iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: XII Month of publication: December 2021

DOI: https://doi.org/10.22214/ijraset.2021.39074

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

Optimization of Energy Efficiency for Electric Power Distribution System Losses

Okorie N. S. [1], Idoniboyeobu D. C. [2], Braide S. L.[3]
[1, 2, 3]Department of Electrical, Faculty of Engineering, Rivers State University, Port Harcourt

***Abstract:** This study evaluated the existing electric power network of Mile 2 Diobu zone, Port Harcourt distribution network which consists of four (4) 11kV distribution feeders namely; Ojoto, Nsukka, Udi and Silverbird. This work considered Ojoto and Nsukka Street distribution network for improved power quality. The three (3) 33/11kv injection substations are fed from 165 MVA transmission station (PH Town) at Amadi junction by Nzimiro. Collection and analysis of data collected from the injection substations that supply electricity to mile 2 Diobu, Port Harcourt was the first consideration. The distribution network was modeled in Electrical Transient Analyzer Program (ETAP) using Newton-Raphson Load Flow equations. The simulation result of the existing condition network shows that the network has low voltage profile problem on Nsukka network and overloading of distribution transformers on Ojoto networks. The following optimization techniques are applied: up-gradation of distribution transformers, and transformer load tap changer to improve the distribution network for Mile 2 Diobu, Port Harcourt electrical power network. The simulation result of the improved distribution network for Mile 2 Diobu, Port Harcourt power network shows that the voltage profile Nsukka network has improved within the statutory limit which is between 95.0 -105.0% and the loading of the distribution transformers on Ojoto and Nsukka networks are all below 70% required capacity.*
***Keywords:** Optimization, Energy Efficiency Distribution*

I. INTRODUCTION

Transformers, feeders line, injection or sub stations overload are resultant effects of increasing load, wrong sizing of transformers, unilateral expansion or extension of network without matching or commensurate increase in power supply that all culminates to non-effective energy dispatch to meet the increasing loads demand of the consumers [1]. Therefore, consumers connected to the affected substations often time experiences under- voltage and epileptic power supply and blackout (outage). Considering the majority of distribution lines are too large in size especially the secondary distribution networks, in an attempt to meet the daily electricity demand, many households and commercial organizations obviously have to run their own independent power generator to augment their power need [4]. Then power distribution companies in an attempt to mitigate these challenges resorts to an unplanned load-shedding and rationing the power supply as an alternative source of electricity power supply. However, to meet the ever-growing load demand of the distribution system the system upgrade is required and this can be achieved by conducting a power flow study on the existing network to ascertain the various levels of the inadequacy of the power system networks. Consequently this setback suffered by distribution networks has resulted into inadequate power injection into substations as compared with the net power delivered to the load. Hence, applying network reconfiguration techniques create the possibility for upgrading the network instability under investigation for the purpose of better performance with the view of improving the voltage profile of the distribution network within the acceptable limit to reduce network losses, while reducing transformers working stress, thereby proffer proper accessibility of the power supply to the consumers at the receiving end [5].

Therefore, this study focused on how to optimize energy saving efficiency strategy for electric power losses in the distribution network in order to secure and minimize loss reduction levels for efficient power quality and improves voltage profile.

II. LITERATURE REVIEW

Distribution network is an integral and vital component of power system assessment for improved power quality and reliable electric power supply. Since the growing trend of electricity supply on daily basis are not matching the needed energy demand at consumer ends. Port Harcourt is a fast growing city that experience constant high level migration of people into the metropolis and this increase the daily need for energy by both individual and industrial users within. Although, previous studies have been carried out relating to the electric power distribution for other cities ([1]; [8]; [2]; [9]), but it was perceived that not enough study have been undertaken to ascertain the optimization of energy efficiency for electric power distribution system losses in Mile 2 Diobu, Port Harcourt distribution network which consists of four (4) 11kV distribution feeders namely; Ojoto, Nsukka, Udi and Silverbird.

The electricity distribution network connected to Nsukka and Ojoto injection Substations, fed from 165 MVA transmission station (PH town) for the period of three (3) years and thereafter. Newton-Raphson load flow analysis method and ETAP software will be used for the simulation (Asha *et al.*, 2014). Therefore, this research work identified strongly the need for reliable assessment of electric power delivery to the consumer with respect to consideration of energy losses on continuous basis particularly to the study case under investigation knowing that reliability is a measure of the probability of performance from the sending to the receiving and power supply, on the new to propose a power electronic controller (Facts-device) with particularly 0.3 MVAR capacitor bank on Ojoto 11kv distribution and network 0.2 MVAR capacitor bank on Nsukka 11kv distribution network for reliable power supply, in order make saving due to minimization of electric power losses.

