Actual Demand of Power Calculation by Using Statistical Method

A thesis report submitted to the department of Electrical & Electronic Engineering (EEE), Sonargaon University, for partial fulfillment of the requirements for the degree of Science in Electrical & Electronic Engineering.

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Candidates' Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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CERTIFICATION

I certify that I have read this thesis work and that, in my opinion, it is fully adequate, in scope & quality as a dissertation for the degree of BSc in Engineering.

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ABSTRACT

Electricity, the most convenient form of energy is one of the most important issues in Bangladesh perspectives. It is very important to know the actual demand (i.e. if there were no load-shed) of electricity for proper planning and managing electricity generation. It will help the decision-makers to provide directions on cost-effective investment and on scheduling the operation of the power plants. But it is very difficult to know the actual demand of Bangladesh due to lack of computerized and systematic recording of data. In this research, a method, supported by statistical test, has been proposed to determine the total demand of Bangladesh in a typical peak hour. This method is suitable for a power system like that in Bangladesh where proper information is not available.

Contents

Chapter-01

Introduction

Power Generation and Demand of Bangladesh

1.1 Overview of Power generation and demand of Bangladesh

Power system is the combination of three terms generation, transmission and distribution. But, power generation is the most important part of a power system. Bangladesh Power Development Board (BPDB), Independent Power Producers (IPPs) and Electricity Generation Company of Bangladesh Ltd. (EGCB) generates electricity in Bangladesh. However, generation lags in demand in Bangladesh due to various reasons such as ageing of generation units, inadequate supply of gas and other primary fuels, lack of funds and delaying of decision making/implementation to install new generation units and overhaul the old ones. According to National Load Dispatch Center (NLDC) for the year 2014, peak generation was 5167 MW on 29th September and peak demand was 5100 MW on 1st September [1]. Unfortunately there is no mechanism to know the actual demand as the load shed is usually done at grass root level by tripping 132/33KV feeders. But that record is not maintained by most of the distribution utilities or not done in a systematic way. The residential classification includes year-round and seasonal households, churches, and farms. The general service classification comprises mostly commercial and institutional establishments. The industrial classification is for customers involved in the extraction of raw materials or the manufacturing and processing of goods. The residential, general service and industrial forecasts are then separated into seven customer classifications: residential, general service, street lighting, industrial distribution, industrial transmission and wholesale (includes the sales to the preceding classifications by the municipal utilities in the cities of Saint John and Edmunds ton).Forecasts by customer classification are required for facilities and financial planning. The relative proportions of in-province energy sales in fiscal year 2013/14 to each of the seven customer.

1.2 Power Distribution Companies of Bangladesh

There are five power distribution companies in Bangladesh supplying electricity all over the country. The power distribution companies are-

- **Dhaka Power Distribution Company Limited (DPDC)**
- **Dhaka Electric Supply Company Limited (DESCO)**
- **Rural Electrification Board (REB)**
- **West Zone Power Distribution Company Limited (WZPDCL)**
- **Bangladesh Power Development Board (BPDB)**

Bangladesh has been divided into nine zones for power distribution. The above power distribution companies are supplying electricity in these zones.

Chapter:02

Proposed Demand Calculation Procedure

In this chapter we have discussed the demand calculation procedures for all the five power distribution companies of Bangladesh. These companies are supplying electricity throughout Bangladesh dividing it by nine zones. Zone-wise demand calculation has been shown in the next chapter.

2.1 DPDC demand calculation procedure

Data Collection:

We have collected the daily supply data of 132/33 feeders from some selective 132/33 KV substations for the months of September. These data have been collected from 132/33KV sub-stations because load-shedding is normally controlled from these type of sub-stations.

Load-shed Calculation of a sub-station:

Due to shortage of electricity, load-shed has to be done from 132/33KV feeders. To calculate the demand of an 132/33KV feeder it has to be turned on for 24 hours. But during the summer season every feeder has to be turned off on an average 3-4 hours daily due to load-shed. From hourly supply data of the log book of a sub-station, we have found that the load-shed time for an 132/33KV feeder is not fixed. It means the feeder which is turned off at 8.00 pm on a particular day is found turned on at that time before or after that day. So, analyzing the supply data for different days for that particular time 8.00 pm, a probable demand has been assumed for that 132/33KV feeder. All the feeders demand which were turned off during load-shed hour have been calculated in this way.

Demand Calculation of a sub-station:

The main purpose is to calculate the actual peak demand of all the substations. Then summing all the peak demands, total demand of the DPDC will be found. But it is very difficult to collect the daily supply data of all the 132/33KV substations and then calculate the actual peak demand. So, we have taken five typical 132/33 KV substations of DPDC in our account. The actual peak demand of a sub-station has been calculated by summing the daily supply and load-shed data. We have calculated the actual peak demand for 7-8 days of a month for each of the selected substations. Then we have determined a ratio of supply/actual peak demand for all these days individually. This ratio varies very slightly for different days in the same season. So, an average ratio of supply/actual peak demand has been calculated for each month of September for all the substations we have selected. From these average ratios of supply/actual peak demand another set of actual demands has been calculated for each sub-station.

Hypothesis Test:

We have tested the set of actual demands which have been calculated using the average ratio of supply/actual peak demand. In this case, '**z**' test has been used to identify whether the set of actual demands should be accepted or rejected. The details about '**z**' test [2] have been discussed in **Appendix A.**

Total demand of DPDC:

We have determined the total supply of DPDC at peak hour for different days of the months September. The average ratio of supply/actual peak demand of these one months has been calculated for all the selected DPDC substations. Then using these supply data and the average ratio, the actual demands of DPDC at peak hour have been calculated. The details about the calculation have been shown in chapter 3.

