Present Situation of Electrical Energy Demand, Supply, Projection of Demand-supply and Renewable Energy Utilization and Progress

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Abstract—A brief overview of present electricity demand, supply, projection of them and renewable energy generation and progress has been presented in this paper. Electricity is the major source of power for most of the country's economic activities. According to the Bangladesh Power Development Board in July 2018, 90 percent of the population had access to electricity. However per capita energy consumption in Bangladesh is considered low. The country has a very limited energy reserve; small amounts of oil, coal and countable natural gas reserves. The country suffers an internal energy struggle, as about 88% of the country's power producing thermal plants are gas-based. To solve this problem, renewable energy is being used.

Keywords—Electrical Energy Supply, Energy Demand, Present Situation, Projection Supply and Demand, Consumption Pattern, Renewable Energy, Distribution loss.

I. INTRODUCTION

Electricity is the major source of power for most of the country's economic activities. Bangladesh being a developing country, the electric energy demand has been increasing at a significantly high rate as well as electric energy supply has been increasing but the state-owned electricity utilities suffer from large energy shortages. The electricity Demand in the system varies one hours to other hours. The maximum demand is occurred during 5 pm to 11 pm which is termed as 'peak hour' and other part of the time is termed as off-peak hour. The extent of this 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 higher Load Factor, as this would permit

better utilization of plant capacity. Moreover, the cost of energy supply during peak hour is higher, because some relatively costlier power plants are required to put in operation during the peak hour. For these reasons, load management is essential throughout the year for better capacity utilization of power plants and minimum generation cost.

In the time of Nawab Khwaja Ahsanullah, electrification of the capital city Dhaka began in 1901, only 19 years after New York and 13 years after London. [2] Later, an Electricity Directorate was established in East Pakistan in 1948. There were few Steam Turbines in Siddhirganj (maximum size 10MW), Chittagong and Khulna area at that time. In 1962, 40 MW Kaptai hydro-electric project was installed a 132kV transmission line between Dhaka and Chittagong was commissioned. [8] In 1971, after the independence of Bangladesh only 3% of the population had access to electricity. In 2010, Shikalbaha and Siddhirganj power plant start to generated 255MW and also start to generated 520MW in some private sector. About 1763MW electricity add in national grid and captive power. It has been increased to 59.6% in 2012. However, 79 % percent of the connected consumers suffer from load-shedding, and 60% of the consumers face low voltage supply. In 1974-75, the installed electricity generation capacity was 667 MW whereas in August 2016 it was 12780 MW including the 600 MW power import from India. Bangladesh's total installed electricity generation capacity (including captive power) was 15,351 megawatts (MW) as of January

2017[4] and 15,500-megawatts in 2018[6]. The 88% of the population had access to electricity in 2018. [6] There are 52 public power plant in 2019 which generated about 8,845-Megawatt electricity.

The total installed capacity is 20,000 MW (combining solar power). Bangladesh's energy sector is booming.

The present government is committed to ensuring access to affordable and reliable electricity for all citizens by 2021. Recently, Bangladesh started construction of the 2.4-gigawatt (GW) Rooppur Nuclear Power Plant expected to go into operation in 2023. Also start construction of 7,554 MW power plant (such as Matarbari Power Station, Payra Thermal Power Plant, Rampal Power Plant, Feni Lanka Power Limited, Payra LNG Power Plant). Bangladesh will need an estimated 35,000 MW power by 2030. Bangladesh Government has undertaken various projects to meet this rapidly growing demand. They propose some new power plant. Our government is expecting to fill-up all shortage of electricity supply after completing these projects.

II. ELECTRICAL ENERGY SYSTEM IN BANGLADESH

Electrical energy system discusses about mainly generation & supply sector, demand sector, consumption sector. The supply sector is categorical as commercial energy and biomass fuels. The commercial energy comprises of natural gas, oil and electricity while the biomass fuels are agricultural wastes, animal wastes and fuel wood. In the demand sector, energy consumers make decision to utilize gas, oil and electricity based on both fuel price and the availability of the fuels whereas the biomass fuel consumption is mainly based on the availability of biomass fuels. The supply sectors (commercial and biomass) are the fuel supplies and imports. The imports are equal to the shortfalls in domestic supply.

