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Understanding blackouts

Analysing detailed blackouts information of Dhaka

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Understanding Blackouts: Analyzing detailed blackouts information of Dhaka

Abu S. Shonchoy*

Introduction

There is a growing volume of literature that shows convincing evidence of electrification on economic growth, welfare, and poverty reduction (see Rud (2012); Asaduzzaman, Barnes, and Khandker (2010); Ketlogetswe, Mothudi, and Mothibi (2007); Khandker et al. (2009) to name a few). A few recent papers have also shown that public provision of electricity affects growth by improving labour productivity, reducing poverty by improving provisions for employment and salaries and investments in education, (Lipscomb, Mobarak, and Barham 2013) and by increasing rural female employment (Dinkelman 2011).

Developing countries often suffer from the problem of inadequate and ineffective power generation capacity which leads to power management through load-shedding technique, leading to frequent blackouts. In Bangladesh, for instance, electricity production has fallen way below the demand over the last two decades, resulting in extensive frequent daily load-shedding. In turn, load-shedding has obscured the reality of unmet demand in Bangladesh. According to official sources, Power Development Board (PDB) of Bangladesh is supplying on an average of 5000 MW[1] of electricity daily against the requirement of 8500 MW (Although the official capacity of electricity generation in Bangladesh is stated as 8525 MW[2]of which only 75 percent is considered to be is available with highest generation was 6675 MW a**s** recorded on 12/07/2013[3]) the according to the government estimates, power demand will reach almost 9500 MW by April 2014 which will lead to more frequent blackouts in the peak and off-peak time and seasons.

Blackouts are common and regular incidents in Developing countries where the poor provision of publicly provided utility like electricity could cause serious impact on daily living as well as

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[1]September 2012 to September 2013 average, authors own calculation.
[2]http://www.eprothomalo.com/index.php?opt=view&page=1&date=2013-03-06 (Page 14)
[3]http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=126&Itemid=17

could drive up firms and industries direct and indirect cost of production. However, academic literature on blackouts is very limited and there exists only a few rigorous empirical paper on effects of the blackout on firm economics. Reinikka and Svensson (2002) has shown the negative impact of blackouts, as a measure of the poor public provision of infrastructure, on firms in case of Uganda. Their paper found that firms invest privately in the complementary capital at the cost of installation of less productive capital. Fisher-Vanden *at el.* (2012) in their recent paper has paid attention to the impact of blackouts on firm productivity. While studying 32,000 enterprises in 11 industries from 1999-2004 in China, this paper found a substantial rise in material shares for the firms due to blackouts which increased unit costs of production for firms by 10 percent.

One interesting aspect of blackouts is, how the decision and management of load-shedding are being made by the power distribution authorities, especially in Bangladesh. What are their priorities and how do they ration such an important necessity throughout the day whose production is far below the demand? Several discussions with the authorities of power distribution have confirmed that in Dhaka, where the electricity demand is the highest, typical load-shedding practice is based on the daily demand and supply and each local electricity distribution center manages this on its own. However, there is no central body that keeps all the information of blackouts (both scheduled and actual) - their frequency and durations. To the best of our knowledge, there is no academic paper that so far looked into the distribution and management side of the electricity shortage related load-shedding, which we believe is an important contribution to the growing literature of blackouts.

The aim of this research is to fill this gap by collecting extensive data on blackouts of Dhaka city to understand seasonal, spatial, time-of-the-day and neighbourhood variations of load-shedding to better our understanding of how local authorities are managing this limited resource. This research also aims to establish a system to get continued collection of data which would be used to delve into interesting public policy and political economy questions. The extent and the distributive implications of the capture of public good allocation process to further individual interests by the political elite, for example, are policy-relevant issues that can be also be looked at using this data. My preliminary analysis of the load-shedding data suggest that day, week, month, weekend, season, and daily weather variation are strong determinants of electricity outage of the Dhaka City. This finding confirms that such determinants could be used as strong instruments to predict electricity outage on important outcome variables of policy interest, which could include firm performance, productivity, and revenue.

Electric Power Sector in Bangladesh

Appendix Figure A1 represents the institutional structure of the electric power sector in Bangladesh. A brief description of the institutions of the electric power sector is presented in Appendix II. The generation of electricity in Bangladesh involves both public and private sector participation. Over the years more and more private sector investment is encouraged by government and as a result, we see a larger proportion of the electricity is coming out of private entities.

Figure A2 in the Appendix presents the composition of different sources of energy that are being converted into electricity over 2012-2014. Natural gas has been the predominant source of energy in Bangladesh. However, as it is evident from Figure A2 (in the Appendix) that the dependence has been shifting slowly on fossil fuel from natural gas over the years. This is largely due to government policy to address the chronic deficiency of electricity supply through "quick rental" access, which involves a large number of small scale electricity producers producing and supplying electricity in shortest possible time. One major concern of "quick rental" comes from the production efficiency side. Figure A3 in the Appendix shows the cost composition of fuel used in electricity production. From Figure A2 and A3 (in the Appendix) we can see a relatively small portion of the electricity is being produced using fossil fuel, however, the cost associated with such production involves the largest proportion of costs associated with different fuel sources.[4]

Appendix Figure A4 presents a typical electricity transmission and distribution scenario. From the generation source generally, 800kV or 400kV lines goes into the 220kV or 132kV substations. Using a step-down transformer the electricity then either transmitted into 33kV substations or goes through 33kV or 66kV feeder to supply electricity to very large industrial units. Using another form of the step-down transformer from the 33kV substations electricity is transmitted into 11kv feeders. From the 11kV feeders, connections are given to the end users. Residential users get 240V and small scale industries get 415V connections.

[4] It is argued that the gas price in Bangladesh is highly subsidized, which makes the fuel cost comparison unfair.

Table A1 in Appendix presents daily electricity generation report for the month of September, as an example of typical electricity generation, distribution and demand analysis on a point-to-point scale for the period of 2012-2014. Over the years there is a steady increase in generation of electricity, and so is the demand for electricity, hence, there is always a shortage of electricity supply compared with demand. However, the magnitude of load-shedding has a decreasing trend over the years. Still, the maximum daily load-shedding in September 2014 was 780MW and minimum was 112MW for the country, which is 11.1 percent and 1.6 percent of the peak demand for electricity during the same time period, respectively. As a result, it is very important to understand the load-shedding management as it has got interesting public policy and finance implications.

Electricity transmission in Bangladesh currently is primarily carried out by PGCB. Figure A5 in the Appendix presents the map of 400kV, 230kV, and 132kV grid network in Bangladesh. Dhaka is the capital city of Bangladesh and is the most densely populated area of the country. As can be seen from Figure A5 (in the Appendix) there is a high concentration of transmission network in Dhaka followed by Chittagong, which is the major port city of the country and considered to be the second important city and commercial capital of Bangladesh. The electricity distribution in Dhaka in recent years is carried out by DPDC and DESCO, both of which are private limited companies.

In terms of number of connections, DPDC serves 58 percent of Dhaka city whereas the rest is covered by DESCO. Figure A6 in the Appendix represents the circle wise map of covered area under DPDC and location of 132kV and 33kV substations. Figure A7 in the appendix provided the circle wise map of DESCO coverage area. Table A2 of Appendix provides a profile of electricity distribution status of DPDC and DESCO. DPDC covers 350 square kilometers with 4282 kilometers of electricity lines, whereas DESCO covers 250 square kilometers with 1978 kilometer of electricity lines. DPDC has got a total of 54 substations among which 42 are 33/11kV ones, and most of their customers are residential (87.99 percent). DESCO got 32 substations, out of which 30 substations are 33/11kV type and like DPDC, the majority of their customers are residential. DPDC and DESCO jointly distribute about 40% percent of the electricity demanded of the country. However, it does not always receive the required supply of electricity from the national greed to meet its customers' demand. Maximum load-shedding recorded in a day in April 2013 was 301MW for DPDC and 186MW for DESCO. As a result like other electricity distribution authorities, DPDC and DESCO need to manage the shortage of electricity supplied to its customers, using load-shedding management at the 33/11kV substations at their distribution lines.

Research Methodology and Approach

We will first get the daily blackout information, duration of each blackout and the planned and unplanned information of blackouts of each suburbs of the Dhaka city from the respected power distribution authorities and its sub-divisions. Since this required dataset is currently not available and there exists no functional digital data acquisition system of high frequency blackout data in Dhaka, it will be logistically and administratively very difficult to collect the on a regular basis. However, there exists a manual paper based record keeping (known as "load-shedding and interruption" register) at the 33/11kV sub-stations of the electricity distribution authorities in Bangladesh. We first collected this paper based records either by sending research assistants to digitalize the data at the spot or by talking an image (photo) or making a photocopy of the register of each record page and later digitalize the data to construct a data-base of the outage. See Figure A8 to have an understanding of how such record keeping was made in a roaster.