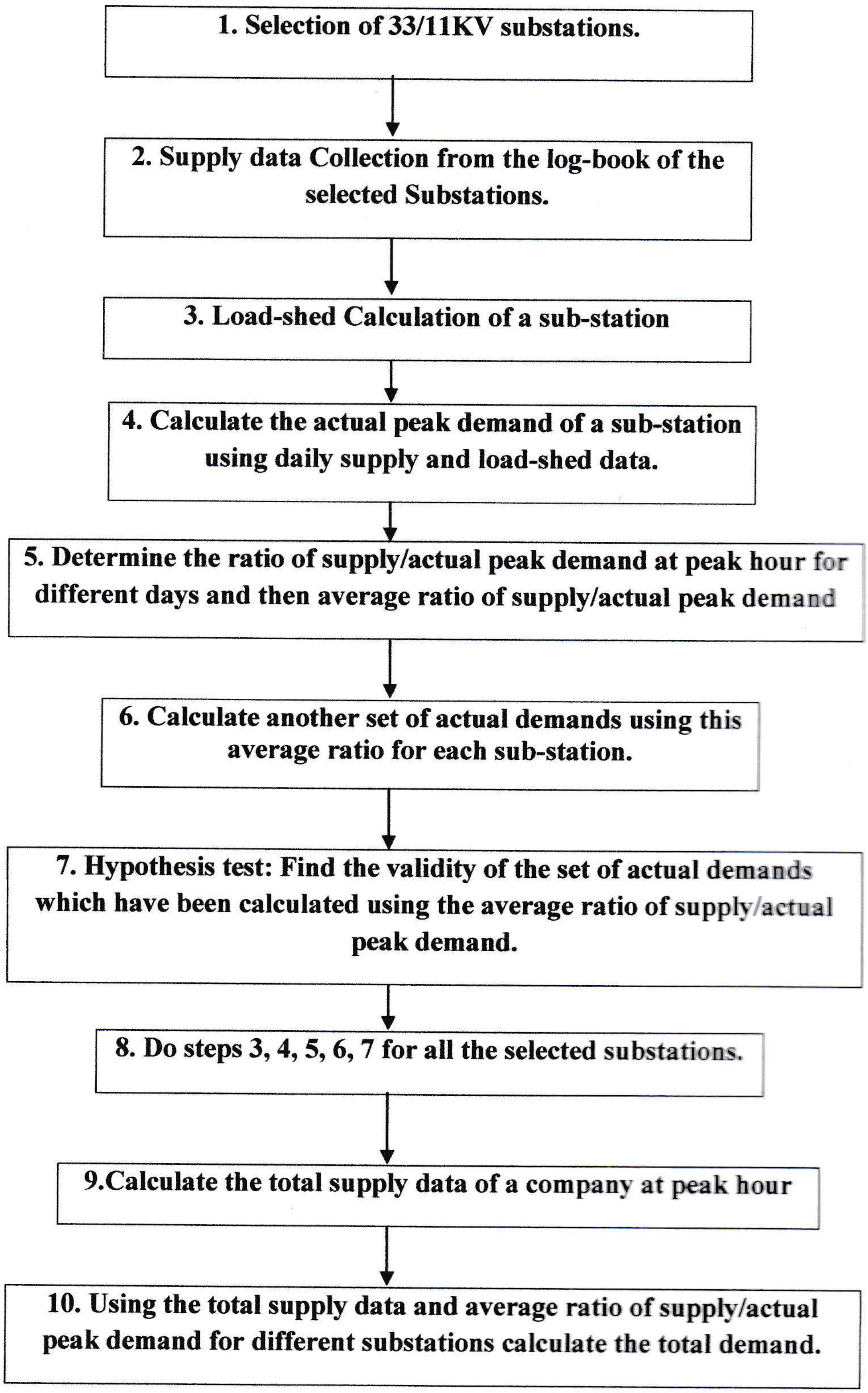

Figure 2.1: Flow chart of calculating the total demand of a power distribution company.

2.2 DESCO demand calculation procedure

- Like DPDC, the power distribution company DESCO also maintains log book for hourly supply data. Both the companies supply electricity in the same zone, Dhaka.
- Assuming both the companies have almost the same characteristics, the demand calculation of DESCO has been done with the help of DPDC demand analysis.
- The actual demand has been calculated using the average ratio of supply/actual peak demand which we have evaluated in DPDC demand analysis.

2.3 REB demand calculation procedure

The Rural Electrification Board has divided the whole country in nine zones according to the electricity demand. The demand data calculation procedure is discussed in the following:

- Unlike DPDC and DESCO, the power distribution company Rural Electrification Board (REB) maintains log book for hourly supply data.
- Every district under REB has one or more administrative offices called PBS. And every office has a network server itself to upload the supply data every day. The members of these offices collect supply data from Power Grid Company of Bangladesh for those above mentioned particular times.
- The demand data calculation of REB is experience based. Suppose, a substation has five feeders and the maximum demand of each feeder is known to the person who visits the sub-station to turn on/off the feeder. During peak hour, not all the feeders are turned on at the same time. So, the demand of the peak hour is calculated by summing the demand of the feeders which are already on and the previously observed maximum demand of the feeders which are turned off at that time.
- These supply and demand data are uploaded to REB head office server every day.
- So, in this way, demand calculation has been done using the information of REB mentioned above.

2.4 WZPDCL demand calculation procedure

The West Zone Power Distribution Company Limited (WZPDCL) supplies electricity to the urban areas of Greater Faridpur district, Khulna and Barisal divisions. The demand calculation procedure of WZPDCL is discussed in the following:

- WZPDCL maintains log book to record the hourly supply and load-shed data.
- To calculate the actual demand of each zone, we have directly used the demand and load-shed data collected from WZPDCL head office.

- **BPDB demand calculation procedure**

Bangladesh Power Development Board (BPDB) supplies electricity to the urban areas all over Bangladesh except Dhaka, Greater Faridpur district, Khulna and Barisal Divisions.

- It was difficult to collect the supply and load-shed data for about hundred numbers of 132/33KV substations of BPDB scattered over the country.
- NLDC records the total supply of all the zones [3]. The supply data of BPDB for a zone has been calculated by deducting REB supply from the total supply of that zone.
- In this work, an average ratio of supply/actual demand during peak hour has been calculated for WZPDCL served zones (Khulna and Barisal). This average ratio is then applied to BPDB served zones such as Comilla, Rajshahi, Rangpur and Mymensingh because both the companies supply electricity in the urban areas.
- For Chittagong zone of BPDB, we have used the average ratio of supply/actual demand during peak hour which was worked out for DPDC as demand characteristics of urban areas of Dhaka and Chittagong zones are almost similar.
- For Sylhet zone of BPDB, the average ratio of supply/actual demand during peak hour is assumed 0.95. This is because; Sylhet zone gets the highest amount of electricity supply during the summer season than any other zones.

Chapter :3

Results and Discussion

In the previous chapter we have proposed a method for calculating the actual demand of a power distribution company. In this chapter, we have shown the details calculation for determining actual demand of the power distribution company DPDC during peak hour. Then we have calculated the actual demand for all the nine zones. And finally we have determined the actual demand of Bangladesh at the132/33KV feeder end for the months of September, 2014.

3.1 DPDC demand analysis

To calculate the demand of an 132/33KV feeder, we have assumed Voltage, V = 10.5KV and power factor. So, the demand of any feeder at any hour can be calculated if the current drawn by that feeder is known. The demand of a feeder in MW is given by-

$$P_D = \sqrt{3}VICOS\emptyset$$

3.1.1 Mirpur (132/33 KV) substation demand calculation

Among all the substations of DPDC this sub-station is the biggest one. Normally, other substations have a capacity of around 30 MW, while this sub-station has around 45MW.

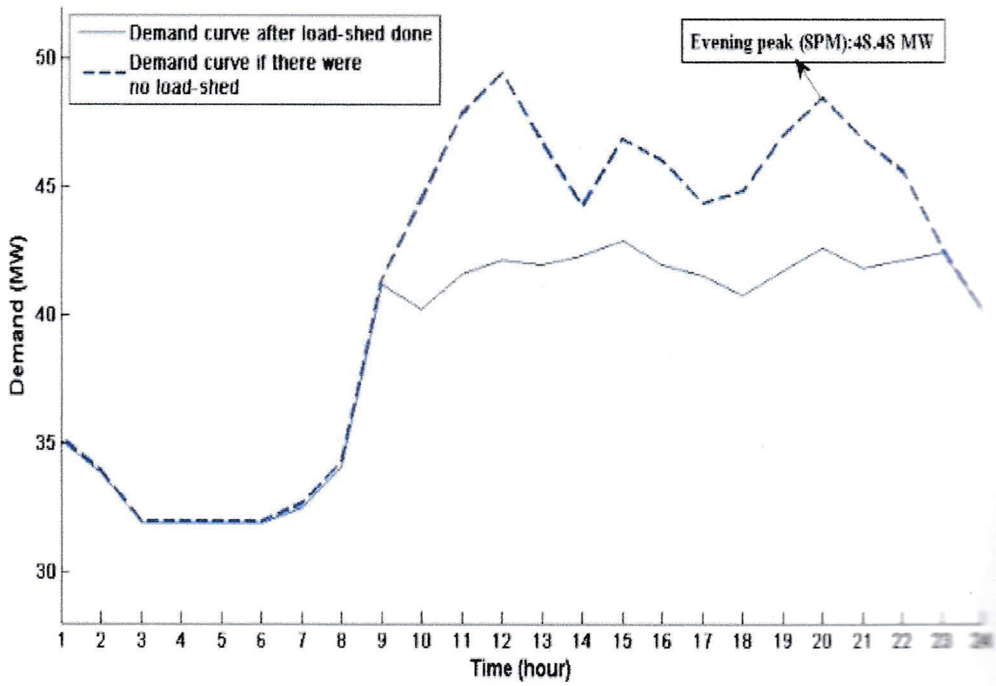

Figure 3.1.1: Load curve of Mirpur sub-station on September, 2014

* In these hours the feeders were under load-shed. So, the data have been taken from other days' records for the same hour when there was no load-shed at those feeders

3.1.1.2 Actual Peak demand and load-shed data of September, 2014:

The following table is showing the actual demand and the load-shed data during evening peak (8.00 pm) for some typical dates of the month September, 2014 [4].