A. *Electrical Energy Generation*

The power sector has experienced considerable progress in meeting the demand for electricity. Access, coverage, and level of consumption have significantly increased over the years. Daily load shedding has significantly dropped. Natural gas and coal are the main sources for power generation in the country. About 62.9% of Bangladeshi generated electricity comes from natural gas, while 10% is from diesel, 5% comes from coal, 3% of heavy oil, and 3.3% is of renewable sources.[2] There also some power plants are under construction and some are proposed. Total installed capacity was 15,953 MW which includes 4,452 MW IPP/SIPP, 1745 MW Rental Power Plant & 251 MW in REB (for PBS) and 660MW Power Import from India. The maximum peak generation was 10,958 MW which was 15.60% higher than that in the previous year. The reasons for lower peak generation with respect to generation capacity were: (i) some plants are out of operation for maintenance, rehabilitation & overhauling (ii) capacity of some plants dated due to aging and (iii) gas shortage.

Total net energy generation in FY 2018 was 62,678 GWh, which was about 9.43% higher than previous year's net generation of 57,276 GWh. Net energy generation in the public sector was 31,082 GWh and 26,813 GWh in the private sector (including REB). Another 4,783 GWh was imported from India through the interconnection in Bheramara and Tripura.

The list of power plants in Bangladesh is given below:

Table-1: List of all power plant in Bangladesh [3,11]

SL No	Name of power plant	Type of fuel	Installed Capacity (As of June) (MW)
1	Ghorashal 2x55 MW ST	Gas	110
	Ghorashal 2x210 MW ST	Gas	420
	Ghorashal 210 MW ST (5th Unit)	Gas	210
	Ghorashal 210 MW 7 th	Gas	365
2	Tongi 105MW GT	Gas	105
3	Haripur 3x33 MW GT	Gas	64
4	Siddhirganj 210 MW ST	Gas	210
5	Siddhirganj 2x120 MW GT	Gas	210
6	Haripur 412 MW CCPP	Gas	412
7	RPCL Gazipur 52 MW	F.oil	52
8	Kodda Gazipur 150 MW (PDB-RPCL)	F.oil	149
9	Siddhirganj 335 MW CCPP (EGCB)	Gas	217
10	Karnafuli Hydro	Hydro	230
11	Rauzan 210 MW /ST (1st)	Gas	210
	Rauzan 210 MW /ST (2nd)	Gas	210
12	Chattogram 60 MW /ST	Gas	60
13	Shikalbaha 150 MW Peaking PP	Gas	150
		HSD	
14	Hathazari 100 MW Peaking PP	F.oil	98
15	Sangu, Dohazari-kaliaish 100 MW PPP	F.oil	102
16	RPCL Raozan 25 MW	F.oil	25
17	Shikalbaha 225 MW PS	Gas	225
		HSD	
18	Sonagazi 1 MW Wind PP	Gas	0
19	Kutubdia 900KW Wind PP	Gas	0
20	Ashuganj 2x64 MW Steam Turbine	Gas	
21	Ashuganj 3x150 MW Steam Turbine	Gas	450
22	Ashuganj 50 MW GE	Gas	53
23	Ashuganj 225 MW CCPP	Gas	221
24	Ashuganj (South) 450 MW CCPP	Gas	360
25	Ashuganj (North) 450 MW CCPP	Gas	360
26	Chandpur 150 MW CCPP	Gas	163
27	Titas (Doudkandi) 50 MW RE	F.oil	52
28	Shahjibazar 70 MW GT, Habiganj	Gas	70
29	Shahjibazar 330 MW CCPP	Gas	330
30	Fenchuganj C.C. (Unit #1)	Gas	97
	Fenchuganj C.C. (Unit #2)	Gas	104
31	Sylhet 1x20 MW /GT	Gas	20
32	Sylhet 1x150 MW /GT	Gas	142
33	Khulna 1x110 MW Steam Turbine	F.oil	0
34	Khulna 225 MW (NWPGL)	HSD	230
35	Bheramara 3x20 MW /GT	HSD	60
36	Bheramara 360 MW CCPP (NWPGL)	Gas	410
37	Faridpur 50 MW Peaking PP	F.oil	54
38	Gopalganj 100 MW Peaking PP	F.oil	109
39	Barishal 2x20 MW /GT	HSD	40
40	Bhola 225 MW CCPP	Gas	194
41	Baghabari 71 MW /GT	Gas	71
	Baghabari 100 MW /GT	Gas	100
42	Sirajgonj 210 MW CC (NWPGL) Unit-1	Gas	210
		HSD	
43	Baghabari 50 MW Peaking RE	F.oil	52
44	Bera 70 MW Peaking RE	F.oil	71
45	Santahar 50 MW PP	F.oil	50

