QUICK RENTAL POWER PLANTS IN BANGLADESH: AN ECONOMIC APPRAISAL

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Executive Summary

1. The generation and supply of adequate electricity has always remained an unresolved challenge for Bangladesh. During 1991-92, the country's total installed capacity of electricity generation was 2,350 MW while the derated capacity was 1,719 MW. The installed capacity increased to 5,719 MW in 2008-09 and further to 8,819 MW in 2011-12 with the corresponding derated capacity of 5,166 MW and 8,149 MW respectively. The increase in production, however, was not enough to meet the rapidly rising demand for electricity resulting in persistent load shedding and adoption of other measures of demand management.

Liquid Fuel Based and Quick Rental Power Plants

2. One important aspect of recent developments is that a significant portion of the additional electricity generation has come from liquid fuel based power plants which has raised the total contribution of liquid fuels in power generation to 17 percent in 2012 from 13 percent in 2011 and 5 percent in 2010. Moreover, most of the liquid fuel based electricity has come from rental, quick rental, and peaking plants which were undertaken on a fast-track basis to address the nagging power crisis.

3. Over the last few years, severe power crisis compelled the government to enter into contractual agreements for high-cost temporary solution, such as rental power and small independent power producers (IPPs, mostly diesel or liquid-fuel based) on an emergency basis. In view of the gravity of the situation, the government's Power System Master Plan 2010 decided to use the quick rental power plants (QRPPs) as its major strategic tool to reduce power shortage in the short run. Under the plan, a total of 20 QRPPs was commissioned by 2012 with a total capacity of more than 1,000 MW.

Relative Cost of Quick Rental Power Plants

4. It is rather difficult to assess the costs of QRPPs; one usual practice is to compare the cost of QRPPs with that of independent power producers (IPPs). However, IPPs are not necessarily the ideal and the best ones for the comparison purpose as the conceptual underpinnings of the contractual arrangements of the two are very different especially in terms of risks/returns.

5. A comparison of per unit cost of electricity under different modes shows that the public sector units have the lowest per unit cost mostly due to fuel advantage. Between the rentals and the quick rentals, the average per unit cost of gas based electricity generation is more than 75 percent higher for QRPPs than the rental units while, in the case of furnace oil, the rental units are 21 percent costlier than the QRPPs. The per unit fixed cost in the case of gas

based generation units for the QRPPs is nearly two-and-a half times higher than that of the rentals but, for the furnace oil based units the per unit cost of the rentals is more than twice that of the QRPPs. The per unit fuel cost is not very different between the two in the case of gas but, in the case of furnace oil, the cost of QRPPs is nearly 14 percent higher.

Rising Generation Cost and Government Subsidy

6. Over the years, the provision of low cost electricity through subsidized prices has played a critical role in growth and development of the Bangladesh economy. However, as the selling price has fallen behind the rising cost of electricity supply, the government support to BPDB which amounted to Tk. 1,007 crore in 2008-09 increased to Tk. 6,357 crore in 2011-12 and is projected to rise to Tk. 13,758 in 2012-13. Considering the rising supply cost of electricity, the bulk electricity tariff rate has recently been increased to reduce BPDB's losses. As a result, the bulk price of per unit electricity increased from Tk. 2.37 to Tk. 2.61 in February 2011 and further to Tk. 4.02 in October 2012.

7. According to the BPDB, fuel consumption is expected to rise to 7 million tons in 2012-13, up from an average of 3 million tons in the last decade and 5.4 million tons in 2010-11 and 2.6 million tons in 2009-10. Of the total, more than 30 percent is expected to be consumed by the power plants. In 2011-12, the country imported 4.8 million tons at a cost of Tk. 29,000 crore; while the cost is likely to reach Tk. 49,000 crore during 2012-13. The main factor contributing to soaring fuel consumption is the introduction of the liquid fuel based QRPPs as well as a rise in captive power plants in industrial and commercial establishments.

Estimated Cost of Unserved Energy

8. The estimates show that that the total cost of unserved energy was Tk. 47,183 crore over the last two fiscal years—2010-11 and 2011-12. Of the total, the cost of unserved energy for QRPPs was nearly Tk. 29,348 crore and the remaining Tk. 17,935 crore was the cost for the rental power plants.

Growth Impact of Quick Rentals

9. At the aggregate level, the estimated relationship between GDP and electricity generation shows that an extra economic output (value added) within the range of Tk. 46 million to Tk. 107 million (at constant 1995/96 prices) is generated for every one MkWh increase in electricity supply in Bangladesh. This implies that in the fiscal year 2011-12 alone, the contribution of additional electricity generated by the QRPPs to the GDP has been between Tk. 23,312 crore and Tk. 54,226 crore at constant 1995/96 prices, which are equivalent to between Tk. 52,093 crore and Tk. 121,168 crore at 2011-12 prices. Obviously, non-availability of electricity from the QRPPs, along with lower GDP growth and reduced sectoral output, would have reduced the export growth rate and created adverse impact on other macroeconomic and sectoral indicators including employment and poverty reduction.

A Big Achievement Indeed

10. Overall, it needs to be admitted that, for a country like Bangladesh, increasing the gross generation capacity by 3,100 MW within a period of around three years is no doubt a big achievement. However, the demand over the period also shot up to around 7,500 MW as a consequence of which not much impact could be seen on the deficit and consequent load shedding. The above developments point out that the power situation could have been much worse if no new power could be added and if the government did not go for the quick rental option.

11. During the time when decision regarding the QRPPs was taken in Bangladesh, the deficit of electricity was nearly 2,000 MW in the system and this deficit was primarily due to generation deficiency which could not be met through augmentation of existing plants or saving of line losses. It is agreed that existing capacity augmentation and reduction of line losses could add only 'drops to the ocean'; and hence improving the situation depended on expansion of additional generation capacity within the shortest possible time. The choice in front of the government was either to opt for the QRPPs or take recourse to ever rising load shedding and shutdowns hampering livelihoods of the people and creating adverse impact on economic growth and development.

12. It must be admitted that although the deficit situation may not have improved perceptibly, the additional power supplied to the national grid through the QRPPs has made significant positive impact in many areas of the economy. The supply of additional power has no doubt contributed to the expansion of economic activities in various sectors including manufacturing industries, RMGs, commercial and business activities, agriculture through providing irrigation and better marketing and processing services, and in trade, communication, and other services. This has significantly helped to keep the GDP growth rate over 6 percent along with a healthy export growth despite global recession and other constraints.

Priority Policy Options for the Longer Term

13. Keeping a longer term perspective, several policy options are called for within a time bound framework such as the need for rethinking of the policy of importing coal and LNG leaving the country's substantial coal resources underground and making little time bound effort of exploring the potential and huge untapped gas and petroleum resources at onshore frontiers and offshore.

14. There is also a need to deal with the problems associated with the timely implementation of the gas based large power projects (e.g. at Bibiyana) and take time bound actions for fast track gas exploration. While Petrobangla and BAPEX have been making commendable

efforts, the outcomes are small relative to the enormity of the problems. One of the major problems in the sector is the inordinate delays in implementing some key gas infrastructures.

15. The desired role of small IPPs/contingency plants/quick rental plants is to give the required relief for the interim period of 3-5 years till large base load projects and major plants could be installed and become operational. But the process of implementation of the Power System Master Plan 2010 is taking more time than anticipated in the Plan and, in the process, some flaws seem to have cropped in including relaxed qualification criteria.

16. It appears that the positive impact of additional power from QRPPs to the national grid has been constrained by inadequate action for load management and ensuring better efficiency. This requires more effective measures to promote energy efficient appliances, actions against delinquent consumers, installations of pre-paid meters, and similar measures.

17. It is usually held that rental power is more expensive than power generated by normal IPPs. This is not necessarily true as prices depend on a host of factors including capacity, return on capital, interest on loans and loan repayments, O&M and other variable cost components of the two options.

18. Rental plants are simple cycle plants and consume marginally more fuel than combined cycle power plants. However, most IPPs normally start as simple cycle plants and are converted to combined cycle over a period of time. Moreover, despite the fact that rental contacts are between 3-5 years and not 20 years (as with most IPPs), rental tariffs are low. When lower tariffs to rental plants are taken into account and a further allowance is made for higher fuel costs, the difference is almost equal or marginally higher in the case of rental plants. As such, rental power costs may not necessarily be substantially higher than those of IPPs.

Focus on Least Cost Option

19. Prudent economics requires that the strategy for meeting the electricity demand be based on least cost option in Bangladesh. For this, an integrated approach to the power sector is needed since the current crisis is, to a large extent, a fuel crisis caused by delays in decision making regarding power generation and finding a substitute for the depleting domestic gas supply. The shortage of gas increases the cost of power by raising the dependence on imported liquid fuel and lowering the efficiency and capacity of power plants designed to run on gas.

20. Obviously, DSM is by far the cheapest option that increases virtual generation by reducing demand. The DSM measures are therefore more cost effective than creating new capacity and hence DSM opportunities need to be fully exploited. For the liquid fuel based plants, fuel cost far exceeds the capacity cost. The efficiency of these plants is therefore an important parameter. Moreover, the capacity cost of existing plants is a sunk cost and their incremental cost is fuel and variable O&M. On the other hand, new plants involve capacity cost as well as fuel and variable O&M costs.

21. In the above context, the IPPs are operating for about a decade with fixed capital cost which is already sunk. Since the IPPs are available for generation at marginal cost (fuel and variable O&M costs), their capacity needs to be utilized to their maximum contracted availability.

Affordability: A Major Consideration

22. The financial constraints of the government as well as the majority of electricity consumers, especially the poorer groups, require that affordability be considered as a major consideration in adopting the appropriate strategy for tackling the problem of electricity shortage. In the short run, a realistic target of the share of the peak demand that would be met needs to be set and additional demand management options implemented. In the existing situation, a target of 100 percent is probably not a viable option. Based on relevant considerations, an informed decision should be taken to balance between creating additional capacity, load shedding, and affordability. The lower cost options for augmenting supply needs to be fully exploited and the QRPP option should be periodically reviewed in the light of affordability of different options.

23. The availability of gas is a major parameter in determining the affordability of electricity in the country. The energy sector needs an integrated analysis to maximize the benefit of this scarce resource (gas). In principle, gas should only be used in combined cycle plants to ensure the maximum efficiency. Meanwhile, all the commissioned QRPPs should be fully utilized, especially during the early phases of their life, so that adequate time is available for upgrading and improving efficiency of the existing plants. The dispatch criteria should be reviewed from time to time in the context of existing demand and available generation system.