Date	Actual demand during peak hour (MW),	Supply at peak (MW)	Load-shed (MW)	Ratio of $\frac{\text{Supply}}{\text{Actual demand}}$ during peak hour
1/09/14	115	90.5	24.5	0786
5/09/14	110	89.5	20.5	0.813
09/09/14	115	87.5	27.5	0.760
15/09/14	115	85.5	29.5	0.743
6/09/14	114	86.5	27.5	0.758
18/09/14	90	62.5	27.5	0.694
23/09/14	95	67.5	27.5	0.710
28/09/14	90	67.5	22.5	0.750

Table 3.2: Actual Peak demand of Mirpur sub-station for September, 2014

$$\text{Average actual peak demand,}\mu_0 = \frac{\sum \text{Actual peak demand,} x_p}{\text{No.of data taken,n}} = 105.5$$

From the above table, the ratio of Supply/Actual demand during peak is different from day to day. The average ratio of Supply/Actual demand during peak is 0.751, It means that the substation was provided on an average 0.751 supply of its actual demand during the peak hour in the month of September. 2015

3.1.1.3. 'Actual demand' calculation using average ratio & Hypothesis test:

$$'\text{Actual demand}' = \frac{\text{Supply(MW)}}{\text{Average ratio}}$$

Using the average ratio found above, another set of 'actual demands' have been calculated and tested whether the set of 'actual demands' is acceptable or not.

Date	Supply at peak (MW)	Average ratio of during peak hour	'Actual demand' using average ratio(MW),	Mean 'actual demand' using average ratio(MW),	Average of actual peak demands using data (MW),	Random variable, z = , =14.48 & n = 8
1/09/14	90.5	0.751	120.50	106.02	105.5	0.102
5/09/14	89.5		119.17			
9/09/14	87.5		116.51			
15/09/14	85.5		113.84			
16/09/14	86.5		115.17			
18/09/14	62.5		83.22			
23/09/14	67.5		89.88			
28/09/14	67.5		89.88			

Table 3.3: Actual demand of Mirpur sub-station in September, using average ratio and 'z' test

Result of 'z' Test:

Standard deviation, $\sigma = \sqrt{\frac{\sum(\bar{x}-x_i)^2}{n}}$ = 14.48 MW & number of sample, n = 8.

Average actual peak demand using data, μ_0 = 105.5 MW

Mean 'actual demand' using average ratio, $\bar{x}$ = 106.02 MW.

Here, the mean of 'actual demands' using average ratio is claimed to be equal to the average of actual peak demands using data.

Now, the Null Hypothesis H_0: μ = 105.5 MW has been tested against H_1 : $\mu \neq$ 105.5 MW if the mean 'actual demand' using average ratio is 106.02 MW with standard deviation, σ = 14.48 MW. The null hypothesis will be accepted if and only if $-1.96 \leq z \leq 1.96$ with the level of significance 0.05. Here, the value of z found is 0.102 which is in the acceptance region. So, the null hypothesis is accepted.

3.1.2 Kallyanpur (132/33KV) Substation demand analysis

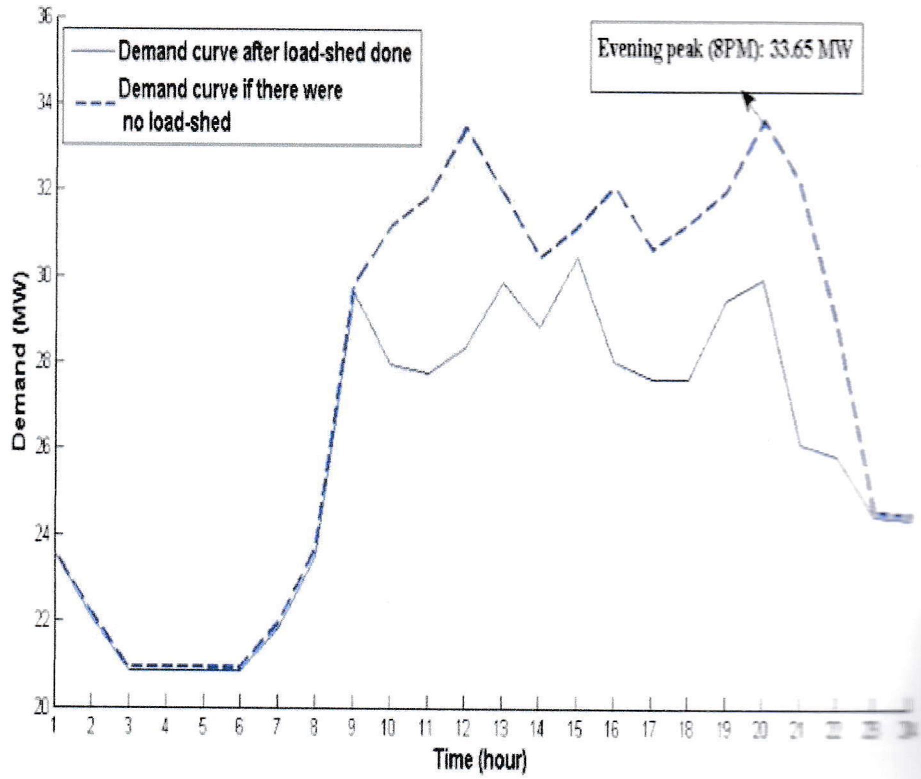

Figure 3.2: Load curve of Kallyanpur sub-station on September, 2014

3.1.2.1 Actual peak Demand and load-shed calculation

The following table is showing the actual demand and the load-shed data during evening peak (8.00 pm) for some typical dates of the month September, 2014 [5].

Date	Actual demand during peak hour (MW),	Supply at peak (MW	Load-shed (MW)	Ratio of $\frac{\text{Supply}}{\text{Actual demand}}$ during peak hour
1/09/14	170	153	17	09
5/09/14	168	152	16	0.905
9/09/14	167	153	14	0.916
15/09/14	170	159	11	0.935
16/09/14	172	162	10	0.941
18/09/14	170	150	20	0.882
23/09/14	173	150	23	0.867
28/09/14	150	138	12	0.92

Table 3.4: Actual Peak demand of Kallyanpur sub-station for selective dates of September , 2014

Average actual peak demand, $\mu_0 = \frac{\sum \text{Actual peak demand},(x_p)}{\text{No.of data taken,n}}$ =167.5 MW.

Standard deviation, $\sigma = \sqrt{\frac{\sum (x_0 - x_i)^2}{n}}$ = 7.33 MW.

The average ratio of Supply/Actual demand during peak hour is 0.908

3.1.2.2. 'Actual demand' calculation using average ratio & Hypothesis test

Using the average ratio found above, another set of 'actual demands' has been calculated and tested whether the set of 'actual demands' is acceptable or not.