III. MATERIALS AND METHODOLOGY

In this study the materials utilized were line parameters of network 11KV distribution, transformer rating/capacity, bus bar, single diagram (SLD) were modeled in electrical analyzer. Similarly, the methodology considered was the application of Newton-Raphson load flow, embedded in Etap tools, with voltage drop equation technique which include the rates of the basic load configuration:

1) A concentrated load is the simplest arrangement
2) Equal loads disbursed evenly on a line may be replaced by a single total load.
3) Non-equal loads unevenly disbursed require analysis by nodes and sections.

The real world most feeders required many calculations.
The .simplified system configuration are presented as in equation 1:

I - Current in amperes

R - $$\frac{kW}{kV_{LL} \times \sqrt{3}} \qquad (1)$$

KVLL - Line to line voltage at the load (kilo volts or 1000's of volts)
KVLL - KV Source - Voltage Drop (l000's of volts)
KW - Three Phase Load (kilowatts or 1000's of watts)
Volts Drop - I (R Cos 0 + X Sin 0) (2)
1 - Current (Amps)
R - Resistance (ohms)
X - Reactance (ohms)
Cos ϕ - Power Factor of Load
Voltage drop is for one conductor (line to neutral).

IV. RESULTS AND DISCUSSION

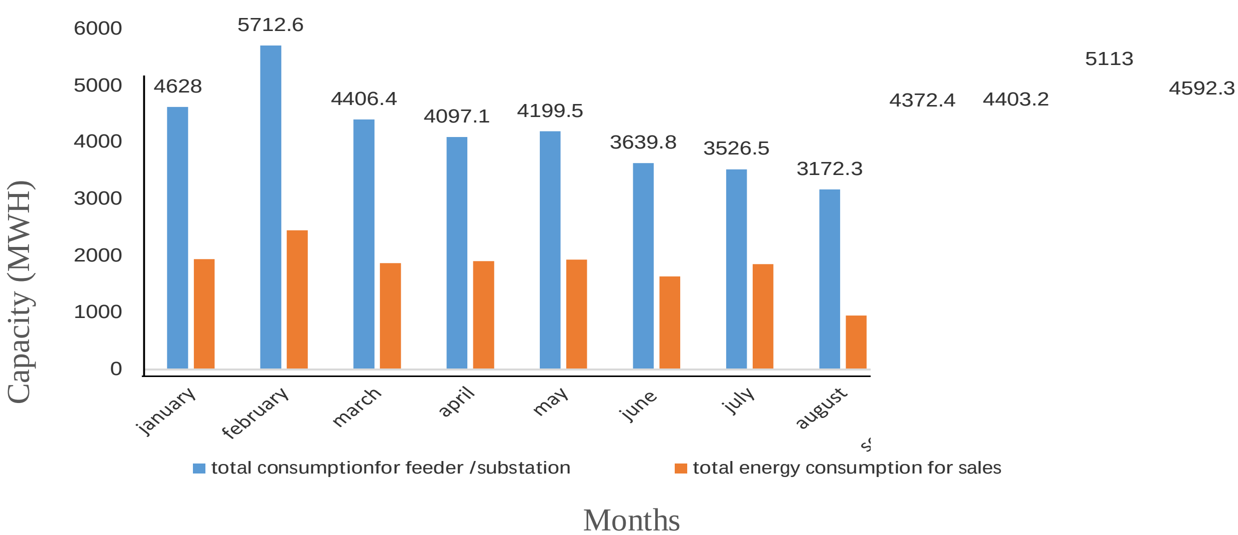


Figure 1: Total Energy Delivered (MWH) to the Feeders/Substation-2018

The figure 1 shows the total energy delivered for consumption as compared to the energy delivered for sales in 2018. The electric utility suffered losses over the period of January – December, 2018, this means that PHEDC and the utilities need to install digital meter monitoring and capturing device to actually determine the customers who is actually consuming and not paying for electricity bills.

