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RELIABILITY OF DISTRIBUTION NETWORKS IN NIGERIA: IKORODU, LAGOS STATE AS A CASE STUDY

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ABSTRACT

Nigerians are experiencing a lot of difficulties as a result of poor Generation, Transmission and Distribution of electricity. As of 2016, the electricity energy consumption in the world from the world fact book revealed that the average power per capital (watts per person) in the United States is 1,377 Watts. In Canada, it is as high as 1,704 Watts per person and in South Africa; it is 445 Watts per person. The average power per capital in Australia is 1,112 Watts and in New Zealand it is 1,020 W per person. Whereas, the average electricity consumed in watts per person in Nigeria is just 14 Watts. This has put Nigeria in a rank of 189 out of 219 countries estimated.

Currently, power generating capacity in Nigeria is estimated to be 6,803 megawatts, with average working capacity between 3,500 MW for over 170 million people (20.59 W/person). The power Companies in Nigeria face a lot of problems. Some of the highest priority issues being low generation of power, inadequate equipment and technical team for the clearance of faults, inadequate protection devices, transmission losses and low reliability of the distribution system. The Nigerian power problem has resulted to incessant planned, forced and unplanned outages. This has grounded many activities and has destroyed many industrial operations and processes. In addition, it has resulted to erratic and unreliable supply of electricity. It has reduced productivity and has increased unemployment and crime rates in the country. Hence, an analytical method is developed to study the dynamic- reliability of the distribution system, as well as optimizes the occurrence of faults and outages along the consumer point in each feeder in order to improve the performance of the system. A great need for fault evaluation and reliability studies of electric power system was observed. This research work analyzed the problems facing the Distribution System. Efforts were made to provide adequate solutions to the problems. The research work evaluated the occurrence and causes of faults and outages in the Distribution Network Area for a period of 8 years. In addition, it analyzed and reduced the effects of power losses along each of the feeders in the Distribution Network Area. This research work revealed the downtime, failure rate and reliability index along each of the eight feeders. It also improved the reliability and performance of the distribution system

Keywords

Fault Evaluation, Improvement of Electric Power Distribution Network, Reliability, Occurrence of Faults, Failure Rates, Outages, Reliability, Fault Clearing, Improvement Techniques, Supply of Electricity, Productivity, Load Flow Analysis

INTRODUCTION

An electric power system consists of three major components: Generation, Transmission and Distribution. A Generating station generally employs the action of a prime mover coupled to an alternator and at least an external exciter for the production of electric power. The prime mover may be a steam turbine, a wind mill or a water turbine which converts energy from other sources into mechanical energy. The external exciter produces the magnetic field. In many cases, the field will be electro-magnetic, and field coils carrying the field current will be wound on a magnetic structure. The iron forming structure will be laminated. This is to reduce field iron losses. Then the field coils are concentrated and wound around protruding poles called salient poles, or distributed in slots cut into a cylindrical magnetic structure commonly used for AC generators. With this arrangement, a DC current is applied to the field winding (rotor winding) which produces a magnetic field (a rotor magnetic field). The rotor of the generator is then turned by a prime mover producing a rotating magnetic field within the machine. The rotating magnetic fields induces a three phase set of voltages within the stator winding from which output voltage ranging between 11kV and 25kV can be obtained. This is in accordance to Faraday's laws of electromagnetic induction. The electrical energy produced by the generating station is then transmitted over long distance and distributed with the help of transmission lines and distributors to various consumers. In view of the insufficient electric power generation capacity and coupled with power losses and constant outages many industries and consumers faced with unreliable power supply in the country. Hence the focus of this research work is based on Fault Evaluation and Improvement of Electricity in Power Distribution Network: Ikorodu in Lagos State, Nigeria as a case study.

PROBLEM STATEMENT

The incessant electric power supply problems facing the existence of industries in Nigeria is a pointer to the fact that there is great need for fault evaluation and reliability assessment of electric power system in the country and provides solutions. As it has been earlier said, this problem has grounded many activities and has destroyed many industrial processes. In view of this, a traditional analytical method is developed to access the occurrence of faults and outages along each of the individual consumer point in a feeder, as well as optimizes the reliability of the generation, transmission and distribution system.