Date	Supply at peak (MW)	Average ratio of during peak hour	'Actual demand' using average ratio (MW),	Mean 'actual demand' using average ratio(MW),	Average of actual peak demands using data(MW),	Random variable, $z = \frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}}$, $\sigma = 167.5$ & $n = 8$
1/09/14	153		168.50			
5/09/14	152		167.40			
9/09/14	153		164.50			
15/09/14	159	0.908	175.11	167.53	167.5	0.011
16/09/14	162		174.41			
18/09/14	150		165.19			
23/09/14	150		165.19			
28/09/14	138		151.98			

Table 3.5: 'Actual demand' using average ratio for September, 2014 of Kallyanpur sub-station and 'z' test

3.1.3. Gulshan (132/33 KV) Substation demand analysis

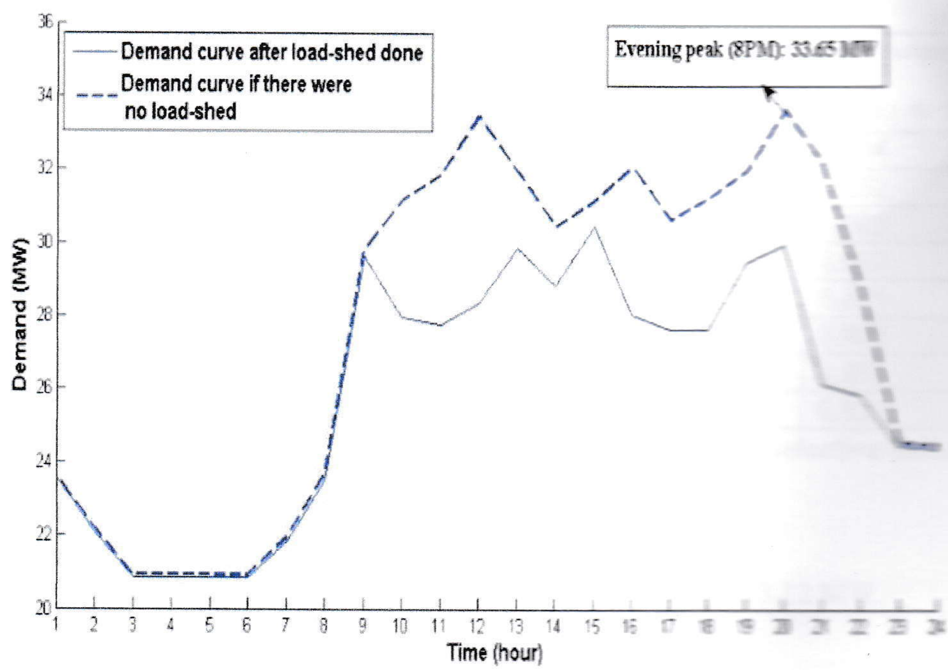

Figure 3.3: Load curve of Gulshan sub-station on September, 2014

3.1.2.1. Actual peak Demand and load-shed calculation

The following table is showing the actual demand and the load-shed data during evening peak (8.00 pm) for some typical dates of the month September, 2014 [6].

Result of 'z' Test:

Now, the Null Hypothesis H_0: μ = 167.5 MW has been tested against H_1 : $\mu \neq 167.5$ MW if the mean 'actual demand' using average ratio is 167.53 MW with standard deviation, σ = 7.33 MW.

The null hypothesis will be accepted if and only if $-1.96 \leq z \leq 1.96$ with level of significance 0.05. Here, the value of z found is 0.011 which is in the acceptance region. So, the null hypothesis is accepted.

3.1.3.1. Actual peak Demand and load-shed calculation

The following table is showing the actual demand and the load-shed data of Gulshan sub-station during evening peak (8.00 pm) for some typical dates of the month September, 2014 [6].

Date	Actual demand during peak hour (MW),	Supply at peak (MW)	Load-shed (MW)	Ratio of $\frac{\text{Supply}}{\text{Actual demand}}$ during peak hour
1/09/14	140	128	12	0.914
5/09/14	125	104	21	0.832
9/09/14	135	122	13	0.903
15/09/14	130	118	12	0.907
16/09/14	140	124	16	0.885
18/09/14	137	124	13	0.905
23/09/14	130	116	14	0.892
28/09/14	128	118	10	0.921

Table 3.6: Actual Peak demand of Gulshan sub-station for some selective dates of September, 2014

Average actual peak demand, $\mu_0 = \frac{\sum \text{Actual peak demand}(x_p)}{\text{No.of data taken,n}} = 133.12$ MW.

The average ratio of Supply/Actual demand = 0.894Using the average ratio, another set of 'actual demands' have been calculated and the average of these demands has been tested whether it should be accepted or not.

3.1.3.2. 'Actual demand' calculation using average ratio & Hypothesis test

Using the average ratio found above, another set of 'actual demands' has been calculated and tested whether the set of 'actual demands' is acceptable or not.

Date	Supply at peak (MW)	Average ratio of $\frac{\text{Supply}}{\text{Actual demand}}$ during peak hour	'Actual demand' using average ratio (MW), x_i	Mean 'actual demand' using average ratio(MW), $\bar{x}$	Average of actual peak demands using data(MW), μ_0	Random variable, $z = \frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}}$ $\sigma = 7.66$ & $n=8$
1/09/14	128	0.894	143.17	133.38	133.12	[illegible]
5/09/14	104		116.33			
9/09/14	122		136.46			
15/09/14	118		131.99			
16/09/14	124		138.70			
18/09/14	124		138.70			
23/09/14	116		129.75			
28/09/14	118		131.99			

Table 3.7: 'Actual demand' using average ratio for September 2014 of Gulshan Sub-station and 'z' test

Result of 'z' Test:

Standard deviation, $\sigma = \sqrt{\frac{\sum(\bar{x}-x_i)^2}{n}}$ = 7.66MW and number of sample, n = 8.

Here, the mean of actual demands using average ratio is claimed to be equal of the average of actual peak demands using data.

Now, the Null Hypothesis H_0: $\mu = 133.12$ MW has been tested against H_1: $\mu \neq 133.12$MW if the mean actual demand using average ratio is 0.894 MW with standard deviation, $\sigma = 7.66$ MW. The null hypothesis will be accepted if and only if $-1.96 \leq z \leq 1.96$ with level of significance 0.05. Here, the value of z found is 0.044 which is in the acceptance region. So, the null hypothesis is accepted.