46	Katakhali 50 MW PP	Gas	50
47	Chapainobabgonj Peaking Power Station	HSD	104
48	Sirajgonj 210 MW CC (NWPGL) Unit-2	Gas	220
		HSD	
49	Sirajgonj 210 MW CC (NWPGL) Unit-3	Gas	0
		HSD	
50	Barapukuria Coal based S/T (unit 1,2)	Coal	250
	Barapukuria Coal based S/T (unit 3)	Coal	274
51	Saidpur 20 MW /GT	HSD	20
52	Rangpur 20 MW /GT	HSD	20
	Sub-Total grid (Public)		8845
Private Sector			
SL No.	Name	Fuel Type	Capacity (MW)
1.	Midland Power Co. Ashuganj 51 MW	Gas	51
2.	Rural Power Company Ltd.(RPCL) 210 MW	Gas	210
3.	Haripur Power Ltd. (CDC)	Gas	360
4.	Meghnaghat Power Ltd.	Gas	450
5.	Ghorashal, Regent Energy & Power Ltd. 108 MW	Gas	108
6.	Ashuganj Modular (United Power Co. Ltd.) 195 MW	Gas	195
7.	Summit Bibiyana-2 Power Co. Ltd. 341 MW	Gas	341
8.	Kushiara Power Co. Ltd(163 MW) CCPP	Gas	163
	Fenchuganj		
9.	Daudkandi 200MW(Bangla Trac.)	HSD	200
10.	Noapara 100 MW9Bangla Trac)	HSD	100
11.	Kodda Gazipur 300MW Power Ltd.(Unit-2) Summit	F. Oil	300
12.	KPCI (110MW),U-1 Tiger-1,3 (Burg) BMPP	F. Oil	110
	(summit-United)		
13.	NEPC Construction Power Ltd. (Haripur BMPP)	F. Oil	100
	110MW		
14.	Raj. Lanka Power Gen. Com Ltd. 55 MW, Natore	F. Oil	52
15.	Summit Meghnaghat Power Co. Ltd.	HSD	305
16.	Digital power & Associates Gagnagar	F. Oil	102
17.	Baraka Patenga	F. Oil	50
18.	ECPV Chattogram Limited 108 MW	F. Oil	108
19.	Lakdhanvi lanka –Bangla Jangalia Cumilla 52 MW	F. Oil	52
20.	Sinha Peoples Energy Ltd. Katpatti 52.5 MW Exp.	F. Oil	51
21.	Summit Barishal 110MW	F. Oil	110
22.	Sumit Narayangonj Power Unit-2 Madangonj 55MW	F. Oil	55
23.	Dhaka (Doreen) Northan Power Ltd. Manikganj	F. Oil	55
24.	Dhaka (Doreen) Southern Power Ltd. Nobabgonj	F. Oil	55
25.	Power Pac Mutiara Jamalpur 95 MW Power Plant Ltd.	F. Oil	95
26.	CLC Power CO. Ltd. 108 MW Bosila Keranigonj	F. Oil	108
27.	Banco Energy Generation 54 MW, Kamalaghat, Munshiganj	F. Oil	54
28.	Aggreko, Brahmangaon 100MW	HSD	100
29.	APR Energy 300MW	HSD	0
30.	United Mymensingh Power Ltd.(UMPL) 200MW,	F. Oil	200
31.	Aggreko, Aourahati 100MW	HSD	100