The access to the 33/11kV substations is restricted. It took a good amount of work to collect all the clearance required for our research team to visit the substations and start collecting the data. Our research team has visited all the 33/11kV substations under DPDC and DESCO to make a photocopy of the load-shedding and interruption register of two years from September 2012 to September 2014.

Data

A total of 648 feeder's load shedding information of two years have been collected and digitalized, which makes total number of observation of 151,723 at the feeder level of daily frequency of load shedding outage substations (see in the appendix Figure A9 to get the satellite image of the Dhaka based sub-stations and see Figure A10 for the feeder maps of the distribution lines). Table 1 and 2 provide a number of feeders and number of observations at the substation level for the data collected for both DPDC and DESCO.

Note that each load shedding event is determined at a specific substation and impacts power supply along with an entire feeder line. In our data, which covers the urban electricity network in Dhaka in the residential areas of Dhaka, there are 52 and 648 feeder lines. At each substation, the number of feeder lines ranges from 4 to 35, with a median of 13. Over the course of the 25 months covered by our dataset, there were nearly 180,000 load shedding outages in total or 7,157 outages per month on average. The median duration of each outage in our dataset is 60 minutes.

Table 1: Data Summary of DPDC

	Substation	Number of feeders	Total observation
Dhaka Power Distribution Company (DPDC) Ltd.	Kakrail 33/11 kV	12	2,344
	Kawranbazar 33/11 kV	8	5,309
	New Ramna 33/11 kV	23	2,094
	Moghbazar 33/11 kV	13	5,393
	Green Road 33/11 kV	10	2,038
	Lalmatia 33/11 kV	14	3,745
	Tejgaon 33/11 kV	16	5,003
	Lalbagh 33/11 kV	14	6,754
	Jigatala 33/11 kV	15	4,650
	Satmoszid 33/11 kV	26	4,973
	Ullon Local 33/11 kV	6	1,197
	Goran 33/11 kV	6	2,056
	Maniknagar 33/11 kV	5	1,973
	Madartek 33/11 kV	13	5,751
	Kazla 33/11 kV	18	5,430
	Bangshal 33/11 kV	9	4,319
	Shyampur 33/11 kV	25	3,837
	Postogola 33/11 kV	18	4,480
	Matuail 33/11 kV	12	4,582
	Shitalakhya 33/11 kV	8	2,097
	Panchabati BSCIC 33/11 kV	11	4,108
	Char-Syedpur 33/11 kV	6	1,778
	Khanpur 33/11 kV	12	4,999
	Mondolpara 33/11 kV	4	1,191
	Siddhirgonj 33/11 kV	11	2,988
	Sarulia 33/11 kV	9	3,109
	Total	324	96,198

Additionally, we obtained historical weather estimates from a commercial service.[5] The weather estimates include variables such as temperature, humidity, and cloud-cover, among others. Temporally, these estimates are provided at the hour-level. Spatially, they can be estimated at any point on the globe. However, for the purposes of this project, we collected hour-level weather estimates at the location of each Dhaka substation.

Table 2: Data Summary of DESCO

Substation	Number of feeders	Total Observation
Mirpur dohs 33/11 kV	8	1,621
Bashundhara 33/11 kV	6	1,292
Gulshan 2 33/11 kV	11	2,605
Mirpur Old 33/11 kV	14	6,148
ADA 33/11 kV	18	1,423
Aftabnagar 33/11 kV	10	1,712
Kazi para 11 KV	22	2,830
Banani 33/11	28	2,409
Baridhara 33/11 kV	23	4,289
CAAB 33/11 kV	6	1,099
Dakshinkhan 33/11 kV	10	2,664
Dhamalkot 33/11 kV	7	611
Digun 33/11 kV	16	4,166
Gulshan-1 33/11 kV	21	4,696
Joarshahara 33/11 kV	9	2,180
Kafrul 33/11 kV	14	3,272
Mirpur SS-2 33/11 kV	17	4,301
Nikunzo-2 33/11 kV	9	2,079
Uttara 33/11 kV	16	3,775
Uttara grid 33/11 kV	10	2,353
Total	275	55,525

Our Data suggests that weather may be an effective instrument for load shedding. Load-sheddings are clearly correlated with weather. Admittedly, a valid concern is that the weather-load shedding trends depicted in may not be causal. Weather is also correlated with other trends that are themselves correlated with outage frequency. For example, time of day (see

Figure 1 below), Day of Week, month of year (

[5] Specifically, we purchased weather data from darksky.net.

Figure 2 below), or geographic location of a substation may all be correlated to outage frequency.

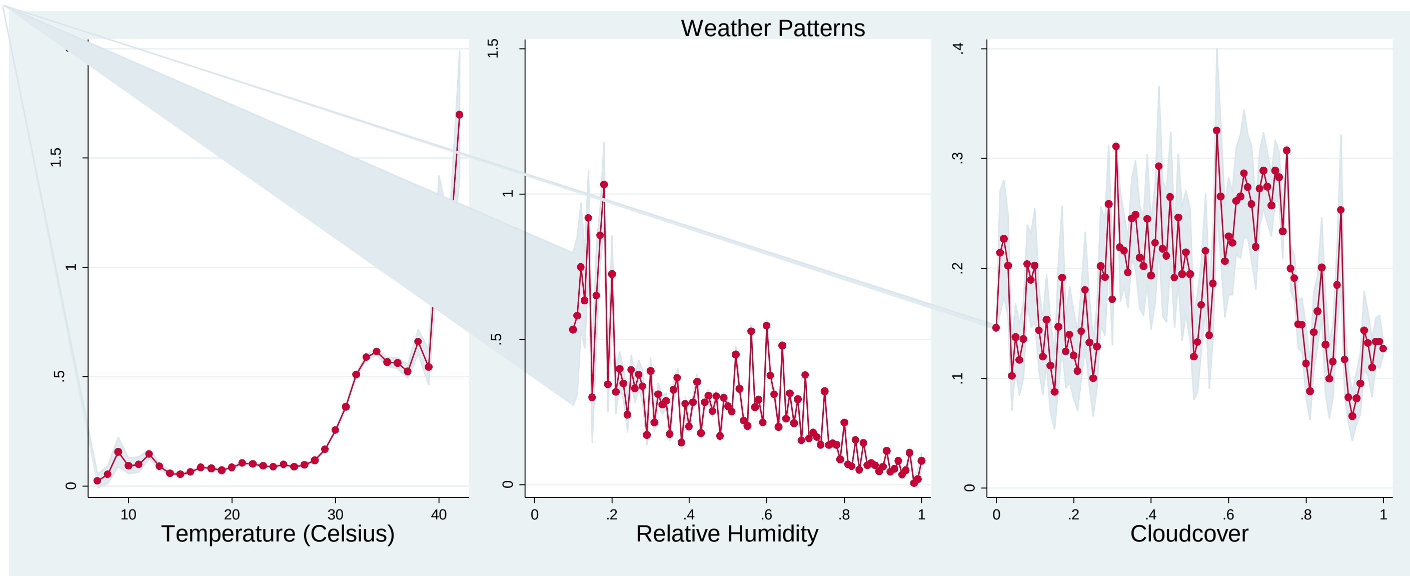

Figure 1*:* Hourly substation-level outage frequency shows a clear correlation with weather variables. 95% CI shown in bluish gray area plot.

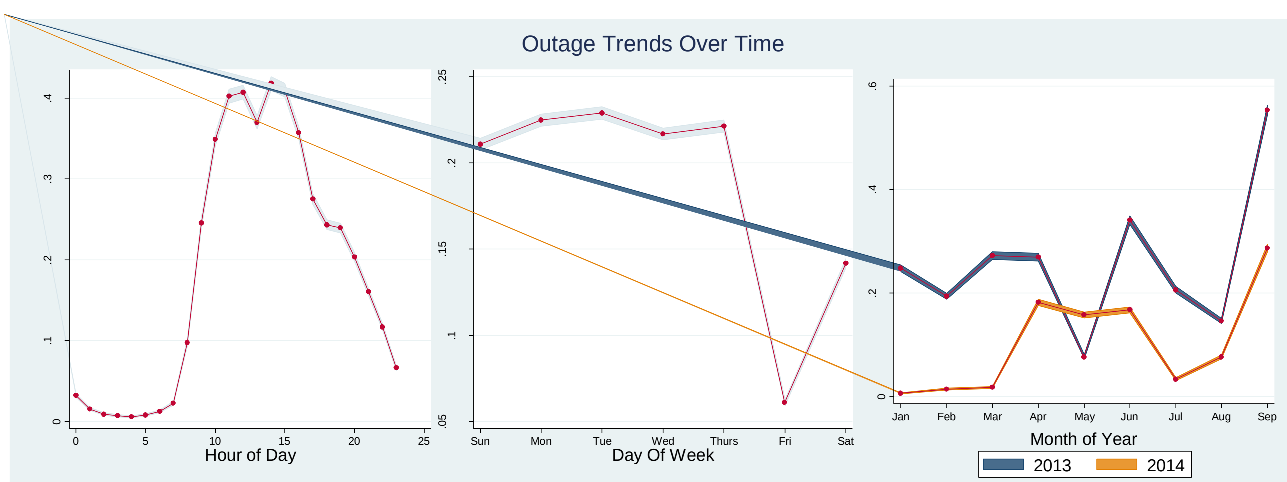

Figure 2: Hourly Substation-Level Outage Frequency is correlated with temporal variables. Weekend in Bangladesh consists of Friday and Saturday and corresponds to a drop in outages (middle panel).