3.1.4. Dhanmondi (132/33 KV) Substation demand analysis

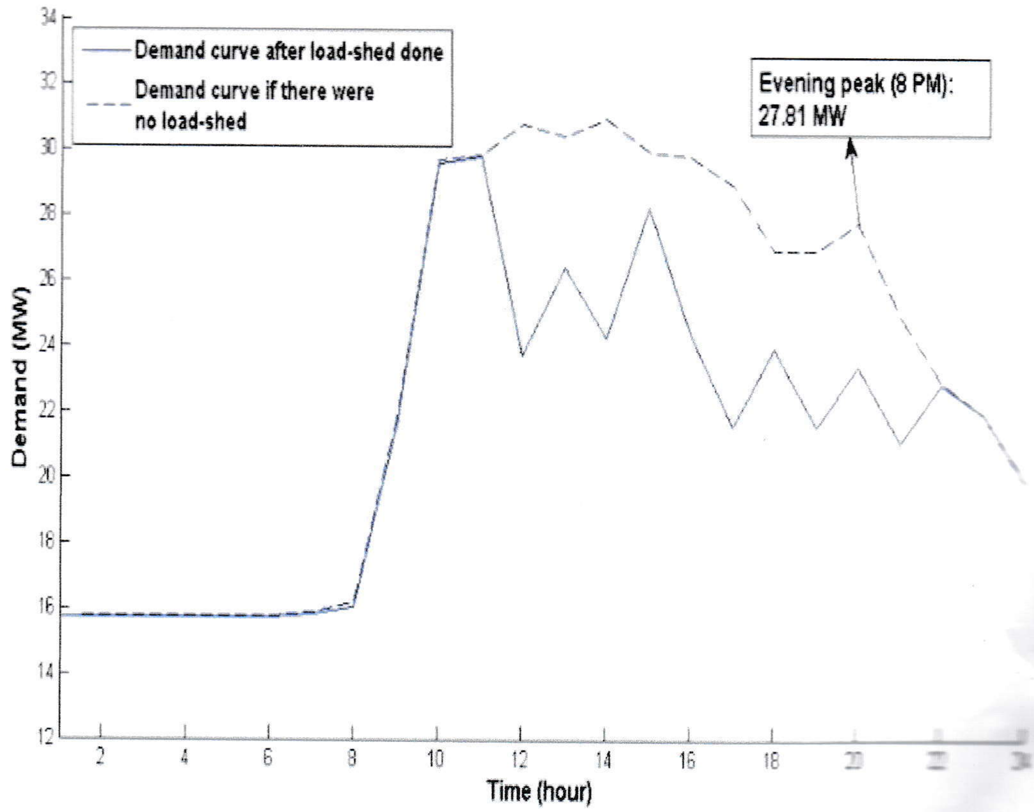

Figure 3.3: Load curve of Dhanmondi sub-station on September, 2014

3.1.4.1. Actual peak Demand and load-shed calculation

The following table is showing the actual demand and load-shed data of Dhanmondi sub-station at peak hour for some typical dates of the month September, 2014 [7]

Date	Actual demand during peak hour (MW), x_p	Supply at peak (MW)	Load-shed (MW)	Ratio of $\frac{\text{Supply}}{\text{Actual demand}}$ during peak hour
1/09/14	140	124	16	0.855
5/09/14	125	82	43	0.656
9/09/14	140	108	32	0.771
15/09/14	145	141	4	0.972
16/09/14	145	129	16	0.889
18/09/14	140	126	14	0.9
20/08/11	140	129	11	0.921
23/08/11	145	141	4	0.972

Table 3.8: Actual Peak demand of Dhanmondi sub-station for selective dates of September, 2014.

Average actual peak demand, $\mu_0 = \frac{\sum \text{Actual peak demand,} (x_p)}{\text{No.of data taken,n}}$ = 140 MW.

Standard deviation, $\sigma = \sqrt{\frac{\sum (x_0 - x_i)^2}{n}}$ = 20.85 MW.

The average ratio of Supply/Actual demand during peak hour is 0.870.

3.1.4.2. 'Actual demand' calculation using average ratio & Hypothesis test

Using the average ratio found above, another set of 'actual demands' has been calculated and tested whether the set of 'actual demands' is acceptable or not.

Date	Supply at peak (MW)	Average ratio of $\frac{\text{Supply}}{\text{Actual demand}}$ during peak hour	'Actual demand' using average ratio (MW), x_i	Mean 'actual demand' using average ratio(MW), $\bar{x}$	Average of actual peak demands using data(MW), μ_0	Random variable, $z = \frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}}$, $\sigma = 20.85$ & $n = 8$
1/09/14	124	0.870	142.52	140.79	140	0.107
5/09/14	82		94.25			
9/09/14	108		124.13			
15/09/14	141		162.06			
16/09/14	129		148.27			
18/09/14	126		144.82			
23/09/14	129		148.27			
28/09/14	141		162.06			

Table 3.9: 'Actual demand' using average ratio for September, 2014 of Dhanmondi sub-station and 'z' test

Result of 'z' Test:

Now, the Null Hypothesis H_0: $\mu = 140$ MW has been tested against H_1 : $\mu \neq 140$ MW if the mean 'actual demand' using average ratio is 0.870 MW with standard deviation, $\sigma = 20.85$ MW. The null hypothesis will be accepted if and only if $-1.96 \leq z \leq 1.96$ with level of significance 0.05. Here, the value of z found is 0.107 which is in the acceptance region. So, the null hypothesis is accepted.

3.1.5. Tongi (132/33 KV) Substation demand calculation

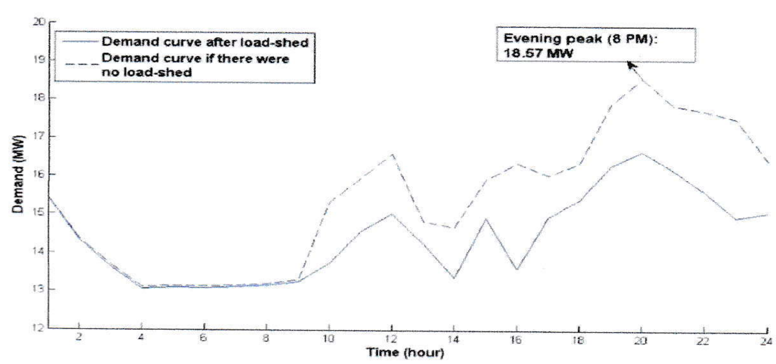

Figure 3.4: Load curve of Tongi sub-station on September, 2014

3.1.5.1. Actual peak Demand and load-shed calculation

The following table is showing the actual demand and load-shed data of Tongi sub-station at peak hour for some typical dates of the month September, 2014 [8].

Date	Actual demand during peak hour (MW), x_p	Supply at peak (MW)	Load-shed (MW)	Ratio of $\frac{\text{Supply(MW)}}{\text{Actual demand(MW)}}$ during peak hour
1/09/14	65	56	9	0.46
5/09/14	72	61	11	0.84
9/09/14	73	62	11	0.84
15/09/14	80	71	9	0.88
16/09/14	65	54	11	0.83
18/09/14	75	64	11	0.85
23/09/14	80	70	10	0.87
28/09/14	81	73	8	0.90

Table 3.10: Actual Peak demand of Tongi sub-station for selective dates of september , 2014.

Average actual peak demand, $\mu_0 = \frac{\sum \text{Actual peak demand,}(x_p)}{\text{No.of data taken,n}}$ = 73.875 MW.

Standard deviation, $\sigma = \sqrt{\frac{\sum (x_0 - x_i)^2}{n}}$ = 7.63 MW.

The average ratio of Supply/Actual demand during peak hour for this sub-station is 0.81

3.1.5.2 'Actual demand' calculation using average ratio & Hypothesis test

Using the average ratio found above, another set of 'actual demands' has been calculated and tested whether the set of 'actual demands' is acceptable or not.

Date	Supply at peak (MW)	Average ratio of $\frac{\text{Supply}}{\text{Actual demand}}$ during peak hour	'Actual demand' using average ratio (MW), x_i	Mean 'actual demand' using average ratio(MW), $\bar{x}$	Average of actual peak demands using data(MW), μ_0	Random variable, $z = \frac{\bar{x} - \mu_0}{\sigma / \sqrt{n}}$, $\sigma = 7.63$ & $n = 8$
1/09/14	56	0.858	65.26	74.44	73.875	0.210
5/09/14	61		71.09			
9/09/14	62		72.26			
15/09/14	71		82.75			
16/09/14	54		62.93			
18/09/14	64		74.59			
23/09/14	70		81.58			
28/09/14	73		85.08			

Table 3.11: 'Actual demand' using average ratio for September, 2014 of Tongi sub-station and 'z' test

Result of 'z' Test:

Now, the Null Hypothesis H_0: $\mu = 73.875$ MW has been tested against H_1 : $\mu \neq 73.875$ MW if the mean 'actual demand' using average ratio is 74.44 MW with standard deviation, $\sigma = 7.63$ MW.

The null hypothesis will be accepted if and only if $-1.96 \leq z \leq 1.96$ with level of significance 0.05. Here, the value of z found is 0.210 which is in the acceptance region. So, the null hypothesis is accepted.

3.1.6. Comments on DPDC demand analysis:

It is clear from the above demand analysis that the concept of actual demand calculation from the average ratio of supply/actual demand during peak hour is trustworthy.

3.1.7. Ratio of supply/Actual demand during peak hour for DPDC demands calculation:

In the following table a mean of average ratios of supply/actual demand during peak hour at summer season for the above mentioned five substations has been calculated. This mean ratio is then applied to calculate the total demand of DPDC during peak hour.