In view of this, it will be possible to improve on the performance of the system. It will also assist in the generation and transmission of sufficient power, clearing of faults, ensuring adequate protection and reliability of the distribution system that is, bringing a steady uninterrupted power supply to consumers within the distribution area and the entire country.

Existing Generation Capabilities in Nigeria

The generation capabilities in Nigeria are shown in Table 1.1

Table 1.1: Generation capabilities in Nigeria

S/N	NAMES OF GENERATING STATIONS	RAW MATERIALS	MW
1	Egbin Thermal Power Plant	Gas, coal	1080
2	Kainji Hydro Power Plant	Hydro(water)	480
3	Jebba Hydro Power Plant	Hydro (water)	360
4	Shiroro Hydro Power Plant	Hydro (water)	450
5	Sapele Thermal Power Plant	Gas Turbine	170
6	Afam Thermal Power Plant	Gas Turbine	72
7	Delta Thermal Power Plant	Gas	329
8	Geregu Gas Power Plant	Gas	414
9	Omotosho Gas Power Plant	Gas	300
10	Papalanto Gas Power Plant	Gas	300
11	Alaoji Gas Power Plant	Gas	346 MW
	Total		4301MW

Source: Power Holding Company of Nigeria Plc, Ikorodu , Lagos State

2.3 EXISTING NATIONAL INDEPENDENT POWER PROJECT (IPP) IN NIGERIA

Table 1.2: The National Independent Power Projects

S/N	**Name/Location**	**Capacity**
1	AES	288MW
2	Okpai	480 MW
3	Afam	300MW
4	Omokun	75MW
5	Afam VI	300MW
6	Ibom Power	188MW
7	Omokun	75 MW
8	ALSCON	360MW
	Total	**2066 MW**

Source: Power Holding Company of Nigeria Plc, Ikorodu ,Lagos State

Although the total installed generating capacity is 5,746MW, the country is only able to generate 3,500 MW because most facilities have been poorly managed and the reliability of the generating, transmission and distribution system being very low due to high failure rates of equipment, large energy losses and poor protection system. In addition, Electricity in Nigeria is facing a lot of problems ranging from financial misappropriation, to inadequacy of facilities and non-commitment of PHCN staff. Therefore, the condition has remained pathetic with failures, power failure and non-reliability of the system on daily basis, the effects has grounded many activities and destroyed many industrial processes, and has open ways for mass unemployment, crimes, slow economic and poor national development.

Since the management of continuous, reliable and constant power supply in Nigeria is a difficult task, there is a need for the reliability assessment of the power system network. This evaluation will reveal the prevalence and frequency of faults and outages on the distribution system. It will also reveal their effects on the supply of electric power to various consumers. Also, it will be possible to analyze the causes of faults along the transmission and distribution lines. Then adequate system techniques for improving the performance of the system will be achievable.

SPECIFIC OBJECTIVES OF THE STUDY

The specific objectives of the research work are to:

(a) Study the causes, nature and effects of faults on the distribution network;
(b) Evaluate the occurrence of faults and outages on feeders and distribution networks, and
(c) Determine the reliability of the network.
(d) Improve electricity supply in Nigeria.

Expected Contribution to knowledge

The study is expected to:

(a) Provide the reliability indices for Ikorodu distribution network; and
(b) Establish procedure to improve electricity supply to consumers within the distribution system
(c) Establish procedure to improve electricity supply in Nigeria

RESEARCH METHODOLOGY

Power System grounding is very important, particularly since a large majority of faults involve ground or re caused by thunderstorm/lighting strikes. In order to carry out fault evaluation of Electric Power Distribution Network, a detail study of Ikorodu 132/33kV substation Network of the Power Holding Company of Nigeria under which there are about 47,739 customers was carried out. The results for Lagos Feeder were presented in this research publication. Types and frequency of faults occurrence were recorded. These data were collated, evaluated and analyzed both mathematically, graphically and with the use of computer excel software.