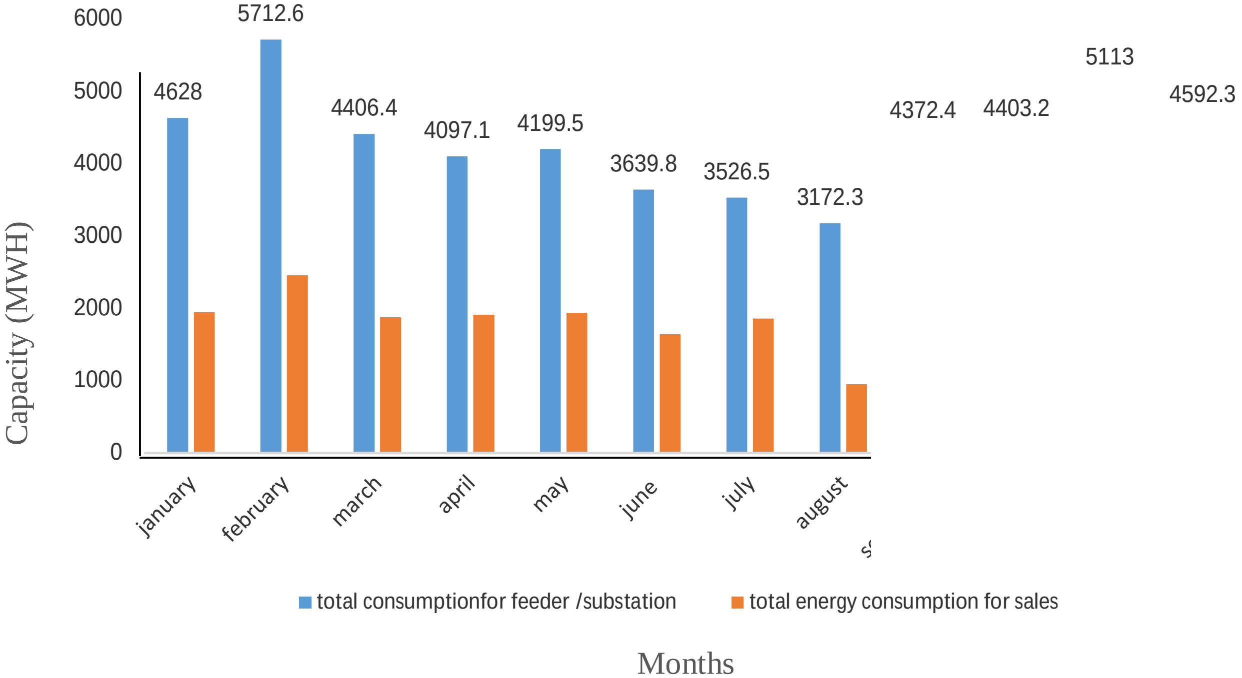


Figure 2: Total Energy Delivered (MWH) to the Feeders/Substation-2019

The figure 2 shows the distribution of total energy delivered for consumption 2019 versus energy delivered for sales with associated monthly losses (MWH) this means that PHEDC and the utilities need to install digital meter monitoring and capturing device to actually determine the customers who is actually consuming and not paying for electricity bills.