(132/33 KV) Sub-station Name	Average ratio of during peak hour
Mirpur	0.751
Kallyanpur	0.908
Gulshan	0.894
Dhanmondi	0.870
Tongi	0.858
Mean of Average ratios for DPDC demand calculation	**0.82**

Table 3.12: Ratio of Supply/Actual peak demand during peak hour

3.2. Zone-wise Demand and Load-shed Calculation

3.2.1. Dhaka zone

1. DPDC, DESCO and REB are the three distribution companies operating in Dhaka zone. Summing up these companies' actual demand, the total demand of Dhaka zone has been calculated.
2. Daily electricity supply of DPDC and DESCO has been calculated from the energy sale percentage [9] which is shown in the following figure.

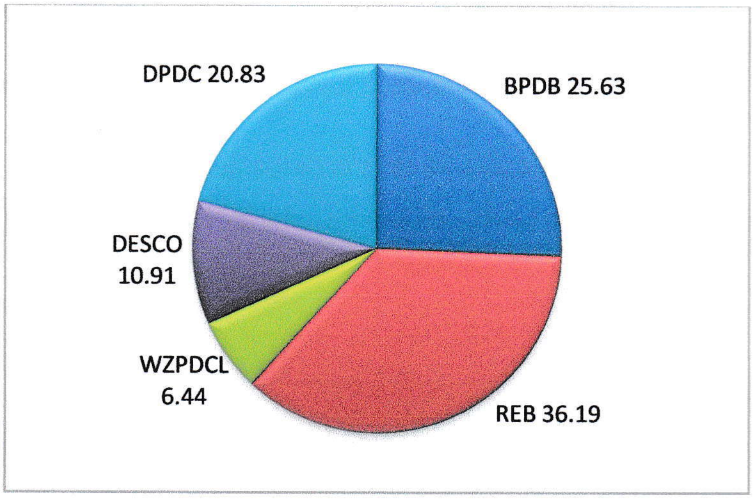

Figure 3.5: Utility wise Energy sale percentage of five powers distribution companies (September 2014)

3. In the previous chapter we have calculated the mean of the average ratios of supply/actual demand during peak hour for the selected five substations. The mean ratio is 0.86 [Table 3.13]. So, the actual demand of DPDC and DESCO during peak hour is given by-

$$\text{Actual demand during peak hour (MW)} = \frac{\text{Supply during peak (MW)}}{0.82}$$

4. Supply and peak demand data of REB is directly collected from REB head-office.
5. According to Power Grid Company of Bangladesh (PGCB) daily electricity generation report [3], it is found that the transmission loss and auxiliary use is about 8-9% of the total generation. So, the supply at the 132/33KV bus is given by-

   Supply at 132/33KV bus =

   Total generation – (Transmission loss + Auxiliary use)……………………(1)

   When, Transmission loss + Auxiliary use = 9% of Total generation (as considered

6. Supply at the 132/33KV bus is calculated deducing the transformer loss from the supply of 132/33KV bus.

   Supply at 132/33KV bus = Supply at 132/33KV bus – (132KV line loss +1 32/33 KV Transformer loss)……...(2)

When, Transformer loss = 3% of Total generation. (As considered)

The data of total generation of Bangladesh at peak hour for different days of July and August have been found from the daily electricity generation report of Power Grid Company of Bangladesh [3].

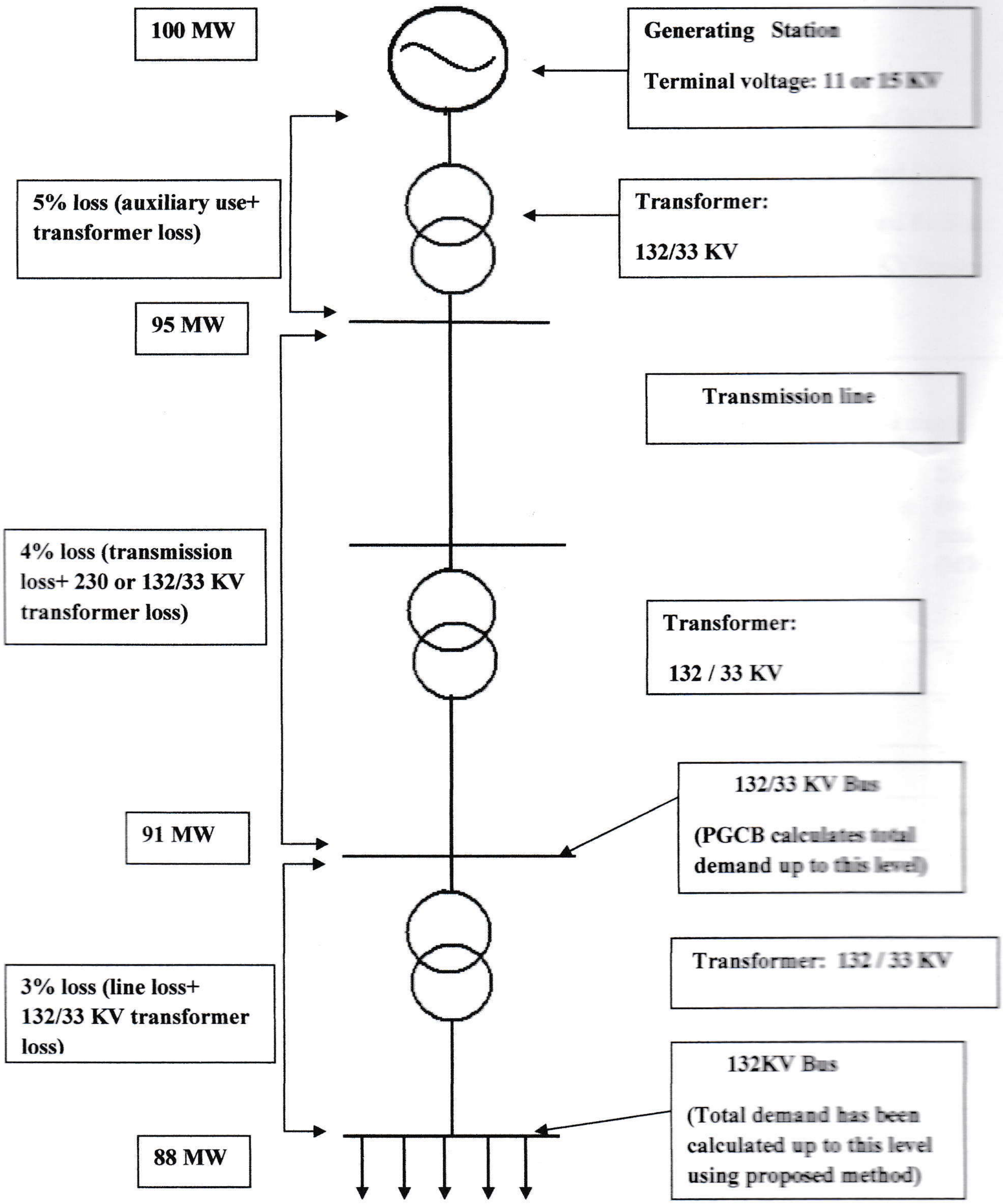

Figure 3.6: Single line diagram from generation to supply end to illustrate the demand calculation process.

3.2.1.1. Demand & Load-shed Calculation of the distribution companies:

According to figure 3.5 we get,

DPDC supply at peak (MW) = 0.2083 × Total supply at 11 KV feeder end (MW)

DESCO supply at peak (MW) = 0.1091 × Total supply at 11 KV feeder end (MW)

In the following tables we have shown the demand and supply of DPDC, DESCO and REB at peak hour for the months of September 2014. To calculate the total supply at 132/3KV feeder end in this table we have used equation no. 1 and 2.

