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Study of Present Scenario of Power Sector in Bangladesh and Proposal to Minimize Losses for Increasing Efficiency

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Abstract

In this research work, an overview of present power sector of Bangladesh has been discussed with some important proposals for getting maximum efficiency in power generation based on the perspective of Bangladesh. Combination of Duel fuel engine system and Combined Cycle Power Plant (CCPP) should be established in every power station for getting higher efficiency. Whereas, power plants have limitation of fuel in Bangladesh, so that the duel fuel system is very effective for every power station. Besides, the micro-grid concept with renewable energy has been proposed for establishing more effective power system in Bangladesh and for rural development. In this research work, various statistics of generation from different types of running power station, their efficiency, power demand, installed capacity, deficiency of power, power plant under construction and the future plan of the govt. in power sector have been discussed. The present billing scenario has been also listed for getting an idea from the customers' point of view. A short list has been shown of different types of transmission & distribution losses, overall system losses of Bangladesh & besides, few important proposals of minimizing losses are also included in this research work.

Keywords: power generation; transmission; distribution; system; loss; capacity.

1. Introduction

Bangladesh's power generation capacity was 4,942 MW in 2009. Over the years, the capacity has increased to 20,775 MW including captive power plant & renewable energy source (ref: Powercell) or 17043 MW (ref: BPDB). With increased power production, the price was also raised many times, leading to dissatisfaction among consumers [1,2].

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But despite all the headway, people continue to suffer from regular power cuts lasting six to eight hours on average every day during the summer. Retail electricity price was last increased by Tk 0.35 per unit, or 5.3% on a weighted average on November 23, 2017. There was a daily demand for 12,000MW while the power generation was little over 9,000MW. The present government has been successful in increasing power generation, distribution and transmission line, raising the number of power plants, increasing the number of consumers, and raising per capita power production capacity since 2009. According to the Power Division, the currently installed power generation capacity is 20,775 MW but is only capable of producing 12,922MW because of reduced power generation capacity of some power plants. The government recently took initiative to set up 20 oil-based small-scale power plants of 100 MW capacity each, instead of building larger ones to deal with load-shedding. However, experts say, this move will raise electricity generation cost and directly contradict the government's proclaimed policy of exiting oil-based power generation. 54% of the power is generated by the government, 41% comes from private sector and the remaining 5% are imported from India.

Main claimed that around 91% of the total population has access to electricity, including renewable energy, and the per capita generation had increased to 464 kWh from 220 kWh. Bangladesh has the highest rate of solar home system installations in the world. Bangladesh has successfully implemented 100% electrification in 26 upazilas as part of the Electricity for all by 2018 programmed. The total transmission and distribution system losses had been significantly reduced to 12.19% from 16.85% during the present government's tenure.

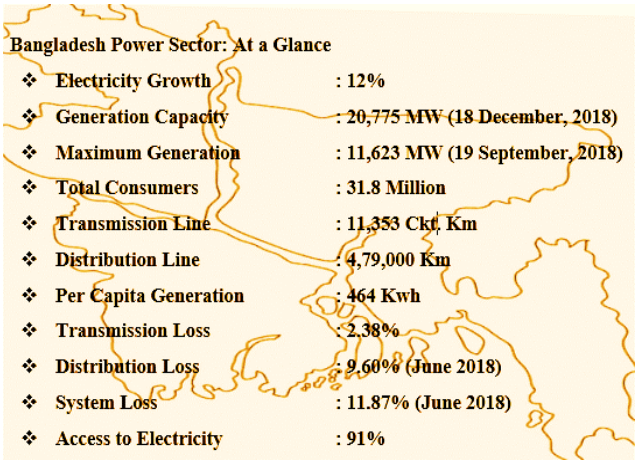


Figure 1: Bangladesh power sector (last update: 18 December, 2018; source: Powercell) [5]

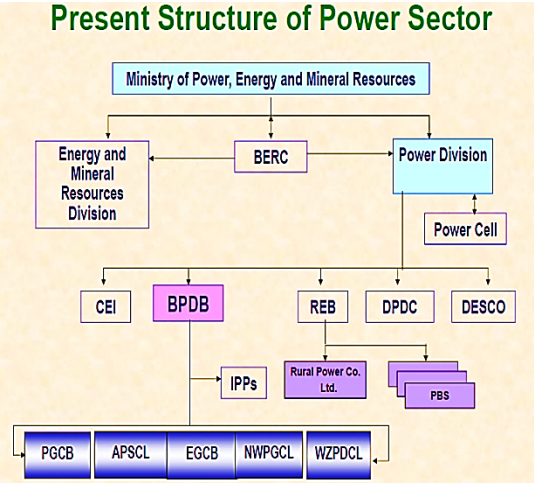


Figure 2: Present structure of power sector in Bangladesh [6]

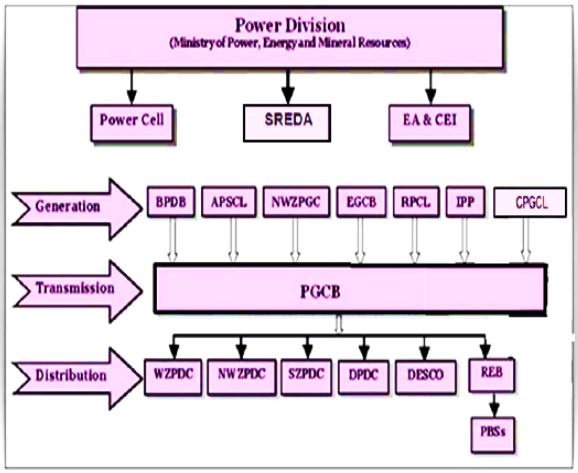


Figure 3: Institutional arrangement of Bangladesh power division [7]

Bangladesh claims the lowest per-capita consumption of commercial energy in South Asia. Bangladesh's power system depends on gas, coal, fossil fuels supplied by both private sector and state-owned power system. With a population of 160 million, Bangladesh is one of the world's most populated countries. Agriculture used to be the main source of income for the people of this country. However, the Gross Domestic Product (GDP) in Bangladesh was 7.28% percent in 2017. Rapid urbanization fueled by stable economic growth has created a huge demand of energy. In Bangladesh, electricity is the most widely used form of energy. So, future economic growth significantly depends on the availability of electricity. Bangladesh Government should ensure affordable and environmentally friendly source of electrical energy for the people. The Government has adopted a comprehensive energy development strategy to explore supply-side options along with demand management that conserves energy and discourages inefficient use [8].