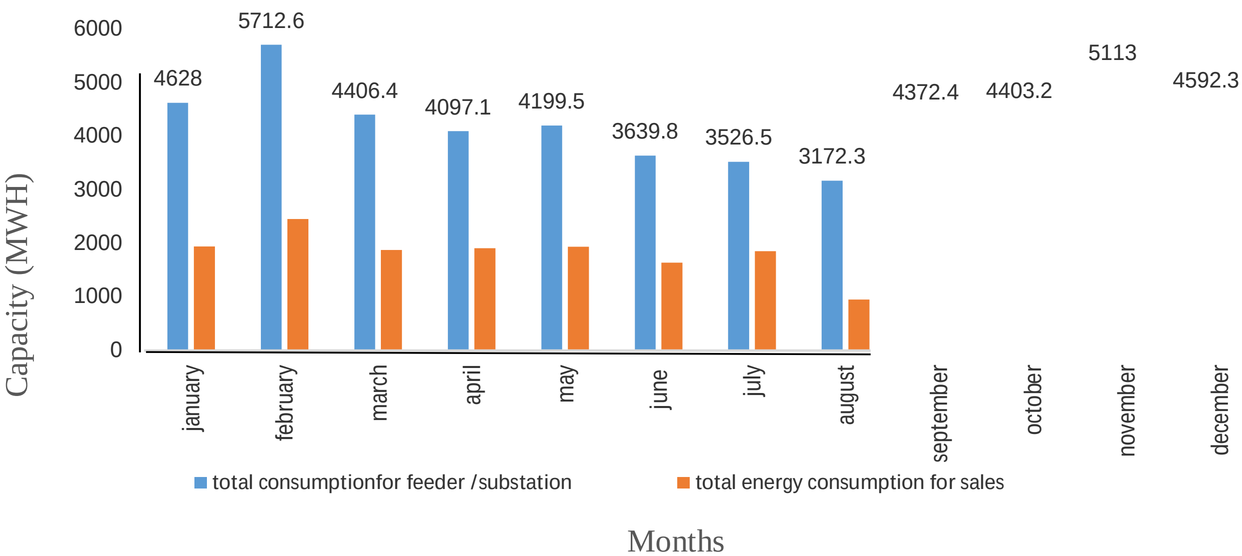


Figure 3: Total Energy Delivered (MWH) to the Feeders/Substation-2020

The figure 3 shows the composite bar-chart distribution of total energy delivered for consumption – 2020 as compared to energy delivered for sales. That is energy actively delivered to the feeder/station does not match energy sales for consumption as a results of technical losses, overload and non-installation of prepaid meter capturing (pay as you use).

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

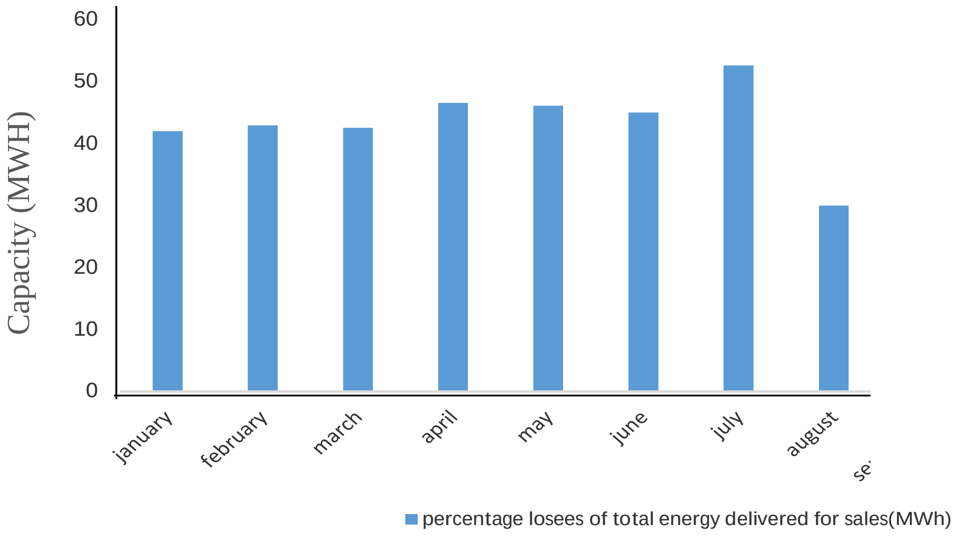


Figure 4: Percentage Monthly Losses Energy Delivered to the Feeder/Substation -2019

The figure 4 shows the distribution of percentage losses of total energy delivered for sales (MWH) as compared to the monthly activities in 2018. The loss of energy during technical or non-technical losses can be minimized with the integration of digital meter in order to make a savings.