Date	Total Generation of Bangladesh (at evening peak) (MW)	Total Supply at the 132/33KV feeder end (at evening peak) (MW)	DPDC		DESCO		REB (Dhaka zone)	
			Supply (evening peak) (MW)	Demand (evening peak) (MW)	Supply (evening peak) (MW)	Demand (evening peak) (MW)	Supply (evening peak) (MW)	Demand (evening peak) (MW)
12/09/14	4712	4147	863	1052	452	551	510	762
13/09/14	4546	4000	833	1016	436	532	512	764
19/09/14	4814	4236	882	1076	462	565	501	748
21/09/14	4707	4142	862	1051	452	551	552	754
23/09/14	4822	4243	884	1077	463	566	521	771
25/09/14	4700	4136	861	1049	451	551	520	807
26/09/14	4669	4109	855	1043	448	550	523	797
27/09/14	4719	4153	865	1055	453	553	506	766
28/09/14	4598	4046	842	1027	441	538	504	775

Table 3.13: Actual demand of DPDC, DESCO and REB in Dhaka zone for September, 2014.

Date	From Data Analysis (REB+DESCO+DPDC)					From NLDC Statistics	
	Total Supply at 11KV Bus during evening peak (MW) **A**	Total demand at 11KV Bus during evening peak (MW) **B**	Total supply at 33KV Bus during evening peak(MW) **C=A/0.97**	Total demand at 33KV Bus during evening peak (MW) **D=B/0.97**	Load-shed (MW)	Demand (MW)	Load-shed (MW)
13/09/1	1781	2312	1836	2383	547	2060	
19/0-/14	1845	2389	1902	2463	561	1891	
21/09/14	1866	2356	1924	2429	505	1960	
23/09/14	1868	2414	1927	2489	562	1970	
25/09/14	1832	2407	**1889**	**2481**	**592**	1990	
26/09/14	1826	2390	1882	2464	582	2020	
27/09/14	1824	2374	1880	2447	567	2050	

Table 3.15: Comparison of the total demand of Dhaka zone using data analysis and that from NLDC for September 2014

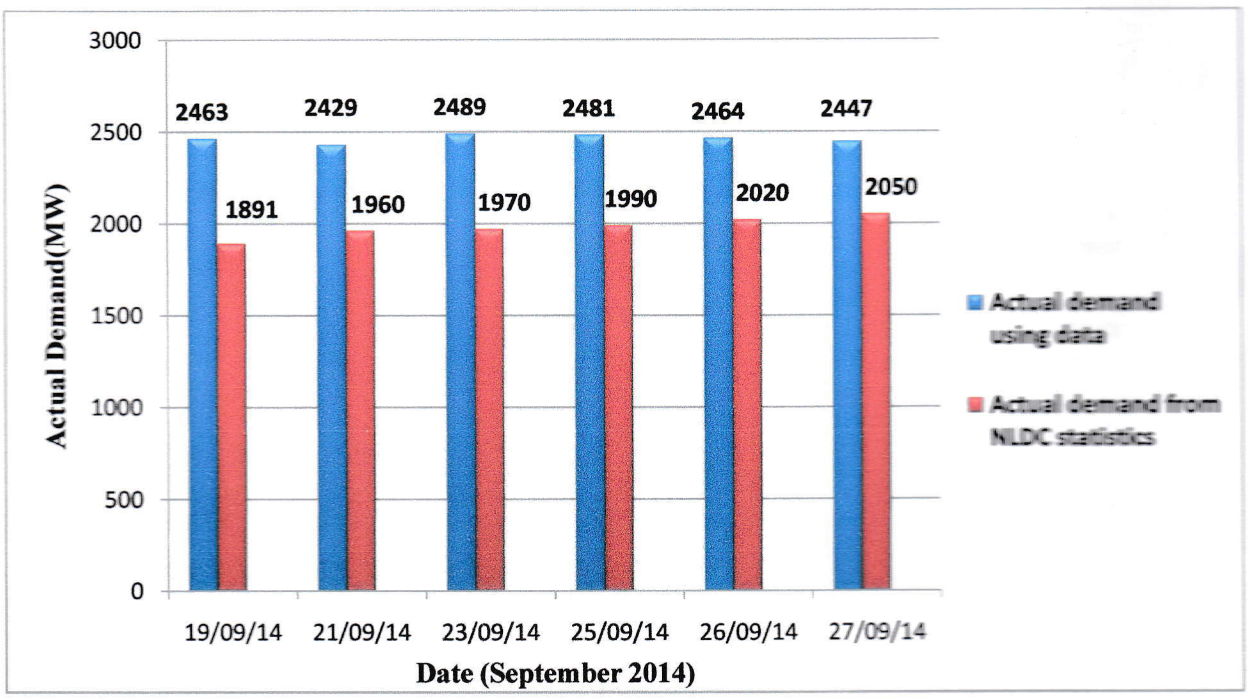

Figure 3.7: Comparison of the total demand of Dhaka zone using data analysis and that from NLDC for September 2014

Date	Total demand of Bangladesh at 33 KV Bus end using proposed method if there were no load-shed	Total demand at 33 KV Bus end from NLDC statistics
19/09/14	**6272**	4694
21/09/14	6035	4757
23/09/14	6165	4656
25/09/14	6140	4723
26/09/14	6144	4750

Table 3.39: Comparison between the total demands obtained from proposed method and NLDC statistics for September 2014.

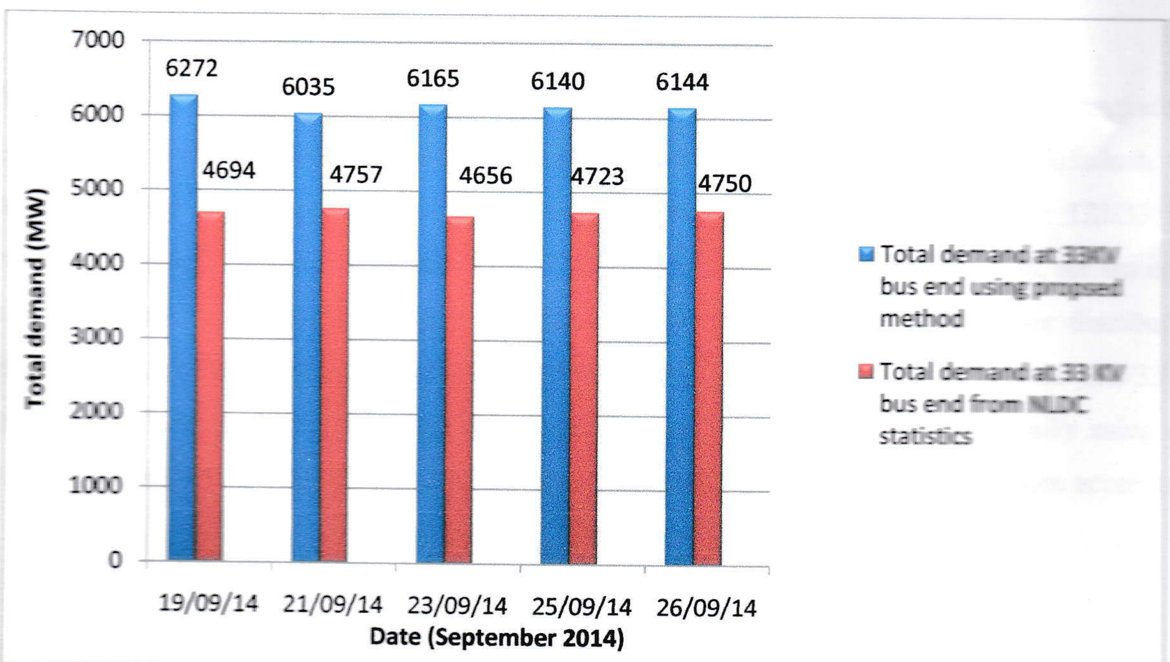

Figure 3.9: Comparison between two actual demands at 33 KV bus obtained from proposed method and NLDC statistics (September 2014)

Chapter: 4

Conclusion and Future Work

4.1. Conclusion:

In Bangladesh, the electricity demand is increasing every year. But the generation does not increase at the same pace. So, there is massive load shed. But due to inadequate data, it is very difficult to know the actual demand at peak hour. In our proposed method we have tried to determine the actual demand of Bangladesh from root level using available raw data and applying a statistical test. The total demand we have determined is % higher than NLDC's estimation but our result is accurate with 95% level of confidence.

