is enormous. In November it was reported that Adani Green Energy is already seeking to make the most of this potential with the company submitting a proposal to the Bangladesh government to construct up to four solar power plants in the country with a combined capacity of 320MW[167].

Given the strategic prominence of "Make in India" and the need to develop new export industries for India, there is significant scope for Adani Green's solar manufacturing and solar project development arms to be a key supplier and to be a lead EPC player in the development of Bangladesh's utility scale solar sector. The Indian EXIM Bank could provide much needed multi-billion-dollar financing of such a venture.

Reliance Power Ltd of India

The Anil Ambani led Reliance Power Ltd is another of the largest, profitable power generation firms in India, listed on the Bombay Stock Exchange, and part of a conglomerate that also spans infrastructure, communications and financial services. Having historically operated in the coal and gas fired power generation sector, Reliance Power has long evaluated a move with a proposal for over 5GW of hydro electricity generation across Northern India. While the company still references 10GW of thermal power generation project proposals across five key sites, all appear to be at a standstill after the company dramatically changed its strategic direction.

Over the last five years Reliance Power has significantly increased its focus on renewable energy generation. In March 2012 it commissioned its first 40 MW solar PV project in Pokharan, Jaisalmer, Rajasthan. In the wind energy sector, in June 2013 Reliance commissioned a 45 MW wind project in Vashpet, Maharashtra. In November 2014 Reliance commissioned the world's largest compact linear Fresnel reflector (CLFR) based

[163] http://www.livemint.com/Industry/0TKMidWdROvBVVkYTkcUYK/Adani-Power-project-to-supply-electricity-to-Bangladesh-cros.html
[164] http://www.reuters.com/article/bangladesh-india-power-idUSL3N0YS03W20150606
[165] http://www.coalpost.in/reliance-adani-change-plan-for-power-projects-in-bangladesh/
[166] http://www.thefinancialexpress-bd.com/2016/08/26/43436/Adani's-power-export-to-BD-depends-on-new-law
[167] http://www.dhakatribune.com/bangladesh/power-energy/2016/11/06/adani-group-install-solar-power-bd/

100MW Concentrated Solar Power project. In 2015 Reliance Power and the Government of Rajasthan signed a MoU to develop 6,000MW of Solar Power projects in the State of Rajasthan over the next decade.

In June 2015 it was announced that Reliance Power Ltd had signed a MoU with BPDB to build a US$3bn, 3,000MW imported LNG-fired power plant in Bangladesh as part of a state visit there by the Indian Prime Minister Narendra Modi.[168]

In May 2016 Reliance Power announced the first phase of this proposal was to be a 750MW plant to be built at Mehnaghat, just South of Dhaka for commissioning by 2018/19. This facility would require construction of a supporting 2Mtpa LNG floating storage and regasification unit (FSRU) at Maheshkhali Island in Cox's Bazar district at a combined US$1.3bn.[169] Reliance proposes relocating gas fired power equipment it had originally ordered for its now stranded Samalkot 2.4GW gas fired plant in Andhra Pradesh, India.

Rahimafrooz Renewable Energy Ltd.

A division of the Rahimafrooz business conglomerate (a Bangladesh trading firm established in 1954 and employing over 3,500 staff), Rahimafrooz Renewable Energy Ltd. (RREL) has been providing Solar Energy solutions for households, agriculture, healthcare, education, telecommunication, rural streets and marketplaces, as well as government and private institutions for 25 years. To date, RREL has lit up more than 100,000 rural homes in Bangladesh. RREL is also the pioneer in providing solar-hybrid solutions for Telecom Operators' BTS towers and solar powered irrigation systems in Bangladesh.[170]

Working closely with Bangladesh Government's agencies, NGOs, donor organizations and international agencies, RREL offers a full range of solar solutions including home lighting, street lighting, water heating systems, PV centralized systems, irrigation systems, vaccine refrigeration, support for computer and other electronic systems. To-date RREL has so far installed more than 25 MW of solar systems across a variety of forms including SHS, solar pumping solutions, telecom solutions, and on-grid roof-top solutions (Including installation of the largest on-grid power project of 50KW at Independent University, Dhaka) and decentralized solar community electrification projects.