In order to address this concern, we controlled for various temporal and geographic fixed effects in a regression model (See Table A3). Even after controlling for these additional variables, the weather-Load shedding trends remained qualitatively unchanged (figure 3). This preliminary analysis suggests that weather may be a powerful instrument for measuring the effect of outages on welfare variables.

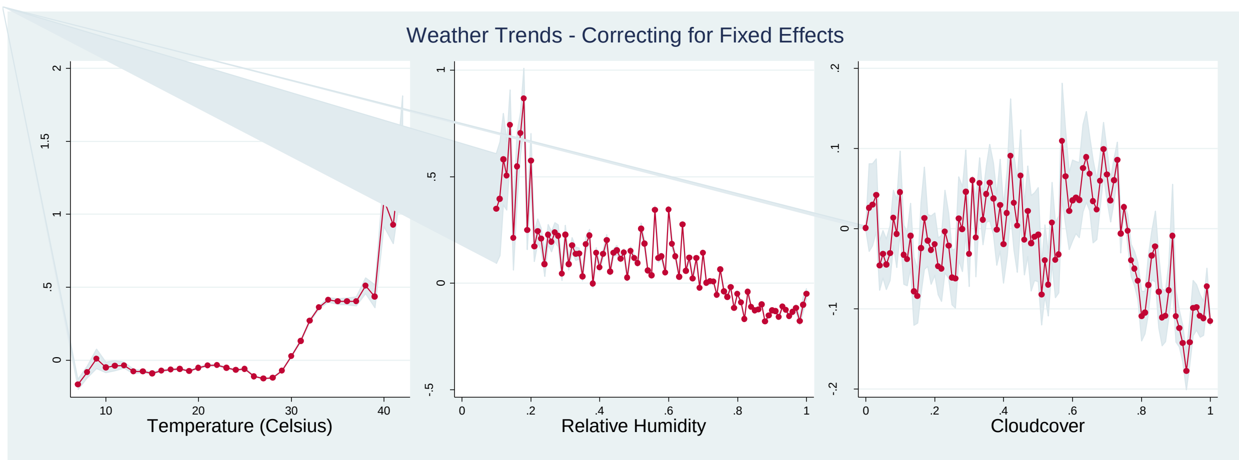

Figure 3: Weather Trends, post correcting for fixed effects. Temporal and Geographic fixed effects were included in a linear regression. We regressed outage frequency on year, substation ID, day of week, month of year, holiday dates and occurrences of political strikes (Hartal). Residuals were plotted against weather variables, revealing trends essentially identical to those prior correcting for fixed effects (See Table A3).

Our data suggests that the randomness in weather can be used to estimate the cost of load sheddings in an unbiased manner. An interesting question moving forward is whether this cost is born equitably by all regions of Dhaka. Do poor neighborhoods or neighborhoods with fewer political connections bear a disproportionate share of the cost? To this end, we are compiling data on land prices and political connections throughout Dhaka. Furthermore, because the cost of an outage can vary by region, the question of equitable distribution of cost is not necessarily equivalent to the question of equal distribution of load sheddings. Taken together, estimates on welfare cost of each outage based on location together with data on the geographic distribution of wealth and political connections can help shed light on whether access to electricity is efficiently distributed among a governments constituents.

Conclusion

In 2010, the Bangladesh government subsidized the average unit of electricity consumption by 25 percent.[6] Furthermore, electricity subsidies make up about a quarter of the Bangladesh national budget.[7] Proponents of these subsidies have argued that they are necessary for electricity to be affordable to all.[8] However, subsidies can also drive a wedge between demand and supply. When the total demand for electricity exceeds the total amount of electricity available, utilities may be forced to ration power through a system of load shedding. In this situation, the supply of electricity is intentionally interrupted in certain areas for non-overlapping periods of time. In Dhaka, utilities load shed by interrupting the supply of electricity to specific feeder lines.

Electricity subsidies such as those in Dhaka are common throughout the developing world. As mentioned above, subsidies may cause additional outages by driving a wedge between electricity supply and demand. Thus, it desirable to estimate the welfare costs of such a policy due to outages. However, welfare may already be correlated with number of outages for any number of reasons (eg: wealthier regions tend to consume more electricity), necessitating an exogenous instrument for outages. Through the data collection effort of this project, we present evidence that weather variables can serve as an effect instrument for outages.

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[6] Ahmed, Faizuddin, Christopher Trimble, and Nobuo Yoshida. 2013. "The Transition from Underpricing Residential Electricity in Bangladesh: Fiscal and Distributional Impacts." *World Bank Report* #76441-BD.

[7] Pg. 5 http://www.iisd.org/gsi/sites/default/files/ffs_bangladesh_czguide.pdf

[8] Mujeri, Mustafa A., Siban Shahana, and Tahreen Tahrima Chowdhury. 2012. "A Citizen's Guide to Energy Subsidies in Bangladesh." Bangladesh Institute of Development Studies (BIDS) and the International Institute for Sustainable Development's Global Subsidies Initiative (GSI). Available at: http://www.iisd.org/gsi/sites/default/files/ffs_bangladesh_czguide.pdf

Managing insufficient electricity is a big challenge that the government of Bangladesh faces in the present day. Prioritizing the use of electricity and the distribution of load-shedding needs clearer and a more systematic analysis to understand how we can improve electricity management (or blackout management) in the Dhaka city.

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Appendix I

Table A1: Report on Daily Electricity Generation System of Bangladesh

Description of Item	Unit	Sep-14	Sep-13	Sep-12
Peak Genaration	MW	6742.00	6293.00	6011.00
Maximum day peak Genaration	MW	5853.00	5226.00	5147.00
Peak Demand	MW	7000.00	6700.00	6600.00
Minimum Generation	MW	4393.00	4157.00	3846.00
Average of the daily evening peak Genaration	MW	6357.10	5979.33	5551.63
Average of the daily day peak Genaration	MW	5391.43	4959.67	4621.77
Maximum load-shed	MW	780	932	1048
Minimum load-shed	MW	112	105	308
Total nos. of load-shed days	Day	29	29	29
Average load-shed (Avg. of the 30 days)	MW	392	456	658
Total Generation	MKWH	4044.37	3725.15	3455.29
Total Generation by IPP	MKWH	293.65	604.09	748.59
Total Generation by BPDB	MKWH	1897.63	1831.99	1576.86
A) Total Generation by RPCL	MKWH	87.38	86.02	102.48
B) Total Generation by REB	MKWH	172.20	146.45	119.65
C) Total Generation by RENTAL	MKWH	1324.66	1056.60	907.71
D) Total Generation by HVDC	MKWH	268.85		
Fuel wise Generation.				
A) Gas	MKWH	2516.77	2706.09	2586.77
B) Oil	MKWH	1068.26	817.71	652.10
C) Hydro	MKWH	98.44	87.96	113.30
D) Coal	MKWH	92.05	113.39	103.12
E) HVDC	MKWH	268.85		
Total fuel cost (BPDB + PVT.) (Calculated)	M.Taka	16729.36	13971.79	11453.96
A) Gas	M.Taka	1896.73	2120.24	2333.37
B) Liquid fuel	M.Taka	14468.76	11387.57	8721.68
C) Coal	M.Taka	363.86	463.98	398.90
Fuel cost of per unit Generation				
Including Hydro (Excluding HVDC)	Tk/KWHR	4.43	3.75	3.31
Excluding Hydro & HVDC	Tk/KWHR	4.55	3.84	3.43