SL No	Name of power plant	Type of fuel	Installed Capacity (As of June) (MW)
32.	Engreen Solar Power Plant 3MW, Sharishabari	Solar	3
33.	Sailo Solar Power Plant Shantahar	Solar	0
34.	Shalla 400 KW Solar	Solar	0
	RENTAL & SIPP		
1.	Bogura RPP (24MW) 15 yrs GBB	Gas	22
2.	Bogura 20 RPP (3 Yrs) Energy Prima	Gas	20
3.	Ghorashal 78 MW QRPP (3 Yrs Max Power)	Gas	78
4.	Tangail SIPP (22 MW) (Doreen Power Ltd)	Gas	22
5.	Feni SIPP (22 MW) (Doreen Power Ltd.)	Gas	22
6.	Jangalia 33 MW (Summit Purbanchol Po. Co. Ltd.	Gas	33
7.	Ashugonj 55 MW 3 Years Rental (Precision Energy)	Gas	55
8.	B.Barua 70 MW QRPP (3 Yrs Aggreco)	Gas	85
9.	Ashugonj 53 MW Q. Rental PP (3 Years, United Power)	Gas	53
10.	Kumargaon 50 MW 3 yrs (Energyprima)	Gas	50
11.	Shahzibazar 86 MW RPP (15 yrs)	Gas	86
12.	Shahzibazar 50 MW RPP (3 yrs) (Energyprima)	Gas	50
13.	Kumargaon 10 MW Desh Combridge (15 Yrs)	Gas	10
14.	Fenchugonj 51 MW Rental (15 Yrs) (Barakatullah)	Gas	51
15.	Fenchugonj 50 MW Rental (Energy Prima)	Gas	44
16.	Barabkundu SIPP 22 MW (Regent Power)	Gas	22
17.	Malancha, EPZ, Ctg	Gas	0
18.	Bhola 32 MW (Venture Energy Resources Ltd.)	Gas	33
19.	Ghorashal 45 MW (Aggreko)	Gas	0
20.	Ghorashal 100 MW RPP (Aggreko)	Gas	0
21.	Shahjahanullah Power Gen Co. Ltd. (REB, Marchant)	Gas	0
22.	Aggreko 95 MW Bhola	Gas	95
23.	Khulna 55 MW RPP 3 yrs (Aggreko)	HSD	55
24.	Bheramara 110 MW 3 Yrs Rental (Quantum)	HSD	0
25.	Khulna 115 MW QRPP (5 Yrs Summit) (KPCL U-2)	F. Oil	115
26.	Noapara 40 MW QRPP (5 Yrs Khan Jahan Ali)	F. Oil	40
27.	Pagla 50 MW (DPA)	HSD	50
28.	Shiddirgonj 100 MW Q. Rental 3 Yrs (Desh Energies)	HSD	100
29.	Madangonj 100 MW QRPP (5 Yrs Summit)	F. Oil	102
30.	Meghnagat 100 MW QRPP (5 Yrs) IEL	F. Oil	100
31.	Siddhirganj 100 MW QRPP (5 Yrs) Dutch Bangla	F. Oil	100
32.	Shikalbaha 55 MW Rental (3 Years) Energies	F. Oil	51
33.	Amnura 50 MW QRPP (5Yrs, Sinha Power)	F. Oil	50
34.	Mutiara, Keranigonj 100 MW QRPP (5 Yrs) Power Pac	F. Oil	100
35.	Julda 100 MW QRPP (5 Yrs, Acron Infra)	F. Oil	100
36.	Katakhali 50 MW QRPP (ENA)	F. Oil	50
	IMPORT		
1.	Import from NVVN & PTC (Bheramara)	Import	
2.	Import from Tripura 100MW	Import	
3.	Import from India 40 MW	Import	
	GRAND TOTAL		15,953

Table-2: List of under-construction power plant [2,3,5,11]

SL No	Name	Type	Capacity (MW)
1	Matarbari Power Station	Coal fired	1200
2	Payra Thermal Power Plant	Coal fired	1320
3	Rampal Power Plant	Coal fired	1320
4	Feni Lanka Power Limited	Oil and gas fired	114
5	Payra LNG Power Plant	Oil and gas fired	3600
6	Rooppur Nuclear Power Plant	Nuclear	2,400
7	Teknaf Solar Park	Solar	200
Total		10154	

There is some proposed power plant. These power plant will start electricity generation within next few years. When all of proposed power plant start generation of electricity, we hope that there will no load-shedding occur.