1.1. Installed capacity and demand in Bangladesh

The present installed electricity generation capacity in the country is just meeting the demand which is in ever growing mode. In 1974-75, the installed electricity generation capacity was 667 MW whereas in September 2018 it was 20,775 MW including the 600 MW power import from India. It is evident from that the capacity has grown rapidly over the last few years. Promising Government policies have attracted private investment and Independent Power Producers (IPP). They are now producing approximate 46% of total power in Bangladesh. On top of this, 2650 MW, 2027 MW, 2763 MW, 2811 MW and 3812 MW power plants are expected to be synchronized with the national grid by the end of 2018, 2019, 2020 and 2021, respectively. Major portion of this power will be generated from coal-based power stations. The maximum power demand in the country has always been increasing and the rate has increased over the past couple of years. The demand increased rapidly after 2010. This is due to the fact that this demand actually represents the demand of connected loads of the grid. The installed capacity also has similar trend in terms of increase [8].

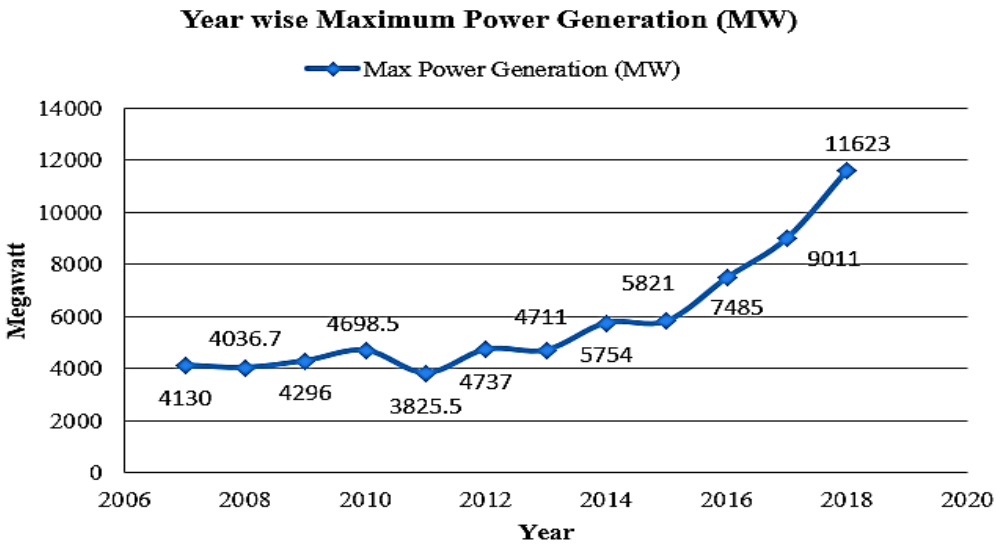


Figure 4: Year wise (2007-2018) maximum gross power generation in Bangladesh [9]

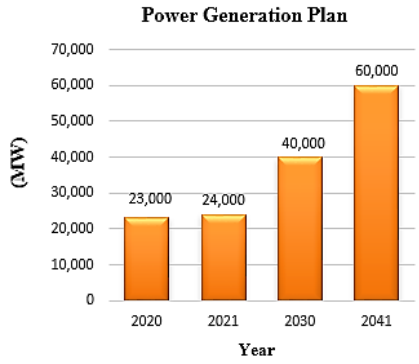


Figure 5: Year wise forecast of power generation plan (2020-2040) [31]

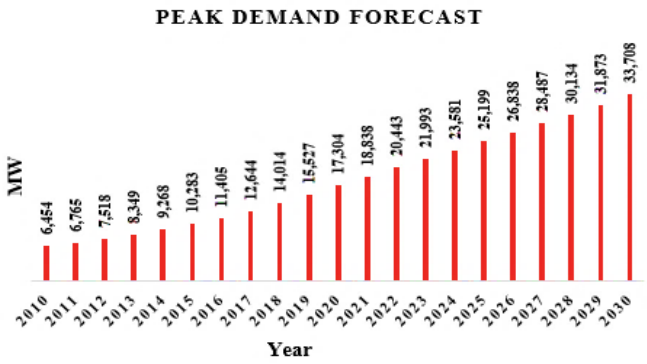


Figure 6: Year wise forecast of peak demand (2010-2030) [31]

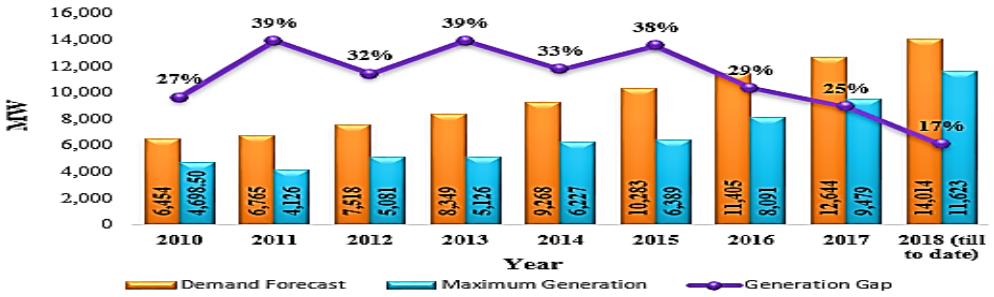


Figure 7: Year wise demand & generation gap

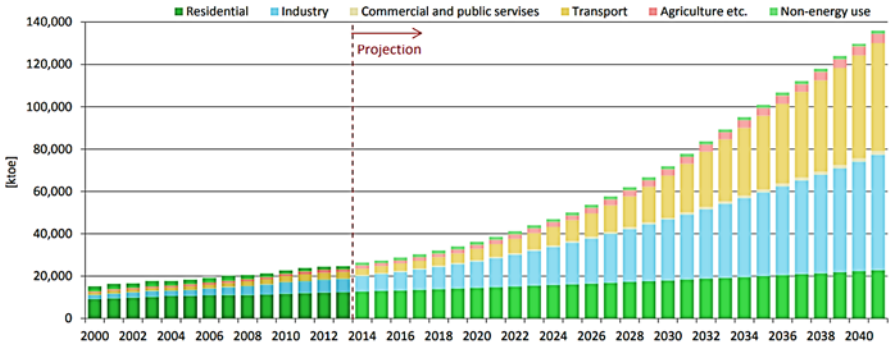


Figure 8: JICA survey: projection of final energy consumption (BAU Scenario) [29]

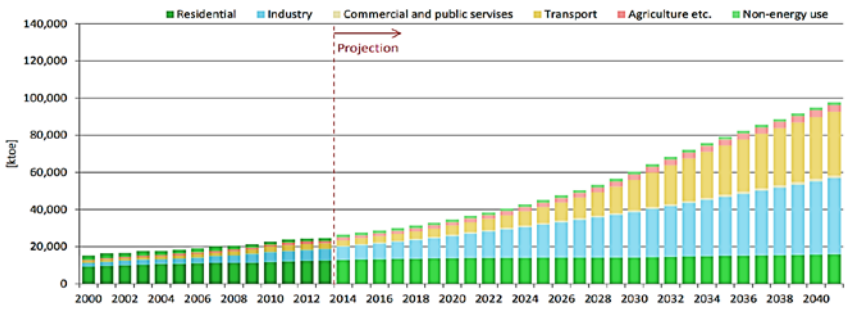


Figure 9: JICA survey: projection of final energy consumption (energy efficiency scenario) [29]