Source: Information Management Division, PGCB

Table A2: Operational Information of DPDC and DESCO

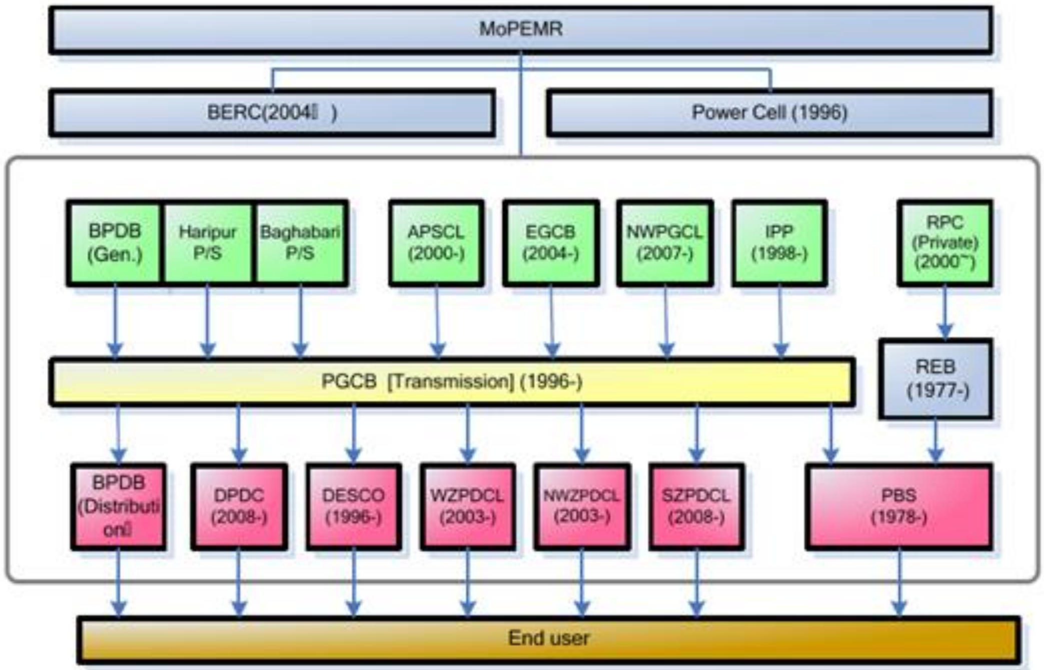
Variable description	DPDC	DESCO
Total covered area (2014)	350 sq. km.	250 sq. km
Total electricity line	4282 km.	1978 km.
132kV transmission line	224 km.	-
33kV transmission line	320 km.	416 km.
11/.4kV line	3708 km.	1722 km.
Total number of substations (2014)	54	32
132/33kV substation	11	2
132/11kV substation	1	0
33/11kV substation	42	30
Maximum demand (2013)	1280 MW	680MW
Maximum received load (2013)	1140 MW	786MW
Maximum load shedding (2013)	301 MW	186 MW
Number of customers (2014)	922,325	641,933
Residential	811541 (87.99%)	577,739 (90 %)
Lt. Industrial	19227 (2.09%)	6,419 (1 %)
Commercial	83187 (9.02%)	44,935 (7 %)
Others	8320 (0.90%)	12,838 (2 %)

Source: https://www.dpdc.org.bd/ and annual general reports of DESCO, 2015.

Table A3: Determinants of Outage in Dhaka

	(1)	(2)	(3)	(4)
	# of times loadshedding occurred	# of times loadshedding occurred	# of times loadshedding occurred	# of times loadshedding occurred
Monday	0.0134***	0.0130***	0.0134***	0.0130***
	(0.002)	(0.002)	(0.002)	(0.002)
Tuesday	0.0207***	0.0224***	0.0217***	0.0234***
	(0.002)	(0.002)	(0.002)	(0.002)
Wednesday	0.0111***	0.0116***	0.0111***	0.0116***
	(0.002)	(0.002)	(0.002)	(0.002)
Thursday	0.0184***	0.0179***	0.0193***	0.0189***
	(0.002)	(0.002)	(0.002)	(0.002)
Friday	-0.0357***	-0.0401***	-0.0358***	-0.0403***
	(0.006)	(0.006)	(0.006)	(0.006)
Saturday	0.0403***	0.0363***	0.0403***	0.0362***
	(0.006)	(0.006)	(0.006)	(0.006)
February	0.00631	0.00296	0.00631	0.00291
	(0.004)	(0.004)	(0.004)	(0.004)
March	0.00939**	0.00346	0.00942**	0.00339
	(0.004)	(0.004)	(0.004)	(0.004)
April	0.171***	0.165***	0.171***	0.165***
	(0.004)	(0.004)	(0.004)	(0.004)
May	0.154***	0.148***	0.157***	0.151***
	(0.004)	(0.004)	(0.004)	(0.004)
June	0.157***	0.151***	0.158***	0.151***
	(0.004)	(0.004)	(0.004)	(0.004)
July	0.0218***	0.0156***	0.0217***	0.0155***
	(0.004)	(0.004)	(0.004)	(0.004)
August	0.0729***	0.0671***	0.0730***	0.0671***
	(0.004)	(0.004)	(0.004)	(0.004)
September	0.00831	0.0214***	0.00833	0.0217***
	(0.006)	(0.006)	(0.006)	(0.006)
October	0.00260	0.0143**	0.00259	0.0145***
	(0.006)	(0.006)	(0.006)	(0.006)
November	-0.220***	-0.208***	-0.220***	-0.208***
	(0.006)	(0.006)	(0.006)	(0.006)
December	-0.242***	-0.225***	-0.242***	-0.224***
	(0.005)	(0.005)	(0.005)	(0.005)
Political Strikes		-0.0368***		-0.0373***
		(0.002)		(0.002)
National Holidays			-0.108***	-0.114***
			(0.011)	(0.011)
N	948480	948480	948480	948480
r2	0.165	0.165	0.165	0.165
Weather control	Yes	Yes	Yes	Yes

Figure. A1 The Structure of the Electric Power Sector in Bangladesh

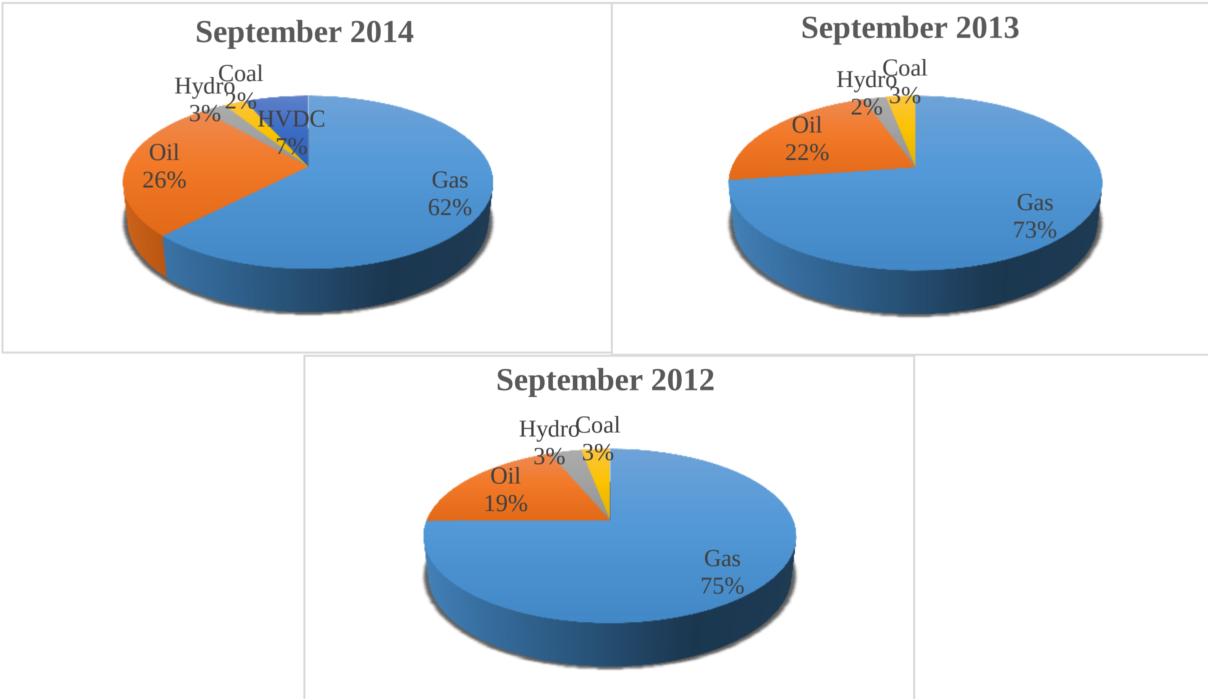


Note: ⟶ Power flow、

Abbreviation	List
MoPEMR	Ministry of Power, Energy & Mineral Resource
BERC	Bangladesh Energy Regulatory Commission
BPDB	Bangladesh Power Development Board
APSCL	Ashuganj Power Station Company Ltd.
EGCB	Electricity Generation Company of Bangladesh
NWPGCL	North-West Power Generation Company Ltd.
IPP	Independent Power Producer
RPC	Rural Power Company Ltd.
PGCB	Power Grid Company of Bangladesh
DPDC	Dhaka Power Distribution Company Ltd.
DESCO	Dhaka Electric supply Company Ltd.
WZPDCL	West Zone Power Distribution Company Ltd.
NWZPDCL	North-West Zone Power Generation Company Ltd.
SZPDCL	South Done Power Distribution Company Ltd.
REB	Rural Electrification Board
PBS	Palli Biddyut Samities