GCM Resources Plc (UK)

Efforts to develop a second domestic Bangladesh coal deposit, such as in the Dinajpur District of Northwest Bangladesh by way of the 15Mtpa Phulbari Coal project, have yielded no progress. Coal reserves in the area are reported at 572Mt, and in addition to the mine proposal, a 250MW mine-mouth coal-fired power plant has been proposed.

Owned by GCM Resources Plc(listed on the London Stock Exchange), the projects remain underdeveloped due to government-approval delays and significant community resistance that has forced potential funders of the project like ADB to pull out of proposals to finance the plant.[171] The plant's Feasibility Study and Scheme of Development is still

[168] http://www.reuters.com/article/bangladesh-india-power-idUSL3N0YS03W20150606
[169] http://www.coalpost.in/rpower-gets-principle-nod-lng-based-plant-bangladesh/
[170] http://www.rahimafrooz-solar.com/index.php/component/content/article/84-rahim-afrooz-solar/page-content/91-about-us
[171] https://banglapraxis.wordpress.com/2008/04/04/press-release-asian-development-bank-pulls-out-of-controversial-phulbari-coal-project-in-bangladesh/

awaiting government approval nearly 11 years after it was submitted.[172] The project was first conceived with BHP involvement in 1984, and GCM so far claims to have invested £38m. The delay highlights the typical financial risks coal-based projects face. GCM Resources reported in September 2016 that press speculation was incorrect that formal ban on open cut mining in Bangladesh had been implemented.

Maheshkhali, Cox's Bazar Power Complex

In August 2013 BPDB announced that it intended to build the multi-plant Maheshkhali power complex around Cox's Bazar in South East Bangladesh including both coal-fired plants and combined cycle gas-fired plants. A January 2014 announcement by the BPDB invited expressions of interest given it "intends to build 6000 MW Ultra Super Critical Coal Based Thermal Power Plant and 3000 MW LNG Based Combined Cycle Power Plant in different phases."[173] The announcement stated that the fuel for the projects would be imported coal and LNG. Five thousand acres are said to be in the process of acquisition. Since then, a number of MoUs have been announced. However, little substantive progress appears to have been made on any.[174]

Singapore - Sembcorp

The Bangladesh government was reported to be thinking to set up two more coal-fired power plants, each of 700MW capacity, at Matarbari Island. It was reported the state-run CPGCBL looked to sign a joint venture MoU with Singapore based Sembcorp Utilities Pte Ltd[175] and is working on site preparation for phase1.

In August 2016 Sembcorp signed a MoU for a US$413m, 414MW duel fuel power plant at Sirajgani. The Tariff for gas was Tk3.19/kWh (courtesy of the heavily subsidised Bangladesh domestic gas price) and for high speed diesel Tk13.57/kWh. Commissioning is due by end 2018.[176] Sembcorp will own 71% of the equity and BPDB's NWPGCL the remaining 29%.

Japan – Toshiba, Mitsubishi and JICA

The 1.2GW Matarbari power station involves a Japanese consortium that had signed a MoU in early 2016 for the proposed financing of an imported coal fired plant on Matarbari Island in the Cox's Bazar district. Toshiba Corp. and Mitsubishi Hitachi Power System Ltd were named as expected to take part in the equity financing and construction, while Japan International Cooperation Agency (JICA) was reported to be considering US$3.7bn of government subsidised debt financing. This project was first discussed in February 2014 when a feasibility study was reported to be undertaken by JICA and Tokyo Electric Power, the latter now being unlikely to be involved given the financial distress resulting from its Fukushima disaster in 2011.