Table-3: List of proposed power plant [2,3,5,11]

SL No	Name	Type	Capacity (MW)
1	Sutiakhali, Mymensingh Solar Park	Solar	50
2	Sunamganj Solar Park	Solar	32
Total			82

In present, Bangladesh generate electricity about 15,042MW (including 8,845MW in public sector & 6,197MW in private sector). Bangladesh government also import 660MW electricity from India. To fulfil our demand of electricity the 7554MW power plant are under construction and 2682MW power are proposed. At present, only 58% electricity generate by publicly and privately. About 29% power plants are under construction. After completing their construction about 7554 MW generation capacity add with our national grids.

B. Electrical Energy Demand and supply

Demand and supply: Though electricity supply is less than the demand, this difference is closing gradually according to the government. After Bangladesh's independence in 1971, only 3% of the total population had access to electricity. This ratio has gone up to 59.6% in 2012, and almost 76% by 2016.[2] The government have already taken some steps to increase electricity supply like Ruppur Nuclear Powerplant. [2,3,5,7] The demand of electricity was 3900 MW in 2000 and supply only 2030 MW. The demand is increase to 6454 MW in 2010 and 14014 MW in 2018. The supply also increases to 4200MW in 2010 and 8845 MW in 2019. We determine some projection of demand and supply up to 2036. This projection show that we overcome from storage of electricity in 2034.

Table-4: Year wise demand & supply of electricity in Bangladesh. [3,4,6,9]

Year	Grid system Demand (MW)	Supply (MW)
2000	3900	2030
2002	4000	2400
2004	4300	3103
2006	4730	3675
2008	5569	4033
2010	6454	4200
2012	7518	4960
2014	9268	6434
2016	11405	7360
2018	14014	8845

Demand & Supply Curve in Bangladesh (2000-2018):

The demand and supply curve show that the shortage of electricity in present. So, some time we face load shedding. It also shows that we can fulfil our all demand in 2032. In 2035, we hope some extra electricity will generate after fulfil all demand.

II. CONSUMPTION PATTERN OF BANGLADESH

Most of the energy consumption occur in domestic and Industrial sector. [6] According to the Bangladesh Power Development Board Energy Consumption Pattern of our Country is given in table:

Table-5: All retail consumption:

Year	Domestic	Agriculture	Commercial	Industrial	Others
2018	52.65%	2.60%	9.19%	33.42%	2.14%
2017	50.18%	3.09%	9.27%	35.45%	2.0%
2016	50.89%	3.61%	9.34%	34.28%	1.88%
2015	51.66%	4.13%	9.30%	33.58%	1.32%

The table show that about 53% electricity consumption by domestic uses and 33% electricity consumption by

industrial uses and Only 14% electricity used by Agricultural and commercial fields.

III. DISTRIBUTION SYSTEM LOSS

In 1991, Distribution loss in Bangladesh about 40% but present it reduce to only 10% in 2018. [2,3,6,13]

Total system loss (Distribution and Transmission loss) last 12 years is given below:

Table-6: All system loss(2006-2018)[7]

Year	Distribution Loss (%)	Transmission loss (%)	Total System Loss (%)
2006	19.06	4.97	21.25
2007	16.58	3.99	20.25
2008	14.43	2.9	18.45
2009	13.57	2.52	16.85
2010	13.10	2.24	15.73
2011	13.06	2.18	14.73
2012	12.15	2.35	14.61
2013	11.95	2.75	14.36
2014	11.89	2.72	14.13
2015	11.17	2.74	13.55
2016	11.01	2.73	13.10
2017	10.92	2.71	12.74
2018	9.89	2.76	11.87

In 2006, the total system loss 21.25% which is a large loss in our system. These losses can be reduced to 11.87 % in 2018.

TARGETS OF POWER GENERATION FROM RENEWABLE ENERGY

The source of gas and fuel are limited that is why the government taken some step to use renewable source to generate electricity and already started some project such as Teknaf Solar Park, Sutiakhali, Mymensingh Solar Park, Sunamganj Solar Park.