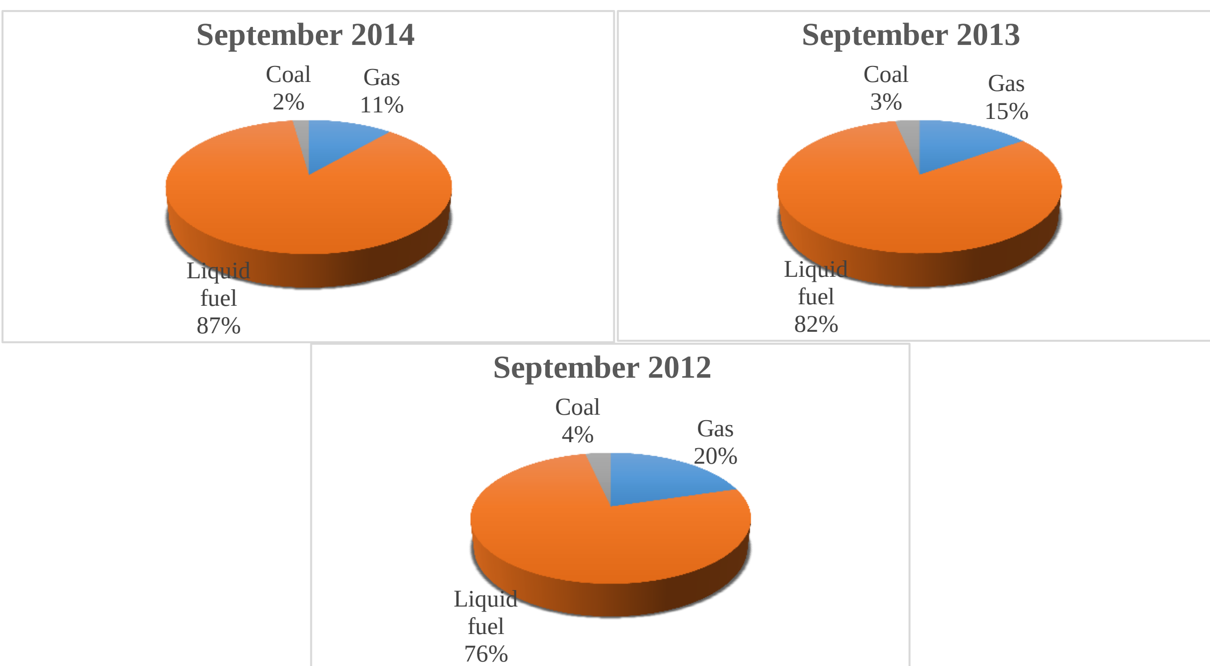
Source: “Electric Energy Situations in Foreign Countries” Vol.2 (2010) JEPIC BPDP Annual Report

Figure. A2 Fuel Categories Used in Electricity Generation in Bangladesh



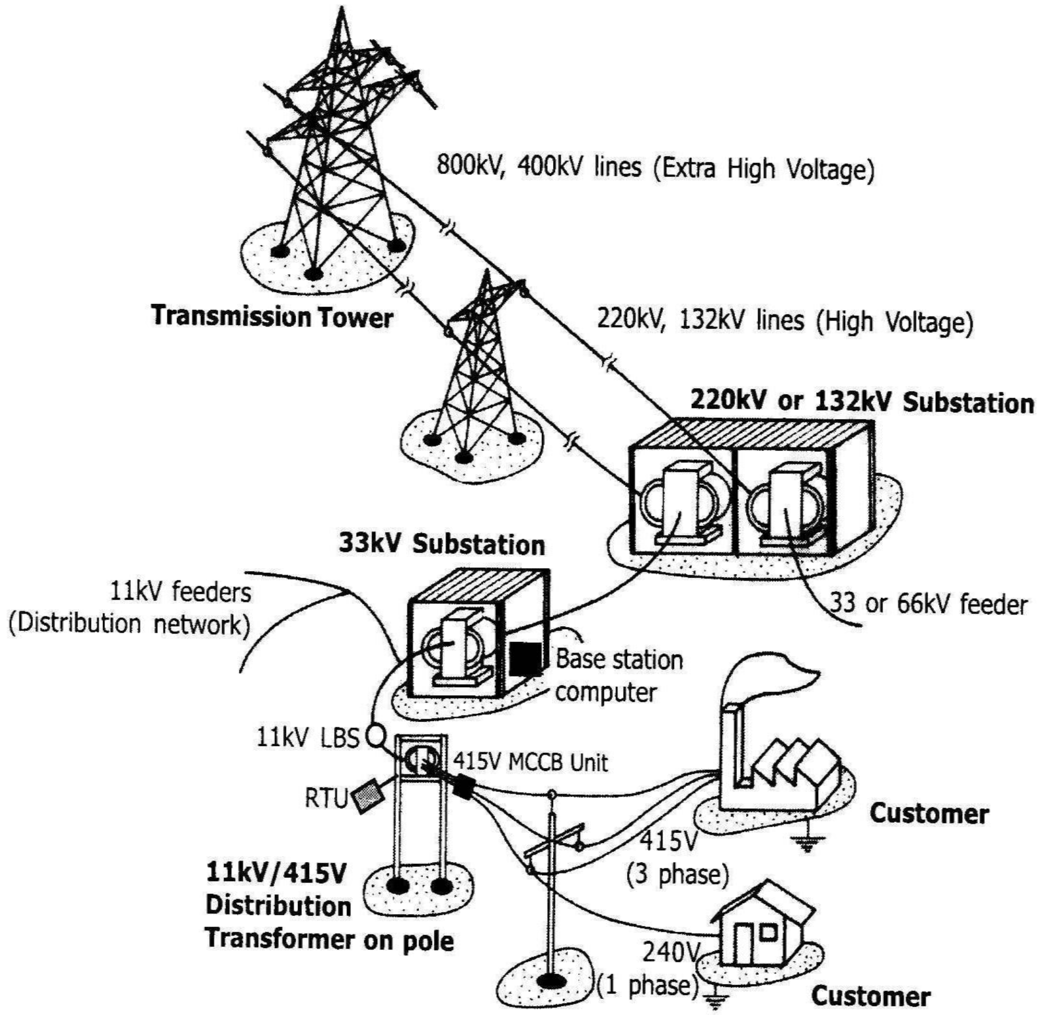
Source: Authors' own calculation using data from Information Management Division, PGCB

Figure. A3 Cost of Fuel by Categories in Electricity Generation in Bangladesh



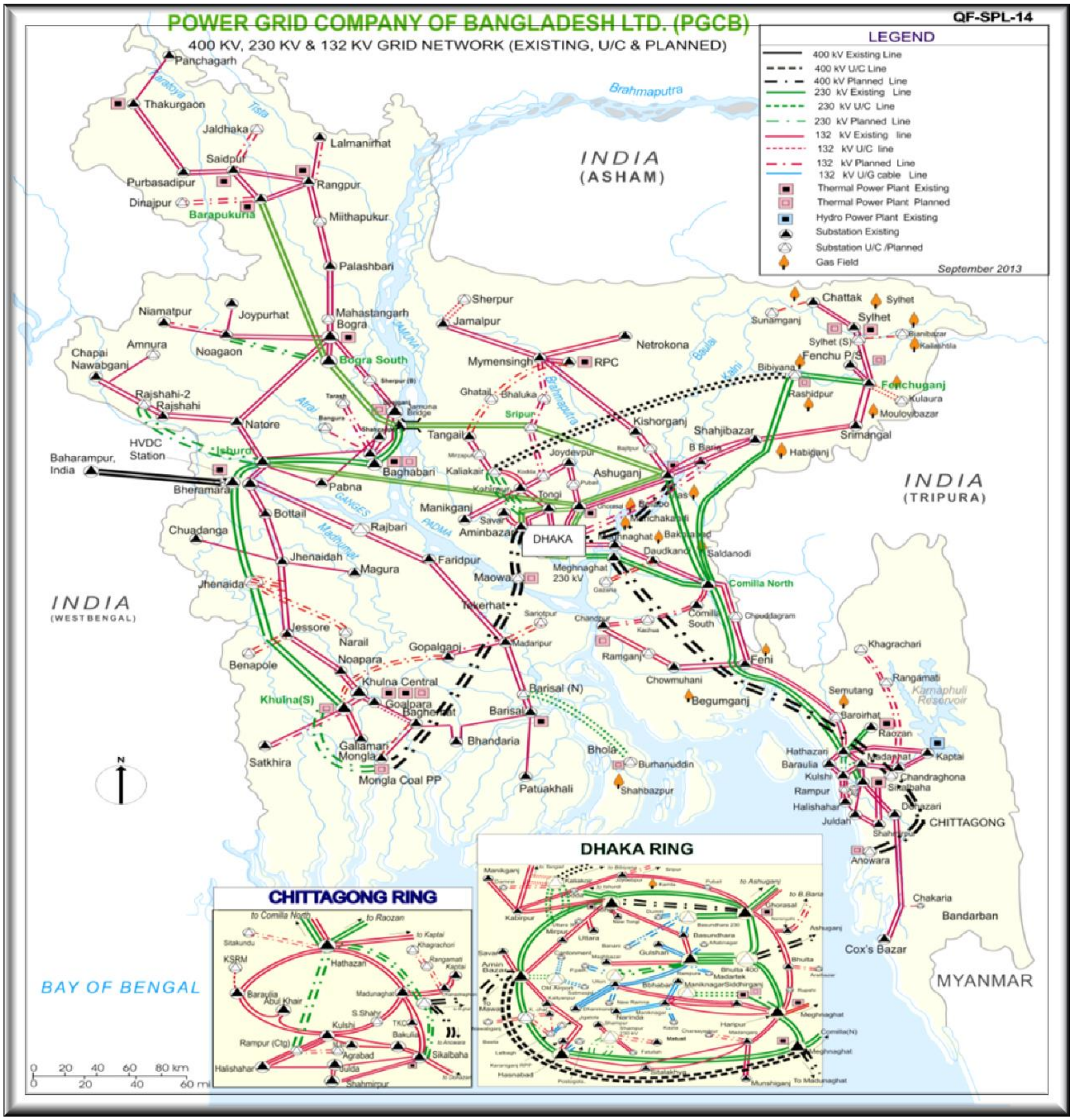
Source: Authors' own calculation using data from Information Management Division, PGCB