1.2. A shortlist of some upcoming important power plants of Bangladesh

The following 10 crucial and most important projects are upcoming under Power, energy and mineral resources ministry: [30]

- 1320MW Maitree Super Thermal Power project taken by Bangladesh-India joint venture with a target to implement it by 2019 in Rampal.
- 1200MW Matarbari coal-based power plant of Coal Power General Company Bangladesh Ltd (CPGCBL) in Cox's Bazar financed by Japan International Cooperation agency with a targeted implementation time of 2021.
- 1320 MW Payra Power plant a joint venture of North-West Power Generation Company Ltd (NWPGCL) of Bangladesh and Chinese power company CMC in Patuakhali.
- 1320MW Pekua power plant of Electricity Generation Company of Bangladesh – Mitsui joint venture with targeted implementation time 2023.
- Bangladesh Power Development Board's 1200MW Moheshkhali coal-fired with an implementation target of 2024.
- 1320MW Moheshkhali coal-fired power plant with an implementation target of 2022.
- 1320MW Ashuganj power plant with implementation target of 2021.
- 1200MW coal-fired power plant of CPGCBL-SEMBCORP with an implementation target of 2023.
- LNG-based combined cycle power plant of Reliance group of India with targeted implementation time 2023.
- Installation of two units of 1200 MW each VVER nuclear power plant at Ruppur, Pabna, commissioned by the year 2024.

1.3. Some graphical and tabular presentation of generation capacity, daily generation of power sector of Bangladesh

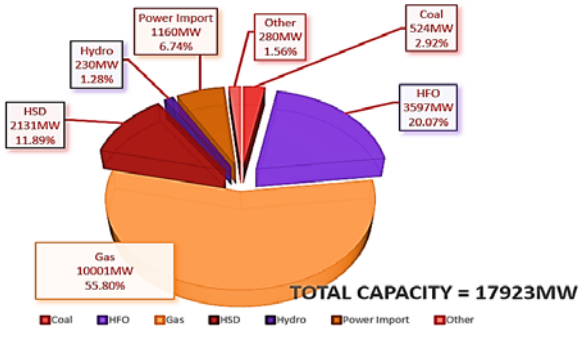


Figure 10: Fuel wise power generation capacity (MW) of Bangladesh (installed capacity of BPDB power plants as on October 2018) in year 2018 [11]

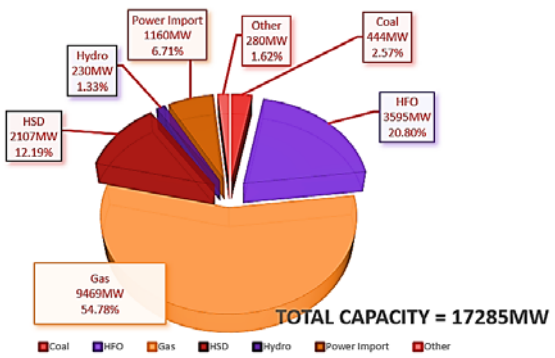


Figure 11: Fuel wise de-rated power generation capacity (MW) of Bangladesh (installed capacity of BPDB power plants as on October 2018) in year 2018 [11]

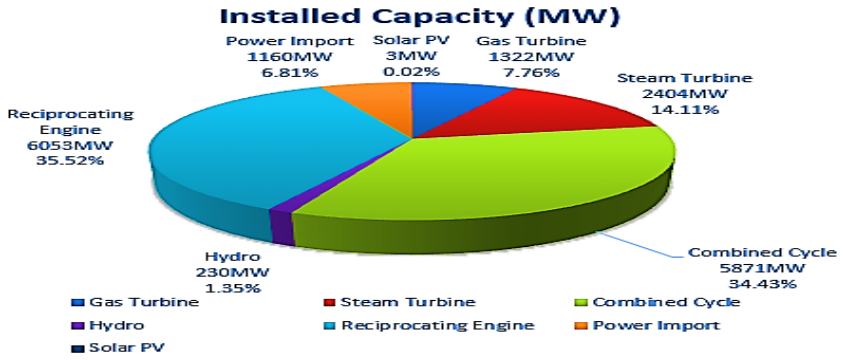
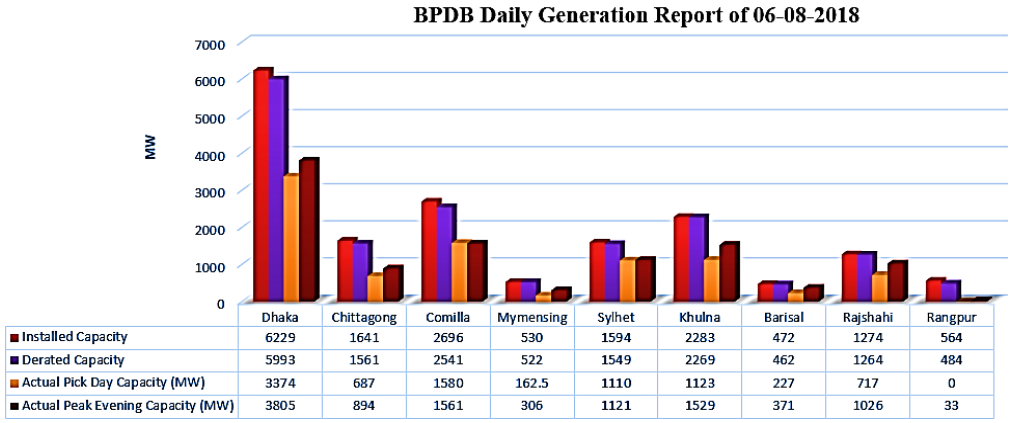


Figure 12: Technology wise power generation capacity (MW) of Bangladesh in year 2018 [10]



	Dhaka	Chittagong	Comilla	Mymensing	Sylhet	Khulna	Barisal	Rajshahi	Rangpur
Installed Capacity	6229	1641	2696	530	1594	2283	472	1274	564
Derated Capacity	5993	1561	2541	522	1549	2269	462	1264	484
Actual Pick Day Capacity (MW)	3374	687	1580	162.5	1110	1123	227	717	0
Actual Peak Evening Capacity (MW)	3805	894	1561	306	1121	1529	371	1026	33

Figure 13: Zone wise per day (actual pick day & evening) capacity (MW) of Bangladesh [12]

Table 1: Summation of total data of Bangladesh power generation [12]

Installed capacity	De-rated capacity	Actual peak day	Actual peak evening
17923.00	17285.00	9227.00	11485.00
N.B.: All data capacity value is megawatt (MW)			