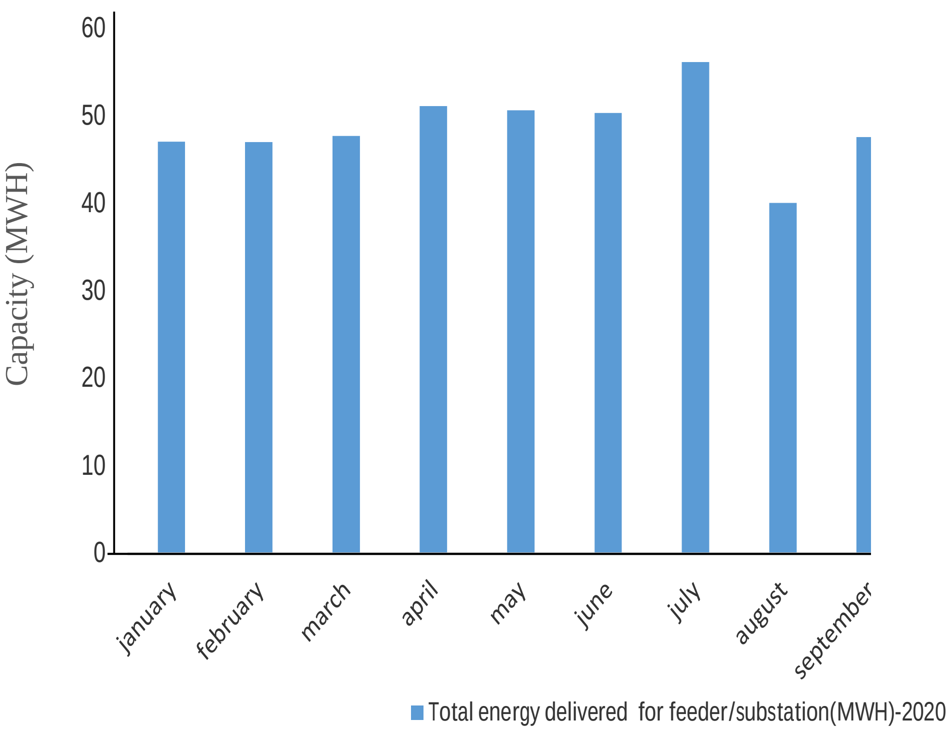


Figure 5: Percentage Monthly Losses Energy Delivered to the Feeder/Substation -2020

The figure 5 shows the energy profile distribution of total energy delivered for feeder/substation (MWH) for monthly activities under study. The energy delivered ideally need to match the needed energy demand but due to losses, the profit (saving) return on investment is poor as compared to expected on energy sales.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

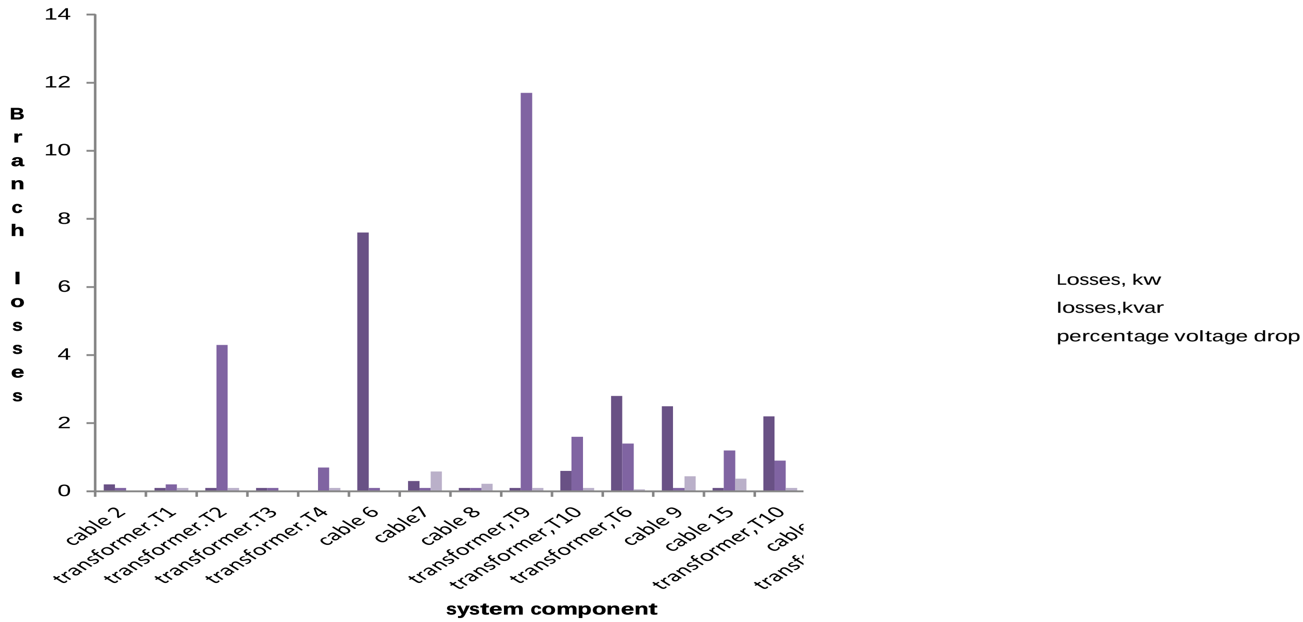


Figure 6a: Without Capacitor Bank Placement in the Network

The figure 6a branch system losses in KW, KVAR and percentage voltage with the distribution of system component as cables, transformer etc. The branch losses due to power (KW, KVAR etc) need to be compensated in order to improve power quality and reliable electricity supply in order to encourage and promote economic activities.