Figure. A4 Typical Power Transmission and Distribution Scenario



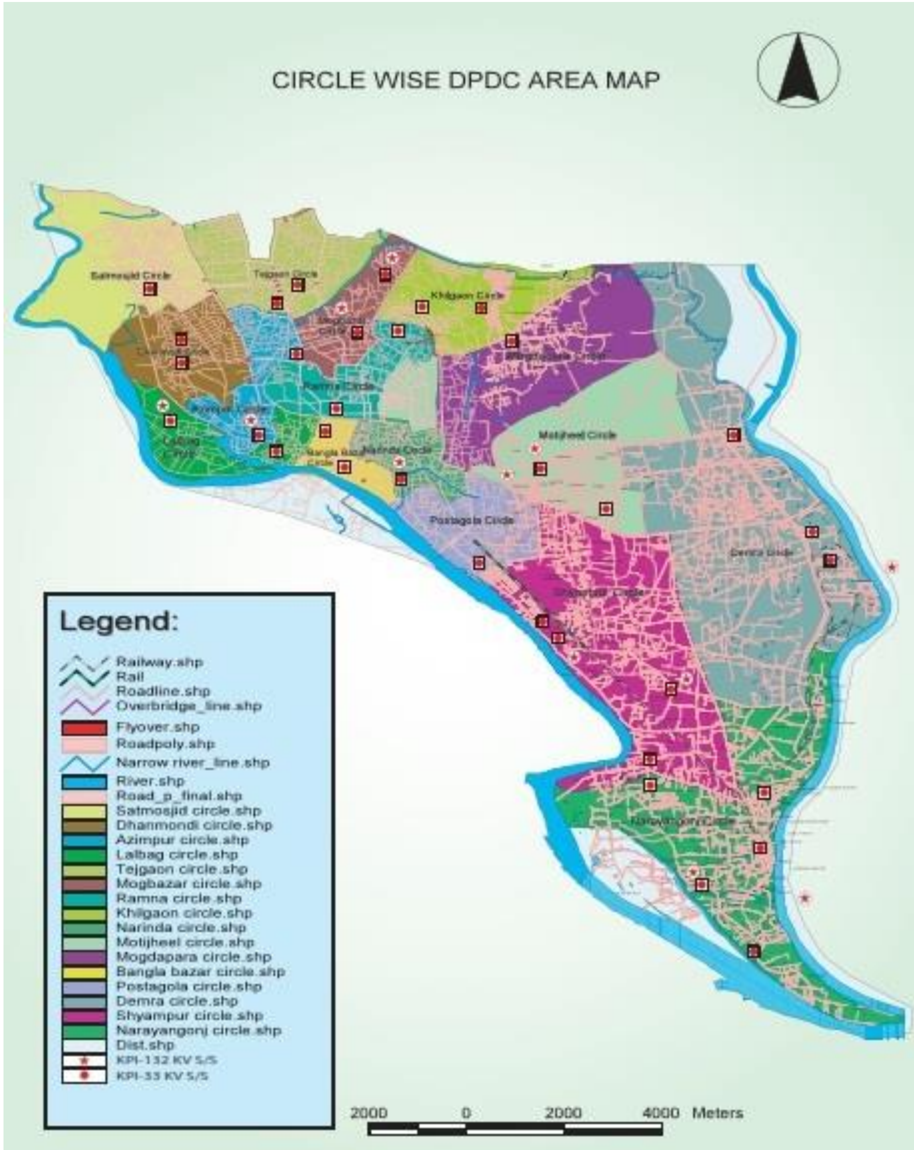
Source: Sachchidanand, 1999. "Automation in Power Distribution", volume 2.