[172] http://www.gcmplc.com/project-status
[173] http://www.bpdb.gov.bd/download/maheshkhali9000MW/
[174] http://archive.dhakatribune.com/bangladesh/2015/oct/16/govts-coal-power-miracle-rocks#sthash.tV5Iol6h.dpuf
[175] http://newagebd.net/180962/2-more-coal-fired-power-plants-at-matarbari-on-cards/
[176] http://newagebd.net/245140/bpdb-sembcorp-ink-deal-414-mw-power-plant/

Further, the Gulshan terrorist attack of July 2016 saw reports that the Japanese have ceased the tender process.[177] The prohibitively high projected construction cost (including required bridges, a new import coal port and high voltage cabling connections) would suggest exceptionally high tariffs well in-excess of the Tk7/kWh originally proposed.[178]

Malaysia - TNB and Powertek Energy Berhad

In July 2016 the Malaysian government signed a MoU for a Malaysian consortium to undertake a feasibility into a US$2.5bn, 1,320MW imported coal fired power plant to be located at Maheshkhali, Cox's Bazar.[179] The proposal is said to be 30% equity and 70% debt financed. The BPDB would own 50% of the equity, and the Malaysian consortium the other 50% of the equity, likely to be two Malaysian power firms -- Tenaga Nasional Berhad (TNB) and Powertek Energy Berhad.[180] BPDB would provide the off-take agreement and the Malaysian government would have to procure non-recourse subsidised debt financing for 70% of the project cost. Malaysia and Bangladesh signed a Government-to-Government MoU to implement the project in 2014.

With a nine-month feasibility, six months EPC tender process, 12 months for project documentation and then four years for construction, this project proposal would be unlikely to generate commercial electricity for Bangladesh until 2023 at the earliest.

China – China Huadian Hong Kong

Reports suggest a MoU was signed between BPDB and China Huadian Hong Kong (a subsidiary of China Huadian Group), likewise for a 1,320MW import coal fired power plant in one of two locations reported as Maheshkhali Island or Anwara Upazila in the Chittagong District. No progress is reported since and the corporate website doesn't mention this project.

China – Sepco Electric Power Construction Corp (SEPCO)

In June 2016 the BPDB signed another MoU with China-based Sepco (a division of PowerChina Huadong Engineering Corp.) to set up a 1,320MW ultra-critical project at Maheshkhali using imported coal. Both the parties have agreed to finance 50% of the project.[181] In October 2015, the Chinese President Xi Jinping visited Bangladesh for a visit and it was reported China would be providing financial support for a series of 22 infrastructure projects, including a 66MW power plant, possibly stage I of SEPCO or China Huadian's proposals.[182] Given China's world leading solar manufacturing and project

[177] http://m.bdnews24.com/en/detail/economy/1190543
[178] http://www.thedailystar.net/maheshkhali-to-house-massive-power-plant-10801
[179] http://www.freemalaysiatoday.com/category/business/2016/07/21/bdesh-awards-usd2-5b-coal-fired-power-project-to-msia/
[180] http://ep-bd.com/online/details.php?cid=14&id=17744
[181] http://archive.dhakatribune.com/bangladesh/2016/jun/29/another-1320mw-power-plant-maheshkhali#sthash.kuJnAaXq.dpuf
[182] http://www.dhakatribune.com/business/2016/10/09/bangladesh-china-sign-mou-investment/

construction capabilities, we are surprised that China's sponsorship of a series of solar projects is not a central focus of this visit.

Korea – Korea Electric Power Corporation (KEPCO)

It was reported in May 2014 that KEPCO was considering a 1,320MW Maheshkhali imported coal fired power station at Maheshkhali. No progress is reported since.

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About the Authors

Tim Buckley

Tim Buckley has 25 years of financial market experience covering the Australian, Asian and global equity markets from both a buy and sell side perspective. Tim was a top rated Equity Research Analyst and has covered most sectors of the Australian economy. Tim was a Managing Director, Head of Equity Research at Citigroup for many years, as well as co-Managing Director of Arkx Investment Management, a global listed clean energy investment firm that was jointly owned by management and Westpac Banking Group.

Simon Nicholas

Simon Nicholas is a Research Associate with IEEFA in Australia. Simon is a Fellow of the Institute of Chartered Accountants of England and Wales and has 16 years' experience working within the finance sector in both London and Sydney at ABN Amro, Macquarie Bank and Commonwealth Bank of Australia.

Sara Jane Ahmed

Sara Jane Ahmed is IEEFA's energy finance analyst based in the Philippines specializing in originating and structuring energy opportunities in emerging markets. She has worked for the World Resources Institute and a private investment firm focusing on the emerging markets.

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