Some Specific Recommendations

24. The present study recommends that new capacity procurement should be based on least cost criteria to minimize the cost of power to the economy to support poverty reduction and improve competitiveness of the economy. In arriving at the desired mix, a combination of several options should be considered such as:

(i) In view of the present situation, since the base load power plants like coal fired steam turbines, nuclear power and gas fired combined cycle plants are likely to take either a longer time to come into generation than expected or are constrained by the availability of natural gas, plans may have to be worked out to make strategic use of the existing rental/quick rental power plants. One option could be to explore the costs and benefits of using these plants (only those which pass the 'fitness test') for a longer period than presently conceived under changed contractual arrangements instead of shutting them down after the expiry of the present contract period. For each quick rental plant, the fitness test should cover a number of areas such as techno-economic feasibility study, assessment of environmental costs due to operation of the plant including SOX, NOX, CO, noise pollution, air quality and environmental dimensions, present derated value and fuel efficiency of the plant, and estimation of NPV, IRR and BCR. Since a significant amount of the country's foreign currency has already been spent in building these plants, the possibility of converting these plants into gas-based plants (with some additional investment) could be explored as running these with liquid fuel will entail high generation cost in the long term. The above would support their strategic use like the IPPs. If the rental/quick rental plants are converted into IPPs, the plants can run on HFO as long as sufficient gas is not available; and when gas would be available these can run on gas. The option would facilitate the utilization of the existing rental/quick rental capacity as IPPs for say another 10-15 years without investing much additional foreign exchange. This would give adequate time to implement the phase 4 of the Power Sector Master Plan 2010. The option is expected to reduce the generation cost of electricity as the IPPs are likely to have lower tariff and fuel flexibility. If the option is found feasible and profitable, agreements may be reached with the selected local entrepreneurs who have already made significant investments in the rental/quick rental plants to restructure their investments to turn their plants into IPPs.

(ii) Optimize existing installed capacity e.g. capacity stalled due to administrative reasons or non-repair/non-overhauling, and gas supply constraints;

(iii) Implement programs to reduce transmission and distribution losses and undertake energy efficiency and energy improvement projects including rehabilitation of old plants and improving their efficiencies;

(iv) Adopt measures for demand side management (DSM) such as popularizing the use of CFL; and

(v) Take quick decisions for accelerating the implementation of Phase 3 (medium term) and Phase 4 (long term) of the government's Power Generation Plan.

Quick Rental Power Plants in Bangladesh: An Economic Appraisal

1. Introduction

In Bangladesh, rapidly rising energy consumption is likely to continue in the coming years as economic growth accelerates and economic activities intensify further. Development experience in other countries shows that energy consumption rises fast when per capita income is between US$1,000 and US$10,000. Bangladesh will be entering this high energy consumption phase shortly and hence energy supply has to be increased rapidly to sustain the country's growth momentum.

Energy and power is not only vital for economic growth, it is also the key ingredient to improve the socioeconomic conditions of the people and for reducing poverty. In Bangladesh, electricity is the most widely used form of energy, but the country has always faced the problem of inadequate generation of electricity compared with national demand since Independence. As a result, the consumers have failed to get uninterrupted and quality supply of electricity even after more than forty years of independence.

The commitment of the present government is to provide access to affordable and reliable electricity to all citizens by 2021. At present, only about half of the population has access to electricity which, however, is not reliable. The challenge is no doubt significant but it is a worthwhile target to pursue for accelerating growth and development and raising the welfare of the country's population.

When the present government came to power in 2009, the average electricity generation was around 3,200-3,400 MW against the national demand of about 5,200 MW which reflected an excess demand of about 2,000 MW. For meeting the shortage, the government prepared an emergency plan to increase electricity generation to 5,000 MW by 2011 and 7,000 MW by 2013. Unfortunately, there was no easy solution to electricity generation as, in addition to investing huge financial resources, this also had to overcome the shortage of primary energy for generating electricity.

Traditionally, electricity generation in Bangladesh is overwhelmingly dependent (more than 80 percent) on natural gas fired generation, and the country had been facing a simultaneous shortage of both natural gas and electricity over the last decade(which is still continuing). Even the generation of around 400-800 MW of electricity using the installed capacity of the existing power plants was not considered feasible during the time due to shortage of natural gas. Other fuels for generating low-cost base-load energy, such as coal, or renewable sources like hydropower, were also not feasible at least in the short run and the government had no other option but to go for fuel diversity option for electricity generation—a short-term but costly solution.

Although there were simultaneous efforts to establish gas and coal-based power plants by the Bangladesh Power Development Board (BPDB), in view of the long time gap needed for such generation plants to come into operation, the government opted for liquid fuel based electricity generation for the short run. Moreover, the limited financial resources available with the government forced the decision makers to go for quick rental power plants established by the private entrepreneurs. Since taking the decision in 2009, agreements were signed with the private sector electricity generating companies to purchase electricity from the rental power plants.

At present, the country has a total of 34 oil-fired power plants, of which 23 plants having a total generation capacity of 1,956 MW are furnace oil-fired and the remaining 11 plants having a total generation capacity of 537 MW are diesel-based plants. One may also note that incidents have taken place in the past when some oil-fired plants had to be kept closed as financing additional fuel imports emerged as a constraint and BPDB was not in a position to purchase electricity from them due to shortage of funds.[1] For this, however, BPDB is required to make 'capacity payment' to these plants as penalty, as per the contracts signed with them. This shows that financing costly power generation is a burden that the country is not in a position to sustain for a long period.

In 2009, the average electricity production cost was estimated at below Tk. 3.00/kWh. At the time, the energy mix for power generation was around 82 percent gas, 10 percent oil, 4 percent hydro, and 4 percent coal. With the introduction of the quick rental power plants as well as liquid fuel based plants operated by BPDB, the share of oil-fired electricity generation has shot up to 30 percent while the share of the gas component has reduced to 67 percent within a span of the last three years. As a result, the average generation cost of electricity has more than doubled to around Tk. 5.16/kWh in 2011-12. With rising cost, the power subsidy given by the government also increased rapidly which is now widely considered as fiscally unsustainable. To improve the situation, the government has already increased electricity tariff several times over the last years to contain subsidies at manageable levels but still the subsidy issue remains a vexing problem in fiscal management of the country.

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[1] For instance, on one occasion a total of 12 oil-fired plants with a combined capacity of 600 MW power generation had to be kept closed temporarily as fuel import and subsidy management could not be properly done due to fund and other constraints.

There are arguments both in favour and against the decision of purchasing electricity at high price from the quick rental power plants (QRPPs). The proponents of quick rentals argue that the cost of not supplying a kWh of electricity is around Tk. 25-50 in terms of value added to the economy. In addition, there are productivity losses due to shortage and non-availability of electricity. While these observations appear sensible and are mostly valid; the claims are not backed by any credible and strong analysis. On the other hand, those opposing the decision to purchase electricity from the QRPPs argue that such a decision is probably tenable to meet short term exigencies but their key question is: how long is the short term for Bangladesh? It appears that many of the contracts would exceed the normal time horizon of short term rental of 3-5 years. The critics also observe the absence of any hard decision and definite time bound programs to bring the economy out of this high cost electricity generation path within a reasonable period of time. In this respect, the major deficiency lies in delays in decision making and implementation. As a result of the likely extended use of the liquid fuel based power plants, the economy may find it difficult to sustain the pressure of prolonged (high) cost of oil import and high cost of electricity. This may result in a situation akin to what some countries (e.g. Pakistan) are facing in terms of unsustainable oil import bill or like in Sri Lanka having a very high electricity tariff that creates adverse effect on inflation and growth.

1.1 Scope and Major Objectives

In view of the heightened controversy over the use of the QRPPs, the issue needs in-depth analysis to better understand the underlying issues and design appropriate policies for future. In particular, a comprehensive analysis of the net benefits is necessary in order to take pragmatic measures relating to electricity generation through adopting the right mix of primary fuel keeping the relevant time horizon in view. The present study intends to make a beginning in this direction by analyzing some of the pros and cons of the quick rental power generation approach adopted in Bangladesh.

The specific objectives of the study are as follows:

(i) Examine the additional economic cost of purchasing electricity from the rental power plants and assess its impact on the economy.
(ii) Compare growth and other implications of using rental energy vis-à-vis a policy of no purchase of rental electricity from private electricity generators.
(iii) Estimate the cost of unserved energy.

More specifically, the study aims to answer the following questions:

- What is the net impact on economic growth and macroeconomic stability of the policy of purchasing electricity from the QRPPs established under the private initiatives?
- How sustainable is the approach in view of its impact on fiscal and external balances and cost implications on electricity generation on economic activities?
- What alternatives are available to the government to make the quick rental power generation viable and sustainable?
- What is the cost of unserved energy to the economy?
- What policy options are available to the government for meeting the gap in the electricity sector considering implications of different alternative options?

2. Recent Developments in the Electricity Sector

The generation and supply of adequate quantity of electricity has always remained an unresolved challenge for Bangladesh. During 1991-92, the country's total installed capacity of electricity generation was 2,350 MW while the derated capacity was 1,719 MW. The installed capacity increased to 4,680 MW in 2001-02 and further to 8,819 MW in 2011-12 with the corresponding derated capacity of 3,428 MW and 8,149 MW respectively (Table 1).[2] The increase in production, however, was not enough to meet the rapidly rising demand for electricity resulting in increased load shedding and adoption of other measures of demand management. The situation was further aggravated by antiquation of a number of generation units and shortage in gas supply forcing their operation at reduced capacity.

Table 1: Electricity Generation in Bangladesh

Year	Capacity (MW)	
	Installed	Derated
1991-92	2,398	1,724
1995-96	2,908	2,105
2001-02	4,230	3,217.5
2006-07	5,202	3,717
2008-09	5,719	5,166
2011-12	8,819	8,149

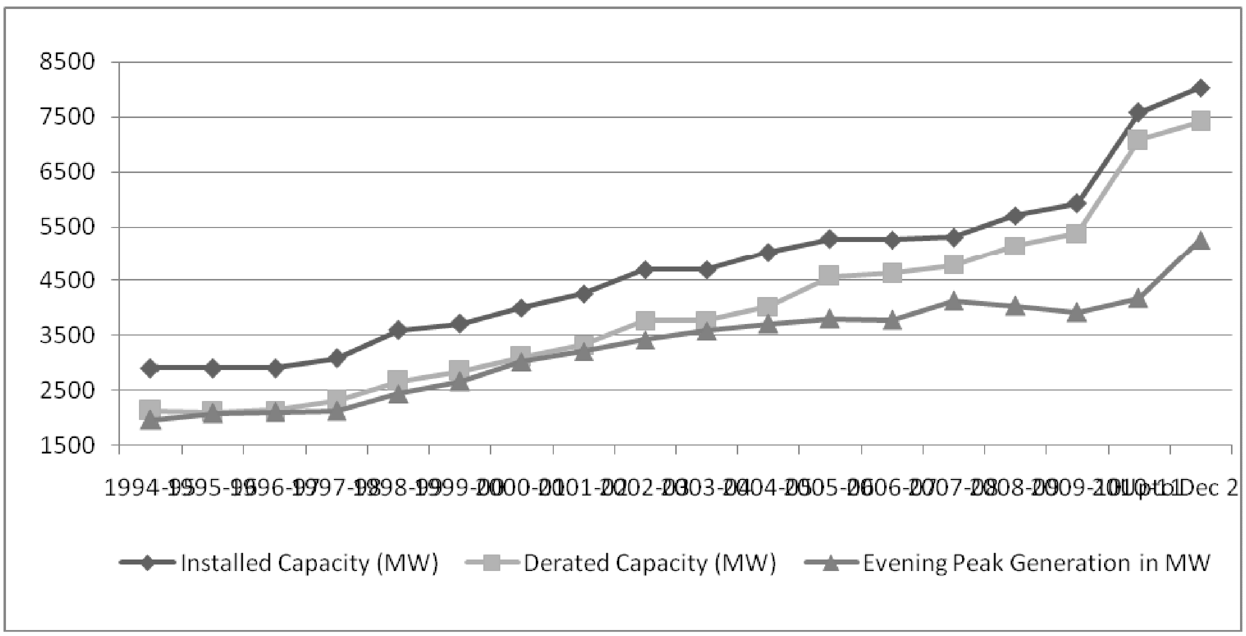
Source: BPDB

One important aspect of the recent developments is that a significant portion of the additional electricity generation has come from liquid fuel based (diesel, HFO) power plants which has raised the total contribution of liquid fuels in power generation to 17

[2]There are many factors which contribute to differences between installed capacity and the maximum available generation (derated capacity) such as (i) some plants may remain out of operation for maintenance, rehabilitation and overhauling; (ii) capacity of some plants may be derated due to aging; and (iii) shortage of natural gas.