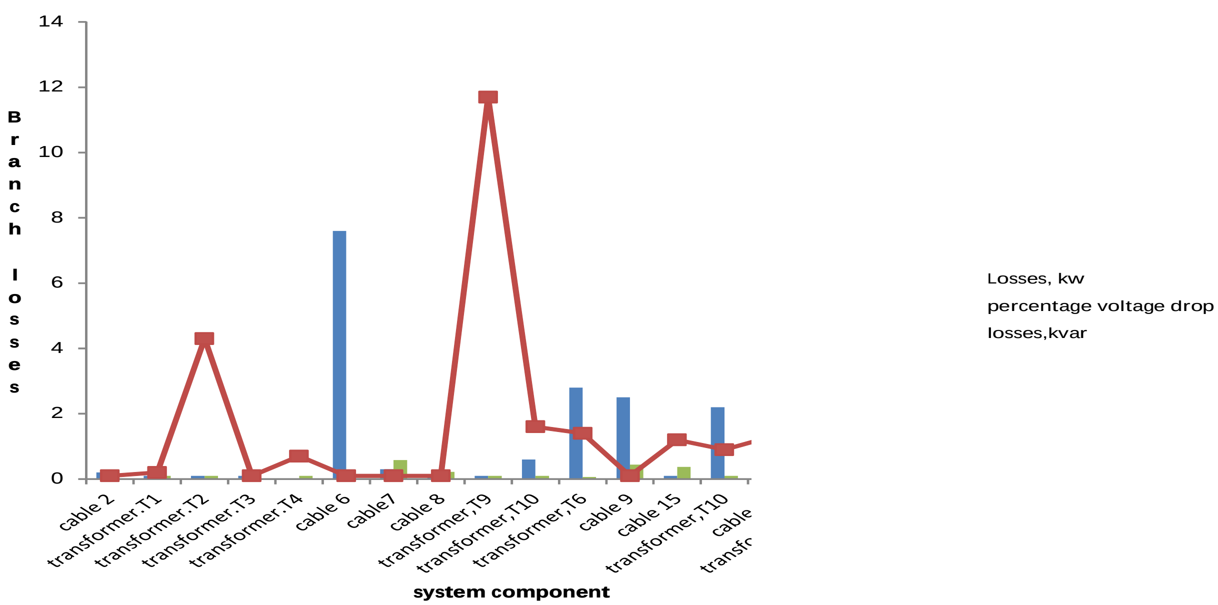


Figure 6b: System Component Losses Percentage Voltage, Drop, Losses KVAR

The figure 6b shows the branch losses and system component with respect. The losses due to power system component a cable, transformer. Composite representation of line of bar chart showing the losses due to overload on the already congestion network. proposed for improved power factor and quality.

