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Technical Power Losses Determination: Abeokuta, Ogun State, Nigeria Distribution Network as a Case Study

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Abstract: *Nigerian Power system is faced with problems of inadequate generation, huge losses in the system and inefficient use of electricity. Losses in power system are depicted by mismatch in generated power and quantity of power that can be accounted for. The losses due to inherent properties of the power system are Technical while those due to factors external to the power system are Non-Technical. Technical Power losses in Abeokuta distribution network were computed from data obtained on Totoro, Kolobo, Abiola-Way, Ijeun-Titun, Ake-Road,GRA, Obantoko and Odeda feeders for three years (2012 to 2014) from Ibadan Electricity Distribution Company (IBEDC), Ijeun District, Abeokuta Ogun State Nigeria using loss factor approach. The results revealed that Obantoko Feeder has highest technical losses in all the years considered while Odeda has minimum technical losses. The high technical losses on Obantoko feeder was attributed to span of the feeder (29.5km) and illegal connections resulting in overloading of the feeder. The study suggests periodic preventive and corrective maintenance as well as expansion of the distribution network by installing new substation very close to Obantoko area as ways of minimizing technical losses on the feeder.*

Keywords: *Distribution Feeders, Loss Factor, Non-technical Losses, Technical Losses*

I. Introduction

The increasing problem of voltage instability was identified in [1] as one major operational challenge facing the electricity supply utility in Nigeria. Aside this, other challenges such as acute low power generation, presently about 3800MW out of generation capacity of 5500MW for Nigeria [2], huge losses in the system and inefficient use of electricity also pose greater treat to overall efficiency of the power system. The bulk of losses on power system occur as distribution losses owing to high value of Resistance-Reactance ratio (R/X) of distribution System [3]. Distribution systems take electric power from transmission system and deliver it to consumer via feeder circuits [3]. Distribution Transformers (DTs) and Distribution lines are the two major components of feeder circuits. A reasonable amount of electric energy generated by utility company is lost in distribution process. These losses occur in relatively small size in components of the distribution system. However the large number of components involved necessitates the need to compute the losses in distribution network [4]. Power system losses refer to the difference between bulk energy purchased from the national grid and the total energy accounted for [5, 6, 7, 8]. Power losses can be divided into two categories technical and non-technical losses [9].

Technical losses are inherent to the power system and are naturally occurring. Technical losses occur during transmission and distribution and involve substation, transformer, and line related losses. They are due to current flowing in the electrical network. Non-Technical losses are those that result from actions external to the power system or are caused by loads and condition that the Technical losses computation failed to take into account. Non technical losses account for larger percentage of utility company net revenue loss which in turn has been the reason why electricity is poorly supplied in Nigeria [10, 11]. Non-technical losses include defective/incorrect metering, human error on installation, administrative processes, and non-metered authorized customers, especially, theft. In several cases, when total power losses of the system are large, it becomes evident that part of non-technical losses (net company revenue loss) is serious because theoretically the technical losses typically vary between 3 % and 6 % [12, 13].

There are quite handful approaches that can be employed in estimating the technical losses of distribution networks. The use of loss factor and load loss factor was reported in [6, 7]. The use of estimate non-technical losses to compute technical losses was used in [14]. Reference [15] was inclined to the Energy flow models approach in estimation of technical losses in distribution network.

This paper employs the use of loss factor to compute the technical losses in Primary Distribution Network of Abeokuta, Ogun State using sampled network data.

II. Power Transformer Losses

Losses in power transformer are combination of the power dissipated by the cores magnetizing inductance (iron loss) and winding impedance (copper loss) [6]. These losses are generally classified into three as given below [16]:

- No Load Losses (W_{NL}): These comprise of hysteresis losses and eddy current losses in the core. It is always constant irrespective of the load.
- Load Losses (W_L): These take place in the winding part and it is load dependent. It is subdivided into (I^2R) loss and stray losses. The stray losses are as a result of eddy currents that produce stray electromagnetic flux in the winding core, core clamps, magnetic shield and other parts of the transformer
- Other Losses (W_{other}) : These are dielectric losses, load unbalance loss, oil leakage loss, loss of life, lack of maintenance, improper up keep of distribution boxes and joint loose connections.

Other Losses (W_{other}) is negligibly small (most of time less than 1%) and as such W_{NL} and W_L are most important losses considered in this work.

In calculating the technical losses of the power transformer, the method of load factor and load loss factor can be employed.