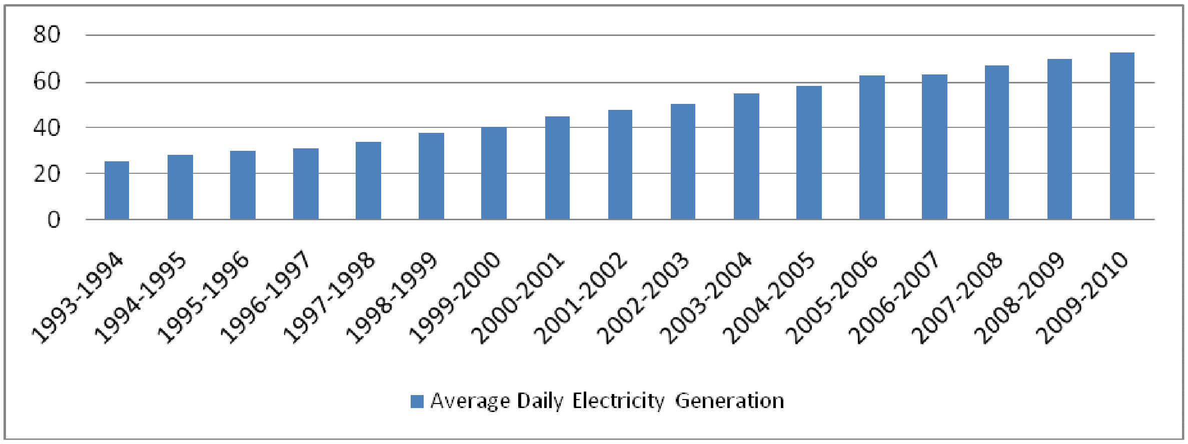
percent in 2012 from 13 percent in 2011 and 5 percent in 2010. Moreover, the addition in installed capacity has not been fully reflected in terms of proportional increase in power generation since many power plants which are old have become non-operational in recent years resulting in huge gap between derated capacity and evening peak generation especially since 2005-06 (Figure 1). It may be added here that most of the liquid fuel based electricity has come from rental, quick rental, and peaking plants which were undertaken on a fast-track basis to address the nagging power crisis. Along with the increase in generation capacity, average daily electricity generation has also increased steadily from 25.3MkWh in 1994-95 to 72.3 MkWh in 2009-10 (Figure 2).

Figure 1: Installed, Derated Capacity and Evening Peak Generation 1994-2008 (MW)



Source: Power Cell

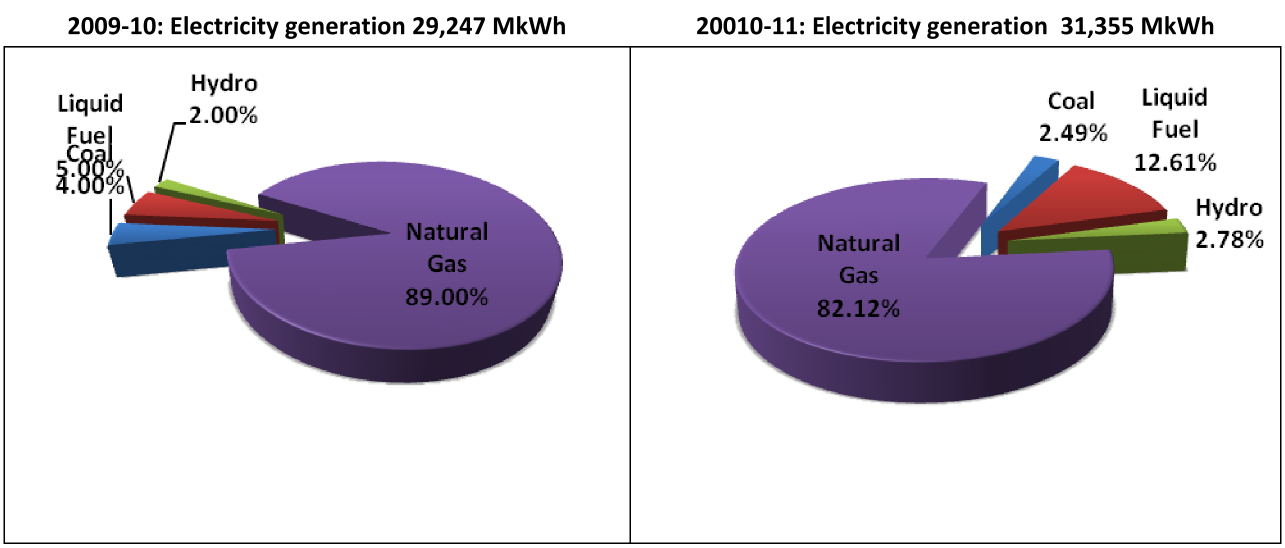
Figure 2: Average Daily Electricity Generation (in MkWh)



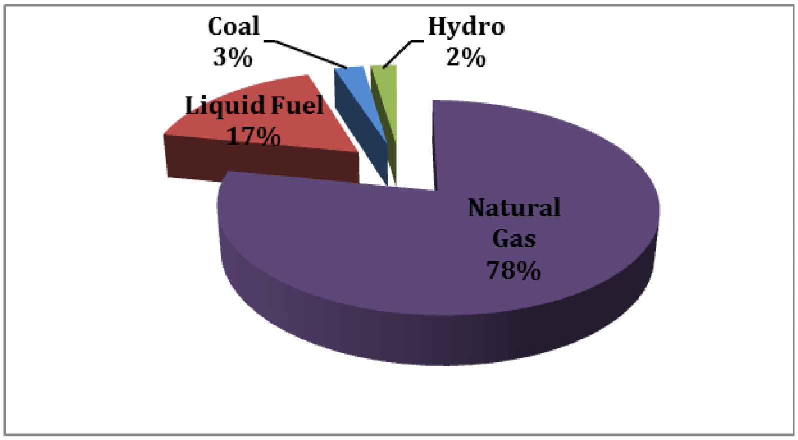
Source: Power Cell

As mentioned earlier, electricity generation in Bangladesh is overwhelmingly gas based (Figure 3). In 2010-11, 82 percent of the evening peak electricity was generated by using natural gas. This was followed by liquid fuel and coal with generation shares of 12.6 percent and 2.5 percent respectively. Hydro accounted for 2.8 percent of total generation. It can be seen that the power generation mix in the previous year (2009-10) was somewhat different in which the contribution of natural gas was 89 percent while the share of liquid fuel was only 5 percent. In 2009-10, around 1,169.88 MkWh of electricity was generated using coal whereas only 780.74 M kWh of electricity was generated from the coal based power plants in 2010-11.

Figure 3: Fuel Mix of Electricity Generation, 2010-2012



2011-12: Electricity generation 33397 MkWh



Source: Power Cell

Current Demand-Supply Balance and Future Projections

As mentioned earlier, there exists a rapidly widening gap between the demand for and the supply of electricity in the country.[3] The average maximum demand for electricity was reported at 3,970 MW in 2006-07 which increased to 4,833 MW in May 2011. Over the last ten years, net energy demand has grown at an annual rate of 8.1 percent. The Power System Master Plan (PSMP) 2010 forecasts that the grid system demand with demand side management for 2015, 2020 and 2030 would be 10,283 MW, 17,304 MW and 33,708 MW respectively as opposed to the demand of approximately 7,518 MW in 2012 (Figure 4).[4] Captive demands for areas where grid is not likely to reach within the projected years are estimated to be 1,335 MW, 1,515 MW and 2,951 MW for 2015, 2020 and 2030 respectively.

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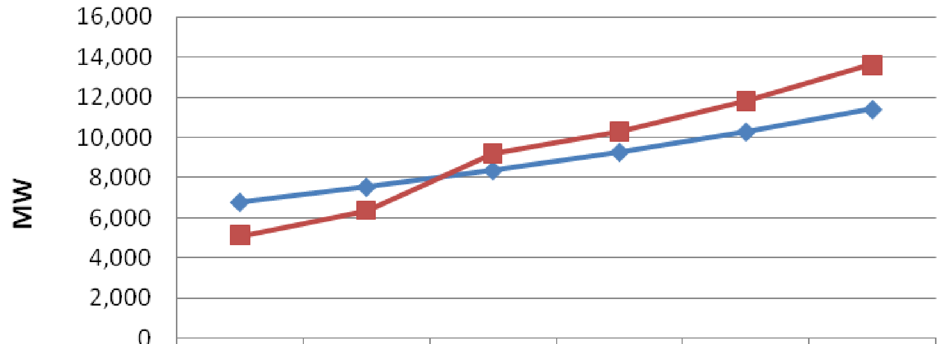
[3]The demand for electricity varies at different times during the day and night. The maximum demand occurs during 5 pm to 11 pm which is termed as the 'peak hour'. The extent of the variation is measured in terms of Load Factor which is the ratio of average and maximum demand. For economic reasons, it is desirable to have a high Load Factor, as this would permit better utilization of plant capacity. Moreover, the cost of energy supply is high during peak hour as relatively costlier plants are required to be used during the peak hour to meet the additional demand. The Load Factor in Bangladesh is around 70 percent which could be increased by adopting better load management.

[4]The projections are based on assumed GDP growth and the elasticity of demand for electricity. The projections also consider the possible impact of demand-side management (DSM) programs including the use of energy-saving equipment and machinery, holiday staggering programs in the industrial segment, and avoiding wastage of electricity.