Now Bangladesh generate only 550 MW electricity from renewable sources. Targets of power generation

capacity by 2030 from renewable energy source given below: [1,2,10,13]

Table-7: Target use of renewable energy

Renewable Energy source	Achievements in 2019 (MW)	Target production in 2030 (MW)	Potential (MW)
Solar PV	210	500	5045
Wind	78	450	2000
Biomass	12	50	274
Biogas	7	10	-
Hydro-electric	230	400	-
Others	13	20	-
Total	550	1430	-

Scope of Renewable Energy:

Solar PV: Bangladesh is subtropical country. The daily solar radiation is 4-6.5 kWh/m². So, it makes the use of solar panels very effective. The government introduced a scheme known as solar home systems (SHS) to provide electricity to households with no grid access.

Wind: The average wind speed in Bangladesh between 3-4.5 m/s. There is a good opportunity in island and coastal areas for the application of wind mills for pumping and electrification.

Biomass: The common biomass resources available in Bangladesh are agricultural crop residues, wood residues, animal waste and municipal solid waste, etc.

Biogas: Bangladesh has the potential to generate 5204 Mm³ of biogas which could add around 7.30 GWh electricity to the national grid. The energy starved Bangladesh needs to promote biogas technology to reduce the dependence on conventional energy system as well to ensure energy security for the future.

Hydro-electric: Power can be produced through using the gravitational force of falling or flowing water. It is

the most widely used form of renewable energy. The dam at Kaptaimukh, built on the River Karnafuli in the Chittagong Hill Tracts (CHT), is the only hydro-electric power project in Bangladesh.

METHODOLOGY

NEWTON'S EXTRAPOLATION

Extrapolation is a type of estimation, beyond the original observation range, the value of a variable on the basis of its relationship with another variable. The formula of newton's extrapolation is given by:

$$Y_{n+1} = Y_n + \frac{Y_n - Y_{n-1}}{X_n - X_{n-1}} \times (X_{n+1} - X_n)$$

- Y_n = Present demand/supply
- X_n = Present Year
- Y_{n+1} = Demand/Supply of Projection
- X_{n+1} = Year of Projection

Demand and Supply projection

Newton's Extrapolation is linear extrapolation but our past data is not linear so we should be considering some factor such as transmission loss, Distribution loss, System losses, Target of renewable energy use and use of captive power. We consider decrement when calculated grid demand, K_d which depend on captive power use (such as personal solar, Biogas etc.) and consider increment when calculate grid supply, K_s which depend on reducing transmission loss, distribution loss and target of renewable energy used. For projection of demand,

$$Y_{n+1} = Y_n + \frac{Y_n - Y_{n-1}}{X_n - X_{n-1}} \times (X_{n+1} - X_n) - K_d$$

For projection of Supply,

$$Y_{n+1} = Y_n + \frac{Y_n - Y_{n-1}}{X_n - X_{n-1}} \times (X_{n+1} - X_n) + K_s$$

We determine some projection of demand and supply up to 2036. This projection show that we overcome from storage of electricity in 2034.

Table-5.1: projection of demand and supply up to 2036

Year	Grid system Demand (MW)	Grid Supply (MW)
2020	16473	10590
2022	18782	12505
2024	20941	14620
2026	22950	16935
2028	24809	19450
2030	26518	22165
2032	28077	25080
2034	29486	28195
2036	30745	31510

The demand and supply curve show that the shortage of electricity in present. So, some time we face load shedding. It also shows that we can fulfil our all demand in 2035. In 2036, we hope some extra electricity will generate after fulfil all demand.

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CONCLUTION

In this paper, we have briefly discussed about electrical energy situation in Bangladesh-demand, supply and future projection. According to the research, total electricity supply is almost 15000 MW whether total demand is more than supply [3]. The government have taken some steps to balance this demand and supply. We also projected energy generation till 2036 regarding to the generation improvement. We have calculated that the total grid power generated in Bangladesh is 8845 MW and total captive power generated is 6197 MW [1,3]. As the energy sources are limited, renewable energy sources are also been used.

If we use of captive power, reduce system, distribution and transmission loss and use targets of Renewable Energy, we hope to solve shortage of electricity and our projection will be successful.

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