Loss Factor (L_f) is the ratio of average power consumed during a designated period to maximum demand occurring in the same period [18]. Mathematically:

$$L_f = \frac{KVA_{average}}{KVA_{MaxDemand}} \quad (1)$$

Load Loss Factor (L_{lf}) describes the average electrical energy losses for electricity distributed during a designated period [7]. In [6], Load Loss Factor is presented mathematically as:

$$L_{lf} = \frac{\text{Actual Loss during a Period (KWh)}}{\text{Loss at Maximum current (KWh)}} \quad (2)$$

The relationship between Load Factor and Load Loss Factor, as reported in [5] is given as:

$$L_{lf} = k * L_f + (1-k) * (l_f)^2 \quad (3)$$

Where k is co-efficient of loading, as per loading, given in [7] as :

$$k = \frac{\text{Minimum Demand } (KVA_{min})}{\text{Maximun Demand } (KVA_{max})} \quad (4)$$

The Total power loss in the power transformer (W_{TLoss}) in KW is given as:

$$W_{TLoss} = \{\text{Load Loss } (W_L) + \text{No Load Loss } (W_{NL})\} * 10^{-3} \quad (5)$$

Where,

$$W_L = W_C \left(\frac{KVA_{MD}}{KVA_{Rating}}\right)^2 * L_{lf} \quad (6)$$

W_C is full load copper loss

KVA_{MD} is maximum KVA Demand in a period

KVA_{Rating} is the KVA rating of the transformer

W_C and W_{NL} can be obtained from standard losses table for transformers available.

Combining (5) and (6) yields (7) below:

$$W_{TLoss} = \{ W_C \left({KVA_{MD}}/{KVA_{Rating}} \right)^2 * L_{lf} + W_{NL} \} \quad (7)$$

III. Feeder Line Losses

When current passes through line of feeders, feeder load loss results due to imperfection of the conductors of the lines. The load losses of feeders, as reported in [15] are typically computed under peak demand condition. In [4], feeder losses were computed using maximum return on loading of feeders without considering the place of loss factor. The value of the current at all times is less than the maximum current [18]. Due to this, the computation of feeder losses in this research employs the loss factor approach.

The power loss on a feeder (P_{LOSS}) is given in [4] as;

$$P_{LOSS} = I_L^2 R \quad (8)$$

Upon considering loss factor, (8) becomes:

$$P_{LOSS} = I_L^2 R * (\text{Loss Factor}) \quad (9)$$

Where Loss Factor as given in [17] is:

$$\text{Loss } Factor = (0.3 * Load\ Factor) + 0.7 * (Load\ Factor)^2 \quad (10)$$

And,

$$Load\ Factor = {Average\ Load}/{Peak\ Load} \quad (11)$$

The maximum current (I_L) in Ampere, drawn from feeder is expressed as:

$$I_L = \frac{P}{\sqrt{3}\, V * pf} \quad (12)$$

The resistance (R, in Ω) of the line is given as:

$$R = \frac{\rho l}{A} \quad (13)$$

Substituting Equations (10,12 and 13) into equation (9), equation (9) becomes:

$$P_{LOSS} = \frac{P^2 \rho l}{3A(V * pf)^2}\{(0.3 * \text{Load Factor}) + 0.7 * (\text{Load Factor})^2\} \quad (14)$$

Where:

P is maximum monthly loading on the feeder (MW)
ρ is resistivity of the conductor (Ω-m)
l is route length of the feeder (km)
A is the cross-sectional area of the conductor (mm^2)
V is the voltage (V)
Pf is the power factor
P_{LOSS} is the feeder loss (MW)

Consequent upon the above equations, the total power in the system can be expressed as:

$$\text{Total Loss} = W_{TLoss} + P_{LOSS} \quad (15)$$

However, it stated in [19] that many transformers work off constant voltage mains and as such the W_{TLoss} component of the total loss can be assumed to be constant. Hence:

$$\text{Total Loss} = \text{Constant} + P_{LOSS} \quad (16)$$

IV. Methodology

Equations (8 to 14) are applied on sampled network data of the case study-Abeokuta Distribution Network, to compute technical losses in the feeder circuit respectively. For ease of computation, MATLAB 7.9.0 (R2009b) was used as a computational tool. Abeokuta Distribution Network is under Ibadan Electricity Distribution Company (IBEDCO) with two (2) Districts- Ijeun and Olumo Districts. The network altogether has Seven (7) injection Substations namely: Poly Road (with 3 Numbers 15MVA, 33/11 KV Transformer), Abiola Way (with 2 Numbers 15MVA, 33/11 KV Transformer), Eleweran (with 1 Number 15MVA, 33/11 KV Transformer), Iberekodo (with 1 Number 15MVA, 33/11 KV Transformer), Onijanganjagan (with 1 Number 15MVA, 33/11 KV Transformer), Rounder (with 1 Number 7.5MVA, 33/11 KV Transformer) and Aiyetoro (with 1 Number 15MVA, 33/11 KV Transformer). There are eighteen (18) feeders in the network each rated 11KV, these are; Kolobo Road, Totoro, GRA, Ake, Akin-Olugbade, Ijeun, Abiola Way, Ijeun Titun, Obantoko, Odeda Road, Iberekodo Road, Mawuko, Lagos Road, Industrial, Ita-Oshin Road, Sokoto Express, Soyooye and Imeko Road. Eight (8) loaded feeders were considered for this study. The considered feeders are: Abiola way, Ijeun-Titun, Totoro, Kolobo,Ake-Road,GRA-Road,Obantoko, and Odeda.

The following data were collected on the feeders considered:

(i) Three (3) years (2012-2014) Monthly average return on loading of feeders.
(ii) Three (3) years (2012-2014) Monthly maximum return on loading of feeders.
(iii) Feeders route length.

V. Results, Analysis and Discussion

The feeders' conductors are made of Aluminum Conductor of size $300mm^2$ with resistivity of 2.8×10^{-8}Ω-m. The sampled data- loading on the 11KV feeders from January 2012 to December 2014 obtained for this work are presented in Tables 1, 2, 3, 4, 5, 6, 7 and 8. The Load Factor, Loss Factor and Technical loss in the system were computed using power factor of 0.8 and the sampled data obtained. The results are as presented in Table 9, 10, 11, 12, 13, 14, 15 and 16. The yearly average power losses and the average maximum loading on the feeders are presented in tables 17 and 18. The average maximum loading and Average power losses on the feeders for the three years considered are shown in fig. 1 and 2 respectively.

Table 1: Monthly Loading (MW) on Totoro Feeder from January, 2012 to December, 2014 [20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	3.0	6.2	5.30	4.0	6.0	4.63	2.0	4.5	3.76
February	4.0	6.0	4.39	3.0	5.8	4.36	3.0	4.3	3.49
March	4.0	6.8	4.98	3.5	5.0	4.19	1.5	4.5	3.36
April	4.0	6.0	4.79	3.5	4.8	4.02	2.3	4.8	3.56
May	3.8	7.0	5.06	3.8	5.0	4.62	1.5	6.0	3.92
June	4.0	6.0	4.51	3.5	5.0	4.14	1.5	4.8	3.58
July	2.8	6.8	4.84	3.4	4.8	4.19	1.5	4.8	3.45
August	3.8	6.8	5.05	3.0	4.5	3.80	0.8	6.0	3.70
September	3.8	6.8	4.88	3.5	4.2	3.27	2.8	6.0	3.84

October	2.8	6.0	4.67	2.8	4.5	3.80	2.8	6.0	3.70
November	3.8	6.0	4.85	2.8	4.5	3.42	2.8	6.0	3.84
December	3.8	6.2	4.74	2.8	4.5	3.40	2.0	4.0	3.22

Table 2: Monthly Loading (MW) on Kolobo Feeder from January, 2012 to December, 2014 [20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	4.0	7.0	5.36	3.8	7.0	5.84	4.4	5.5	4.86
February	6.0	6.8	6.16	2.3	5.8	4.42	3.2	5.2	4.58
March	2.0	7.8	5.47	3.8	6.0	4.38	3.8	5.2	4.63
April	3.2	7.0	4.79	3.0	6.2	5.05	3.8	5.8	4.69
May	2.0	6.0	4.56	4.1	5.8	4.79	3.8	6.8	4.75
June	4.0	8.0	5.94	3.8	5.0	4.63	3.5	5.8	4.58
July	2.8	6.8	5.38	3.5	5.2	4.59	2.8	5.5	4.49
August	3.8	6.8	5.26	3.8	5.0	4.70	3.0	6.8	4.64
September	3.8	7.0	5.31	4.0	5.3	3.99	3.8	5.8	4.72
October	3.0	7.0	5.30	3.8	5.0	4.76	3.8	5.8	4.63
November	2.8	7.0	5.08	4.0	5.0	4.30	3.5	6.5	4.57
December	2.2	7.0	5.31	3.8	5.3	4.43	3.0	5.5	4.59

Table 3: Monthly Loading (MW) on Abiola-Way Feeder from January, 2012 to December, 2014 [20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	2.7	7.0	5.46	3.0	6.8	5.45	3.0	5.8	4.44
February	2.3	7.0	5.58	3.8	6.3	5.34	3.1	5.8	4.37
March	2.7	7.0	5.58	3.8	6.5	5.26	3.1	6.0	4.70
April	2.7	6.7	5.53	3.8	6.2	5.25	3.0	5.8	4.58
May	2.8	7.0	5.22	3.8	6.0	5.13	3.0	5.5	4.54
June	2.0	7.0	4.08	3.0	6.0	5.33	3.0	6.0	4.84
July	2.0	6.8	4.42	3.0	6.0	5.30	3.0	5.8	4.38
August	2.0	7.2	4.68	3.8	6.1	5.50	3	5.8	4.14
September	2.5	7.0	5.42	3.8	6.0	5.26	3.0	6.0	4.66
October	2.8	7.0	4.40	4.2	6.0	5.35	3.0	5.7	4.65
November	2.8	6.8	4.11	2.8	6.5	5.24	3.0	6.7	4.54
December	0.5	6.7	4.41	2.8	6.0	5.13	3.0	6.0	4.49