The data collected from the Power Holding Company of Nigeria include: Geographical map of the Distribution Area Network, fault records, causes and duration of outages, feeder-by-feeder load loss and system downtime, frequency of faults, inventory of distribution transformers on each feeder, feeder length, transformer capacity and conductor capacity, load demand of customers, number of customers and their categories.

From the collated data obtained for 8 years (2004-2011), the network reliability, failure rate (λ), Mean Time Between Failures (MTBF), Mean Down Time (MDT) and Availability (A) were calculated using equations (3.1) to (3.5).

Then the failure rate of the system on yearly basis was evaluated which was used to determine the reliability of the system on yearly basis. Also, feeder-by-feeder load loss and was evaluated for each year using equations (3.6) to (3.9). The month that fault occurred, the date of fault, the time the feeder tripped, the time it was restored, duration of fault (downtime), load loss in megawatts, phase on which fault occurred and nature of faults were recorded and evaluated.

From the data, the failure rates (λ) of the feeders were evaluated using equation (3.1)

$$\text{Failure rate} = \frac{\text{fault frequency on each feeder}}{\text{Period of operation of the feeder (hour)}} \quad \ldots\ldots\ldots\ldots \text{(3.1)}$$

The results of the failure rates were used to determine the reliability R(t) of the feeders according to equation (2):

$$R(t) = e^{-\lambda t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.2)}$$

Where λ is failure rate (failure/hour) and t is time (hour).

Mean Time between Failures (MTBF) of all the feeders were evaluated using equation (3):

MTBF ……………………………………………….(3.3)

Mean Down Time were also estimated on feeder by feeder basis using equation (3.4):

$$\text{Mean Down Time (MDT)} = \frac{\text{Total down time of each feeder}}{\text{Fault frequency}} \quad \ldots\ldots\ldots\ldots \text{(3.4)}$$

Finally, availability (A) of electricity within the distribution network on yearly and feeder by feeder basis were evaluated using equation (5):

$$\text{Availability} = \frac{\text{operating time of the feeder in a year}}{\text{total number of hours in a year}} \quad \ldots\ldots\ldots\ldots \text{(3.5)}$$

In fact, Reliability Indices recovered in section (2.25) to (2.29) and the relevant equations (2.31) to (2.51) were used for all calculations which are repeated here for clarity as follows:

Reliability customer-oriented indices were obtained using the following equations.

System Average Interruption Frequency Index (SAIFI)

$$\text{SAIFI} = \frac{\text{Total numer of sustained customers interruption in a year}}{\text{Total number of customer served}}$$

…………..(3.6)

System Average Interruption Duration Index (SAIDI)

$$\text{SAIDI} = \frac{\text{Total duration of sustained interruption in a year}}{\text{Total number of customer served}}$$

……………………(3.7)

Customer Average Interruption Frequency Index (CAIFI)

$$\text{CAIFI} = \frac{\text{Total number of annual customer interruptions}}{\text{Total number of customers affected}}$$

………………..……(3.8)

Customer Average Interruption Duration Index (CAIDI)

$$\text{CAIDI} = \frac{\text{Total Duration of sustained interruption in a year}}{\text{Total number of customer interuptions}}$$ ....(3.9)

Average Service Availability Index (ASAI)

$$\text{ASAI} = \frac{\text{Customer hours of availble service}}{\text{customer hours demnded}}$$

………………….…………….(3.10)

Average Service Availability Index (ASUI)

$$\text{ASUI} = \frac{\text{Customer hours of unavailble/ service in a year}}{\text{customer hours demnded in a year}}$$

…………...………(3.11)

The power losses on the available feeders are calculated on the basis of the monthly maximum loading on the feeders, the resistance, size of each feeder conductor, route length of each feeder and maximum current drawn from each feeder conductor using equations (3.12 to 3.15).