4.2. Suggestions for Further Research:

We have focused mainly on Dhaka zone while calculating the total demand of Bangladesh, because the total demand of Dhaka zone is almost half of the total demand of Bangladesh. We have analyzed the supply data of the power distribution company DPDC from 132/33 KV substations level. So, the total demand for Dhaka zone is much more accurate. But, for the other zones we had to rely on the supply and demand data given by other four power distribution entities. Future researches may collect feeder readings of other four entities from 132/33KV substations level and then calculate the actual demand of these entities individually using our proposed method. In that case the total demand of Bangladesh can be calculated more accurately.

References

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[4] **Log book of Mrirpur 132/33 KV Sub-station** [September, 2014]

[5] **Log book of Kallyanpur 132/33 KV Sub-station** [September, 2014]

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[9] **Bangladesh Power Development Board, Executive Summary, September 2014** [Online] [Cited: January 15, 2013]

[10] **Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers**, Probability and statistic for engineers and scientists, 9th ed.

[11] http://www.bpdb.gov.bd/bpdb/images/mis/.pdf

[12] http://www.pgcb.org.bd/pdf

Appendix

Hypothesis Test:

A statistical hypothesis is an assertion or conjecture concerning one or more populations. The true or falsity of a statistical hypothesis is never known with absolute certainty unless the entire population is examined. This, of course, would be impractical in most situations. Instead, a random sample is taken from the population and using the data contained in this sample provides evidence that either supports or does not support the hypothesis.

The Null and Alternative Hypothesis:

The Null and Alternative Hypothesis:

The structure of hypothesis testing has been formulated with the use of the term null hypothesis. This refers to any hypothesis that is to be tested and is denoted by H_0. The rejection of H_0 leads to the acceptance of an alternative hypothesis, denoted by H_1.

One-tailed and two-tailed tests:

A test of any statistical hypothesis where the alternative is two sided such as

$$H_0: \mu = \mu_0$$

$$H_1: \mu \neq \mu_0,$$ is called a two-tailed test.

The alternative hypothesis states that either $\mu > \mu_0$ or $\mu < \mu_0$.

A test of any statistical hypothesis where the alternative is two sided such as

$$H_0: \mu = \mu_0$$

$$H_1: \mu > \mu_0,$$

Or perhaps $$H_0: \mu = \mu_0$$

$$H_1: \mu < \mu_0, \text{ is called a one-tailed test.}$$

In general, two-sided alternative $\mu \neq \mu_0$ is used if the null hypothesis is to be rejected regardless of whether μ_0 happens to be too large or too small.

Level of significance:

The level of significance, α is essential to decide on the cut-off points, called critical values that separate the acceptance and rejections regions. The choice of α is usually made between 0.01 and 0.05.

Z test Procedure:

Suppose, a sample of size n is drawn from a normal population with mean μ and standard deviation σ. The problem is to test the hypothesis that the population mean μ equals a specified value μ_0 against the two-sided alternative that the mean μ is not equal to μ_0. Stated symbolically,

$$H_0: \mu = \mu_0$$

$$H_1: \mu \neq \mu_0.$$

It is known that the sample mean $\bar{x}$ is a good estimator of the population mean. It is therefore appropriate to use the sample mean $\bar{x}$ as a statistic to test the null hypothesis. If we use the significance level α, it is possible to find two critical values $\bar{x}_1$ and $\bar{x}_2$ such that the interval $\bar{x}_1 < \bar{x} < \bar{x}_2$ defines the acceptance region and the two tails of the distribution $\bar{x} < \bar{x}_1$ and $\bar{x} > \bar{x}_2$ constitute the critical region. Since the critical value is stated in terms of z value rather than $\bar{x}$, we can apply the normal transformation,

$$z = \frac{\bar{x} - \mu_0}{\sigma / \sqrt{n}}$$

for probability occurrence of the sample mean $\bar{x}$. The denominator is the standard error of the sample mean. Since, it is a two-tailed test, the critical values of the random variable z corresponding to $\bar{x}_1$ and $\bar{x}_2$ are $-z_{\alpha/2} = \frac{\bar{x}_1 - \mu_0}{\sigma/\sqrt{n}}$ and $z_{\alpha/2} = \frac{\bar{x}_2 - \mu_0}{\sigma/\sqrt{n}}$

Thus, if $\bar{x}$ falls in the acceptance region $\bar{x}_1 < \bar{x} < \bar{x}_2$, then $z = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}}$ will fall in the region $-z_{\alpha/2} < z < z_{\alpha/2}$ and it is concluded that H_0: $\mu = \mu_0$. Clearly, the critical regions are

$$z < -z_{\alpha/2} \text{ Or } z > z_{\alpha/2}$$

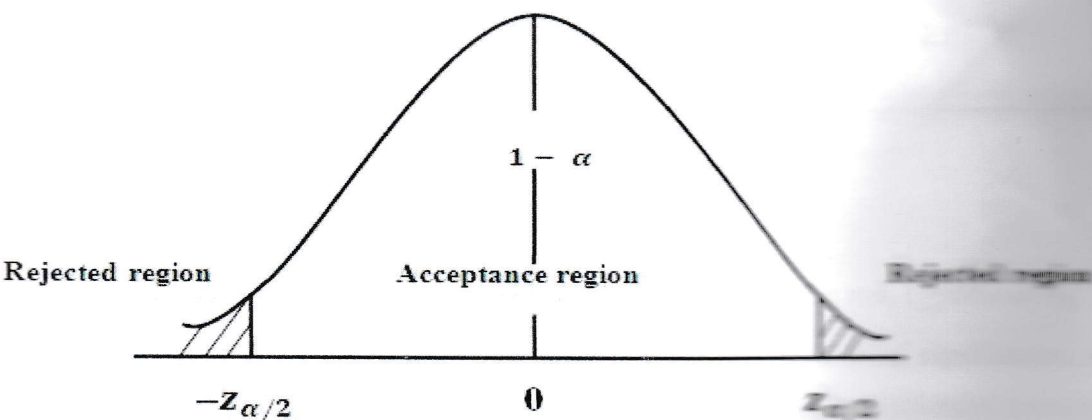

Figure A.1: Acceptance region in terms of z values

In the above figure, the region of acceptance is 1-α percent.

	Decision rule	
H_1	For α=0.05 reject H_0 if and only if	For α=0.01 reject H_0 if and only if
$\mu > \mu_0$	$\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \geq 1.64$	$\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \geq 2.33$
$\mu < \mu_0$	$\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \leq -1.64$	$\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \leq -2.33$
$\mu \neq \mu_0$	$\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \geq 1.96$ Or $\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \leq -1.96$	$\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \geq 2.58$ Or $\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \leq -2.58$

A guide to decision rule:

In the following table a guide has been given to choose between the null hypothesis H_0: $\mu = \mu_0$ and each of the alternative hypotheses H_0: $\mu \neq \mu_0$ at two different level of significance, *viz.* $\alpha = 0.05$ and $\alpha = 0.01$.