Table 4: Monthly Loading (MW) on Ijeun-Titun Feeder from January, 2012 to December, 2014 [20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	3.5	6.0	4.86	2.2	6.2	4.25	3.0	6.5	4.32
February	2.5	6.3	4.33	3.0	5.4	4.38	3.0	5.8	4.51
March	2.5	6.5	4.55	3.0	6.0	4.64	3.0	5.8	4.23
April	2.7	6.4	4.48	3.0	5.8	4.59	3.0	5.8	4.24
May	2.0	6.0	4.34	3.8	6.0	4.67	3.0	5.8	4.14
June	2.0	6.0	4.61	2.4	6.5	4.60	3.0	5.5	4.17
July	2.0	6.3	4.02	2.8	6.0	4.63	2.3	5.5	4.33
August	0.5	6.5	3.85	2.8	6.0	4.44	3.0	5.5	4.43
September	1.5	6.7	4.52	2.8	6.2	4.58	3.0	5.8	4.25
October	1.8	6.8	3.94	3.0	5.8	4.68	3.0	6.0	4.26
November	2.0	6.2	4.14	3.3	5.8	4.68	3.0	5.5	4.26
December	2.0	6.7	4.88	3.0	5.5	4.41	3.0	6.0	4.32

Table 5: Monthly Loading (MW) on Ake-Road Feeder from January, 2012 to December, 2014[20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	2.8	6.2	4.86	3.8	6.0	5.29	3.8	6.0	4.48
February	3.0	6.2	4.78	3.0	6.5	4.50	4.0	5.8	4.47
March	3.0	6.0	4.61	3.0	5.6	4.52	3.8	5.2	4.44
April	2.0	7.0	4.63	2.0	5.8	4.08	3.8	5.2	4.58
May	2.0	6.8	4.99	3.1	6.0	4.84	3.8	5.0	4.42
June	2.2	6.8	4.87	3.0	6.2	4.88	4.1	5.1	4.57
July	2.1	6.0	4.65	2.8	5.2	3.92	3.0	5.2	4.44
August	2.8	6.0	4.86	3.5	5.5	4.52	3.0	4.8	4.29
September	2.8	6.8	4.64	3.2	5.5	4.57	3.8	5.0	4.43
October	3.4	7.0	4.86	3.0	6.0	4.42	4.0	6.0	4.57
November	2.0	6.2	4.46	2.0	6.0	4.30	3.8	5.1	3.37
December	2.8	6.0	4.61	3.0	5.1	4.35	3.8	5.2	4.33

Table 6: Monthly Loading (MW) on GRA Feeder from January, 2012 to December, 2014[20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	0.8	3.0	1.93	1.0	3.0	1.91	1.0	3.0	1.84
February	1.1	3.1	2.05	0.8	5.3	1.80	0.8	2.8	1.71
March	1.0	3.0	1.78	0.8	3.0	1.61	0.8	2.5	1.71
April	0.8	3.0	1.88	0.8	2.8	1.52	0.8	2.8	1.69
May	1.0	3.0	2.09	1.0	3.0	1.81	0.8	2.8	1.68
June	0.5	2.8	1.83	0.8	2.8	1.68	1.2	3.0	1.70
July	0.8	2.8	1.91	1.0	2.8	1.55	0.8	2.5	1.59
August	0.5	2.8	1.79	0.8	2.8	1.56	1.2	2.5	1.71
September	0.8	2.8	1.83	1.0	3.0	1.90	1.0	2.3	1.62
October	0.5	2.8	1.79	0.8	2.0	1.52	0.8	2.3	1.67
November	0.8	4.8	1.95	0.8	3.0	1.47	0.8	2.8	1.72
December	0.5	2.8	1.75	0.8	4.0	1.91	1.0	4.2	1.77

Table 7: Monthly Loading (MW) on Obantoko Feeder from January, 2012 to December, 2014[20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	4.2	7.3	6.73	3.0	7.0	5.73	2.1	7.0	4.56
February	3.8	7.0	5.66	4.8	7.0	5.84	3.0	6.0	5.12
March	3.5	7.0	5.34	4.8	6.8	5.72	2.0	6.1	4.96
April	3.4	6.8	5.43	3.8	7.0	5.59	2.0	7.0	5.28
May	4.5	6.8	5.64	2.8	7.0	5.32	4.0	5.2	4.56
June	4.2	6.8	5.57	4.5	7.0	5.40	3.8	6.2	5.33
July	4.1	6.5	5.45	3.8	7.0	5.40	4.0	5.8	4.93
August	3.2	7.0	5.59	3.0	7.0	5.29	4.2	6.2	4.84
September	3.8	7.0	5.46	3.5	7.0	5.31	3.0	6.0	4.68
October	3.8	7.0	5.48	3.0	6.1	5.05	3.8	6.0	4.83
November	3.8	6.8	5.45	3.0	6.1	5.04	3.8	6.0	4.87
December	3.8	6.8	5.44	3.0	6.2	4.97	2.0	6.2	4.65

Table 8: Monthly Loading (MW) on Odeda Feeder from January, 2012 to December, 2014[20]

Months	2012			2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
January	1.7	3.0	2.13	0.8	3.0	2.11	1.0	3.1	2.18
February	0.5	2.8	1.72	1.8	2.8	2.01	2.0	3.0	2.19
March	1.8	3.0	2.30	0.8	2.3	1.97	0.5	4.5	2.30
April	1.5	3.0	2.28	0.8	3.5	2.14	0.8	3.0	2.19
May	1.8	3.0	2.35	0.8	3.5	2.11	2.0	3.0	2.12
June	2.0	3.0	2.45	0.8	3.0	2.04	2.0	2.5	2.08
July	2.0	3.5	2.49	1.8	3.0	2.12	1.8	2.8	2.01
August	1.5	3.0	2.37	1.0	3.0	2.11	1.8	2.8	2.09
September	1.8	3.0	2.42	0.8	3.0	2.11	1.8	3.0	2.11
October	1.0	2.8	2.24	1.0	3.1	2.08	0.8	2.8	2.12
November	1.0	3.0	2.31	1.0	2.5	1.99	1.8	2.8	2.08
December	1.5	3.8	2.41	0.8	5.2	2.14	1.8	3.0	2.08

Table 9: Calculated Load Factor, Loss Factor and Power losses (MW) on Totoro 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 20km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses
January	0.8548	0.7680	0.2389	0.7717	0.6483	0.1889	0.8356	0.7394	0.1212
February	0.7317	0.5942	0.1731	0.7517	0.6211	0.1691	0.8116	0.7046	0.1054
March	0.7324	0.5951	0.2227	0.8380	0.7430	0.1503	0.7467	0.6143	0.1007
April	0.7983	0.6856	0.1997	0.8375	0.7422	0.1384	0.7417	0.6075	0.1133
May	0.7229	0.5826	0.2310	0.9240	0.8748	0.1770	0.6533	0.4948	0.1441
June	0.7517	0.6210	0.1809	0.8280	0.7283	0.1473	0.7458	0.6131	0.1143
July	0.7118	0.5682	0.2126	0.8729	0.7953	0.1483	0.7188	0.5772	0.1076
August	0.7426	0.6089	0.2278	0.8444	0.7525	0.1233	0.6167	0.4512	0.1314
September	0.7176	0.5758	0.2155	0.7786	0.6579	0.0939	0.6400	0.4787	0.1395
October	0.7783	0.6576	0.1916	0.8444	0.7525	0.1233	0.6167	0.4512	0.1314
November	0.8083	0.6999	0.2039	0.7600	0.6323	0.1036	0.6400	0.4787	0.1395
December	0.7645	0.6385	0.1986	0.7556	0.6263	0.1026	0.8050	0.6951	0.0900

Table 10: Calculated Load Factor, Loss Factor and Power losses on Kolobo 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 15km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)
January	0.7657	0.6401	0.1904	0.8343	0.7375	0.2193	0.8836	0.8117	0.1490
February	0.9059	0.8462	0.2375	0.7621	0.6351	0.1297	0.8808	0.8073	0.1325
March	0.7013	0.5546	0.2048	0.7300	0.5920	0.1294	0.8904	0.8221	0.1349
April	0.6843	0.5331	0.1585	0.8145	0.7088	0.1654	0.8086	0.7003	0.1430
May	0.7600	0.6323	0.1382	0.8259	0.7252	0.1481	0.6985	0.5511	0.1547
June	0.7425	0.6087	0.2364	0.9260	0.8780	0.1332	0.7897	0.6734	0.1375
July	0.7912	0.6755	0.1896	0.8827	0.8102	0.1330	0.8164	0.7114	0.1306
August	0.7735	0.6509	0.1827	0.9400	0.9005	0.1366	0.6824	0.5306	0.1489
September	0.7586	0.6304	0.1875	0.7528	0.6226	0.1061	0.8138	0.7077	0.1445
October	0.7571	0.6284	0.1869	0.9520	0.9200	0.1396	0.7983	0.6856	0.1400
November	0.7257	0.5864	0.1744	0.8600	0.7757	0.1177	0.7031	0.5569	0.1428
December	0.7586	0.6304	0.1875	0.8358	0.7398	0.1261	0.8345	0.7379	0.1355

Table 11: Calculated Load Factor, Loss Factor and Power losses on Abiola-Way 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 15km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)
January	0.7800	0.6599	0.1962	0.8015	0.6901	0.1937	0.7655	0.6399	0.1306
February	0.7971	0.6839	0.2034	0.8476	0.7572	0.1824	0.7534	0.6234	0.1273
March	0.7971	0.6839	0.2034	0.8092	0.7012	0.1798	0.7833	0.6645	0.1452
April	0.8254	0.7245	0.1974	0.8468	0.7560	0.1764	0.7897	0.6734	0.1375
May	0.7457	0.6130	0.1823	0.8550	0.7682	0.1678	0.8255	0.7246	0.1330
June	0.5829	0.4127	0.1227	0.8883	0.8189	0.1789	0.8067	0.6975	0.1524
July	0.6500	0.4908	0.1377	0.8833	0.8112	0.1772	0.7552	0.6258	0.1278
August	0.6500	0.4907	0.1544	0.9016	0.8396	0.1896	0.7138	0.5708	0.1165
September	0.7743	0.6519	0.1939	0.8767	0.8010	0.1750	0.7767	0.6552	0.1432
October	0.6286	0.4651	0.1383	0.8917	0.8240	0.1800	0.8158	0.7106	0.1401
November	0.6044	0.4370	0.1227	0.8062	0.6968	0.1787	0.6776	0.5247	0.1430
December	0.6582	0.5007	0.1364	0.8550	0.7682	0.1678	0.7483	0.6165	0.1347

Table 12: Calculated Load Factor, Loss Factor and Power losses on Ijeun-Titun 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 14km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)
January	0.8100	0.7023	0.1432	0.6855	0.5346	0.1164	0.6646	0.5086	0.1217
February	0.6873	0.5369	0.1207	0.8111	0.7039	0.1163	0.7776	0.6565	0.1251
March	0.7000	0.5530	0.1323	0.7733	0.6506	0.1327	0.7293	0.5911	0.1126
April	0.7000	0.5530	0.1283	0.7914	0.6758	0.1288	0.7310	0.5934	0.1131
May	0.7233	0.5832	0.1189	0.7783	0.6576	0.1341	0.7138	0.5708	0.1088
June	0.7683	0.6437	0.1313	0.7077	0.5629	0.1347	0.7582	0.6298	0.1079
July	0.6381	0.4764	0.1071	0.7717	0.6483	0.1322	0.7873	0.6700	0.1148
August	0.5923	0.4233	0.1013	0.7400	0.6053	0.1234	0.8055	0.6958	0.1192
September	0.6746	0.5210	0.1325	0.7387	0.6036	0.1314	0.7328	0.5957	0.1135
October	0.5794	0.4088	0.1071	0.8069	0.6978	0.1330	0.7100	0.5659	0.1154
November	0.6677	0.5124	0.1116	0.8069	0.6978	0.1330	0.7745	0.6523	0.1118
December	0.7284	0.5899	0.1500	0.8018	0.6906	0.1183	0.7200	0.5789	0.1180

Table 13: Calculated Load Factor, Loss Factor and Power losses on Ake-Road 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 15.3km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)
January	0.7839	0.6653	0.1583	0.8817	0.8086	0.1802	0.7467	0.6143	0.1369
February	0.7710	0.6474	0.1541	0.6923	0.5432	0.1421	0.7707	0.6470	0.1347
March	0.7683	0.6437	0.1435	0.8071	0.6982	0.1355	0.8538	0.7665	0.1283
April	0.6614	0.5047	0.1531	0.7034	0.5574	0.1161	0.8808	0.8073	0.1351
May	0.7338	0.5971	0.1709	0.8067	0.6975	0.1554	0.8840	0.8122	0.1257
June	0.7162	0.5739	0.1643	0.7871	0.6698	0.1594	0.8961	0.8309	0.1338
July	0.7750	0.6529	0.1455	0.7538	0.6240	0.1044	0.8538	0.7665	0.1283
August	0.8100	0.7023	0.1565	0.8218	0.7193	0.1347	0.8938	0.8273	0.1180
September	0.6824	0.5306	0.1519	0.8309	0.7326	0.1372	0.8860	0.8153	0.1262
October	0.6943	0.5457	0.1655	0.7367	0.6009	0.1339	0.7617	0.6346	0.1414
November	0.7194	0.5780	0.1376	0.7167	0.5745	0.1280	0.6608	0.5039	0.0811
December	0.7683	0.6437	0.1435	0.8529	0.7651	0.1232	0.8327	0.7352	0.1231