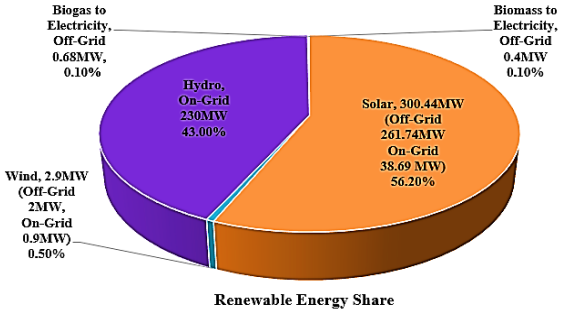


Figure 14: Technology wise present renewable energy resource 534.42MW (Off-Grid 264.82MW & On-Grid 269.59MW) [28]

Table 2: Comparison among different power plants (running & upcoming) of Bangladesh [8,13,14,25,27]

Plant type	Capacity	Efficiency
Natural gas power plants	61% power generation.	48% to 49%
Hydroelectric power plants	230 MW in Kaptai, Rangamati.	55%
Diesel power station	880 MW	overall 45%
Duel-fuel engine		High efficiency up to 50%.
Combined cycle power plant (CCPP)	By using combined cycle power plant, Bangladesh is getting 68% electricity.	up to 55%
Nuclear power plant	Install two units of 1200 MW each VVER nuclear power plant at Ruppur, Pabna, commissioned by the year 2024	• Approximately 55% efficiency • The life of the two new generation nuclear power plants will be 60 years
Coal based power plant	The plan is to produce about 7,500 MW from coal-based power plant by 2021.	45% to 48%
Renewable Energy	• Almost 18 million beneficiaries are getting solar electricity which is around 11% of the total population of Bangladesh. Currently <2% of total generation. • BPDB installed 900 KW capacity grid connected Wind Plant. • 1000 KW Wind Battery Hybrid Power Plant is installed (50 Wind Turbines of 20 kW capacity each). • BPDB has plans to setup 7.5 MW off Grid Wind-Solar Hybrid System with HFO/Diesel Based Engine Driven Generator. • IDCOL has financed 9 bio-gas based power plants, having total capacity of 618 KW and two rice-husk based power plants having total capacity of 650 KW in the country.	• IDCOL have approved 16 Solar Mini-Grid Projects, among which 7 are operational while the rest are under construction. • The mini-grid project has created access to low- emission electricity for almost 5000 rural households in Bangladesh. • IDCOL has additional targets to install 50 solar mini-grid by 2018. IDCOL has approved 459 solar irrigation pumps of which 324 are already in operation. IDCOL has financed solar powered solution for 138 telecom base transceiver stations (BTS) in off-grid areas

Table 3: Present scenario of renewable energy [28]

Operational condition	Capacity
Completed & Running	302.95 MW
Implementation Ongoing	542.79MW
Under Planning	1,339.41 MW
Obsolete System/Plant	2MW
Total	2,187.15 MW

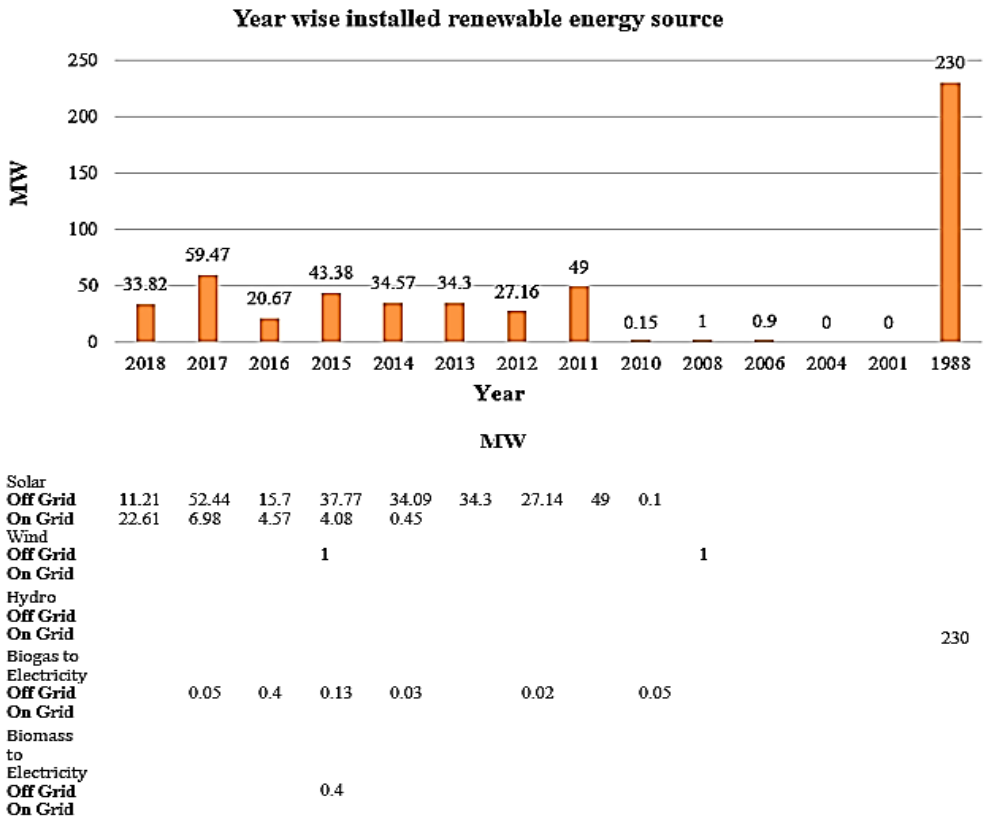
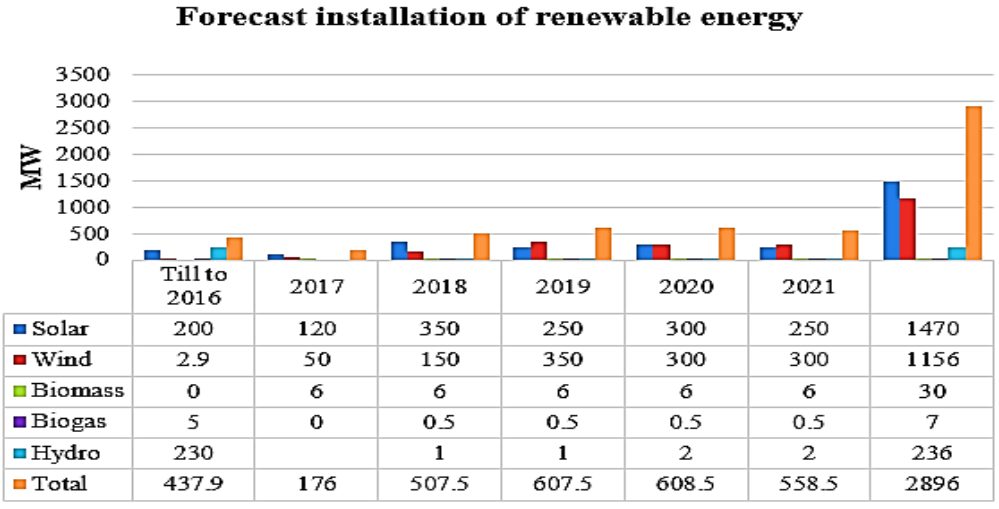