Figure. A5 PGCB Electricity Transmission Map of Bangladesh



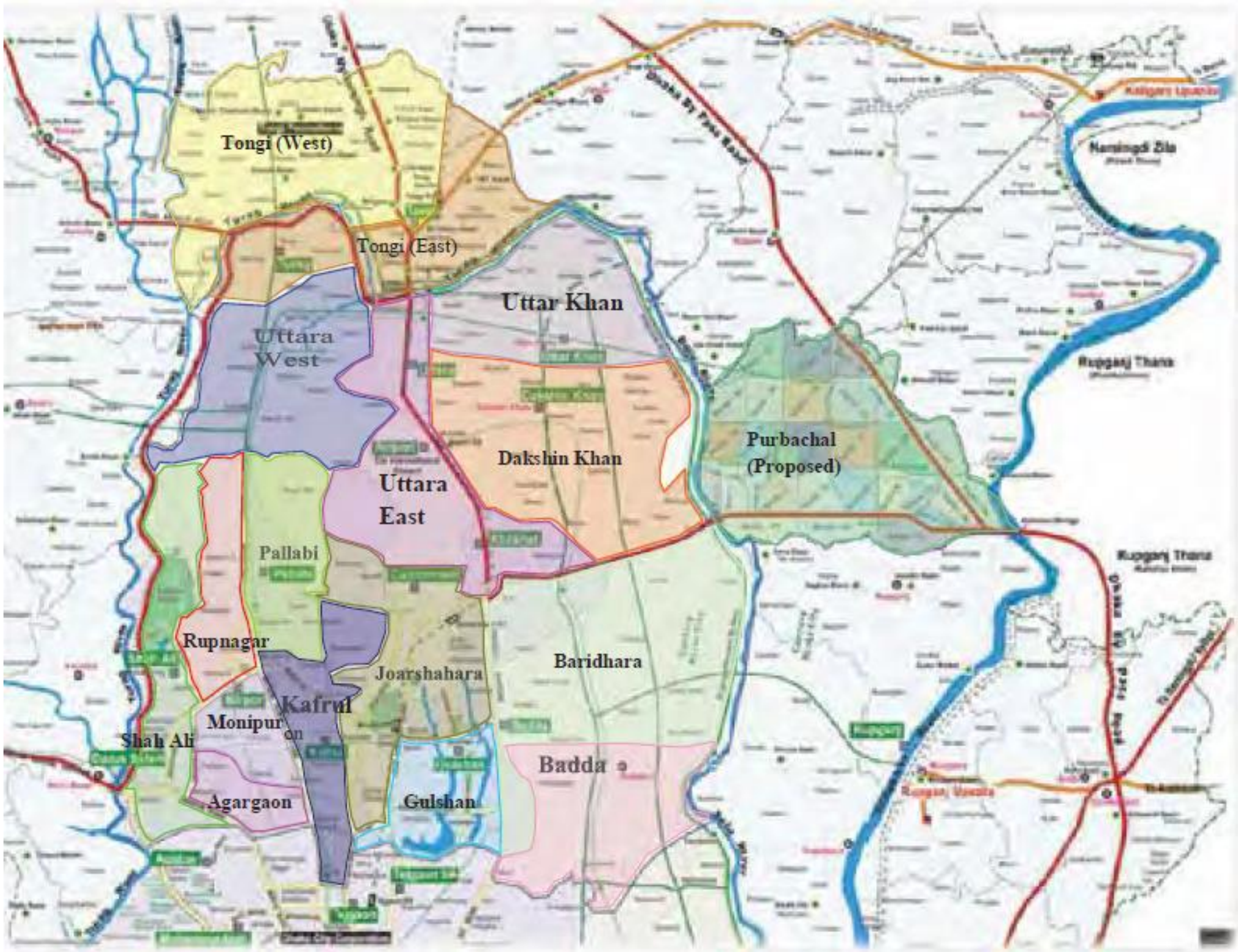
Source: http://www.pgcb.org.bd/

Figure A6: DPDC Coverage Area



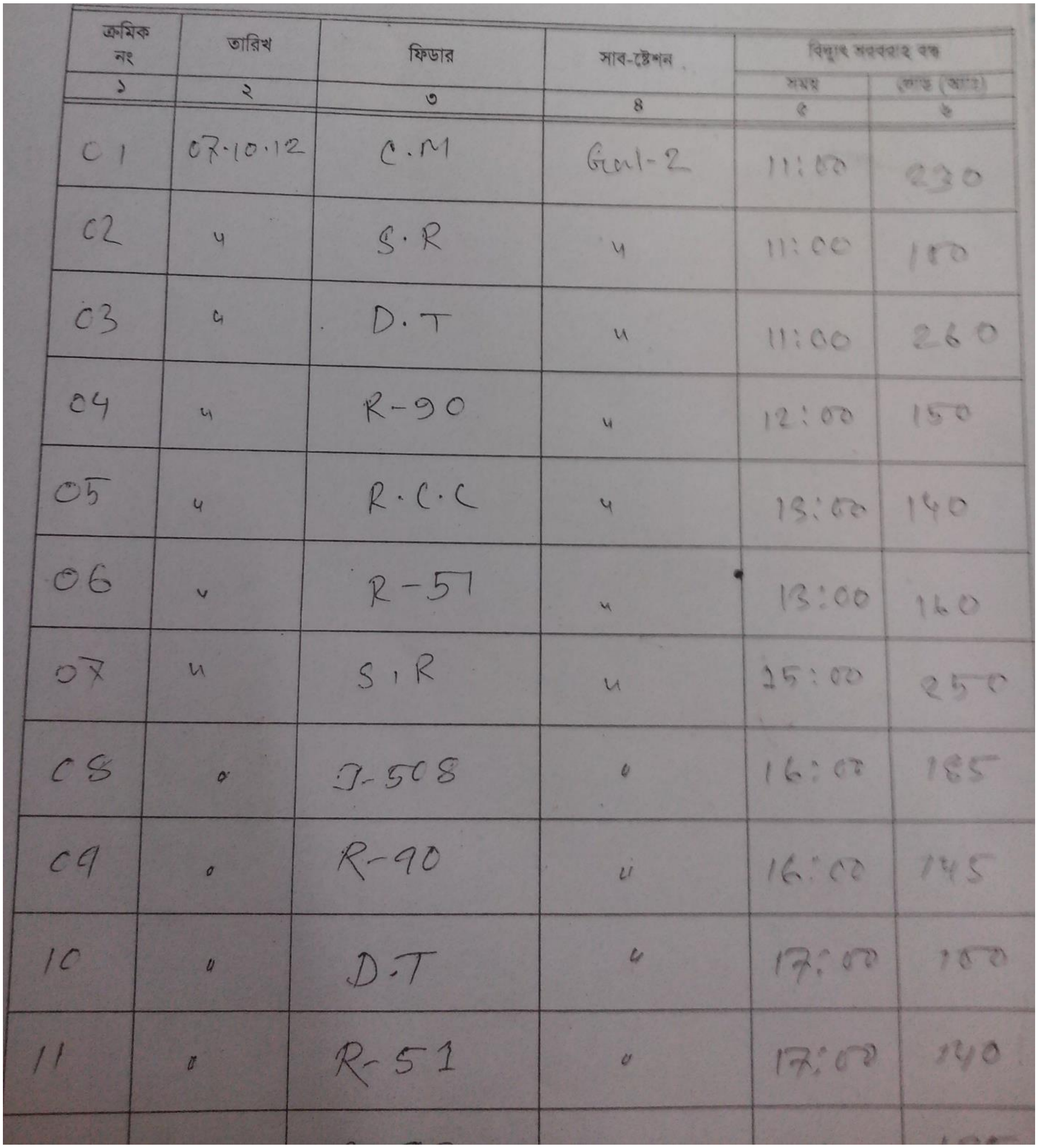
Source: DPDC website: https://www.dpdc.org.bd/

Figure A7: DESCO Coverage Area



Source: DPDC website: https://www.desco.org.bd

Figure A8: Copy of a typical record keeping of load-shedding at the 33/11kV sub-stations



ক্রমিক নং	তারিখ	ফিডার	সাব-ষ্টেশন	বিদ্যুৎ সরবরাহ বন্ধ	
				সময়	লোড (আম্প)
১	২	৩	৪	৫	৬
01	07.10.12	C.M	Gul-2	11:00	230
02	"	S.R	"	11:00	180
03	"	D.T	"	11:00	260
04	"	R-90	"	12:00	150
05	"	R.C.C	"	13:00	140
06	"	R-51	"	13:00	160
07	"	S.R	"	15:00	250
08	"	J-508	"	16:00	185
09	"	R-90	"	16:00	145
10	"	D.T	"	17:00	180
11	"	R-51	"	17:00	140

Figure A9: A satellite view of Dhaka with Gray dots represent substations

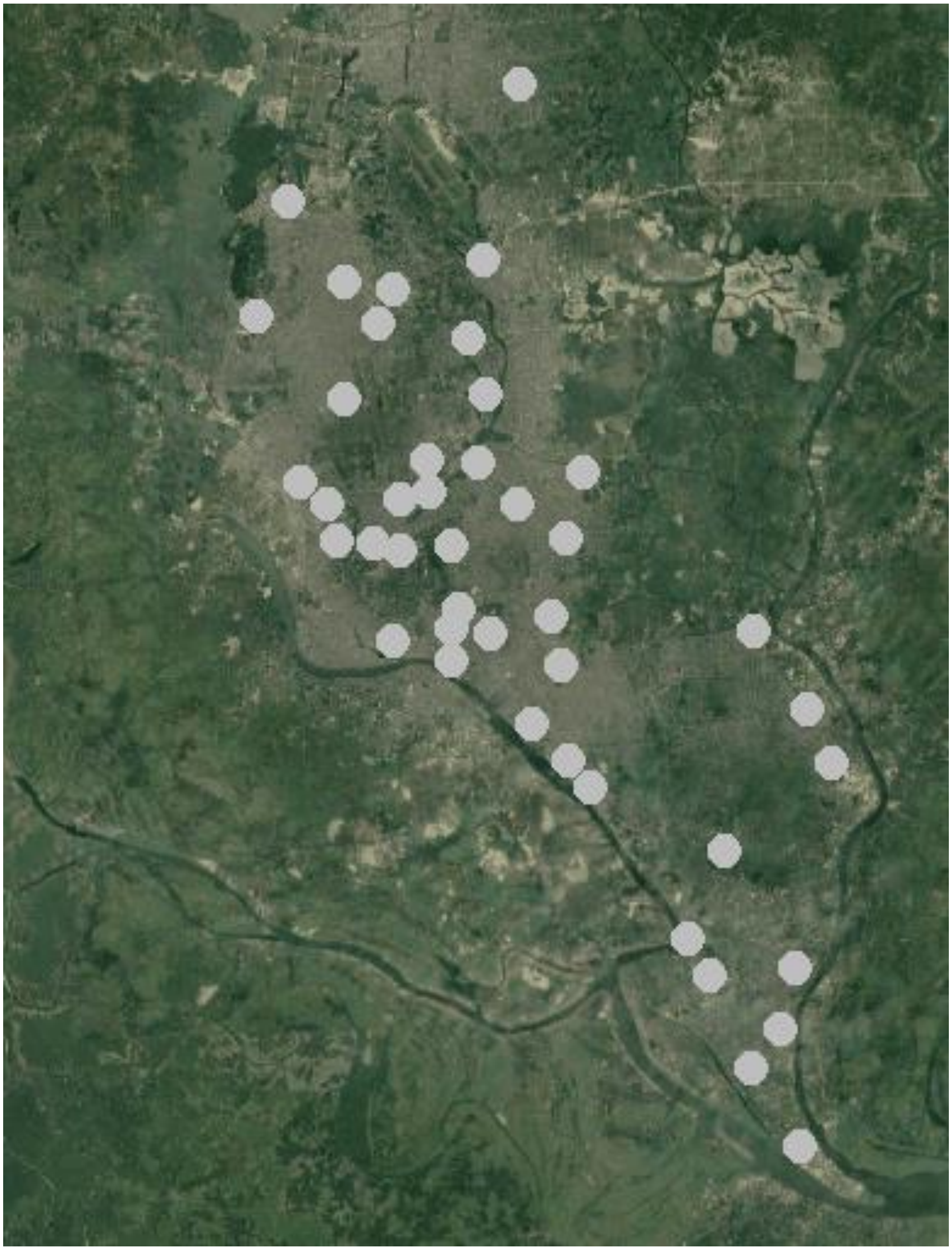
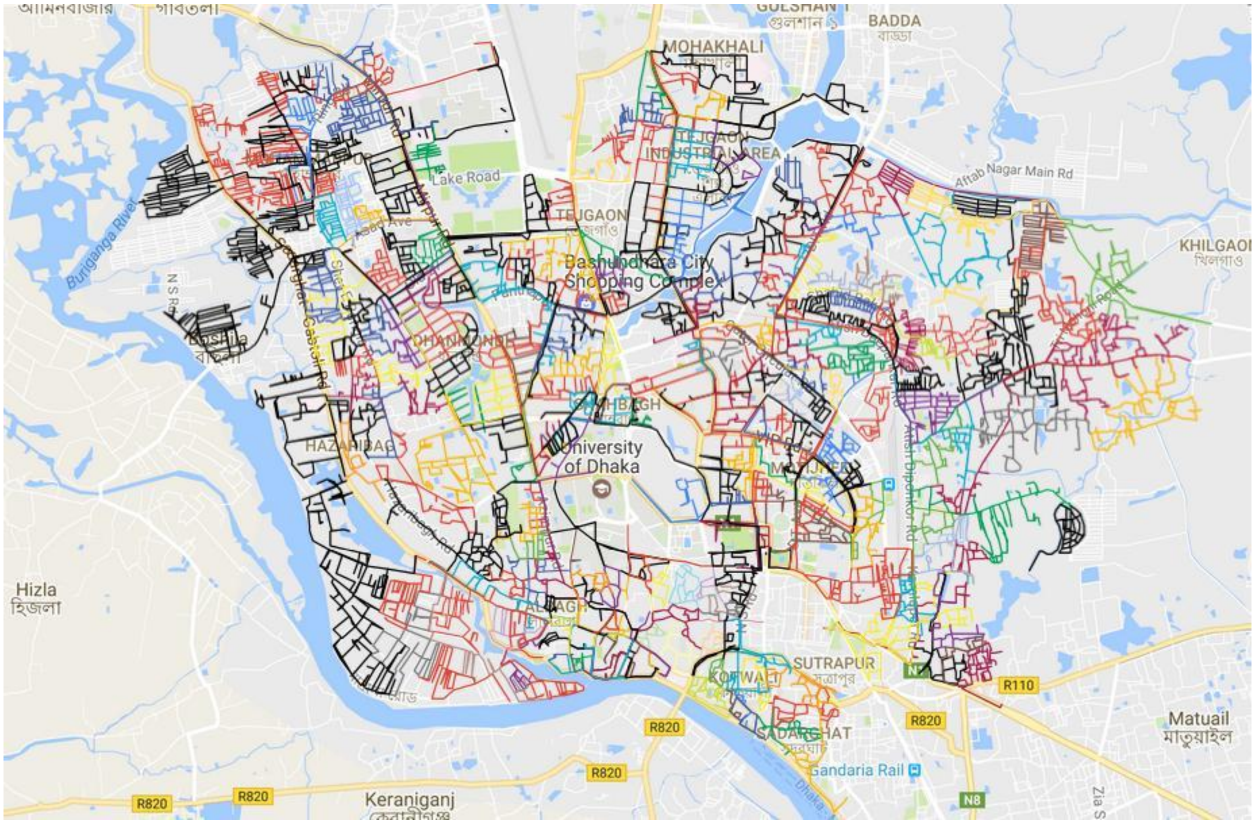


