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# Investigation of Electric Power Losses on Primary Distribution Feeder: A Case Study of Sango - Ota Distribution Company, Ogun State, Nigeria

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**Abstract**

The role of distribution system in energy management system cannot be over-emphasized; it linked and served the generated energy to final consumers. Sadly, to know, the integrity of distribution system is being questioned due to its inability to return expected profit. This was not unconnected to power loss occurring on the distribution feeders. It was on this background, that this paper presents investigation of electric power losses on primary distribution feeder; a case study of Sango- Ota Distribution Company, Ogun State. The results of the analysis showed that losses experienced on the selected feeders increases annually and the average annual power losses was found to be 4.4555MW, 10.6935MW, 4.3795MW, 4.1635MW and 2.7175MW for Sango, Ota Ind, Idiroko, Odigbo and Ilaro 33kV feeders respectively. The research revealed that most of industries sited in Ota runs at lower power factor due to lack of capacitor and inductive bank and this contributed immensely to power loss on this feeder. It was observed that among the selected feeders, Ota 33kV feeder experienced the highest power losses while the Ilaro 33kV experienced the least power losses.

**Keywords:** Primary Distribution System, Distribution feeders, Power Losses, Technical Losses, Non-Technical Losses, MATLAB

## INTRODUCTION

Distribution systems account financially for energy generated and its consumption by various categories of consumers and also in recent years, expansion of distribution system is not unconnected to growing demand for electrical energy in newly constructed residential buildings, rural electrification project, urbanization and industrialization. These had contributed in no small measure to energy losses incurred on the distribution system as it increased the feeder route length against initial planned length, and it as well placed unplanned pressure on distribution transformers. Electrical energy losses can be viewed as a portion of electricity supplied into the transmission and distribution grids that are not paid for by users [1]. Energy losses manifest at every stage of the power distribution process, starting with the step-up transformers that link power plants with the transmission system, and ending with the customer wiring beyond the retail meter [2].

The entire losses incurred at the distribution end have been broadly grouped into technical and non-technical losses (commercial loss) [3, 4]. Technical losses in distribution system are inevitable regardless how carefully the system is designed, it occurs naturally in system components such as distribution lines, transformers, feeders and measurement system [5, 6]. Non-technical losses on the other hand, are caused by actions external to the power system or are caused by loads and conditions that the technical losses computation failed to take into account it includes pilferage, defective meters, administrative processes, terrorism, errors in meter reading and in billing unmetered supply of energy etc. [7-9].

Among other factors that determine the level of integrity of power distribution systems are the level of security of the network against losses and the extent to which distributed energy yields profit to the utility company. A clear understanding on the magnitude of technical and commercial losses is a fundamental step in the move to reducing distribution system losses [10] and with adequate feeders' analysis, sources of these losses will be identified and appropriately addressed, this will help Distribution Companies to minimize, if not completely eliminated, the huge capital losses arising from these losses.

This paper presents the investigation of electric power losses on primary distribution feeder; a case study of Sango- Ota Distribution Company, Ogun State, and the analysis was implemented in MATLAB environment, and the results obtained on all the five selected feeders were compared in terms of technical losses experienced.

## STUDY LOCATION: OTA BUSINESS HUB

Ota Business Hub is situated in Ogun State, Nigeria and controls eight undertaken service hubs namely, Ijoko, Ijako, Iganmode, Iyesi, Ifo, Ilaro, Owode and Baby-O service hub. Five important feeders (Sango 33 kV, Idiroko 33 kV, Odigbo 33 kV, Ilaro 33 kV and Ota industrial 33 kV feeders) within the control axis of this hub were selected for the analysis with the aim of investigating the level of technical losses.

## MATERIALS AND METHOD

### A. MATERIALS

The following data over a period of two years (January, 2014 to December, 2015) were collected on each of the selected feeders itemized above and it is a shown in appendix A;

I. Monthly return loading of 33kV

II. Feeder route length

III. Cable type

For the purpose of this analysis Cross sectional Area of Aluminum Conductor of size 150mm$^2$ having a resistivity of $2.82\times10^{-8}\Omega$m was used for both feeder and distribution lines.