Figure 15: Year wise installed renewable energy [28]



	Till to 2016	2017	2018	2019	2020	2021	
Solar	200	120	350	250	300	250	1470
Wind	2.9	50	150	350	300	300	1156
Biomass	0	6	6	6	6	6	30
Biogas	5	0	0.5	0.5	0.5	0.5	7
Hydro	230		1	1	2	2	236
Total	437.9	176	507.5	607.5	608.5	558.5	2896

Figure 16: Forecast installation of renewable energy (to 2021) [26]

2. Transmission and network

Power Grid Company of Bangladesh (PGCB) is controlling the total transmission network of Bangladesh. Bangladesh grid sub-station capacity (MVA) data statistic are also given below:

Table 4: At a glance of transmission network of "power grid company of Bangladesh (PGCB)" [19]

PGCB Status: Public limited company; Business: Transmission of power	
Transmission line as on: June, 2018	
400kv	697.762 Circuit km
230kv	3342.622 Circuit km
132kv	6994.788 Circuit km
Substation as on: June, 2018	
400kv	1 Nos. 500MW HVDC back to back station
400/230kv	3 Nos. 2600 MVA
400/132kv	1 Nos. 650 MVA
230/132kv	19 Nos. 10275 MVA
132/33kv	
Last five years achievement	
400kv Substation	1 Nos: 500Mw HVDC back to back station
400/230kv Substation	3 Nos. 2600 MVA
400/132kv Substation	1 Nos. 650 MVA
230/132kv Substation	5 Nos:2300 MVA
132/33kv Substation	13 Nos. 5055 MVA
400kv Transmission Line	697.762 circuit km
230kv Transmission Line	716.726 circuit km
132kv Transmission Line	1129.85 circuit km
N.B: 400kv Transmission station: 01nos. (500 MW HVDC back to back station)	

Table 5: Grid sub-station capacity (MVA) [20,21]

Sub-station type	No. of sub-station	Capacity (MVA)
400/230 kV Sub-Station	02	1560
400/132 kV Sub-Station	01	650
230/132 kV Sub-Station	24	11485
132/33 kV Sub-Station	117	17298
Total	144	30,993

3. Present tariff plan (controlled by BERC)

The following are the list of present tariff plan implementing in Bangladesh depends on different customer types: [26]

Table 6: Comparison of different load connections

	Low Tension (LT)	Mid Tension (MT)	High Tension (HT)	Extra High Tension (EHT)
Electricity service:	AC: Single phase: 230 volt and Three phase: 400 volt	AC: 11 kvolt.	AC: 33 kvolt.	AC: 132 kvolt and 230 kvolt
Frequency:	50 cycles/second	50 cycles/second	50 cycles/second	50 cycles/second
Approved load:	Single phase: 0-7.5 KW and Three phase: 0-50 KW	50 KW to maximum 5 MW	5 MW to maximum 30 MW	**EHT 1:** 20 MW to maximum 140 MW**; EHT 2:** above 140 MW

Table 7: Present tariff plan for customer of LT

Customer Type	Unit	Approved tariff BDT/KWH	Customer Type	Approved tariff BDT/KWH
Type: LT-A: Residential			Type: LT-C 2: Construction	12.00
Life Line	0-50	3.50	Type: LT-D-1: Institution, religious place, charitable organization and hospital	5.73
Step 1	0-75	4.00	Type: LT-D-2: Street light, water pump, battery charging station	7.70
Step 2	76-200	5.45	Type: LT-E: Commercial place and office	
Step 3	201-300	5.70	1. Flat	10.30
Step 4	301-400	6.02	2. Off-pick time	9.27
Step 5	401-600	9.30	3. Pick time	12.36
Step 6	above 600	10.70	Type: LT-T: Temporary	16.00
Type: LT-B: Pump for agricultural		4.00		
Type: LT-C 1: Small industry				
1. Flat		8.20		
2. Off-pick time		7.38		
3. Pick time		9.84		

Table 8: Present tariff plan for customer of MT, HT and EHT

Customer Type	Approved tariff BDT/KWH	Customer Type	Approved tariff BDT/KWH
Type: MT-1: Residential		Type: HT-1: General	
1. Flat	8.00	1. Flat	8.00
2. Off-pick time	7.20	2. Off-pick time	7.20
3. Pick time	10.00	3. Pick time	10.00
Type: MT-2: commercial place and office		Type: HT-2: commercial place and office	
1. Flat	8.40	1. Flat	8.30
2. Off-pick time	7.56	2. Off-pick time	7.47
3. Pick time	10.50	3. Pick time	10.38
Type: MT-3: Industry		Type: HT-3: Industry	
1. Flat	8.15	1. Flat	8.05
2. Off-pick time	7.34	2. Off-pick time	7.25
3. Pick time	10.19	3. Pick time	10.06
Type: MT-4: Construction		Type: HT-4: Construction	
1. Flat	11.00	1. Flat	10.00
2. Off-pick time	9.90	2. Off-pick time	9.00
3. Pick time	13.75	3. Pick time	12.50
Type: MT-5: General		Type: EHT-1: General	
1. Flat	8.05	1. Flat	7.95
2. Off-pick time	7.25	2. Off-pick time	7.16
3. Pick time	10.06	3. Pick time	9.94
Type: MT-6: Temporary	15.00	Type: EHT-2: General	
		1. Flat	7.90
		2. Off-pick time	7.11
		3. Pick time	9.88

4. Statistics of transmission loss, distribution loss and system loss of Bangladesh

The following statistics are presenting the scenario of transmission loss, distribution loss and system loss of Bangladesh: **Transmission loss:**

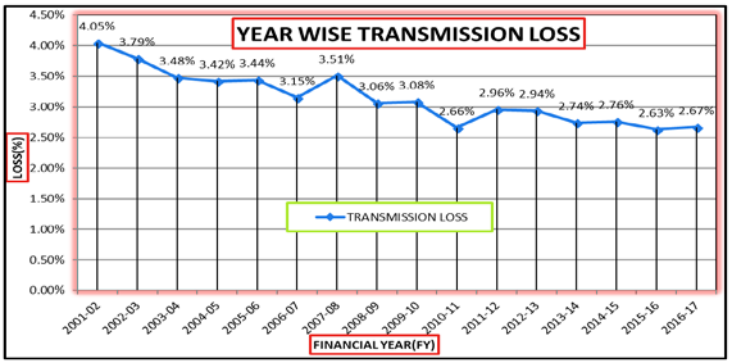


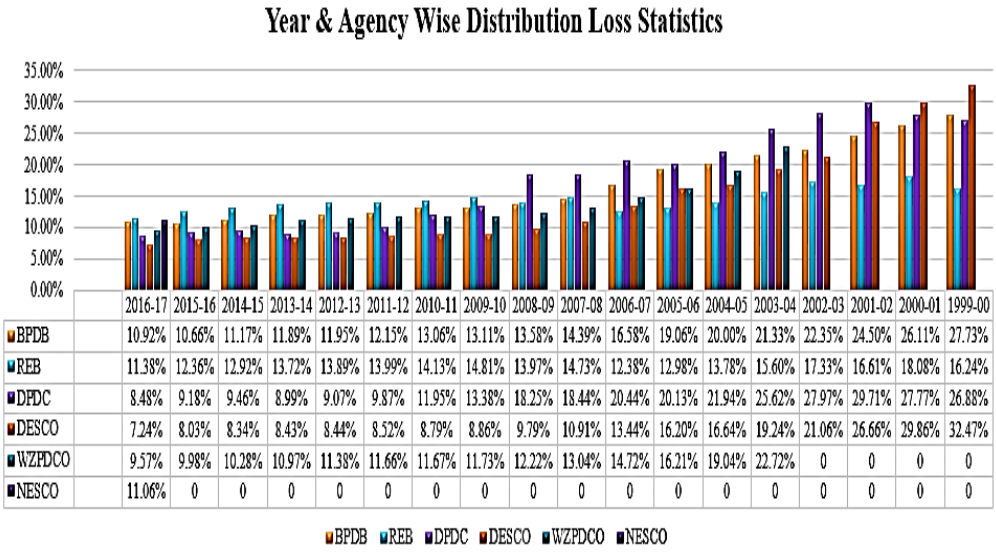
Figure 17: Financial year (2001-02 to 2016-17) wise transmission losses in Bangladesh [21]

Distribution loss:

Table 9: Lines and substation data of five of the distribution companies [20,22]

Quantities	BREB (rural areas)	DPDC (Dhaka)	DESCO (Dhaka)	WZPDCL (west zone)	NESCO (north zone)	BPDB (rural and rest zone)	Total
Line (km)	3,38,294	4,821	4,519	11,044	10,404	28,596	4,01,678
	40%	42% electricity of PGCB		6%		23%	

Figure 18: Financial year (2001-02 to 2016-17) wise distribution losses in Bangladesh [22]



	2016-17	2015-16	2014-15	2013-14	2012-13	2011-12	2010-11	2009-10	2008-09	2007-08	2006-07	2005-06	2004-05	2003-04	2002-03	2001-02	2000-01	1999-00
BPDB	10.92%	10.66%	11.17%	11.89%	11.95%	12.15%	13.06%	13.11%	13.58%	14.39%	16.58%	19.06%	20.00%	21.33%	22.35%	24.50%	26.11%	27.73%
REB	11.38%	12.36%	12.92%	13.72%	13.89%	13.99%	14.13%	14.81%	13.97%	14.73%	12.38%	12.98%	13.78%	15.60%	17.33%	16.61%	18.08%	16.24%
DPDC	8.48%	9.18%	9.46%	8.99%	9.07%	9.87%	11.95%	13.38%	18.25%	18.44%	20.44%	20.13%	21.94%	25.62%	27.97%	29.71%	27.77%	26.88%
DESCO	7.24%	8.03%	8.34%	8.43%	8.44%	8.52%	8.79%	8.86%	9.79%	10.91%	13.44%	16.20%	16.64%	19.24%	21.06%	26.66%	29.86%	32.47%
WZPDCO	9.57%	9.98%	10.28%	10.97%	11.38%	11.66%	11.67%	11.73%	12.22%	13.04%	14.72%	16.21%	19.04%	22.72%	0	0	0	0
NESCO	11.06%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 19: Statistics of year & agency wise distribution loss in Bangladesh [22]

System loss:

System loss is one of the key performance indicators. To achieve desirable performance and viability of the sector, there is no alternative to bring down the system loss to an acceptable limit. Various measures like continuous monitoring of the performance of the utilities, reforms & target-oriented measures are underway to reduce the system loss [5].

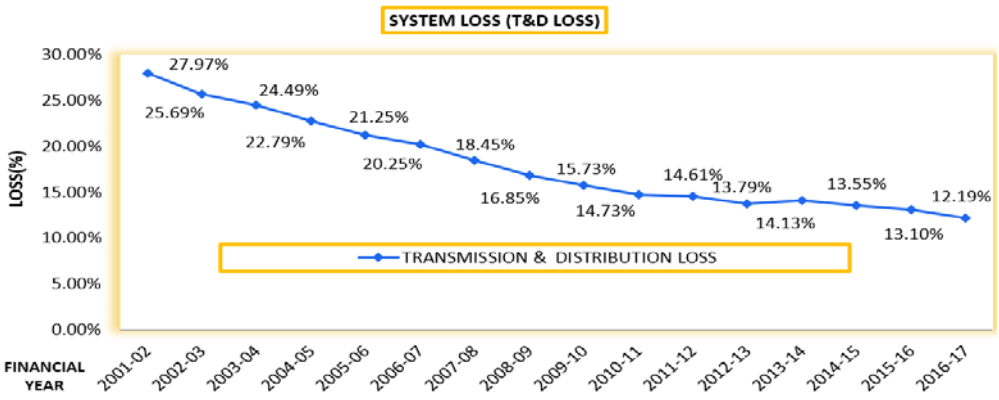


Figure 20: Financial year (2001-02 to 2016-17) wise system loss (transmission & distribution) statistics in Bangladesh power sector [21]

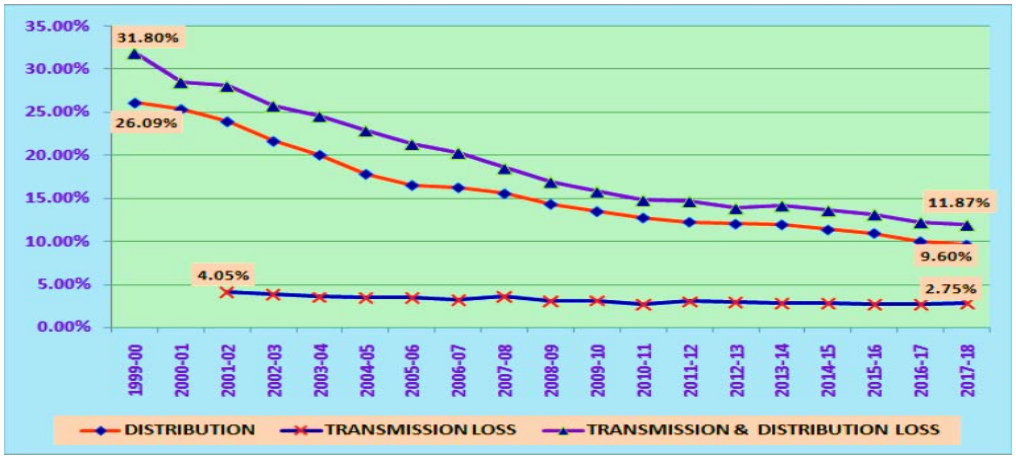


Figure 21: Financial year (1999-00 to 2017-18) wise transmission loss, distribution loss & system Loss (T&D Loss) in Bangladesh power sector [21]

In Bangladesh the percentage of transmission and distribution losses has been quite high. The transmission and distribution losses in the advanced Countries of the world ranging from 2% to 8%. However, the Transmission and Distribution losses in Bangladesh are not comparable with advanced countries as the system operating conditions are different in different countries.