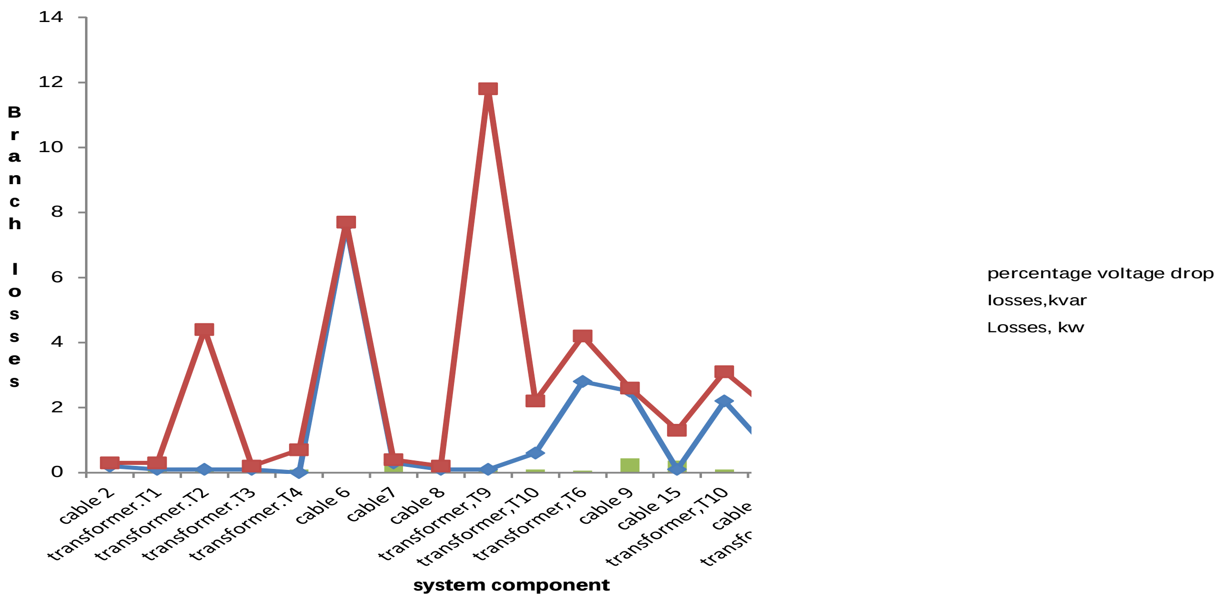


Figure 6c: System Component Losses kw, Percentage Voltage, Drop, Losses KVAR

The figure 6c shows the distribution of branch losses and system. The losses were measured in KVAR, KW, etc. The branch losses are presented versus system component to observed the distribution of consumption of energy, on the view to proposed upgrade of the existing system states.

V. CONCLUSION AND RECOMMENDATIONS

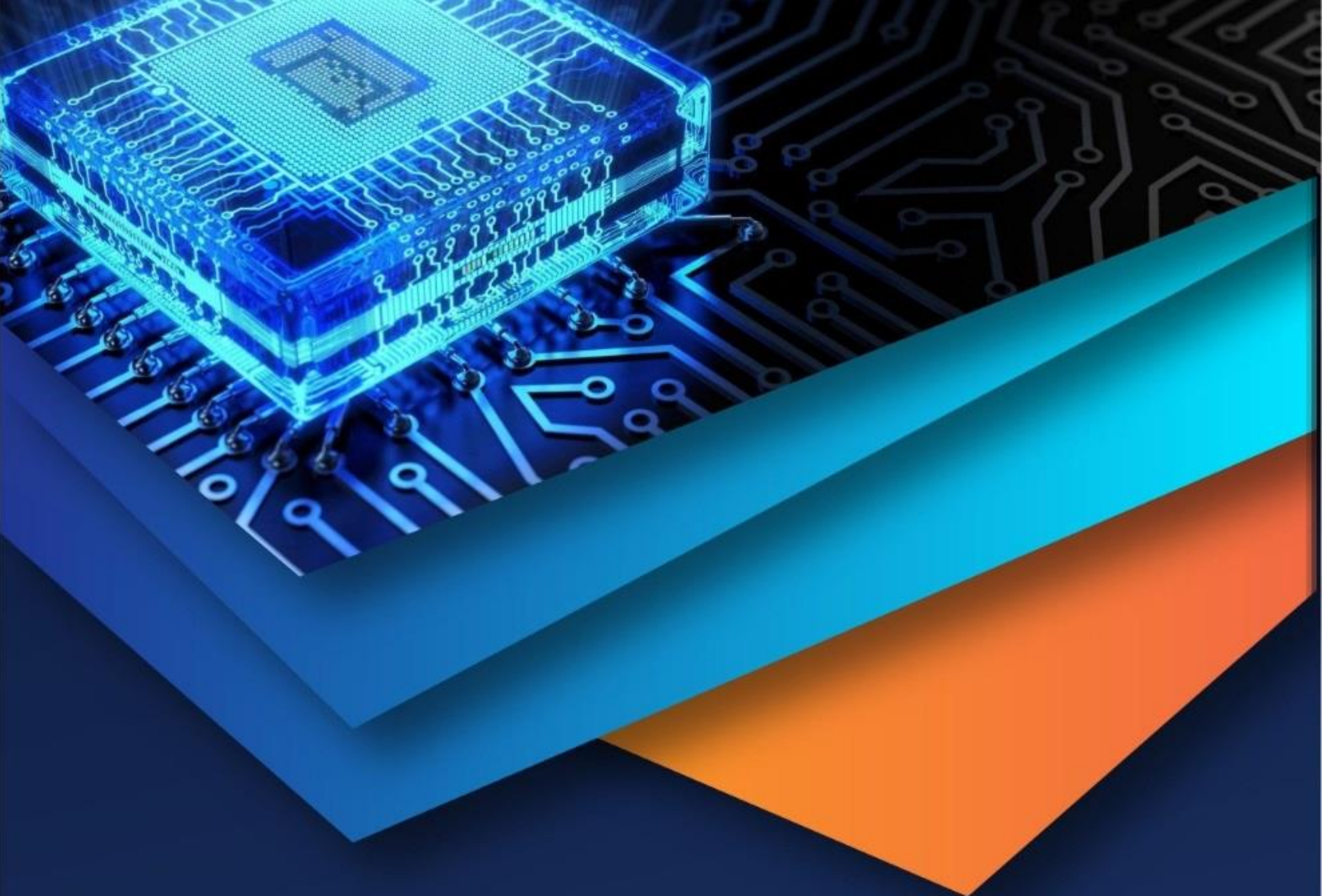
The study examined the existing electric power network of Mile 2 Diobu, Port Harcourt distribution network which consists of four (4) 11kV distribution feeders namely; Ojoto, Nsukka, Udi and Silverbird. Their respective 33/11kv injection substations are fed from 165 MVA transmission station (PH Town) at Amadi junction by Nzimiro. The distribution network was modeled in Electrical Transient analyzer program (E1AP) using Gauss-Seidel power flow equation. Power flow analysis was conducted for both existing pre-upgrade network and the modified (post- upgrade) network.