Figure 4: Projections of Electricity Demand and Supply



	2011	2012	2013	2014	2015	2016
Maximum Demand with DSM (in April)	6,765	7,518	8,349	9,268	10,283	11,405
Dependable Capacity (End of Dec.)	5091	6348	9192	10287	11811	13629

Source: Power Cell

2.1 Power Generation Plan

Under the Power System Master Plan (PSMP) 2010, about 15,000 MW of new generation capacity has been planned by 2016 to meet the growing demand for electricity. The plan stipulates the commissioning of a number of quick rental and rental power plants as immediate measures to meet the demand in the short run. The Plan envisages that, when the generation scenario becomes strengthened with the completion of the large-scale power projects, the small generation units would be gradually uninstalled. The generation expansion program has been planned to be implemented in four phases:

Phase 1: Immediate (6 -12 months)

- Rental and quick rental plants (liquid fuel)

Phase 2: Short term (18 - 24 months)

- Peaking plants (liquid fuel)

Phase 3: Medium term (3 - 5 years)

- Combined cycle plants (gas or dual fuel)
- Peaking plant (gas or dual fuel)
- Coal fired steam plants

Phase 4: Long term (beyond 5 years)

- LNG based combined cycle plants

- Domestic/imported coal power plant
- Gas/oil based peaking plant
- Nuclear power plant
- Renewable energy

The time frame of expected completion of the new power generation projects up to 2016 is given in Table 2. Indigenous natural gas, coal, LPG, LNG, nuclear, and hydro resources are mainly considered as fuel for the additional generation plan. It also includes cross-border trade of electricity.

Planned Mix of New Power Plants

Since there is no system for combined heat and power (CHP) service in Bangladesh, the addition to peak and base load power generation depends upon the demand fluctuation in the daily load curve. Given the general demand fluctuation in a typical day, gas based combined cycle power plant, nuclear and coal-fired power stations have several advantages over a stable fuel supply system including higher economic efficiency making these systems suitable for baseload generation power. On the other hand, gas (LNG) power stations are more suitable for middle load generation power due to environmental adaptability and operational capability as compared with other modes of generation. Oil and hydro powers can operate flexibly over demand fluctuations; hence these powers are suitable for peak load generations.

Table 2: Time Frame of Implementation of the Power Generation Plan, 2010-2016

	2010 commissioned	2011	2012	2013	2014	2015	2016	Total
	In MW							
Public	255	1,107	582	1,040	1,270	450	1,500	6,204
Private	270	105	1319	1,134	1,053	1,900	1,300	7,081
Quick rental	250	1,238	…	…	…	…	…	1,488
Total	775	2,450	1901	2,174	2,323	2,350	2,800	14,773

Source: BPDB

According to the BPDB's Plan, the mix of peaking, large and combined cycle power plants that will be commissioned during 2012-2016 is given in Table 3.In December 2011, 39 power projects were reported in the pipeline with 6,784 MW of installed capacity in the private sector and 5,098 MW of installed capacity in the public sector. During the time, there was no project under pipeline for rental and quick rentals, the last one being commissioned in 2011.

Table 3: Planned Mix of New Power Plants, 2012- 2016

		Peaking plants	Large plants	Combined cycle PP
2012	No. of plants	11	4	1
	Capacity (MW)	1,287	295	163
2013	No. of plants	15	2	8
	Capacity (MW)	3,027	199	1,726
2014	No. of plants	16	0	15
	Capacity (MW)	3,054	0	2463
2015	No. of plants	8	0	8
	Capacity (MW)	2,032	0	1410
2016	No. of plants	3	0	1
	Capacity (MW)	2,350	0	750

Source: BPDB

The fuel-wise distribution of electricity generation over the years shows that the share of liquid energy based generation has significantly increased from 6 percent in 2008-09 to 18 percent in 2011-12 which is expected to rise further to nearly 22 percent in 2012-13 although it is projected to fall afterwards (Table 4). This has significant implications for the generation cost of electricity and consequent subsidy requirements.

Table 4: Electricity Generation by Type of Fuel

	Total production (MkWh)	% of total production					
		Gas based	Coal based	Liquid energy based	Hydro	LNG based	Import based
2008-09	25,622	88.4	4.0	5.9	1.6	...	...
2009-10	29,247	89.2	3.5	4.8	2.5	...	...
2010-11	31,355	82.1	2.5	12.6	2.8	...	...
2011-12	34,174	76.9	2.5	18.0	2.5	...	...
2012-13	41,566	74.0	2.2	21.7	2.1	...	...
2013-14	46,554	77.0	1,9	16.7	1.9	...	2.5
2014-15	52,240	79.4	1.7	12.5	1.7	...	4.8
2015-16	57,943	79.3	7.0	6.1	1.5	1.6	4.5

Source: MoF 2012

3. Quick Rental Power Plants: An Assessment

Rental or quick rental power plants have played a key role in addressing the temporary electricity demand across the world. In addition to high profile events (e.g. Winter Olympics in Salt Lake City), rental power solutions extend into many applications including utility grid support, substitute power sources during scheduled or unscheduled outages in industrial and commercial locations, and power solutions to energy-starved areas. The driving forces behind the rental power market are varied, such as more efficient utilization of capital by spending resources for those assets that can be rented; saving on physical capital by not requiring to provide storage, testing and maintenance facilities; saving on human capital by not having to employ operating, maintenance and repair personnel; and exploiting other benefits of renting over buying.

In Bangladesh, rental power business has gained popularity in the midst and aftermath of recent power shortages. Over the last decade, severe power crisis compelled the government to enter into contractual agreements for high-cost temporary solution, such as rental power and small IPPs mostly diesel or liquid-fuel based on an emergency basis imposing tremendous fiscal pressure on the government budget. One of the major factors that led to this challenging situation was the fact that the country confronted with a simultaneous shortage of both natural gas and electricity during the period having a power sector which is dependent on natural-gas fired generation (more than 80 percent).Nearly 400-800 MW of power could not be availed from the power plants due to shortage of gas supply during these periods. Other fuels for generating low-cost, base-load energy, such as coal, or renewable source like hydropower, were also not readily available and the government was compelled to go for fuel diversity option for power generation. When the present government came to power in 2009, it decided to generate 6,000 MW by 2011, 10,000 MW by 2013 and 15,000 MW by 2016. Under the programme, a total of 2,944 MW of power has already been added to the grid by January 2012. Total generation capacity of plants commissioned until 2011 is shown in Table 5.

Table 5: Generation Capacity of Newly Commissioned Power Plants, 2009-2011

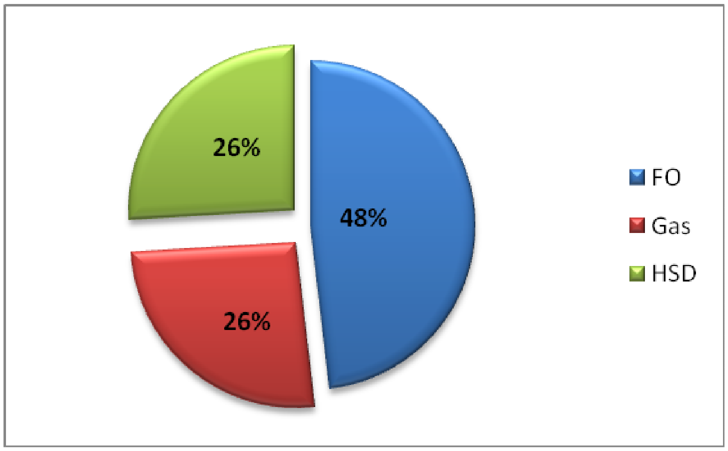
	2009	2010	2011	Total
	In MW			
Public	‘’	255	800	1,055
Private	356	270	125	751
Quick Rentals	…	250	838	1,088
Total	356	775	1,763	2,894

Source: BPDB

In view of the gravity of the situation, the electricity generation plan decided to use the quick rental power plants (QRPPs) as its major strategic tool to reduce power shortage in the short run. Under the plan, a total of 20 QRPPs was commissioned by 2012 with a total capacity of more than 1,000 MW (Table 6). Although no specific information could be collected, it is more likely that many of the QRPPs could not meet their original commissioning dates due to delays at different stages of the projects. Also not much information could be collected regarding whether the plants were procured through

International Competitive Bidding (ICB) through floating of tenders and whether any unsolicited projects were also approved.

Figure 5: Fuel Mix of QRPPs Commissioned in 2010-2011



Source: BPDB

Table 6: Status of Rental and Quick Rental Power Plants till December 2012

Name	Rental period (Years)	Estimated capacity (MW)	Type of energy	Date of commissioning	
				Planned	Actual
Jan-Dec 2009					
Shahzibazar Rental	15	86	Gas	---	10 Feb 2009
Kumargaon Rental	15	10	Gas	---	15 Mar 2009
Bhola Rental	3	33	Gas	---	12 Jul 2009
Fenchuganj Rental	15	51	Gas		18 Oct 2009
Total	...	180	...	...	...
Jan-Dec 2010					
Ghorasal	3	45	Gas	...	10 Aug 2010
Shikalbaha, Chittagong	3	55	HFO	...	15 Apr 2010
Ghorasal	3	100	Gas	...	23 Aug 2010
Khulna	5	55	HSD	...	10 Aug 2010
Thakurgaon	3	50	HSD		4 Aug 2010
Pagla, Narayanganj	5	50	HSD	...	24 Nov 2010
Bheramara	3	110	HSD	...	31 Dec 2010
Total	...	465	...	...	...
Jan-Dec 2011					
Shiddhirganj: Desh Energy	3	100	Diesel	---	23 Dec 2011
B.Baria:Agrico	3	70	Gas	---	6 Mar 2011
Modonganj: Summit	5	102	F. oil	---	1 Apr 2011
Meghnaghat: IEL	5	100	F. oil	---	8 May 2011
Ghorashal: Mask	3	78	Gas	---	27 May 2011
Noapara: Khanjahan Ali	5	40	F. oil	---	28 May 2011
Ashuganj: Agrico	3	80	Gas	---	31 May 2011
Khulna: KPSL	5	115	F. oil	---	1 Jun 2011
Ashuganj: UAPL	3	53	Gas	---	22 Jun 2011

Shiddhirganj: Dutch Bangla	5	100	F. oil	---	22 Jul 2011
Noapara	5	105	F. oil	---	26 Aug 2011
Bogra	----------	20	Gas	---	13 Nov 2011
Total	...	963	...	...	...
Planned to be completed by 2012					
Amnura: Sinha	5	50	F. oil	---	13 Jan 2012
Julda: Infra Service	5	100	F. oil	---	2 Mar 2012
Keraniganj: Power Pack	5	100	F. oil	---	27 Mar 2012
Katakhali: SPSL	5	50	F. oil	April 2012	
Chittagong: Mohra	---------	300	F oil	Nov 2012	
Total	...	600	...	...	...

Source: BPDB

The electricity generation by QRPPs during 2011-12 is given in Table 7.

In principle, if implemented properly, QRPPs help in meeting the energy shortfall within a short time. These power plants are typically installed within 4-6 months and hence are ideal for meeting short-term electricity needs; they utilize scarce resources (e.g. land) efficiently and create local employment. However, plant costs keep on rising as expensive and imported fuel is used to run these plants. One additional benefit of these rental projects is that technically only the amount of electricity supplied would be liable for payment. In reality, most HFO fired rental/quick rental plants in Bangladesh have the same configuration of 15-20 year IPPs and hence these can be used, if necessary, as IPPs with a lower, structured tariff. But the other side of the coin is that the rental power plant route provides an easy, short term but unsustainable solution of the power problem and hence it discourages the government to invest in long term solutions to cap the energy crisis,

Table 7: Energy Generation by Quick Rental Power Plants, 2011-12

Name of QRPP/ location	Present (derated) capacity (MW)	Plant factor	Energy generated (MkWh)
Ghorasal45 MW (Aggreko)	45	0.39	153.738
Ghorasal 100 MW (Aggreko)	100	0.40	350.4
Pagla 50 MW (DPA)	50	0	0
Shiddirgonj 100 MW (Desh Energy)	96	0.50	420.48
B. Baria 70 MW (Aggreco)	70	0.85	521.22
Madangonj 102 MW (Summit Power)	100	0.46	402.96
Meghnaghat 100 MW (IEL)	100	0.50	438
Ghorasal 78 MW (Max Power)	78	0.44	300.6432
Ashugonj 80 MW (Aggreco)	80	0.89	623.712

Ashugonj 53 MW (United Power)	53	0.90	417.852
Siddirganj 100 MW (Dutch Bangla Power)	100	0.31	271.56
Keranigonj 100 MW (Power Pake)	100	0.08	70.08
Julda100 MW (Acron Infra Servicw)	100	0.08	70.08
Khulna 55 MW (Aggreko)	55	0.29	139.722
Noapara 40 MW, Khan Jahan Ali (United)	40	0.52	182.208
Khulna 115 MW, KPCL (Summit-United)	115	0.60	604.44
Amnura 50 MW (Sinha Power)	50	0.15	65.7
Katakhali 50 MW (NPSL)	50	0.08	35.04
Total	...	...	5067.8352
Monthly Average	...	...	422.3196

Source: BPDB

3.1 The Cost of QRPPs

It is rather difficult to assess the costs of QRPPs; one usual practice is to compare the cost of QRPPs with that of IPPs. However, it needs to be recognized that the IPPs are not necessarily the ideal and the best ones for the comparison purpose as the conceptual underpinnings of the contractual arrangements of the two are very different especially in terms of risks/returns. In the first place, time horizons of the two are very different. The IPPs operate for the long term (normally 20 years plus) and hence may be exposed to higher unforeseen country or project risks relative to the QRPPs which are for the short term and can better assess such risks over its limited time horizon. Moreover, the IPPs generally use new plants giving a more transparent and dependable basis to benchmark costs. On the other hand, QRPPs normally tend to employ used plants having non-transparent pricing.

A comparison of per unit cost of electricity generated under different modes (e.g. public sector, rental and quick rental) is given in Table 8. It shows that the public sector units have the lowest per unit cost. Between the rentals and the quick rentals, the average per unit cost of gas based electricity generation is more than 75 percent higher for QRPPs than the rental units while, in the case of furnace oil, the rental units are 21 percent costlier than the QRPPs. The per unit fixed cost in the case of gas based generation units for the QRPPs is nearly two-and-a half times higher than that of the rentals but, for the furnace oil based units the per unit cost of the rentals is more than twice that of the QRPPs. The per unit fuel cost is not very different between the two in the case of gas but, in the case of furnace oil, the cost of QRPPs is nearly 14 percent higher.

Table 8: Per Unit Cost of Electricity for Different Modes

Fuel	Public	Rental	Quick rental
Per unit cost (Tk.)			
Gas	2.10	3.20	5.62
F. oil	...	18.93	15.62
Total	3.37	6.80	11.97
Per unit fixed cost (Tk.)			
Gas	...	2.00	4.42
F.oil	...	8.18	3.66
Total	...	3.24	4.41
Per unit fuel cost (Tk.)			
Gas	...	0.90	0.80
F. oil	...	10.28	11.67
Total	...	3.25	7.20

Source: BPDB

The per unit cost differences between individual QRPPs and IPPs at different plant factors are shown in Table 9.[5] For gas based generation, per unit cost varies between Tk. 4.75-Tk. 5.39 for the QRPPs while the range is Tk. 1.40 to Tk. 3.80 for the IPPs. The variations occur due to differences in fuel cost as well as fixed and variable O&M costs. In the case of furnace oil, per unit cost is between Tk. 15.21 and Tk. 15.30 for the QRPPs while the cost varies between Tk. 16.27 and Tk. 16.70 for the IPPs.

Table 9: Costs of QRPP and IPPs at Different Plant Factors

Range-plant factor (%)	QRPPs						IPPs					
		Plant factor (%)	Cost (Tk.)					Plant factor (%)	Cost (Tk.)			
Gas												
	Plant name		Per unit fuel cost	Per unit fixed cost	Per unit variable O& M	Per unit cost	Plant name		Per unit fuel cost	Per unit fixed cost	Per unit variable O& M	Per unit cost
35-40	Ghorasal 45 MW	39	0.80	3.69	0.44	4.93	Baghabari (West Mont)	39	0.98	2.81	0.00	3.80
	Ghorasal 100 MW	40	0.80	3.73	0.44	4.97	Haripur (CDC)	82	0.58	0.72	0.09	1.40

[5]The plant factor or the plant load factor is the ratio of the actual output of a power plant over a period of time and its output if it had operated at full capacity during the period. It is also expressed as the ratio of the average power load of an electricity power plant to its rated capacity.

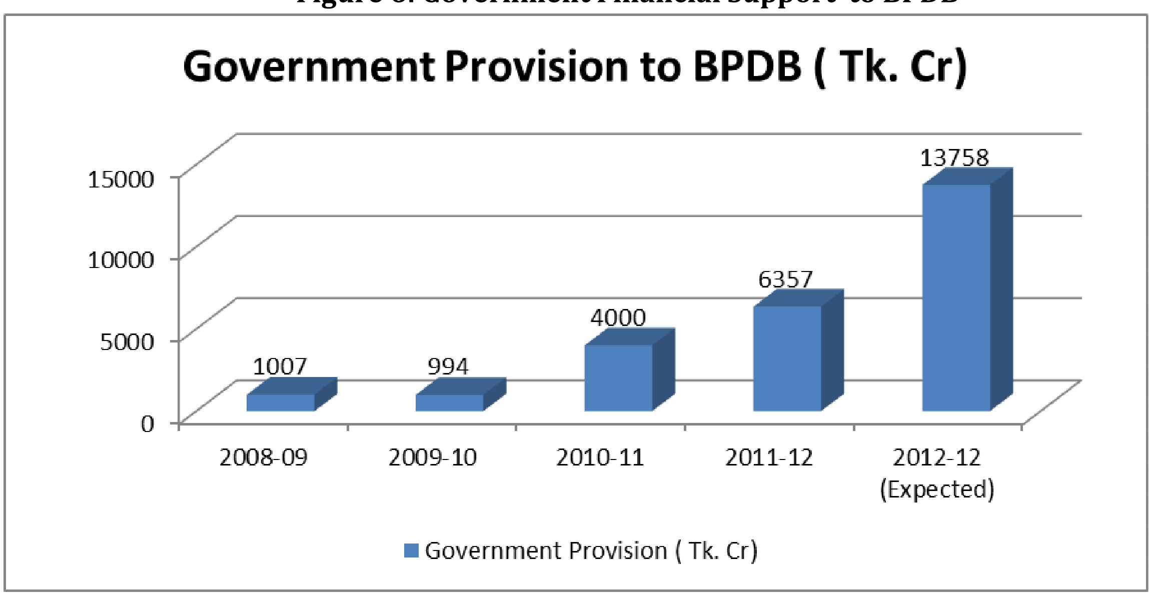
81-85	B. Baria (Aggreko)	85	0.80	4.15	0.44	5.39	Feni SIPP	83	0.76	1.31	0.09	2.16
90-95	Ashugonj (United)	53	0.79	3.75	0.21	4.75	Meghnagh at (CDC)	93	0.63	1.36	0.08	2.08
F .oil												
50-55	MeghnaghatIEL	50	11.42	3.48	0.35	15.24	Haripur (NEPC)	51	13.48	3.21	0.00	16.70
	NoaparaKhanjahan Ali	52	11.59	3.33	0.29	15.21	Khulna BMPP (KPCL-1)	55	12.98	3.29	0.00	16.27
	Siddirganj	50	11.50	3.46	0.35	15.30						

Source: BPDB

3.2 Impact on Fiscal Space and Subsidy Implications

Over the years, the provision of low cost electricity through subsidized prices has played a critical role in growth and development of the Bangladesh economy. However, as the selling price has fallen behind the rising cost of electricity supply over the years, government support has to be provided to BPDB in order to sustain its operation (Figure 6). The government provision which amounted to Tk. 1,007 crore in 2008-09 increased to Tk. 6,357 crore in 2011-12 and is projected to rise to Tk. 13,758 in 2012-13 to purchase electricity from rental producers. Considering the rising supply cost of electricity, the bulk electricity tariff rate has recently been increased to reduce BPDB's losses. As a result, the bulk price of per unit electricity increased from Tk. 2.37 to Tk. 2.61 in February 2011 and further to Tk. 4.02 in October 2012.

Figure 6: Government Financial Support to BPDB



Despite the price adjustments, the fuel cost for running the liquid fuel based generating units, especially the rental and quick rental power plants, is rising fast resulting in rapidly rising subsidy on fuel. According to the BPDB, fuel consumption is expected to rise to 7 million tons in 2012-13, up from an average of 3 million tons in the last decade and 5.4 million tons in 2010-11 and 2.6 million tons in 2009-10. Of the total, more than 30 percent is expected to be consumed by the power plants. In 2011-12, the country imported 4.8 million tons at a cost of Tk. 29,000 crore; while the cost is likely to reach Tk. 49,000 crore during 2012-13. The main factor contributing to soaring fuel consumption is the introduction of the liquid fuel based QRPPs as well as a rise in captive power plants in industrial and commercial establishments. Some estimates show that total energy subsidy for the fiscal year 2011-12 was Tk. 28,200 crore of which nearly 34 percent are off-budget such as government loan for BPDB at favourable lending rates. The subsidy on rental power plants during the year amounted to Tk. 12,356 crore while that on power was Tk. 845 crore and, for petroleum, the subsidy was estimated at Tk. 15,380 crore.

Obviously, the rapidly rising energy subsidies by the government has been squeezing its fiscal space to a great extent and is becoming increasingly unsustainable calling for proper pricing of fuel and energy. Moreover, the average cost of electricity production is expected to rise rapidly as a result of the adoption of the liquid fuel based power plants to enhance electricity supply on an emergency basis. It would therefore be prudent for the country to gradually raise power tariffs. Similarly, the prices of other fossil fuels should follow actual costs of imports in order to keep subsidies within acceptable fiscal limits.

4. Estimating the Cost of Unserved Energy

This section estimates the cost of unserved energy in Bangladesh in the context of commissioning the QRPPs. The consumption of electricity in the country covers different categories of users. During the last decade, the annual growth rate of electricity consumption was around 16 percent for commercial services followed by domestic services (14 percent), industrial services (13 percent) and other services (4 percent). In 2010-11, the country's electricity consumption pattern shows that 48.0 percent of the total amount of 26,578 MkWh was used by domestic consumers, 4.8 percent by agriculture, 28.5 percent by industrial units, 9.8 percent by commercial establishments, and 8.9 percent by others (BBS 2012).

4.1 Unserved Energy in Domestic Sector

The domestic sector is the largest consumer group of electricity in Bangladesh accounting for 48 percent of total consumption. The cost of unserved energy for domestic consumers is, however, a contentious issue. Obviously, the lack of access to electricity is a source of great inconvenience for the domestic consumers, especially during evening hours and at night particularly during the summer, the cost of which is however difficult to measure in monetary terms. In the absence of electricity, households tend to use kerosene lamps, candles or storage lights to perform their routine activities. Thus it becomes rather difficult to tag any measurable financial or economic loss to unserved energy in the domestic sector. In the present analysis, it is therefore assumed that unserved energy in the domestic sector has no direct economic cost to the economy.

4.2 Unserved Energy in Agriculture

In the agriculture sector, electricity is mostly used for running irrigation pumps especially during the boro season. In the absence of electricity, the irrigation is done using diesel operated machines (e.g. tube wells and low lift pumps). For the agriculture sector, we assume that, in the absence of electricity, the users would typically employ diesel operated pumps for irrigation. For our purpose, we take the typical shallow tube well (STW) as the alternative which is run by diesel fuel.

The estimate of the cost of a typical STW (18 KW with a reachable depth of 500 feet) is given in Table 9. The cost, excluding duties and taxes, is Tk. 27,100/kW. In view of the low price for the widely used cheap machines assumed in the present exercise, an economic life of five years is assumed while the installation and related cost is assumed to be Tk. 17,000. We assume an operating time of 175 hours per year per machine. On the basis of these assumptions, the cost of operating the machine comes to Tk. 47.18/kWh (Table 9).

Table 9: Estimating the Cost of Unserved Energy for Agriculture

Machine (shallow tube well, 18 KW, reachable depth 500 feet)	
Unit cost (excl. duties and taxes), thousand Tk./kW	27.1
Total cost, thousand Tk. including installation cost	50
Economic life, year	5
Discount rate, %	12
Annual cost, thousand Tk.	138
Annual operating time, hours	175
Equivalent percent, per year	2
Annual energy generation, kWh	2,363
Annual operating cost/kWh. Tk.	44.22
Fuel (diesel) cost/kWh, Tk., at Tk. 350/MBtu	2.96
Total cost, Tk./kWh	47.18

Note: Authors' calculations

4.3 Unserved Industrial and Commercial Energy

The industrial and commercial sector includes all manufacturing and commercial enterprises including RMGs, mills and factories, small and medium enterprises, informal/small as well as modern commercial establishments. Given the large and heterogeneous character of the sector, a typical generator size of 18 kW for the small segment and a generator size of 500 kW for the large segment of the sector are taken as representative options for the two segments. The cost of an 18 kW diesel generator is taken at Tk. 0.78 million while the cost of a typical 500 kW diesel generator set is Tk. 7.70 million. It may be noted here that a generator with a dual fuel engine to burn both diesel and natural gas costs about twice as much as the one mentioned above. Thus the prices can vary significantly depending upon the specific features of the machine. In addition, one needs to add additional costs of installation, machine room, protective device, control panels and other services. For our purpose, a cost of Tk. 15,400/kW installed has been assumed (Table 10). The economic lives of the generators are taken as 5 years and 10 years respectively. The annual operating time is taken at 175 hours per year. On the basis of these assumptions, a cost of Tk. 94.37 per kWh for the 18 kW generator and Tk. 23.73 per kWh for the 500 kW generator is calculated (Table 10).

4.4 Unserved Energy in Other Uses

Other uses cover a heterogeneous category covering a wide range of activities, both large and small scale in nature. We therefore assume Tk. 59.05 per kWh as the cost of unserved energy for other uses which is the average of the costs of unserved energy for the small and the large segments of industrial and commercial sectors.

Table 10: Estimating the Cost of Unserved Energy for Industrial/Commercial Purposes

	Small industrial/commercial	Large industrial/commercial
Machine (generator) size, kW	18	500
Unit cost (excl. duties and taxes), thousand Tk./kW	43.4	15.4
Total cost, million Tk.	0.78	7.70
Economic life, year	5	10
Discount rate, %	12	12
Annual cost, thousand Tk.	216	1,363
Annual operating time, hours	175	175
Equivalent percent, per year	2	2
Annual energy generation, kWh	2,363	65,625
Annual operating cost/kWh. Tk.	91.41	20.77
Fuel (diesel) cost/kWh, Tk., at Tk. 350/MBtu	2.96	2.96
Total cost, Tk./kWh	94.37	23.73

Note: Authors' calculations

4.5 Average Cost of Unserved Energy

The average cost of unserved energy is calculated using the share of energy consumption of different sectors as reported earlier (Table 11). The weighted average comes to Tk. 26.73per kWh. It may be noted here that the average bulk tariff on electricity in the country at present is Tk. 4.02 per kWh so that the cost of unserved energy is nearly seven times the country's average electricity tariff. This comes close to the commonly used rule of thumb which is normally taken at about ten times the normal tariff.

Table 11: Average Cost of Unserved Energy per kWh

Sector	Share in total consumption	Cost/kWh (Tk.)	Weighted average
Domestic	0.480	0.00	0.00
Agriculture	0.048	47.18	2.27
Industrial/commercial--large	0.240	23.73	5.70
Industrial/commercial--small	0.143	94.37	13.50
Others	0.089	59.05	5.26
Total	1.000	…	26.73

Note: Authors' calculations

4.6 Estimated Cost of Unserved Energy in Bangladesh

The estimated cost of unserved energy over the last two fiscal years, 2010-11 and FY 2011-12, is given in Table 12. It can be seen that the total cost of unserved energy was Tk. 47,183 crore of which the cost of unserved energy for QRPPs was Tk, 29,347.9 crore and the remaining Tk. 17,935.1 crore is the cost for the rental power plants.

Table 12: Cost of Unserved Energy in Bangladesh, 2009-10 to 2011-12

	2010-11		2011-12		Total	
	Gas	Diesel/HFO	Gas	Diesel/HFO	Gas	Diesel/HFO
Electricity generation from rental, MkWh	2,327	1,178	2,543	700	4,870	1,878
Electricity generation from quick rental, MkWh	2,229	3,289	2,786	2,800	5,015	6,089
Cost of unserved energy for rental, crore Tk.	6,150.3	3,113.5	6,721.2	1,850.1	12,871.5	4,963.6
Cost of unserved energy for quick rental, crore Tk.	5,891.3	8,692.8	7,363.4	7,400.4	13,254.7	16,093.2

Source: Authors' calculations

5. Impact of QRPPs on the Real Economy

An adequate and regular power supply is one of the most crucial factors which support economic growth in developing countries. Empirical studies show a strong correlation between electricity use and economic development (see, Ferguson et.al. 2000, Ramcharran 1990, Huang 1990, Mashi and Mashi 1996, Asafu-Adjaye2000). For example, one study calculates that an extra economic output of Rs. 88-137 thousand is generated for every one mWh increase in electricity supply in Sri Lanka (Morimoto and Hope 2001).

The nature of the relationship between electricity use and economic growth in a country like Bangladesh depends on several aspects including different economic and technical factors and how electricity facilitates technological advances and stimulates the economy by providing productivity gains. For tracing the impact of electricity supply on general economic activity (measured by GDP), it is often important to disaggregate GDP into sectoral components and to make disegregations by regions and population groups. In particular, there are important regional differences in providing and using electricity in Bangladesh.

In general, the changes in the composition of the national output over the years in Bangladesh have increased the intensity of electricity use in all major use sectors of the economy. Since independence, there has taken place significant structural shifts in the economy with the share of the contribution of agriculture to GDP declining from nearly half to around a fifth, while the share of industry has risen from 15 percent to around 30 percent and that of the services sector grew from 35 percent to about 50 percent. During the period, there has been a large increase in average electricity intensity in all three sectors especially in modern producing segments in the industrial and commercial sectors.

Within the limited scope of the present analysis, our focus is on the relationship between economic growth and electricity generation by the QRPPs at the aggregate level. However, given the critical importance of the issue, more in-depth research needs to be undertaken to identify and quantify the factors that affect the relationship between electricity and economic growth in view of their complexity, regional diversity and divergence in economic performance.

At the aggregate level, using time series data on GDP at constant prices and derated capacity of electricity generation over the period 1980-2012, the relationship between GDP and electricity generation has been estimated using econometric techniques (see Mujeri and Chowdhury 2013). In view of the excess of demand for electricity over its supply that existed during the entire period, the implicit assumption of the analysis is that whatever amount of electricity that was supplied was fully used by different sectors of the economy. The results of the analysis show that an extra economic output (value added) within the range of Tk. 46 million to Tk. 107 million (at constant 1995/96 prices) is generated for every one MkWh increase in electricity supply in Bangladesh.[6] This implies that in the fiscal year 2011-12 alone, the contribution of additional electricity generated by the QRPPs (5,067.8 MkWh) to the GDP has been between Tk. 23,312 crore and Tk. 54,226 crore at constant 1995/96 prices. Obviously, non-availability of electricity from the QRPPs, along with lower GDP growth and reduced sectoral output, would have reduced the export growth rate and created adverse impact on other macroeconomic and sectoral indicators including employment generation and poverty reduction.

The strong and persistent relationship between electricity use and GDP in Bangladesh requires that close attention be paid to the adequacy of electricity supply to generate and sustain a high future rate of economic growth. The adequacy of electricity supply can be maintained not only through new generation facilities but also through efficiency improvements that use existing generating capacity better. Although adequate electricity supply itself will not assure higher economic growth, a lack of adequate supply would almost certainly constitute a serious impediment to higher growth. This also points to the need to learn more about the causal relationships between economic growth and electricity supply since well directed policy and better management and regulation of electricity rest on such knowledge.

6. Summary and Conclusions

In 2011-12, installed capacity of electricity generation in the country increased to 8,819 MW from 5,719 MW in 2009-10 while the derated capacity was 8,149 MW and 5,166 MW respectively during the two years. The above implies that Bangladesh could generate electricity of more than 8,100 MW in the absence of fuel and other constraints. The average daily electricity generation, however, was about 5,200-5,500 MW in 2011-12.

For a country like Bangladesh, increasing the gross generation capacity by 3,100 MW within a period of around three years is no doubt a big achievement although some critics may differ with the strategy using which the new power generation capacity has been added. In this context, one may also maintain that the government probably could not fully anticipate the total impact of the adopted liquid fuel based QRPP option especially in the

[6] It has however been noted that the results and the corresponding estimates may have some upward biases, since the relationship postulated in the model used in the study does not include the usual production function determinants such as labour and capital which somewhat reduces the credibility of the results of the model. See Mujeri and Chowdhury 2013.

context of price volatility in the world energy market that resulted in huge subsidy obligations. Moreover, the critics may also argue that the government has made significant delays in implementing the traditional fuel based major power plant installations for the future and in initiating exploration of coal mines as one of the major sources of primary energy. As a consequence, fuel constraint is increasingly restricting power generation against the rising demand which is now estimated at about 7,500 MW. As a consequence, load shedding still remains a major feature in the energy sector somewhat hiding many of the positive impacts of significant addition to power generation.

The rationale behind the decision of using short term techniques (e.g. QRPPs) to enhance power generation primarily rested on the increasingly unsustainable situation with respect to demand for and supply of electricity during the period when the decision was made. In 2009-10, the generation was about 3,500 MW while the peak demand was about 5,500 MW indicating a deficit of 2,000 MW. Moreover, the deficit was continuously rising as new demands for electricity were generated in the growing economy. In view of the urgency of the situation, the only feasible option during the time was to opt for rental power option to meet the emergency while, at the same time, adopting a time-bound plan for electricity generation using sustainable options.

Under the above situation, the government adopted a phased approach to power generation starting with an immediate (6-12 months) plan to generate electricity through liquid fuel based rental and quick rental power plants followed by short term (18-24 months) option of liquid fuel based peaking plants. By 2011-12, a total of 3,100 MW (of which 1,488 MW came from quick rentals and 1,287 MW from peaking plants) of generation capacity was added to the national grid bringing the derated capacity to 8,149 MW against which the actual generation has been 5,200-5,500 MW. However, demand over the period also shot up to around 7,500 MW as a consequence of which not much impact could be seen on the deficit and consequent load shedding. The above developments point out that the power situation could have been much worse if no new power could be added and if the government did not go for the quick rental option.

In the backdrop of massive electricity shortages and rapidly rising load shedding across the country, the government adopted the short-term strategy of generating electricity through rental power plants and work concurrently on medium and long term projects to expand electricity generation within a time bound framework. It may be mentioned here that across many countries in the world, rental power plants have been set up to meet the emergency electricity requirements within a short time. Such plants are typically commissioned within 4-6 months based on available technology. Rental periods normally vary covering 3-5 years depending on the country's need.

During the time when decision regarding quick rental power plants was taken in Bangladesh, the deficit of electricity was nearly 2,000 MW in the system and this deficiency was primarily due to generation deficiency which could not be significantly met through augmentation of existing plants or saving of line losses. It was generally agreed that capacity augmentation and reduction of line losses could improve the situation only marginally; and hence improving the situation depended on expansion of additional generation capacity within the shortest possible time. The choice in front of the government was, therefore, either to opt for quick rental power plants (QRPPs) or take recourse to ever rising load shedding and shutdowns hampering livelihoods of the people and creating adverse impact on economic growth and development.

It must, however, be admitted that although the deficit situation may not have improved perceptibly, the additional power supplied to the national grid through the QRPPs has made significant positive impact in many areas of the economy. The supply of additional power has no doubt contributed to the expansion of economic activities in various sectors including manufacturing industries, RMGs, commercial and business activities, agriculture through providing irrigation and better marketing and processing services, and in trade, communication, and other services. This has significantly helped to keep the GDP growth rate over 6 percent along with a healthy export growth despite global recession and other constraints.

However, keeping a longer term perspective, several policy options are called for within a time bound framework. There is a need for rethinking of the policy of importing coal and LNG leaving the country's substantial coal resources underground and making no time bound effort of exploring the potential and huge untapped petroleum resources at onshore frontiers and offshore.

There is also a need to deal with the problems associated with the timely implementation of the gas based large power projects (e.g. at Bibiyana) and take time bound actions for fast track gas exploration. While Petrobangla and BAPEX have been making commendable efforts, the outcomes are small relative to the enormity of the problems. One of the major problems in the sector is the inordinate delays in implementing some key gas infrastructures. For example, the gas pipeline compressor stations of GTCL and the implementation of some key transmission pipelines have been delayed for several years causing transmission constraints. Similarly, the problems of illegal gas connections, theft and pilferage of gas still remain widespread.

The desired role of small IPPs/contingency plants/quick rental plants is to give the required relief for the interim period of 3-5 years till large base load projects and major plants could be installed and become operational. But the process of implementation of the Power System Master Plan is taking more time than anticipated in the Plan and, in the process, some flaws seem to have cropped in including relaxed qualification criteria. These have enabled the relatively inexperienced sponsors to get imported liquid fuel at cheaper prices from BPC and selling power at a relatively higher price. Consequently, allegations are there that some outdated used machineries have forced some plants to generate less than their rated capacity. The government's fiscal space has also been squeezed due to payment of huge subsidies. One may not be entirely wrong to conclude from these developments that the government probably jumped into the decision relating to contingency power plant actions without conducting proper home work covering comprehensive economic, financial and risks analysis. As a result, the government concentrated less on advancing the implementation of large base load power plants and failed to act more positively in replacing old fuel inefficient power plants with new modern plants.

It appears that the positive impact of additional power from QRPPs to the national grid has been constrained by inadequate action for load management and ensuring better efficiency. This requires more effective measures to promote energy efficient appliances, actions against delinquent consumers, installations of pre paid meters, and similar measures.

It is usually held that rental power is more expensive than power generated by normal independent power producers (IPPs). This is not necessarily true always as prices depend on a host of factors including capacity, return on capital, interest on loans and loan repayments, O&M and other variable cost components of the two options.

Rental plants are simple cycle plants and consume marginally more fuel than combined cycle power plants which are set up as IPPs. However, most IPPs normally start as simple cycle plants and are converted to combined cycle over a period of time. Moreover, the fact remains that the rental contacts are between 3-5 years and not 20 years as with most IPPs. When tariffs to rental plants are taken into account and an allowance is made for higher fuel costs, rental power costs may not necessarily be substantially higher than those of IPPs.

The government guarantees on repayment of rental power defaults to the banks are also similar. The government provides no guarantee to cover the rental sponsor's event of default and the entire risk is borne by the rental sponsors and their lenders. The government guarantee is provided, like to the IPPs, to cover only the event of default of BPDB buying the rental power. The sponsors usually provide their own collateral (charge on plant and machinery, personal guarantees and additional collateral) to secure loans.

There exists an impression that the rental power plants are usually old and hence inefficient. Normally, RFO-based rental plants require an 85 percent availability guarantee while almost no BPDB plants and many of the IPPs do not meet this high availability criterion. It is claimed by the rental sponsors that, because of their own obligations and for the sake of protecting their own interest especially since the funding is secured against their personal guarantees and assets, the sponsors' endeavor is always to bring in efficient and robust plants with well trained O&M operators to ensure availability and heat rate requirements under rental contracts.

One may argue that, for the QRPPs, the government is neither the buyer nor the beneficiary of the power plant. The transaction involves the government in terms of purchasing a service for which it pays. All rental payments are usually made 60 days in arrears. From this perspective, rental plants provide a cash float to the BPDB as it could not mobilize the huge resources required to set up the rental plants. The resources were mobilized by the private sector without any government guarantee or obligations to the lenders for repayment in case of rental sponsors' default.

In the case of quality, it is argued that the lenders have their own quality assurance mechanisms (e.g. technical, financial and other aspects) through their independent evaluators/engineers on the rental plants earmarked for purchase. It is only after the lenders are satisfied with the valuation and technical viability of the plants that they agree on funding. Normally, well-designed power plants with efficient O&M management can last for 20-25 years. Therefore, the sponsors argue that the satisfactory operation for the 3-5 years rental terms should not emerge as a problem provided all the steps are rightly followed.

The sponsors further maintain that QRPPs have several other advantages, such as (i) QRPPs reflect short term government commitment to meet emergency requirements which allows the government to opt for long term projects when these are ready; (ii) rental plants do not involve capital investment on the part of the government in these power projects; (iii) if properly managed, the rental plants can serve as examples of efficiency and competence to the country's other power plants particularly in the public sector; and (iv) the cost of purchase and setting up of power plants are borne by the sponsors and the government in no way guarantees any repayments to the lenders of the rental plants. The government's guarantee involves that the state-owned entities would buy the power for which payment would be made at agreed rate which is exactly the case with the IPPs. It needs to be remembered that the fast-track development of the rental plants is a widely used option across the world to resolve the power crisis on an urgent basis, and there does not seem to exist any better solutions to the crisis at present.

Prudent economics requires that the strategy for meeting the electricity demand be based on least cost option. For this, an integrated approach to the power sector is needed since the current crisis is, to a large extent, a fuel crisis caused by delays in decision making regarding power generation and finding a substitute for the depleting domestic gas supply. The shortage of gas increases the cost of power by raising the dependence on imported liquid fuel and lowering the efficiency and capacity of power plants designed to run on gas.

The present study recommends that new capacity procurement should be based on least cost criteria to minimize the cost of power to the economy to support poverty reduction and improve competitiveness of the economy. In arriving at the desired mix, a combination of several options should be considered such as:

(i) In view of the present situation, since the base load power plants like coal fired steam turbines, nuclear power and gas fired combined cycle plants are likely to take either a longer time to come into generation or are constrained by the availability of natural gas, plans may have to be worked out to make strategic use of the existing rental/quick rental power plants. One option could be to explore the costs and benefits of using these plants (only those which pass the 'fitness test') for a longer period than presently conceived instead of shutting them down after the expiry of the present contract period. For each quick rental plant, the fitness test should cover a number of areas such as techno-economic feasibility study, assessment of environmental costs due to operation of the plant including SOX, NOX, CO, noise pollution, air quality and environmental dimensions, present derated value and fuel efficiency of the plant, and estimation of NPV, IRR and BCR. Moreover, since a significant amount of the country's foreign currency has already been spent in building these plants, the possibility of converting these plants into gas-based plants (with some additional investment) could be explored as running these with liquid fuel will entail high generation cost in the long term. The above would support their strategic use like the IPPs. If the rental/quick rental plants are converted into IPPs, the plants can run on HFO as long as sufficient gas is not available; and when gas would be available these can run on gas. The option would facilitate the utilization of the existing rental/quick rental capacity as IPPs for say another 10-15 years without investing much additional foreign exchange. This would also give adequate time to implement the phase 4 of the Power Sector Master Plan 2010. The option is expected to reduce the generation cost of electricity as the IPPs are likely to have lower tariff and fuel flexibility. If the option is found feasible and profitable, agreements may be reached with the selected local entrepreneurs who have already made significant investments in the rental/quick rental plants to restructure their investments to turn their plants into IPPs.

(ii) Optimize existing installed capacity e.g. capacity stalled due to administrative reasons or non-repair/non-overhauling, and gas supply constraints;

(iii) Implement programs to reduce transmission and distribution losses and undertake energy efficiency and energy improvement projects including rehabilitation of old plants and improving their efficiencies;

(iv) Adopt measures for demand side management (DSM) such as popularizing the use of CFL; and

(v) Take quick decisions for accelerating the implementation of Phase 3 (medium term) and Phase 4 (long term) of the government's Power Generation Plan.

Obviously, DSM is by far the cheapest option that increases virtual generation by reducing demand. The DSM measures are therefore more cost effective than creating new capacity and hence DSM opportunities need to be fully exploited. For the liquid fuel based plants, fuel cost far exceeds the capacity cost. The efficiency of these plants is therefore an important parameter. Moreover, the capacity cost of existing plants is a sunk cost and their incremental cost is fuel and variable O&M. On the other hand, new plants involve capacity cost as well as fuel and variable O&M costs.

In the above context, the IPPs are operating for about a decade with fixed capital cost which is already sunk. Since the IPPs are available for generation at marginal cost (fuel and variable O&M costs), their capacity needs to be utilized to their maximum contracted availability.

The financial constraints of the government as well as the majority of electricity consumers, especially the poorer groups, require that affordability be considered as a major consideration in adopting the appropriate strategy for tackling the problem of electricity shortage. In the short run, a realistic target of the share of the peak demand that would be met needs to be set and additional demand management options implemented. In the existing situation, a target of 100 percent is probably not a viable option. Based on relevant information, an informed decision should be taken to balance between creating additional capacity, load shedding, and affordability. The lower cost options for augmenting supply needs to be fully exploited and the QRPP option should be periodically reviewed in the light of affordability of different options.

The availability of gas is a major parameter in determining the affordability of electricity in the country. The energy sector needs an integrated analysis to maximize the benefit of this scarce resource (gas). In principle, gas should only be used in combined cycle plants to ensure the maximum efficiency. Meanwhile, all the commissioned QRPPs should be fully utilized, especially during the early phases of their life, so that adequate time is available for upgrading and improving efficiency of the existing plants. The dispatch criteria should be reviewed from time to time in the context of existing demand and available generation system.

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Annex

Relationship between Electricity Consumption and Economic Growth

The nature of the relationship between electricity use and economic growth in a country like Bangladesh depends on several aspects including different economic and technical factors and how electricity facilitates technological advances and stimulates the economy by providing productivity gains. This annex examines the relationship between economic growth and electricity consumption at the aggregate level in Bangladesh using a simple framework with time series data on GDP at constant prices and electricity generation over the period 1980-2012.

For the purpose, it uses the first differenced real GDP as the dependent variable while lagged first differenced electricity consumption is used as explanatory variables as shown in Equation (1):

$$\Delta GDP_t = \alpha + + \sum \gamma_i \Delta ELEC_{t-i} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

where ΔGDP_t is the first differenced real GDP at time t, $\Delta ELEC_{t-i}$ is the first difference of electricity consumption at time t-i and ε_t is the error term at time t. Equation (1) implies that the change in real GDP at time t depends on past changes in electricity supply (with yearly lags up to t-2). For estimating equation (1), annual data for the period 1980-2012 of real GDP (in million Tk. at 1995-96 prices) and electricity production (MkWh) have been used. The data have been collected from the published statistics of the Bangladesh Bureau of Statistics (BBS) and the Bangladesh Power Development Board (BPDB).

Before estimating equation (1), it is necessary to examine the stationarity of dependent and explanatory variables in order to meet the condition of using the Granger causality model. Although both GDP and electricity production are non-stationary, the results of the Augmented Dickey-Fuller (ADF) test for stationarity and unit roots show that their first differenced values are stationary. The ADF test statistics give the values of 2.795 and 1.758 for the variables GDP and ELEC respectively, which are not significant at 5 percent level. On the other hand, the ADF test shows the values of -3.599 and -3.553 for a first difference of GDP and ELEC respectively which are both significant at 5 percent level. Moreover, the co-integration test for the series of GDP and electricity production is satisfied since both are integrated of order I (1).

For carrying out the Engle-Granger test, OLS regression between GDP_t and $ELEC_t$ has been run in equation (2) to see if the error term $€_t$ is I (0) or stationary.

$$GDP_t = \alpha + \beta\ ELEC_t + €_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Table A1: Results of Lon-Run Equilibrium Model (Equation 2)

GDP_t	Coefficient	Std. Err.	t	P>t	[95% Conf. Interval]	
$ELEC_t$	518.5353	24.92293	20.81	0	467.6359	569.4347
Intercept	562279.1	80386.94	6.99	0	398107.1	726451.2

Number of obs	32
Adj R-squared	0.933

After predicting the residuals from the above regression, the following regression has been run to test the stationarity of the error terms by unit-root tests.

$\Delta €_t = \pi\ €_{t-1}$

The corresponding t statistic shows that the coefficient on $€_{t-1}$ is significant and $€_t$ series is stationary. It can therefore be concluded that GDP and electricity production are co-integrated.

Error-Correction Mechanism

Since the Engle-Granger test is satisfied which ensures the existence of co-integration, it can be inferred that there is long-run relationship between the two variables, real GDP and ELEC. It is, however, plausible that there may exist disequilibrium in the short run and the error-correction mechanism (ECM) can be used to draw conclusions regarding movements to the long-run equilibrium.

The ECM model between the two variables can be specified as follows:

$$\Delta GDP_t = \beta_1 + \beta_2\ \Delta ELEC_t + \beta_3\ €_{t-1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

The results of estimation are presented in Table A2. It can be seen that, as expected, electricity production has a positive effect on GDP in the short run. The equilibrium value of the error term is 0.083824 which shows that GDP has to be adjusted positively with positive changes in electricity generation.

The long-run relationship between electricity production and GDP, on the other hand, shows that 1 MW increase in electricity production raises GDP by nearly Tk. 519 million (see Table 4) in the long run showing fairly high multiplier and pass through effects over time.

Table A2: Results of the ECM Model

ΔGDP_t	Coefficient	Std. Err.	t	P>t	[95% Conf. Interval]	
$\Delta ELEC_t$	0.42503	11.14752	-0.04	0.97	-23.2597	22.40963
$€_{t-1}$	0.083824	0.005928	14.14	0	0.071681	0.095967
Intercept	-56223.3	10395.27	-5.41	0	-77517	-34929.6

Number of obs.	31
Adj. R-squared	0.9316

Model Estimation Results

The model, specified in equation (1), is estimated by the standard OLS method and the results are given in Table A3. The results of the full model are given in column 1. The value of the model fit (adjusted R^2 =0.96) is reasonably high for this type of model and its diagnostic test shows that there are no serial correlation or heteroscedasticity problems. Except ΔGDP_{t-1}, all other coefficients of ΔGDP_{t-i} are not significant at the 5 percent level. Therefore, the model has been re-estimated with only $\Delta ELEC_{t-i}$ variables and the results are presented in column 2 of Table A3.

Table A3: Regression Estimates of First Differenced Real GDP and Electricity Consumption, 1980-2011

	Full Model (1)	All ΔGDP term excluded (2)	$\Delta ELEC_{t-3}$ and ΔGDP_{t-1} added to (2)
Intercept	-3385.92 (5263)	31663.46 (15403.58)	62.261 (5923.504)
ΔGDP_{t-1}	0.454 * (0.169)		0.962 (0.072)
ΔGDP_{t-2}	0.25 (0.199)		
ΔGDP_{t-3}	0.394 (0.185)		
$\Delta ELEC_t$	-1.58 (2.97)	25.08527 * (8.164211)	-0.9412 3.47
$\Delta ELEC_{t-1}$	1.57 (3.07)	21.76677* (9.26778)	3.794 3.53
$\Delta ELEC_{t-2}$	8.05 (3.14)	29.3597* (9.32332)	9.004 3.62
$\Delta ELEC_{t-3}$	…..	……..	dropped
Adjusted R^2	0.96	0.94	0.89

Note: The sample size is 28. The figures in parentheses are t values. * indicates significant at 5 percent level. For variable definition, see text.
Source: Authors' calculations.

The results show that, all the three variables $\Delta ELEC_t$, $\Delta ELEC_{t-1}$, $\Delta ELEC_{t-2}$ emerges as statistically significant. The results furthermore imply that past changes in electricity supply along with present changes, have significant impact on the change in real GDP. According to the specification in column (2) of Table A3, one unit change in $\Delta ELEC_t$, $\Delta ELEC_{t-1}$ and $\Delta ELEC_{t-2}$ separately leads to changes in ΔGDP_t of 25.09, 21.77, and 29.36 units respectively. The higher value of the coefficient of $\Delta ELEC_{t-2}$ than the coefficients of $\Delta ELEC_t$ and $\Delta ELEC_{t-1}$ is somewhat surprising as the general expectation is that the impact decays as time passes. The above results, however, may be due to the time lag that the electricity supply needs in order create its full impact on economic growth.

Expected Increase in Output

Based on the regression results, a value of the expected increase in output (value added) can be estimated. The standard error for the coefficients of $\Delta ELEC_t$, $\Delta ELEC_{t-1}$ and $\Delta ELEC_{t-2}$ are 8.16, 9.26 and 9.32 respectively. Hence, the standard error for their sum would be $[8.16^2 + 9.26^2 + 9.32^2]^{½}$ or 15.47 assuming that these coefficients follow independent normal distributions. Therefore, the 95 percent confidence interval for the joint impact of $\Delta ELEC_t$, $\Delta ELEC_{t-1}$ and $\Delta ELEC_{t-2}$ is [25.09+ 21.77+ 29.36](+/-) 1.96(15.47) = 45.88—106.54. We can therefore express the 5 percent confidence interval for the expected increase in output within a range of Tk. 45.88 million to 106.54 million per MkWh.[7]

[7] Similar estimates of expected increase in economic output in Sri Lanka range between Sri Lankan Rs. 88,000 and Rs. 137.000 (equivalent Bangladesh Tk. 55,440 to Tk. 86,310). The Ceylon Electricity Board, however, uses a value of Rs. 26,000 per MWh. The UK Electricity Pool uses a lower value of Tk. 16,260 (£125) as the value of lost load in UK. The value of outage cost to the Chilean economy is estimated to lie between Tk. 6,520 and Tk. 17,920 (US$ 80-220) for 10 percent 1-month equi-proportional restriction and 30 percent 10-months equi-proportional restriction respectively.