Figure A10: A satellite view of Dhaka with Feeder Maps
(Different color represents different feeder lines)



Appendix II

Institutions Comprising the Power Sector of Bangladesh

Generation of Power

The following government entities are involved in the generation of power:

1. Bangladesh Power Development Board. (BPDB)
2. Ashuganj Power Station Co. Ltd (APSCL)
3. Electricity Generation Company of Bangladesh Ltd. (EGCB)
4. Rural Power Company Ltd. (RPCL)
5. North West Power Generation Company Ltd. (NWPGCL)
6. Independent Power Producers (IPPs)

Transmission of Power

Power Grid Company of Bangladesh (PGCB)

Distribution of Power

The following entities are involved in power distribution:

1. Bangladesh Power Development Board. (BPDB)
2. Rural Electricity Board (REB)
3. Dhaka Electric Supply Co. Ltd (DESCO)
4. Dhaka Power Distribution Co. Ltd. (DPDC)
5. West Zone Power Distribution Co. Ltd (WZPDCL)
6. North West Zone Power Distribution Co. Ltd (NWZPDCL)
7. South Zone Power Distribution Company Ltd (SZPDCL)

Bangladesh Power Development Board (BPDB)

Bangladesh Power Development Board (BPDB) was established in 1972, responsible for power generation, transmission and distribution. The BPDB is responsible for major portion of generation and distribution of electricity mainly in urban areas of the country. In its 39 years of service the generation capacity has increased from a mere 200 MW to 7100 MW in recent time.

Rural Electrification Board (REB)

Rural Electrification Board was established in 1977 as a semi-autonomous government organization and has been providing service to rural consumers since then. It is responsible for electrification in rural areas. As of today, there are 70 operating rural electricity co-operatives called Palli Bidyuit Samity (PBS), which bring service to approximately 79,00,000 connections.

Power Grid Company of Bangladesh (PGCB)

Power Grid Company of Bangladesh is a public limited company registered under companies Act and incorporated in November, 1996. It is responsible to operate the national power grid and to develop and expand the same with efficiency. The PGCB also handles the Operation, Maintenance and Development of the transmission system of the country for distribution of generated electricity.

Ashuganj Power Station Company Ltd (APSCL)

Ashuganj Power Station owned by APSCL is the second largest power station in the country. At present, the total capacity of its 8 units is 642 MW. It fulfills about 15 percent of loads throughout the country. APSCL is a public limited company registered under companies Act and was incorporated on 28 June, 2000.

Electricity Generation Company of Bangladesh Ltd (EGCB)

Electricity Generation Company of Bangladesh Ltd (EGCB) was incorporated with Register of Joint Stock Companies on February 16, 2004. It has existing power plants at two sites, namely Siddirganj 210 MW Power Station and Haripur 100 MW Power Station. A unit of 2x120 MW peaking power plant has been launched on February 2010.

Rural Power Company Ltd (RPCL)

Rural power company Ltd is the first Bangladeshi Independent Power Producer (IPP). RPCL registered as a public limited company under companies Act and was incorporated on 31 December, 1994. Rural Electrification Board (REB) owns 20 percent share and the rest 80 percent is owned by 9 Palli Biddyut Samity (PBS).

North-West Power Generation Company Ltd (NWPGCL)

North-West Power Generation Company Ltd (NWPGCL) is an enterprise of Bangladesh Power Development Board, which intends to establish three power plants at different locations in North-Western Zone of Bangladesh. Proposed power plants of NWPGCL are situated in:

1. Sirajgonj 150MW peaking power plant project-Expected to be commissioned by December 2011.
2. Khulna 150MW peaking power plant project-Expected to be commissioned by December 2011.
3. Bheramara 360MW Combined Cycle Power Development Project- Expected to be commissioned by September 2015.

Dhaka Electric Supply Co. Ltd (DESCO)

Dhaka Electric Supply Co. Ltd (DESCO) is the first electric distribution company, registered under companies Act, 1994, and established on November, 1996. Its distribution comprises 220 sq. kms. of Dhaka Mega City area namely, Mirpur, Pallabi, Kafrul, Kalyanpur, Cantonment, Gulshan, Banani, Uttara, Uttarkhan, Dakkhinkhan, Badda, Baridhara and Tangi.

Dhaka Power Distribution Company Ltd (DPDC)

Dhaka Power Distribution Company Ltd (DPDC) former DESA was registered on the 25 October, 2005 and had started its function as a company from July, 2008. DPDC distribution area comprises 350 sq. kms of Dhaka and Narayanganj.

West Zone Power Distribution Co. Ltd (WZPDCL)

West Zone Power Distribution Co. Ltd (WZPDCL) was registered on 4 November, 2002. WZPDCL is responsible for electricity distribution in 21 districts of Khulna and Barisal Division and greater Faridpur district. It had started its function from March, 2005.

North West Zone Power Distribution Company Ltd (NWZPDCL)

North West Zone Power Distribution Company Ltd (NWZPDCL) was registered on August 3, 2005. Its distribution area is entire Rajshahi Division. It has not started its operation as yet.

South Zone Power Distribution Company Ltd (SZPDCL)

South Zone Power Distribution Company Ltd (SZPDCL) was established on 6 May, 2008. It has not started its operations as yet.

Bangladesh Energy Regulatory Commission (BERC)

Bangladesh Energy Regulatory Commission (BERC) was established on April, 2004 under an Act. BERC frames all rules and regulation to ensure transparency in the management, operation and tariff determination in the electricity, gas and petroleum sector. The commission protects consumers and industry interest and promotes competitive market.

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