### B. METHOD

The research was based on fundamentals of classical concept that the power loss is a function of product of square of the current flowing through the line and the resistance of the line and that load losses result when current flows through the transformer. In this research, route length and route resistance vis-a-vis the load type (resistive, inductive and capacitive) were considered. The total loss in a transformer is given by equation (1) below;

$$Total\ loss\ = P_{o(constant)} + I^2 \times R_{effective} \quad (1)$$

Also, the current drawn from the feeder is given as;

$$I_L = \frac{P}{\sqrt{3}VP_f} \quad (2)$$

where;

P= Power in Mega Watts, V= Voltage in Volts and $P_f$ is the power factor

The resistance $(R)$ is given by;

$$R = \frac{\varrho L}{A} \quad (3)$$

where;

ℓ is resistivity in (Ω-m), R is resistance in (Ω), L is route length of the feeder (mm) and A is cross sectional area in$(mm^2)$.

The power loss which is the difference between the power received and consumed is expressed as;

$$P_{loss} = I_L^2 \times R \quad (4)$$

The total monthly losses on each of the feeders over the experimentation period were obtained using equations (2) to (4) in sequence implemented in MATLAB (R2013a).

## RESULTS AND DISCUSSION

A simple MATLAB program was written to implement the proposed approach; it was run on a portable computer with an Intel Core2 Duo (1.8GHz) processor, 2GB RAM memory and MS Windows 7 as an operating system. The power losses obtained on each of feeder for the year 2014 was as presented in Table 1. From the result obtained, Ota 33kV feeder witnessed the highest power losses compared to other feeders from January to December, 2014, this was not unconnected to the fact that it was densely populated being an industrial site and the industrial inductive electrical machines contributed immensely to these losses. Also, the least power losses were observed on Ilaro 33kV feeder and this was largely due to the low population density and absence of heavy based, electrical energy demanding industries and majorly the loads on this feeder were residential. The power losses on Sango 33kV feeder was found to be the second largest among the feeders investigated, Sango was also densely populated and the feeder route length was long as well, power losses on Idiroko and Odigbo 33 kV feeders were fairly of the same magnitude.

**Table 1:** Estimated Power Losses on the Selected Feeders for 2014

| **ESTIMATED POWER LOSSES (MW)** | | | | | |
|---|---|---|---|---|---|
| **MONTHS** | **SANGO** | **OTA IND** | **IDIROKO** | **ODIGBO** | **ILARO** |
| **January** | 0.279 | 0.701 | 0.249 | 0.344 | 0.233 |
| **February** | 0.256 | 0.632 | 0.249 | 0.288 | 0.184 |
| **March** | 0.213 | 0.632 | 0.265 | 0.288 | 0.151 |
| **April** | 0.234 | 0.684 | 0.326 | 0.229 | 0.151 |
| **May** | 0.303 | 0.812 | 0.249 | 0.262 | 0.136 |
| **June** | 0.303 | 0.815 | 0.364 | 0.344 | 0.208 |
| **July** | 0.303 | 0.851 | 0.364 | 0.415 | 0.233 |
| **August** | 0.459 | 0.812 | 0.265 | 0.177 | 0.184 |
| **September** | 0.372 | 0.756 | 0.265 | 0.229 | 0.184 |
| **October** | 0.459 | 0.756 | 0.210 | 0.229 | 0.173 |
| **November** | 0.459 | 0.993 | 0.265 | 0.306 | 0.233 |
| **December** | 0.312 | 0.632 | 0.273 | 0.288 | 0.252 |
| **Total Loss** | **3.952** | **9.076** | **3.344** | **3.399** | **2.322** |

Also, the power losses obtained on each feeder for the year 2015 was as presented in Table 2; from the results obtained, it was observed that the power losses on each of the feeders increased compared to the previous year. It was also noticed that the trend of power losses on the selected feeders followed the same pattern with Ota 33kV feeder recording the highest power losses, followed by Idiroko 33kV feeder, Sango 33kV feeder, Odigbo 33kV feeder while the least power losses occurred in Ilaro 33kV feeders. The rate of technical losses on Ota 33kV feeder was highly alarming and by economic implication, the feeder needs technical attention.