Current drawn from feeder

$$I_1 = \frac{P}{\sqrt{3}V \times p.f} \quad \ldots\ldots(3.12)$$

and $$R = \frac{\ell l}{A} \quad \ldots\ldots(3.13)$$

where P is power in k Watts

V is voltage in volts

ℓ is resistivity in Ωm

R is resistance in ohms; and

A is cross sectional area in m^2

Power loss = $I_L{}^2 R$ .... (3.14)

Power loss = Power received – Power consumed..................(3.15)

RESULTS AND DISCUSSIONS

Failure Rate and Reliability Index on Lagos Road Feeder

Failure rate of the feeder for the 8 Years

$$= \frac{\text{Fault frequency}}{\text{Period of operation}} \quad \ldots\ldots(4.2)$$

$$= \frac{92}{53690} = 0.00171354\text{failure/hour}$$

Reliability on Lagos Road Feeder

The reliability system for the period of 8 years (2004-2011) was obtained.

$$R(t) = e^{-\lambda t} \quad \ldots\ldots (4.1)$$

$$R(t) = 2.718^{-(0.0017135)(8760)}$$

$$R(t) = 30.3143 * 10^{-8}$$

Mean Time between Failure (MTBF) for the eight years on Lagos Road Feeder

$$= \frac{1}{\lambda}$$

$$= \frac{1}{0.00171354}$$

= 583.587hours (average value within the eight years)… (4.3)

Mean Down Time (MDT) = Mean Time To Repair (MTTR) on Lagos Road Feeder

$$= \frac{\text{Total down time}}{\text{Fault frequency}} \quad \ldots\ldots\ldots\ldots\ldots(4.4)$$

$$= \frac{16{,}390}{92}$$

= 178.152 hours (average result within the eight years)

Availability of Electricity on Lagos Road Feeder in Percentage

$$\text{Availability} = \frac{\text{Operating Time}}{\text{Total hours of time in a year}} \quad \ldots\ldots\ldots(4.5)$$

$$= \frac{53{,}690}{70080} = 0.76612 \text{ or } 76.612\%$$

Table 4.1: Cumulative Load Losses of the Feeders in MW (2004 – 2011)

Feeders	Lagos road feeder	Ayangburen feeder	Ijebu Ode feeder	Eyita feeder	Igbogbo feeder	Ladega feeder	Agric feeder	Isawo feeder	Oriokuta feeder
Load Loss (MW)	203	237	204.5	204.32	180.98	200.9	198.3	189.1	175.01

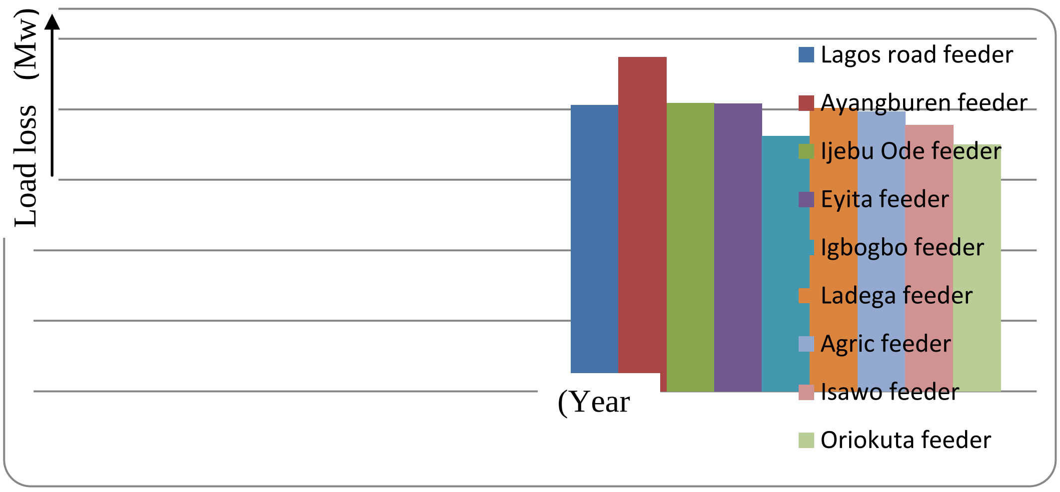

Figure 4.1 Feeder Load losses on the feeders (2004-2011)