Table 14: Calculated Load Factor, Loss Factor and Power losses on GRA 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 17.5km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)
January	0.6433	0.4827	0.0308	0.6367	0.4747	0.0303	0.6133	0.4473	0.0285
February	0.6613	0.5045	0.0343	0.3396	0.1826	0.0363	0.6107	0.4443	0.0247
March	0.5933	0.4244	0.0270	0.5367	0.3626	0.0231	0.6840	0.5327	0.0236
April	0.6267	0.4629	0.0295	0.5429	0.3691	0.0205	0.6036	0.4361	0.0242
May	0.6967	0.5487	0.0350	0.6033	0.4358	0.0278	0.6000	0.4320	0.0240
June	0.6536	0.4951	0.0275	0.6000	0.4320	0.0240	0.5667	0.3948	0.0252
July	0.6821	0.5304	0.0294	0.5536	0.3806	0.0211	0.6360	0.4739	0.0210
August	0.6393	0.4779	0.0265	0.5571	0.3844	0.0213	0.6840	0.5327	0.0236
September	0.6536	0.4951	0.0275	0.6333	0.4708	0.0300	0.7043	0.5586	0.0209
October	0.6393	0.4779	0.0265	0.7600	0.6323	0.0179	0.7261	0.5869	0.0220
November	0.4063	0.2374	0.0387	0.4900	0.3151	0.0201	0.6143	0.4484	0.0249
December	0.6250	0.4609	0.0256	0.4775	0.3029	0.0343	0.4214	0.2507	0.0313

Table 15: Calculated Load Factor, Loss Factor and Power losses on Obantoko 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 29.5km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)
January	0.9219	0.8715	0.5544	0.8186	0.7146	0.4180	0.6514	0.4925	0.2880
February	0.8086	0.7002	0.4095	0.8343	0.7375	0.4313	0.8533	0.7657	0.3290
March	0.7629	0.6362	0.3721	0.8412	0.7477	0.4127	0.8131	0.7067	0.3139
April	0.7985	0.6859	0.3786	0.7986	0.6860	0.4012	0.7543	0.6245	0.3653
May	0.8294	0.7304	0.4031	0.7600	0.6323	0.3698	0.8769	0.8014	0.2586
June	0.8191	0.7154	0.3948	0.7714	0.6480	0.3790	0.8597	0.7752	0.3557
July	0.8385	0.7437	0.3750	0.7714	0.6480	0.3790	0.8500	0.7607	0.3055
August	0.7986	0.6860	0.4012	0.7557	0.6265	0.3664	0.7806	0.6608	0.3032
September	0.7800	0.6599	0.3859	0.7586	0.6304	0.3687	0.7800	0.6599	0.2836
October	0.7829	0.6639	0.3883	0.8279	0.7281	0.3234	0.8050	0.6951	0.2987
November	0.8015	0.6901	0.3809	0.8262	0.7257	0.3223	0.8117	0.7047	0.3028
December	0.8000	0.6880	0.3797	0.8016	0.6903	0.3167	0.7500	0.6187	0.2839

Table 16: Calculated Load Factor, Loss Factor and Power losses on Odeda 11KV Feeder from January, 2012 to December, 2014

Feeder route length= 8.0km									
Months	2012			2013			2014		
	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)	Load Factor	Loss Factor	Power Losses(MW)
January	0.7100	0.5659	0.0165	0.7033	0.5573	0.0162	0.7032	0.5571	0.0173
February	0.6143	0.4484	0.0114	0.7179	0.5761	0.0146	0.7300	0.5920	0.0172
March	0.7667	0.6414	0.0187	0.8565	0.7705	0.0132	0.5111	0.3362	0.0220
April	0.7600	0.6323	0.0184	0.6114	0.4451	0.0176	0.7300	0.5920	0.0172
May	0.7833	0.6645	0.0194	0.6029	0.4353	0.0173	0.7067	0.5616	0.0164
June	0.8167	0.7119	0.0207	0.6800	0.5277	0.0154	0.8320	0.7342	0.0149
July	0.7114	0.5677	0.0225	0.7067	0.5616	0.0164	0.7179	0.5761	0.0146
August	0.7900	0.6739	0.0196	0.7033	0.5573	0.0162	0.7464	0.6139	0.0156
September	0.8067	0.6975	0.0203	0.7033	0.5573	0.0162	0.7033	0.5573	0.0162
October	0.8000	0.6880	0.0175	0.6710	0.5164	0.0161	0.7571	0.6284	0.0159
November	0.7700	0.6460	0.0188	0.7960	0.6823	0.0138	0.7429	0.6091	0.0155
December	0.6342	0.4718	0.0221	0.4115	0.2420	0.0212	0.6933	0.5445	0.0159

Table 17: average losses (MW) on the feeders from 2012 to 2014

Feeder	2012	2013	2014	Total Average Losses
Totoro	0.2080	0.1388	0.1199	0.4667
Kolobo	0.1895	0.1404	0.1412	0.4711
Abiola-Way	0.1657	0.1789	0.1359	0.4805
Ijeun-Titun	0.1237	0.1279	0.1152	0.3668
Ake-road	0.1537	0.1373	0.2161	0.5071
GRA	0.0299	0.0256	0.0245	0.0800
Obantoko	0.4020	0.3740	0.3073	1.0833
Odeda	0.0188	0.0162	0.0166	0.0516
Total	1.2913	1.1391	1.0767	**3.5071**

Table 18: Average Maximum loading (MW) on the feeders from 2012 to 2014

Feeder	2012	2013	2014
Totoro	6.3833	4.8833	5.1417
Kolobo	7.0167	5.5500	5.8500
Abiola-Way	6.9333	6.2000	5.9083
Ijeun-Titun	6.3667	5.9333	5.7917
Ake-road	6.4167	5.7833	5.3000
GRA	3.0583	3.1250	2.7917
Obantoko	6.9000	6.7667	6.1417
Odeda	3.0750	3.1583	3.0250

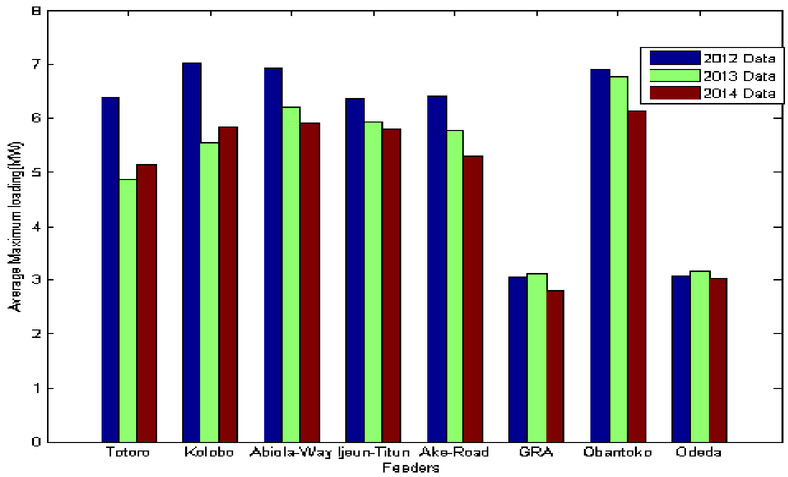

Figure1: Average Maximum Loading on Feeders from 2012 to 2014

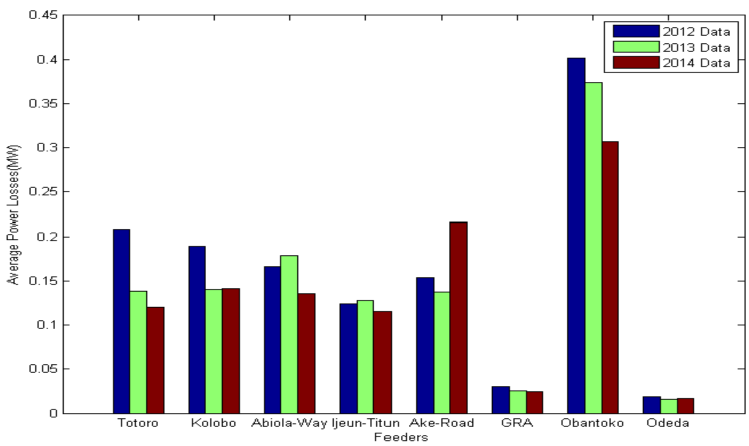

Figure2: Average Maximum Loading on Feeders from 2012 to 2014

From the results presented above, the Total average power loss in the eight (8) feeders for the three years is 3.5071MW. The average power losses on the feeders decrease yearly. From January 2012 to December 2014 the average power losses on the eight feeders are 1.2913MW, 1.1391MW and 1.0767MW in 2012, 2013 and 2014 respectively as shown in Table 9. As can be observed from fig 2, the maximum average power losses occur on Obantoko feeder for the three years considered, while the minimum average power losses occur on Odeda feeder. The high value observed on Obantoko is not unconnected with the length of the feeder (29.5km) as well as high rate of illegal connection in the area resulting into overloading of the feeder.

VI. Conclusion

The computation of technical losses of Abeokuta, Ogun State Nigeria distribution network was done in this work using loss factor approach. The results reveled that Obantoko feeder has highest average Power losses for 2012, 2013 and 2014. It then becomes necessary to gear effort towards minimizing technical losses on the feeder; this can be achieved by periodic carrying out of preventive and corrective maintenance. Also the distribution network should be expanded by installation of an additional distribution substation near Obantoko area so as to reduce the feeder route length.

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