The results were analyzed under voltage buses, overloaded transformers, feeders and substations were identified. Voltage level below 95% was taken as under voltage and transformer loading above 70% are taking as overloading. The reasons for the under voltage and over loading were identified and a cost effective optimization techniques were proposed in the post- upgrade. Based on the finding, it is here by concluded that power flow studies is important for planning of future expansion of power system as well as determining the best operating condition of the existing system. Up-gradation of distribution transformer.-; transformer load tap changer and feeder bifurcation were found to be effective in improving voltage profile of the weak buses, reduce losses and eliminate over loading from the system. Based on the findings, the following recommendations are highlighted to ensure optimum performance and reliability of the distribution system.

1) Two 500kVA transformers should be added to Ojoto 11KV feeder.
2) The existing two 300kVA transformers at Ihediohama and Nwachukwu Streets respectively should be upgraded to 500kVA.
3) One 500kVA transformer should be added to Ikwerre road feeder at Ikoku Junction to relief the overloaded transformer at St. Thomas
4) 500KVA transformer should be added to Udi feeder and feeder bifurcation carried out to relief the overloaded transformer at Abel Jumbo and Azikiwe Street.
5) The existing 200KVA transformer at Anozie Street on Udi feeder should be upgraded to 500KVA. Feeder bifurcation carried out between Anozie and Echue Street should be relief the overloaded transformer at Echue Street.

REFERENCES

[1] Adegboye B. A. (2010) Analysis of Feeders Outages on the Distribution System of Zaria Town. Faculty of Engineering, University of Maiduguri, Nigeria. Arid Zone Journal of Engineering, Technology and Environment. 7, 1-13.
[2] Ale, T. O., & Odesola, A. O. (2015). Unreliable Electric Power Supply in Nigeria (Akure 11kV Feeders a Case Study). International Journal of Emerging Engineering Research and Technology, 3(3), 68-75.
[3] Asha, N., Tamizharasi, P. & Deepalashmi, U. (2014) Energy Saving Using Bifurcation of Distribution Transformer Department of Electrical and Electronic Engineering Adhiparasakthi engineering College Tamihadu, India International Journal of Innovation Research in Advanced Engineering, volume 1.
[4] Behailu, A. (2014) Designing of an Improved Distribution Substation to Mitigate the Power Reliability of Bishoftu City Defence University, College of Engineering, Department ofElectrical Power Engineering, Ethiopia.
[5] Chen X. & Liu L. (2012). Distribution Network Configuration Based on Niche Binary Particle Swarm Optimization Algorithm. Department of Electrical Engineering, Shenyang Institute of Engineering, Shenyang, China. International Conference on Future Electrical Power and Energy System.
[6] Elkadeem, M. R., Alaam, M. A., & Ahmed M. A., (2016). Improving Performance of Underground MV Distribution Networks Using Distribution Automation System: A Case Study. Am Shams Engineering Journal.
[7] Hassan N., Kingsley M. U., & Chinedu P. E., (2017). Optimal Location of Facts Device for Improved Power Transfer Capability and System Stability. International Journal of Energy and Power Engineering, 6(3), 22-27.
[8] Kehinde, O., Ayodele, S. O., Temitope, A., & Adedayo, K. B. (2014). A Fault Analysis of 11kv Distribution System (a Case Study of Ado Ekiti Electrical Power Distribution District). American Journal of Electrical Power and Energy Systems, 3(2), 27-36.
[9] Jibril, Y., & Ekundayo, K. R. (2013). Reliability Assessment of 33kV Kaduna Electricity Distribution Feeders, Northern Region, Nigeria. Proceedings of the World Congress on Engineering and Computer Science, 1.



10.22214/IJRASET

INDEX COPERNICUS

45.98

ISRA JIF

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY