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ANALYSIS OF ELECTRIC POWER LOSSES IN DISTRIBUTION LINES: A CASE STUDY OF JOS AND ENVIRON

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Abstract

Distribution lines serve the purpose of connecting the consumer of electricity from the generating and transmitting stations. However, in the distribution process some amount of the electric power is lost in the line by conductor heating, dielectric heating and radiation. Power losses in 33KV distribution network of the Transmission Company of Nigeria (TCN), Jos, were computed from a three-month (November 2017-January 2018) transmission data. A one-way ANOVA was conducted to compare losses from seven feeders. Significant differences (P<0.05) were notice in the power losses among various feeders except for few. The losses correlate with route length and average maximum loading. Power loss per route length per average maximum loading revealed interesting variation among the feeders. A good linear model is established between per unit losses and average maximum loading. The result could be useful in maintains and planning of power distribution network.

Keywords: Power lost, Power Distribution lines, Feeder stations, Route length, and Power Maximum Loading

1.0 INTRODUCTION

The three major activities that characterize electrical power system aregeneration, transmission and distribution. This is regulated either by single entity or by several entities. In Nigeria for instance, the Nigerian Electricity Regulatory Commission (NERC)regulates the activities of the three major players within the electricity power sector which are the Generation companies (GenCos), the Transmission company of Nigeria (TCN) and Distribution companies (DisCos).

Ramachandra [1] said electric power distribution comprises the application of scientific and technological knowledge to planning, design, construction, operation and maintenance of various electric supply schemes for the benefit of the society. The distribution network is usually divided into smaller networks called Power Feeders. This comprise of distribution wires covering distances called route length and distribution transformers. There is no difference between a transmission line and a distribution line except for the voltage level and power handling capability. Transmission lines are usually capable of transmitting large quantities of electric energy over great distances. They operate at high voltages. Distribution lines carry limited quantities of power over shorter distances.

The purpose of distribution system is to take electric power from transmission system and deliver it to consumers to serve their needs [2].

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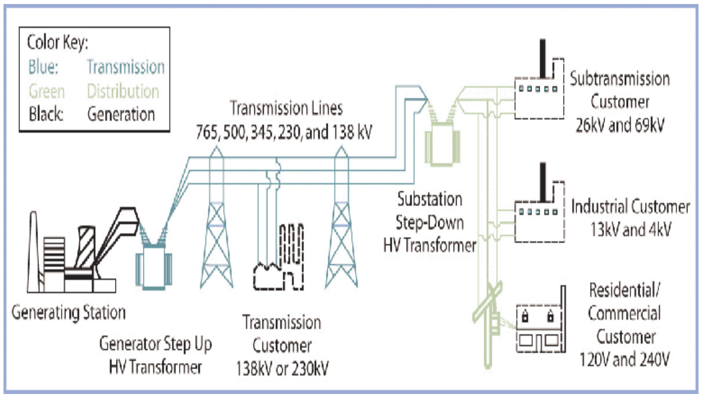

Figure.1 *A descriptive diagram showing the various subdivision of Power sector and the various areas prone to technical and non-technical losses.*[3]

In power distribution, losses are often encountered. In electricity supply to final consumers, losses refer to the amounts of electricity injected into the distribution grids that are not paid for by users.Differences in losses between utilities are normal, even if consistent methodologies and categorization are used. Losses in distribution systems may be different between utilities due to physical and operating differences, such as different voltage levels, feeder lengths, loading patterns, and conductor sizing [4].

The percent losses of total transmission power requirements varied among utilities. The likely causes of the variations are the categorization of losses, differences in the number of load levels evaluated, differences in the age of facilities and voltage classes, and differences in the methodologies used to calculate losses. There is not a uniformly defined approach across the industry because each utility's electrical system is unique, and the availability of information and data varies from utility to utility. Different trusted methodologies have been developed over the years to calculate losses based on the information that is available to each utility, which allows them to arrive at valid results[4].

These losses can be broadly defined as the difference between the amount of electricity entering the transmission system and the aggregated consumption registered at the end user meter points. The implication of power losses is both economic and operational. While economic implication result in high cost of unit of energy consumed, operational implication result in additional energy load on the system[5].

These losses can be technical and non-technical in nature. The technical losses which is at the center of this work occur in numerous small components such as transformers and distribution lines. Due to the lower power level of these components, the losses inherent in each component are lower than those comparable components of the transmission system. While each of these components may have relatively small losses, the large number of components involved and the relatively higher percentage of the total investment in the power sector that goes to electrical power distribution makes it important to examine the losses in the system [1]. These losses typically account for approximately four percent of the total system Load [6].

There are two major sources of technical losses in power distribution systems; these are the transformers and power lines. Additionally, there are two major types of losses that occur in these components. These losses are often referred to as core losses and copper, or I^2R losses. Core losses in transformers account for most losses at low power levels. As load increases, the copper losses become more significant, until they are approximately equal to the core losses at peak load [6].

Calculations of losses in power systems have been attempted since long. Earlier efforts concentrated on energy loss estimation on a yearly basis and power loss estimations for maximum load situations. The estimated losses were important data when calculating the energy losses and planning grids [7].

Voltage drops in line are in relation to the resistance and reactance of line, length and the current drawn for the same quantity of power handled. The current drawn is inversely proportional to the voltage level for the same quantity of power handled. The lower the voltage, the higher the current drawn and the higher the voltage drop [7].

The power loss in line is proportional to resistance and square of current. (i.e. $P_{loss}=I^2R$). Higher voltage transmission and distribution thus would help to minimize losses. Energy loss in transmission lines is wasted in the form of I^2R losses[8].

The study of losses helps in bringing about reduction of losses in general which benefit to the whole electricity system supply. It leads to fair cost coverage for losses and to advancement in the distribution and transmission systems.

In this study, due to available data, only copper losses were considered and hence, the following equations were used for computation.

Current drawn from the feeder $I_L = \frac{P}{(\sqrt{3} \times V \times p.f)}$ (1)

$$R = \frac{\rho \times L}{A} \quad (2)$$

Where **P** is power in megawatts, V is the voltage in volts, ρ is resistivity in (Ωm^{-1}), R is resistance in Ω, A is cross sectional area in mm^2, L is the route length of the feeder in Km.

$$\text{Power loss } (P_L) = I_L^2 R \quad (3)$$

Hence, power loss is power received less power consumed.

METHODOLOGY

Data were collected on:

I Daily return on loading of 33kv feeders

II Feeder route length between transformers

The power outages report was obtained from the transmission company of Nigeria, Jos plateau state. The obtained data involve: the names of the feeder, daily return loading on 33kv, feeder route length and distances between transformers, aluminum conductor of size 150mm^2, with resistivity of 2.82×10^{-8}ohm meter.

The sample data collected are shown in Tables 10, 11, 12 and 13 in appendix from which power losses are obtained for a period of three months duration beginning from 1stNovember 2017 to 31stJanuary 2018.

The power losses on each of the 33kv feeder are obtained,based on the daily maximum loading on the feeders, resistance, size of each feeder conductor, route length of each feeder and maximum current drawn from each feeder and maximum voltage supplied, using equation (1), (2), and(3).

The data was analyzed for descriptive and inferential statistics using SPSS version 25

RESULT

To understand the distribution of the data, normality test was conducted and the result (Table 1) shows that all the feeders, except Anglu-Jos and Zaria Road, had a fairly normal distribution of power losses within the three months considered

Table 1. Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Power Feeders	Statistic	df	Sig.	Statistic	df	Sig.
Power Losses	Anglu-Jos Feeder	.079	92	.200*	.972	92	.045
	Dogon Dutse Feeder	.066	92	.200*	.989	92	.642
	Juth Feeder	.080	92	.189	.990	92	.734
	NNPC Feeder	.084	92	.117	.975	92	.068
	Rukuba Road Feeder	.072	92	.200*	.987	92	.521
	Toro Feeder	.059	92	.200*	.978	92	.124
	Zaria Road Feeder	.159	92	.000	.783	92	.000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The descriptive statistics given in Table 2 reveals that the average power loss was highest in Toro feeder and least at Zaria Road feeder (Figure 1)

Table 2. Descriptive Statistics

Power Losses

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Anglu-Jos Feeder	92	.724916	.1435620	.0149674	.695185	.754647	.4711	1.1141
Dogon Dutse Feeder	92	.402662	.1379799	.0143854	.374087	.431237	.0974	.7822
Juth Feeder	92	.926977	.2587689	.0269785	.873387	.980566	.3518	1.6177
NNPC Feeder	92	.738902	.2209353	.0230341	.693148	.784656	.0000	1.1670
Rukuba Road Feeder	92	.025360	.0042565	.0004438	.024479	.026242	.0133	.0370
Toro Feeder	92	1.420013	.2574307	.0268390	1.366701	1.473325	.6444	1.9736
Zaria Road Feeder	92	.006770	.0017149	.0001788	.006415	.007125	.0044	.0156
Total	644	.606514	.5010052	.0197424	.567747	.645282	.0000	1.9736

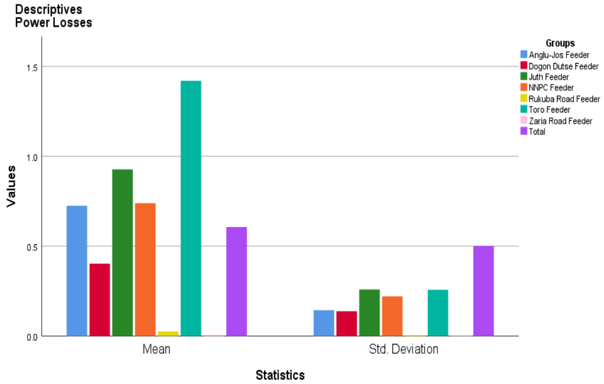

Figure2: Bar Chart Showing the Mean Power loss and Standard Deviation for Each Feeder.

The assumption of homogeneity of variances was tested using levene test and found not tenable as shown in the Table 3. As a result, Welch and Brown-Forythe tests were conducted (Table 5) as the robust test of equality of means to help in interpreting the ANOVA result (Table 4)

Table 3. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Power Losses	Based on Mean	65.113	6	637	.000
	Based on Median	62.930	6	637	.000
	Based on Median and with adjusted df	62.930	6	369.337	.000
	Based on trimmed mean	64.832	6	637	.000

Table 4. ANOVA

Power Losses

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	141.221	6	23.537	743.110	.000
Within Groups	20.176	637	.032		
Total	161.397	643			

Table 5. Robust Tests of Equality of Means

Power Losses

	Statistic[a]	df1	df2	Sig.
Welch	1556.590	6	252.817	.000
Brown-Forsythe	743.110	6	371.366	.000

a. Asymptotically F distributed.

Following the significant (P<0.05) result of the ANOVA, a Post Hoc Tests (Table 6) was conducted to understand where significant difference exists among the mean losses of the various feeders

Table 6. Multiple Comparisons

Dependent Variable: Power Losses

Games-Howell

(I) Power Feeders	(J) Power Feeders	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Anglu-Jos Feeder	Dogon Dutse Feeder	.3222539*	.0207596	.000	.260356	.384152
	Juth Feeder	-.2020609*	.0308523	.000	-.294340	-.109781
	NNPC Feeder	-.0139860	.0274698	.999	-.096042	.068070
	Rukuba Road Feeder	.6995560*	.0149740	.000	.654407	.744705
	Toro Feeder	-.6950969*	.0307303	.000	-.787008	-.603186
	Zaria Road Feeder	.7181460*	.0149684	.000	.673012	.763280
Dogon Dutse Feeder	Anglu-Jos Feeder	-.3222539*	.0207596	.000	-.384152	-.260356
	Juth Feeder	-.5243149*	.0305742	.000	-.615794	-.432836
	NNPC Feeder	-.3362399*	.0271571	.000	-.417387	-.255093
	Rukuba Road Feeder	.3773021*	.0143922	.000	.333907	.420697
	Toro Feeder	-1.0173508*	.0304511	.000	-1.108457	-.926244
	Zaria Road Feeder	.3958921*	.0143865	.000	.352513	.439272
Juth Feeder	Anglu-Jos Feeder	.2020609*	.0308523	.000	.109781	.294340
	Dogon Dutse Feeder	.5243149*	.0305742	.000	.432836	.615794
	NNPC Feeder	.1880750*	.0354741	.000	.082276	.293874
	Rukuba Road Feeder	.9016169*	.0269822	.000	.820258	.982975
	Toro Feeder	-.4930360*	.0380549	.000	-.606501	-.379571
	Zaria Road Feeder	.9202069*	.0269791	.000	.838857	1.001557
NNPC Feeder	Anglu-Jos Feeder	.0139860	.0274698	.999	-.068070	.096042
	Dogon Dutse Feeder	.3362399*	.0271571	.000	.255093	.417387
	Juth Feeder	-.1880750*	.0354741	.000	-.293874	-.082276
	Rukuba Road Feeder	.7135420*	.0230384	.000	.644075	.783009
	Toro Feeder	-.6811109*	.0353681	.000	-.786592	-.575630
	Zaria Road Feeder	.7321320*	.0230348	.000	.662675	.801589
Rukuba Road Feeder	Anglu-Jos Feeder	-.6995560*	.0149740	.000	-.744705	-.654407
	Dogon Dutse Feeder	-.3773021*	.0143922	.000	-.420697	-.333907
	Juth Feeder	-.9016169*	.0269822	.000	-.982975	-.820258
	NNPC Feeder	-.7135420*	.0230384	.000	-.783009	-.644075
	Toro Feeder	-1.3946529*	.0268427	.000	-1.475591	-1.313715
	Zaria Road Feeder	.0185900*	.0004784	.000	.017155	.020025

Toro Feeder	Anglu-Jos Feeder	.6950969*	.0307303	.000	.603186	.787008
	Dogon Dutse Feeder	1.0173508*	.0304511	.000	.926244	1.108457
	Juth Feeder	.4930360*	.0380549	.000	.379571	.606501
	NNPC Feeder	.6811109*	.0353681	.000	.575630	.786592
	Rukuba Road Feeder	1.3946529*	.0268427	.000	1.313715	1.475591
	Zaria Road Feeder	1.4132429*	.0268396	.000	1.332313	1.494172
Zaria Road Feeder	Anglu-Jos Feeder	-.7181460*	.0149684	.000	-.763280	-.673012
	Dogon Dutse Feeder	-.3958921*	.0143865	.000	-.439272	-.352513
	Juth Feeder	-.9202069*	.0269791	.000	-1.001557	-.838857
	NNPC Feeder	-.7321320*	.0230348	.000	-.801589	-.662675
	Rukuba Road Feeder	-.0185900*	.0004784	.000	-.020025	-.017155
	Toro Feeder	-1.4132429*	.0268396	.000	-1.494172	-1.332313

*. The mean difference is significant at the 0.05 level.

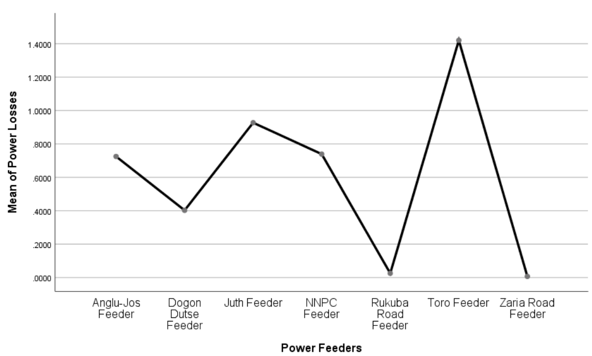

Figure 3: Means Plots

To Understand the relationship between power loss and route length, and power loss and Average maximum Loading, the per unit power loss was calculated from the average power losses by diving it with route length and average maximum loading (Table 7). Pearson correlation coefficient shows not significant correlation between per unit power loss and route length but there is a significant correlation between per unit length and average maximum loading (Table 8 and 9).

Table 7: Summary of important Parameters

Feeder	Average power losse/MW	Route Length/Km	Average Maximum Loading/MW	Per Unit loss/Km
Anglu-Jos	0.724916	37	14.69	0.001334
Dogon Dutse	0.402662	30.1	12.01	0.001114
JUTH	0.926977	48.3	14.46	0.001327
NNPC	0.738902	120	8.14	0.000756
Rukuba Road	0.025368	8.4	5.77	0.000523
Toro	1.420013	155	10.05	0.000912
Zaria Road	0.006771	1.6	6.82	0.00062

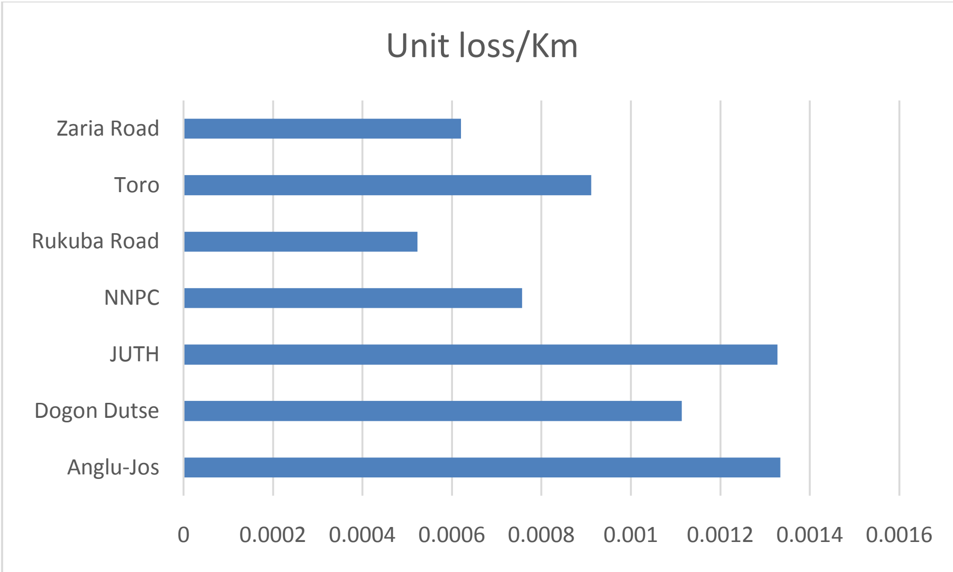

Figure 4: Comparison of the Feeders' Per Unit Losses

Table 8: Correlations Between Per Unit Loss and Route Length

		Per Unit Loss/Km	Route Length (Km)
Per Unit Loss/Km	Pearson Correlation	1	.067
	Sig. (2-tailed)		.886
	N	7	7
Route Length (Km)	Pearson Correlation	.067	1
	Sig. (2-tailed)	.886	
	N	7	7

Table 9: Correlations Between Per Unit Loss and Average maximum Loading

		Per Unit Loss/Km	Average Maximum Loading(MW)
Per Unit Loss/Km	Pearson Correlation	1	1.000**
	Sig. (2-tailed)		.000
	N	7	7
Average Maximum Loading(MW)	Pearson Correlation	1.000**	1
	Sig. (2-tailed)	.000	
	N	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

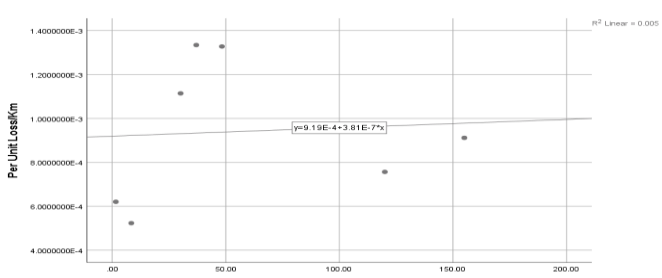

Figure 5. Regression curve for per Unit loss against Route Length

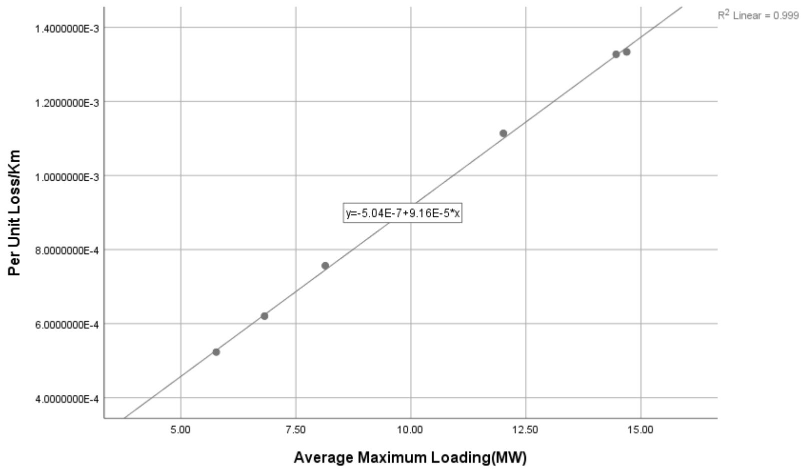

Figure 6. Regression curve for per Unit loss against Average Maximum Loading

DISCUSSION

The Feeders' average power losses were calculated from the power loss relationships; equation 1, 2 and 3 and other recorded parameters such as power loading, voltage, route length of feeder, area of conductor, the resistivity of the conducting material.

Toro Feeder is found to contain the highest average loss of 1.420013 MW and Zaria Road feeder contain the least average loss of 0.006770 MW (Table 2 and Figure 2). The high average loss in Toro could be attributed to it long route length of 155 Km and a relatively high average maximum loading of 10.05 MW (Table 7)

The average power losses vary significantly ($P<0.05$) from Feeder to Feeder except Anglu-Jos and NNPC feeders. The per unit loss is highest in Anglu-Jos' Feeder and Juth's Feeder (Figure 4). This may be connected to high loading and obsolete and worn-out equipment in the feeders as these are some of the oldest Feeders in Jos and environ [6]. The Pearson correlation coefficient shows no significant correlation ($P>0.01$) between the per unit loss and the route length, this implies that the per unit loss cannot be predicted from route length (Table 8 and Figure 5). However, a significant correlation ($P<0.01$) exist between the per unit loss and the average maximum loading (Table 9). The model fit (Figure 6) can predict with a high level of accuracy, the per unit loss from the average maximum loading.

CONCLUSION

In conclusion, the work shows that route length can lead to significant power losses as seen in the case of Toro Feeder. However, the per unit loss depends more on the average maximum loading and the effect of obsolete equipment in increasing power losses has been reveal by this work [6]. This work can useful in designing and constructing power distribution network and maintenance.

Finally, we suggest that either capacitor banks or installation of substation should be considered to minimize power losses in Toro Feeder. Obsoletes equipment should be replaced in the old Feeders and Demand-side Management (DSM) should be embarked on in the Anglu-Jos and Juth Feeders to reduce peak loading to minimize the per unit loss.

ACKNOWLEDGEMENT

We acknowledge the transmission company of Nigeria, Jos Electricity Distribution Company and Attah Abraham Ejimah for their assistance in this research.

Appendix

TABLE 10: DAILY RETURN LOADING OF 33KV FOR NOVEMBER 2017

PEAK DAILY POWER LOADING							
DAY/FEEDER	ANGLU-JOS	DOGON DUSTSE	JUTH	NNPC	RUKUBA ROAD	TORO	ZARIA ROAD
1.	15.7	13.1	15.7	7.5	5.1	9.4	6.2
2.	15.2	13.2	17	6.4	4.2	9	6
3.	15.6	15.2	14.3	5.9	5.2	9.3	6
4.	15.6	15.5	17	6.2	5.1	10	5.8
5.	16.4	15.2	17.5	6.4	4.8	9.5	6.5
6.	16.3	13.5	16	6.5	5	9.2	8
7.	15	14	18	6.3	5	9.5	6.4
8.	14	11.8	17	6.4	5.3	10.1	6.8
9.	14.6	9.3	13.5	6.7	5.5	9.6	6.9
10.	14.3	14.7	15.3	6.8	6	10.6	6.7

11.	14.2	14.3	19.3	7	6.1	9.6	6.3
12.	13.5	12.4	17	7.7	4.7	10.4	9.9
13.	15.1	12.3	11.9	7.8	5.7	10.8	7
14.	14.5	13.5	14.5	7	5.8	9	7.5
15.	14.9	13.9	14	4.8	5.8	10.2	6.5
16.	14.3	13	13.5	7.2	4.8	9.8	7
17.	14.8	11.6	15.5	8	5.7	9.6	7.2
18.	16.5	11.6	10.4	7.7	5.6	9.7	6.6
19.	14.3	12.9	16.9	7.7	5.6	9.9	7.2
20.	15	15	9	7	6	9.5	7
21.	13.5	8.5	15.5	5	6	9.2	7.3
22.	11.9	13.3	16.2	7	5.7	9.5	7.2
23.	13.6	11.2	14.5	7.2	5.5	9	6.5
24.	17.2	9.7	13.3	8.3	4.9	10.2	7.6
25.	13.1	12.1	17.5	8.1	5.7	9.8	7.9
26.	12.5	15.1	13.4	8.7	6.4	10.9	6.2
27.	17.9	16.2	13.3	8.3	5.1	6.8	5.9
28.	12.2	10	16.6	8.1	5.7	10.5	6.2
29.	16.8	13.8	12	8.1	5.7	8.8	6.4
30.	14.2	10.3	12.6	8.6	6	10.3	7.2

TABLE 11: DAILY RETURN LOADING OF 33KV FOR DECEMBER 2017

PEAK DAILY POWER LOADING							
DAY/FEEDER	**ANGLU-JOS**	**DOGON DUSTSE**	**JUTH**	**NNPC**	**RUKUBA ROAD**	**TORO**	**ZARIA ROAD**
1.	12.9	11.5	16.9	8.4	6.6	9.2	7.5
2.	13.2	15.0	12.5	6.7	5.8	10.5	6.7
3.	15.6	11.7	13.2	8.4	5.3	9.5	7.3
4.	12.9	13.8	12	8.4	5.8	9.6	6.7
5.	14.1	13.5	16.7	7.2	5.2	8.2	6.8
6.	13.2	9.3	13	7.5	7.0	9.0	7.5
7.	12.7	8.0	14	7.8	5.5	10.2	8
8.	16.4	12.0	13.5	7	6	10.0	8
9.	15.4	10.1	15.8	8.4	6	10.4	9
10.	12.4	13.6	14.4	8.6	6.2	7.6	6.4
11.	16	11.6	15.4	9.4	6.3	10.1	6.5
12.	12.8	10.3	13.3	7.9	5.8	9.8	5.5
13.	13.8	9.9	14.5	8.4	5.6	10.1	6.9
14.	13.5	11.2	13.5	8.8	5.5	11	6
15.	15.1	8.8	12.8	9.1	5.1	11.1	6.8
16.	16.4	11.4	11.5	8.7	5.6	10.6	6.7
17.	13.2	12.4	9.3	8.3	6.1	10.2	6.2
18.	15	10.4	10.5	O/C	5.7	10.1	7
19.	13.5	14.0	13.1	8.2	5.4	9	6.1
20.	15.2	11.3	11.9	9.3	5.5	9.8	6
21.	13.9	10.4	15	8.1	5.4	10.8	10.4
22.	13.4	13.5	13.7	8.8	5.6	7.6	6.4
23.	13.6	13.5	13.2	8	5.4	10.9	7
24.	13.8	12	15.7	9.2	5.7	10.5	7.2
25.	14.6	14.4	16.1	8.7	6	10.1	7
26.	14.4	12.8	15.1	8.5	5.5	10.0	6.2
27.	14.3	11.2	18.5	9.1	6.2	11.3	6.2
28.	14.9	10.5	14	9.6	5.6	11.4	7.4
29.	13.3	14.8	13.2	9	5.5	11.3	5.8
30.	15.5	10	15	9.1	6.3	11.2	6.4
31.	14	10.4	14.3	9.5	5.8	10.9	7