**Table 2:** Estimated Power Loss on the Selected Feeders for the year 2015

| ESTIMATED POWER LOSSES (MW) | | | | | |
|---|---|---|---|---|---|
| **MONTHS** | **SANGO** | **OTA IND** | **IDIROKO** | **ODIGBO** | **ILARO** |
| **January** | 0.400 | 0.756 | 0.364 | 0.404 | 0.266 |
| **February** | 0.400 | 0.756 | 0.364 | 0.288 | 0.184 |
| **March** | 0.287 | 0.993 | 0.393 | 0.306 | 0.259 |
| **April** | 0.312 | 1.036 | 0.435 | 0.262 | 0.259 |
| **May** | 0.500 | 0.870 | 0.467 | 0.315 | 0.173 |
| **June** | 0.500 | 0.870 | 0.393 | 0.373 | 0.208 |
| **July** | 0.410 | 1.014 | 0.393 | 0.415 | 0.252 |
| **August** | 0.372 | 1.058 | 0.364 | 0.383 | 0.252 |
| **September** | 0.521 | 1.169 | 0.364 | 0.492 | 0.208 |
| **October** | 0.400 | 1.239 | 0.584 | 0.485 | 0.324 |
| **November** | 0.611 | 1.239 | 0.621 | 0.577 | 0.348 |
| **December** | 0.646 | 1.311 | 0.673 | 0.628 | 0.380 |
| **Total Loss** | **4.959** | **12.311** | **5.415** | **4.928** | **3.113** |

Figure 1 illustrates the annual power losses on the selected feeders investigated over the period of two years. The Figure reflected an appreciable increase in power losses on each of the feeders; this actually shows that losses on the feeder tend to increase as the year rolls bye. Several factors could be held accountable for this trend. Among others are long feeder route lengths, absence of reactive power compensation on the grid, unequal load distribution among the three phases of L.T, ageing of equipment and illegal tapping by unscrupulous electricity users.

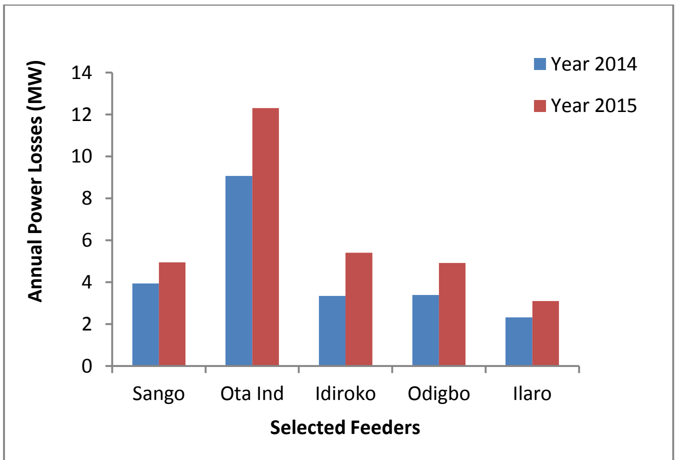


**Figure 1:** A Multiple Bar-Chart Showing Annual Power Loss (MW) on the Selected Feeders

## CONCLUSION

Investigation of electric power losses on primary distribution feeder; a case study of Sango- Ota Distribution Company, Ogun State was presented in this paper. The results of the analysis showed that losses experienced on the selected feeders increases annually and the average annual power losses was found to be 4.4555MW, 10.6935MW, 4.3795MW, 4.1635MW and 2.7175MW for Sango, Ota Ind, Idiroko, Odigbo and Ilaro 33kV feeders respectively. The research showed that Ota Industrial area experienced the highest power losses and this was not unconnected to dense population coupled with presence of industries that use heavy inductive machines while Ilaro consumed less power and the losses incurred on the feeder was minimal compared to other feeders investigated.

Critical examination of the study area revealed that most of the industries sited in Ota Industrial area lack capacitive load banks and inductive load bank and this in no doubt contributed to the reduction in power factor resulting in severe power losses in the distribution system. The paper recommends a management meeting with the owners of industries in the study area on the need to consider the use of power factor correction devices. Also, distribution route feeder length needs attention, and a pattern for distribution of loads among the L.T three phase needs to be developed. Lastly, aged and overloaded primary distribution transformers should be replaced and upgraded.

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## REFERENCES

[1] Reducing Technical and Non-Technical Losses in the Power Sector, Background Paper for the World Bank Group Energy Sector Strategy, July 2009

[2] Adapted from: Cowlitz County (WA) Public Utility District. (Undated). Electricity Transmission (How Electricity Moves). Available at: http://www.cowlitzpud.org/pdf/electricity101/6%20 Electricity%20-%20Transmission.pdf

[3] TURAN GOHEN, Electric Power Transmission System Engineering: Analysis and Design, John Wiley & sons, Inc., 1988

[4] OLLE I. ELGERD, Electric Energy Systems Theory: An Introduction, McGraw Hill Electrical and Electronic Engineering Series, McGraw Hill Inc.,1971

[5] BENEDICT, E., COLLINS, T., & GOTHAM, D. (1992). Losses in electric power systems, *School of Electrical Engineering, Purdue University, West Lafayette, Indiana*, 50-160

[6] MUNGKUNG, N., GOMURUT, N., TANITTEERAPAN, T., ARUNRUNGRUSMI, S., CHAOKUMNERD, W., AND TOSHIFUMI, Y.

(2009). Analysis of technical loss in distribution line system, *Proceedings of the 8th WSEAS International Conference on Telecommunications and Informatics,* 26-30

[7] AJENIKOKO, G.A., & OLABODE, O.E (2017). Development of a B-Loss coefficient model for analysis of non-technical losses on Nigerian transmission network. *International Journal of Renewable Energy Technology Research, 6*(1), 1-5

[8] ARAI, S, & ABDELKADER M. (2011). Characterization of transmission losses. *IEEE Transactions on Power System*, 26, 1, 1-10.

[9] BHATTACHARYYA, A.B., & GOSWAMI, B.S.K. (2014). Optimal placement of FACTS devices by Genetic Algorithm for the increased loadability of a power system. *World Academy of Science, Engineering and Technology*. 3, 5, 16-21

[10] Guidelines for Energy Audit in Power Systems, CEA, New Delhi May 1992

## APPENDIX-1

**Table 3: Power loadings in MW for the year 2014**

**Feeder Monthly Loading (MW)**

| Months | SANGO | OTA IND | IDIROKO | ODIGBO | ILARO |
|---|---|---|---|---|---|
| January | 7.1 | 7.9 | 6.2 | 7.1 | 7.2 |
| February | 6.8 | 7.5 | 6.2 | 6.5 | 6.4 |
| March | 6.2 | 7.5 | 6.4 | 6.5 | 5.8 |
| April | 6.5 | 7.8 | 7.1 | 5.8 | 5.8 |
| May | 7.4 | 8.5 | 6.2 | 6.2 | 5.5 |
| June | 7.4 | 8.7 | 7.5 | 7.1 | 6.8 |
| July | 7.4 | 8.7 | 7.5 | 7.8 | 7.2 |
| August | 9.1 | 8.5 | 6.4 | 5.1 | 6.4 |
| September | 8.2 | 8.2 | 6.4 | 5.8 | 6.4 |
| October | 9.1 | 8.2 | 5.7 | 5.8 | 6.2 |
| November | 9.1 | 9.4 | 6.4 | 6.7 | 7.2 |
| December | 7.5 | 7.5 | 8.2 | 6.5 | 7.5 |

**Table 4: Power loading in MW for the year 2015**

**Feeder Monthly Loading (MW)**

| Months | SANGO | OTA IND | IDIROKO | ODIGBO | ILARO |
|---|---|---|---|---|---|
| January | 8.5 | 8.2 | 7.5 | 7.7 | 7.7 |
| February | 8.5 | 8.2 | 7.5 | 6.5 | 6.4 |
| March | 7.2 | 9.4 | 7.8 | 6.7 | 7.6 |
| April | 7.5 | 9.6 | 8.2 | 6.2 | 7.6 |
| May | 9.5 | 8.8 | 8.2 | 6.8 | 6.2 |
| June | 9.5 | 8.8 | 8.5 | 7.4 | 6.8 |
| July | 8.6 | 9.5 | 7.8 | 7.8 | 7.5 |
| August | 8.2 | 9.7 | 7.8 | 7.5 | 7.5 |
| September | 9.7 | 10.2 | 7.5 | 8.5 | 6.8 |
| October | 8.5 | 10.5 | 7.5 | 8.2 | 8.5 |
| November | 10.5 | 10.5 | 9.5 | 9.2 | 8.8 |
| December | 10.8 | 10.8 | 10.2 | 9.6 | 9.2 |