Table 10: Comparison of Bangladesh & others countries system losses [23]

	System Losses										
Year	Australia	Germany	China	Japan	UK	Bangladesh	Brazil	India	USA	Pakistan	Belgium
2000	7.14	5.96	6.91	4.31	8.32	15.33	17.66	27.22	5.69	24.27	4.58
2001	8.09	5.7	6.98	4.23	8.39	13.87	17.24	28.24	4.41	26.06	4.94
2002	6.62	4.72	7.06	4.54	8.05	12.71	16.74	26.68	6.2	26.48	4.66
2003	6.54	4.47	6.6	4.61	8.11	11.52	16.27	26.74	5.61	25.2	4.5
2004	7.55	4.62	6.45	4.4	8.48	8.26	16.75	25.66	6.41	24.57	4.8
2005	6.72	4.76	6.82	4.27	7.06	7.43	16.59	25.17	6.31	24.04	4.85
2006	6.75	4.49	6.49	4.25	6.99	6.02	16.82	23.66	6.23	22.31	4.95
2007	6.02	4.63	6.28	4.22	7.08	5.17	16.14	22.77	6.18	19.59	4.64
2008	6.09	4.75	6.17	4.46	7.3	12.48	16.65	21.26	5.67	21.17	5.1
2009	5.9	4.24	6.08	4.52	7.55	11.27	17.19	21.13	6.26	19.88	4.53
2010	6.48	3.83	6.12	4.14	7.03	10.54	16.63	19.86	5.99	16.23	4.56
2011	6.52	4.08	5.74	4.36	7.54	10.19	16.46	19.39	6	16.88	4.67
2012	5.8	3.94	5.81	4.1	7.86	11.85	17.08	18.9	6.29	17.03	5.06
2013	5.34	3.87	5.78	4.49	7.49	13.16	16.63	18.46	5.96	16.27	4.87
2014	4.7	3.88	5.47	4.3	8.34	11.4	15.78	19.42	5.91	17.41	5.43

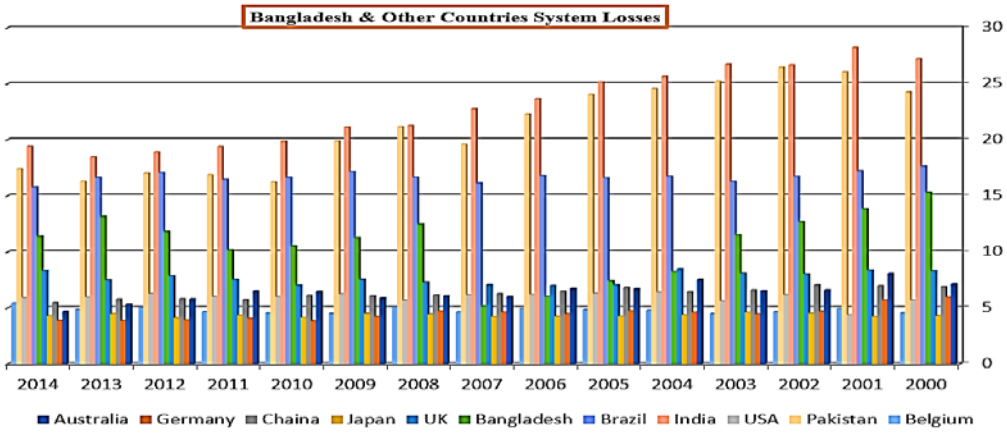


Figure 22: Flow Chart of comparison among Bangladesh & other countries' system losses [23]

5. Main reasons of technical and commercial losses in transmission and distribution system in Bangladesh

Energy losses occur in the process of supplying electricity to consumers due to technical and commercial losses. The technical losses are due to energy dissipated in the conductors and equipment used for transmission, transformation, sub- transmission and distribution of power. These technical losses are inherent in a system and can be reduced to an optimum level. The commercial losses are caused by pilferage, defective meters, and errors in meter reading and in estimating unmetered supplies of energy.

5.1. Reasons/causes of permanent or fixed technical power losses [3, 4, 18]

- Files Fixed losses do not vary according to current. These losses take the form of heat and noise and occur as long as a transformer is energized.
- Between 1/4 and 1/3 of technical losses on distribution networks are fixed losses. Fixed losses on a network can be influenced in the ways set out below.
- Losses: Corona, leakage current, dielectric, open-circuit.
- Losses caused by continuous load of measuring elements and control elements.

5.2. Reasons/causes of variable technical power losses [3, 4, 18, 24]

- Transmission loss due to ohmic resistance, inadequate reactive compensation.
- Loss due to feeding arrangement, used equipment's, self-expenditure within the power station.
- Interconnected network loss, leaking and loss of power.
- Inefficient equipment such as the transformers, pumps, electrical machines and industrial loads, too many stages of transformations.
- Inadequate investment in transmission and distribution, particularly in the sub-transmission and distribution sectors. Low investment has resulted in an overloading of the distribution system without commensurate strengthening and augmentation.
- Inadequate or inappropriate size of conductor in the distribution lines.
- Long distribution lines, load imbalance among the phases, over loading of lines
- Large scale rural electrification through long 11kV and LT lines.
- Unequal load distribution among three phases in LT system causing high neutral currents, distribution transformers are not installed at load centers.
- Load factor effect on losses, Low power factor of primary & secondary distribution system, improper load management.
- Lack of reactive power control of primary & secondary distribution system.
- Overrated distribution transformer & hence their underutilization.
- Haphazard installation of distribution systems to cope with demands to new areas.
- Bad workmanship contributes significantly role towards increasing distribution loss.
- Poor quality of equipment used in agricultural pumping in rural areas, cooler air-conditioners and industrial load in urban area.

5.3. Reasons/causes of commercial or non- technical power losses [3, 4, 18, 24]

- Loss due to illegal connection, billing loss, collection loss
- Consumption loss or Errors in meter reading and recording and bypassing the meter.
- Making unauthorized extensions of loads.
- Tampering the meter readings by mechanical jerks, placement of powerful magnets or disturbing the disc rotation with foreign matter, stopping the meters by remote control.
- Improper testing and calibration of meters.
- Willful burning of meters. Changing the sequence of terminal wiring.
- Changing the C.T. ratio and reducing the recording.

6. Proposals / recommendations for minimizing losses & increasing efficiency of generation, transmission and distribution system in Bangladesh

In Bangladesh, if ministry of Power, Energy & Mineral Resources (MPEMR) & Powercell administrator takes necessary steps (6.1.1 & 6.1.2) & execution those types of proposal, hopefully, system losses will be minimized

under 5% within vision 2030 (where transmission loss under 1.5% & distribution loss under 3.5%). If the government execute primary proposal properly in future trying to minimize system loss under 3% within vision 2041 (where transmission loss under 1% & distribution loss under 2%). When system loss will minimize, then transmission & distribution power efficiency will be increased & voltage regulation will also be increased.