The total load loss for the nine feeders in 2004-2011 is 1792.73MW

Table 4.2: Downtime Results for the Feeders in hours (year 2004-2011)

Feeders Cumulative	Lagos road feeder	Ayangburen feeder	Ijebu Ode feeder	Eyita feeder	Igbogbo feeder	Ladega feeder	Agric feeder	Isawo feeder	Oriokuta feeder
Downtime (hours)	16390	21277	18816	17842	20183	19431	17651	18628	18452

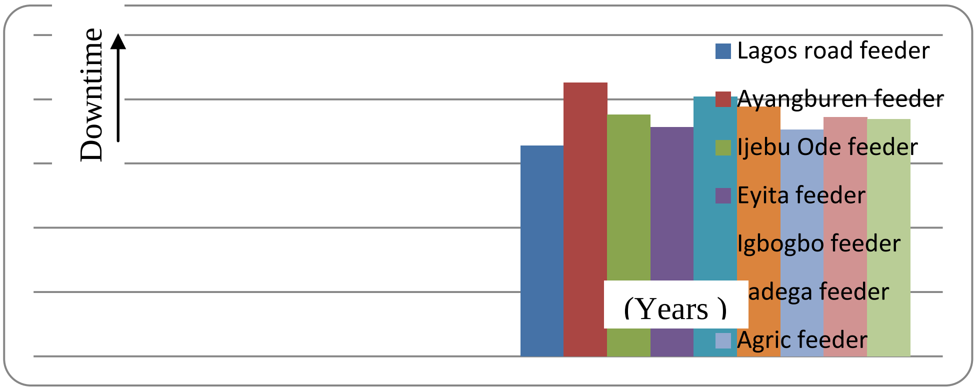

Figure 4.2: Downtime results for the feeders (year 2004-2011)

Total Downtime along all the nine feeders between the 8 years (2004-2011) is equal to 168,670 Hours, out of the total time of 560,640 hours, leaving a total operating time of 391,670 hours

Table 4.3: Frequency of Faults on 11 kV feeders (frequency of faults on all the three phases) (2004-2011)

Feeders	Lagos road feeder	Ayangburen feeder	Ijebu Ode feeder	Eyita feeder	Igbogbo feeder	Ladega feeder	Agric feeder	Isawo feeder	Oriokuta feeder
Frequency	92	106	94	100	95	97	93	90	93

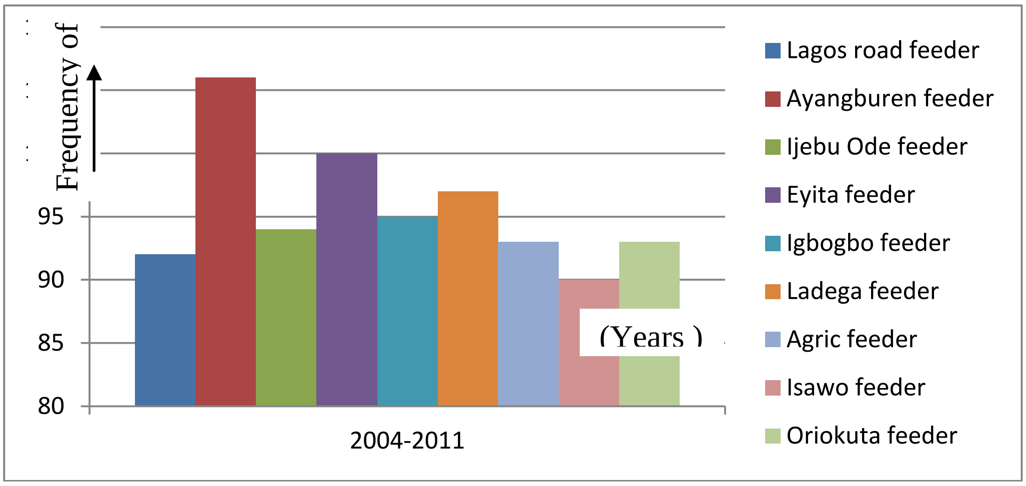

Figure 4.3: Frequency of Faults on 11 kV feeders (frequency of faults on the three phases) (2004-2011)