TABLE 12: DAILY RETURN LOADING OF 33KV FOR JANUARY 2018

PEAK DAILY POWER LOADING							
DAY/FEEDER	ANGLU-JOS	DOGON DUSTSE	JUTH	NNPC	RUKUBA ROAD	TORO	ZARIA ROAD
1.	15.7	9.4	14.7	8.8	6	10.4	6.1
2.	16	10.2	17	7.5	5.4	10.3	7
3.	12.6	11.1	14.1	9.1	5.4	11	6.7
4.	15.1	10.1	15.3	9.5	6.1	9.2	6.5
5.	13.1	11.8	16.8	10.4	6.3	11.9	6.7
6.	14.3	13.4	16.1	9.2	6.7	10	6
7.	16	10.8	12	5.5	6.3	10.4	7.3
8.	15.8	11.1	14	9.1	5.5	10	6.5
9.	12.8	12.9	16.6	9.9	5.5	10.9	6.8
10.	15.3	17	13	8	5.7	11.2	7.2
11.	16.1	11.6	13.3	10.1	6.2	11	6
12.	17.9	14.9	15.5	9.4	6.1	10.1	6.2
13.	12.8	13.2	11.7	9.7	6.2	9.6	6.7
14.	17.5	9.2	14.5	9.4	5.5	10	6.4
15.	14.7	12.6	12	9.3	5.8	11.3	7.2
16.	15	11.6	11.3	9.8	6.2	11.3	7.2
17.	13.9	12.3	13	9.3	6	11.2	7.4
18.	14.2	10.3	11.6	8.7	5.8	10.5	6.8
19.	18.3	7.2	12.7	9.6	5.9	11.3	6.5
20.	14.9	12.2	15.7	8.9	6	10.5	7.8
21.	14.4	9.6	15	8.6	6	9.7	7
22.	16.9	13.8	15	7.2	6	11.5	6.4
23.	17	10	12	9.9	6.5	11.1	6.3
24.	12.3	6	15.9	7	6.5	11.5	7.2
25.	16	13.1	18	9.9	6.5	11.3	7
26.	16.4	11.1	17.5	9.3	6.2	10.6	6.4
27.	14.1	10.8	14.7	9.2	6.3	9.1	6
28.	14.6	12.6	15.3	9.4	5.6	7.9	5.5
29.	13.4	7.1	16.3	9.6	6.1	8.9	6.4
30.	16.3	12.5	15.6	9.2	5.9	10.1	6.7
31.	16.5	15.9	14.6	10.1	6.3	9.5	6.6

Table 13: RELATIONSHIP BETWEEN LENGTH, AVERAGE MAXIMUM LOADING AND AVERAGE POWER LOSSES FROM NOVEMBER 2017-JANUARY 2018

FEEDER	ANGLU-JOS	DOGON DUTSE	JUTH	NNPC	RUKUBA ROAD	TORO	ZARIA ROAD
ROUTE LENGTH (RL)/KM	37	30.1	48.3	120	8.4	155	1.6
AVERAGE MAXIMUM LOADING (AML)/MW	14.6933	12.0167	14.4667	8.1333	5.7700	10.0467	6.8133

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