6.1. Steps or ways to minimize or reduce system loss

Power losses in an electrical distribution network can be minimized by proper planning and designing of the lines, use of efficient equipment at both the distribution and consumer levels. In addition, there should be periodic maintenance, and replacing of malfunctioning and energy inefficient distribution equipment and parts. [3,4]

6.1.1. Steps to minimize technical loss [3, 4, 24]

- Gas Insulated Substation (GIS) must be installed in the grid transmission & distribution line.
- Distribution lines should be modernized. Interconnected network should be updated.
- Feeding arrangement should be renovated.
- High transmission voltage should be used to increase efficiency.
- Grid substation old transformer, switchgear & others controlling unit should be changed.
- The power station build's up beside the load center.
- Local electricity demand can be fulfilled by establishing small power plant.
- Only peak hour or special time, main grid should be used.
- Highly efficient equipment must be installed at both distribution & consumer level.
- Lower power and energy losses can be reduced by raising the load factor, which, evens out feeder demand variation throughout the feeder.
- The conductor size of the feeders should be adequate or appropriate.
- The distribution transformer should be located at the load center to keep voltage drop within permissible limits.
- By connecting the capacitors across individual loads, the line loss is reduced from 4% to 9% depending upon the extent of PF improvement.
- Connections to the transformer bushing-stem, drop out fuse, isolator, and LT switch etc. should be periodically inspected and proper pressure maintained to avoid sparking and heating of contacts & these reduce losses.
- Replacement of deteriorated wires and services should also be maintained timely to avoid any cause of leaking and loss of power.
- Distribution Transformer should be located at load center & reduced losses.
- Feeders are usually considered "balanced" and balancing load among distribution feeders will create lower losses assuming similar conductor resistance.

- Balancing 3-phase loads periodically throughout a network to minimize losses significantly.
- Over loading of lines should be ignored to reduce the losses.
- Poor quality equipment used in transmission line, distribution line, sub- station etc. should be changed to reduce line losses.
- Avoiding over loading of transformer will be very effective.
- Flexible AC Transmission Systems, or FACTS, can help to increase the efficiency of existing power distribution systems by maintaining acceptable voltage limits.

6.1.2. Steps to minimized commercial or non-technical loss [3, 4, 24]

- Advanced technology should be used in transmission & distribution system.
- Illegal connection must be disconnected from line or connect meter from line.
- Illegal connection must be found out & take necessary action against illegal person.
- Replace new meter instead of defect meter. Faultless digital meter should be connected.
- Pre-paid metering system should be used in all over Bangladesh.
- The meter reading should be monitored regularly & matching with electricity bill.
- Electricity billing system should be developed.
- Owing bill should be collected from consumer in regular basis.
- The person who involved in illegal electricity connection should have punished.
- The installed equipment must be protected from stealing by thief.

6.2. Importance of using micro-grid system associated with renewable energy [15, 16, 17]

The following are the basic advantages of Micro-grid system:

- Secure and reliable access to power
- Cost-effective and independent power supply
- Sustainable and low carbon

Micro-grids that include renewable power generation support sustainability goals through CO_2 reduction. This system will be very much effective in power sector of Bangladesh. There are five key categories of Micro-grid. These key Micro-grid categories include the following:

- Campus Environment/Institutional Micro-grids
- Remote “Off-grid” Micro-grids
- Military Base Micro-grids
- Commercial and Industrial (C&I) Micro-grids
- Community/Utility Micro-grids

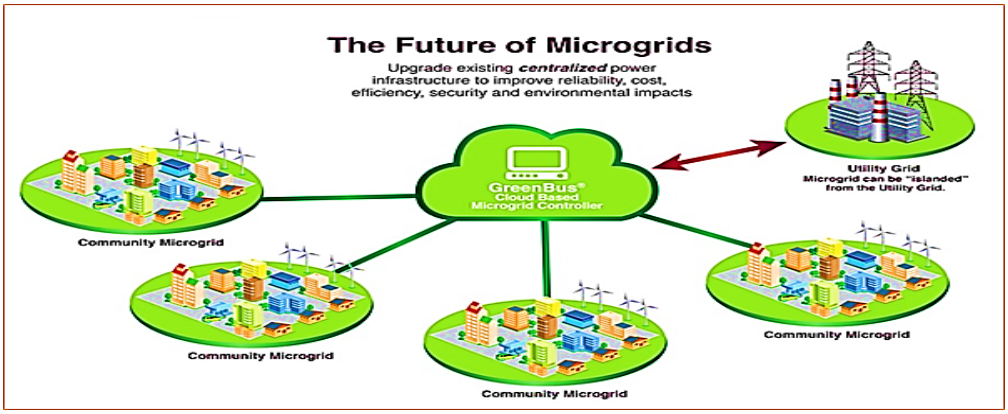


Figure 23: Future of Micro-grid system [15, 16, 17]

6.3. General proposals / recommendations for the development of power sector of Bangladesh

- If most of the power plant will be converted combined cycle power plant (CCPP), then our power generation efficiency will also be increased. To increase power generation efficiency, will be suggested to convert conventional power plant to combine cycle power plant (CCPP).
- Duel fuel engine system is most effective system in power generation efficiency. Though Bangladesh has not enough of fuel resources, so duel fuel engine should be established in new power plants & hopefully, it will increase power efficiency.
- For increasing power generation efficiency, conventional old technology should be replaced to modern technology.
- In modern science, Micro-Grid is new invention for power generation system. The micro-grids should be established where the gas, the fuel oil & others power generation fuel resources are not available in Bangladesh.
- Renewable energy like solar, water, wind etc. must be established elaborately in Bangladesh. Specially, renewable energy will be set up in the local area, island in Bangladesh where electricity connection has not been established yet.
- Hopefully, for proper planning and designing of the power generation, transmission & distribution system in Bangladesh it will be most effective.

7. Constraints\limitations of the study

The overall information, statistics, scenario, and data of present power sector of Bangladesh has been gathered in this research work with highest possible effort. Besides, all the discussed information has been analyzed to suggest some proposals for increasing efficiency according the perspective of power sector of Bangladesh. But it is obvious that the Government has some policy of its own for the power sector which is very much confidential and considering that condition the internal policy for power sector of the Government has not been discussed or analyzed here and no proposal has been suggested on that policy here for developing power sector. The billing system and tariff plan is set by BERC (Bangladesh Energy Regulatory Commission) which is totally controlled by the government. This tariff plan is set maintained some analysis and conversation of different

group of people and organization. So, in this research work that systematic policy has not been discussed.

8. Conclusions

In this research work, an overview of present power sector of Bangladesh has been shown with power losses (technical and non-technical) in an electrical transmission & distribution network. A few effective proposals have been analyzed based on the perspective of the power sector of Bangladesh to develop this sector with greater efficiency.

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