Table 4.4: Failure rate of 11 kV feeders (2004-2011)

Feeders	Lagos road feeder	Ayangburen feeder	Ijebu Ode feeder	Eyita feeder	Igbogbo feeder	Ladega feeder	Agric feeder	Isawo feeder	Oriokuta feeder
Failure rate (hr)	0.00171	0.00217	0.00183	0.00191	0.00190	0.00192	0.00177	0.00175	0.00180

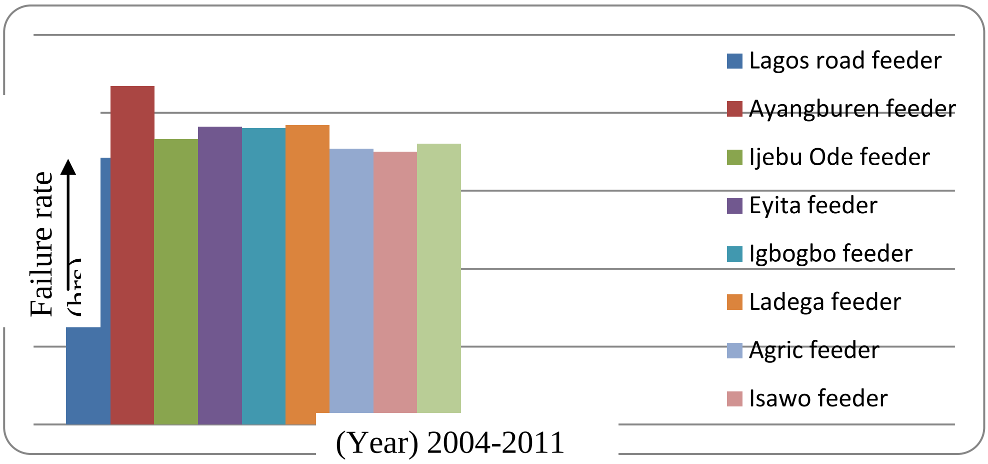

Figure 4.4: Failure rate of 11 kV lines feeders (2004-2011)

4.10 Table 4.5: Reliability of 11 kV Feeders (2004-2011)

Feeders	Lagos road feeder	Ayangburen feeder	Ijebu Ode feeder	Eyita feeder	Igbogbo feeder	Ladega feeder	Agric feeder	Isawo feeder	Oriokuta feeder
Reliability ($*10^{-8}$)	30.314	0.547	10.587	5.223	5.721	5.185	17.878	22.181	14.048

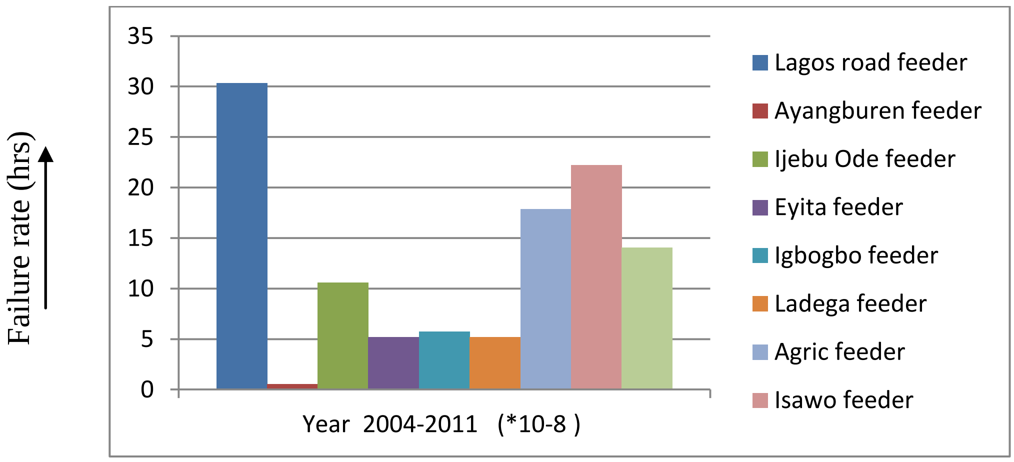

Figure 4.5: Reliability of the 11 kV Feeders (Year 2004-2011)

Resistance of Lagos Road Feeder

i. The length of each of the sections was obtained as shown in equation 3.21

$L = S * 50$ ……………………………………………… (4.6)

Where S = number of spans

50 = Average length span

ii. Resistance at 40^0c (R400c) was obtained

DC Resistance $(R_t)_{DC}$ per km of any line at temperature t (40.5) can be obtained using Equation (3.22)

$$(R_t)_{DC} = (R_{ref})_{DC} * \frac{t + 288}{t_{ref} + 288} \quad (4.7)$$

Where $(R_{ref})_{DC}$ = DC Resistance of the line per km at a reference temperature t_{ref} (20^0C)

$(R_t)_{DC}$ = DC Resistance of the line at 40.5^0c

$t = 40^0C$

$t_{ref} = 20^0C$

The DC Resistance of the line per km at a reference temperature $t_{ref} = 20^0C$ as stated by the manufacturer is 0.27018 Ω/km.

The AC Resistance $Rt_{(AC)}$ /km of the line can then be obtained from

$$R_{t(AC)} /km = (R_t)_{DC} * 1.05 \quad (4.8)$$

Where $R_{t(AC)}$ /km = AC Resistance of the line /km at 40^0c

$(R_t)_{DC}$ = DC Resistance of the line at 40^0c

1.05 is the factor used to multiply the DC resistance in order to obtain the AC resistance. It represents the addition resistance due to skin effects (Mehta and Mehta, 2008)

The resistance of the line at 40°C were then obtained as follows:

$$(R_{40^0}C)_{DC}/km = (R_{20})_{DC} \bullet \frac{t + 288}{t_{ref} + 288}$$

$$(R_{40})_{DC}/km = 0.27018 \bullet \frac{40 + 288}{20 + 288}$$

$$(R_{40})_{DC}/km = 0.27018 \bullet \frac{328.5}{308}$$

$$(R_{40})_{DC}/km = 0.288163$$

$$(R_{40})_{AC}/km = 0.288163 \bullet 1.05$$

$$(R_{40})_{AC}/km = 0.\ 288163 \bullet 1.05$$

$$= 0.3025709$$

Hence, the resistance of the line per kilometer = 0.3025709 ohm. These values were obtained by calculation using Microsoft excel algorithm. The values of the line resistance, inductance and impedance obtained are presented

Inductance of Lagos Road Feeder

The inductance of conductors per phase per meter can be obtained from equation (4.9)

$$= L_o = 10^{-7} * \left\{ 0.5 + 2 \log_e \frac{D_{eq}}{r} \right\} \ldots. (4.9)$$

Where $D_{eq} = = \sqrt[3]{D_{ab} * D_{bc} * D_{ca}}$ … (4.10)

And r = Radius of the $100m^2$ Aluminum conductor

The inductance of the 11KV line along Lagos Road feeder was obtained as illustrated below:

1. Radius of the 100mm2 Aluminum conductor = r

   r = 0.00559m

2. The distances between the pairs of conductors are :

D_{ab} = 0.658

D_{bc} = 0.658 and D_{ca} = 1.316

The equivalent distance of the conductor Deq is given by

$$D_{eq} = 3\sqrt{Dab * Dbc * D_{ca}}$$

$$D_{eq} = 3\sqrt{0.658 * 0.658 * 1.316}$$

$$D_{eq} = 3\sqrt{0.5697806}$$

$$D_{eq} = 0.82902803 \text{ meter}$$

Inductance/phase/meter of the lines was obtained as follows:

$$L_o = 10^{-7} * \{0.5 + 2 \log_e \frac{D_{eq}}{r}.\}$$

$$L_o = 10^{-7} * \{0.5 + 2 \log_e \frac{0.82908}{0.00559}.\}$$

$$L_o = 10^{-7} * \{0.5 + 2 \log_e 148.31485\}$$

Lo/ phase/meter = 0.0010312 Henry

These values were obtained by calculation. Microsoft excel algorithm was used to analyze the results and the values of the line inductive reactance obtained were presented in tables 4.1 – 4.3

Reactance of Lagos Road Feeder/phase/kilometer = $2\pi f L_o$ (4.11)
= 0.32400525 ohm

Resistance of Lagos Road Feeder/ phase/kilometer = 0.302570893 ohm

Load Flow Analysis and Line Parameters along Lagos Road Feeder

The normal operating voltage of Lagos ROAD feeder is 11KV. Its length is 13.52 Km. It originates from the 33/11kV Distribution Substation Located at Sabo in Ikorodu. However, the resistance and inductance along the line form series impedance which usually reduces the voltage at the receiving end. As a result, the output of any of the 11/0.415kV distribution transformers along the feeder is always less than 220 V on a single phase and less than 415V on a three phase system. Voltages along the line were recorded using multi meter at interval of 1km. The results obtained were shown in table 4.6

Analysis and Calculations of Fault Currents on Lagos Road Feeder

Fault currents were estimated and calculated based on the data collected in Ikorodu PHCN Distribution office along 11KV Lagos Road and other feeders. From these data, calculations and analysis were made; the fault currents along the distribution line were also calculated.

From the results obtained the ratings of the protective devices such as: current transformers, relays, circuit breakers and fuses that would be required for the protection of the distribution line and equipment were obtained. Thus the protective devices selected will be able to withstand the large values of fault current which will occur in the event of faults. With this development, the protection of lines, equipment, lives and properties can be safeguarded by proper setting and of choice relays.

Fault currents along the outgoing 11kV Lagos Road feeder were calculated and the results obtained presented:
At the point of fault, 1/Zpu equivalent = 1/ 0.1903823 = 5.253

(1) $\frac{1}{\quad}$ .Z p = $\frac{1}{5.253pu}$ = 0.1903823

(2) Since $VA_{fault} = 1/Z_{f.pu} \times (MVA)base$,

Then $VA_{fault} = 5.253 \times 15 = 78.795$ MVA

(3) $I_f = \frac{1/Z_{f.pu} \times (MVA)base}{KV \times \sqrt{3}}$

$= \frac{5.253 \times 15}{11 \times \sqrt{3}}$

$= 4.135786$ KA

Having obtained the fault currents (I_f) and the fault voltages (V_f) from the control room of the Utility Company, one can now develop a programme that will evaluate and determine the values of the impedance (Z) in ohms at the point of fault and the per unit impedance

(Zpu) up till the point of fault. Given the per km impedance of the distribution lines, the distance (that is the length of line) where repair operations should be carried out can be obtained. This will be useful in fault location, ease the location of the point of faults, speed repair operations and improve the performance of the system.

CONCLUSION AND RECOMMENDATION

CONCLUSION

The supply of electric power in Ikorodu Distribution network is not reliable. It is characterized by a large number of faults. Duration of outages or interruption of power supply is also very high in the area. Load demand kept on increasing on yearly basis. The present demand for electricity in the country is 9437MW and by the year 2015, this value according to the Energy Commission of Nigeria will be increasing to 15,730MW. Yet the country could only generate 3,500MW of electricity out of a total of 6,367 MW power station installed capacity. Because of these irregular problems, many industrial processes have been unfavorably affected. The problem has affected economic growths of local and international industries. Thus production cost and market price of goods and services kept on increasing because the affected industries seek alternative source of power supply through high cost of generators and fuel.

Again, it was observed that many of the power and distribution transformers are too old. Thus, making continuous maintenance at high cost, a regular practice in the distribution area. Fault frequency is also very high. It was observed that this high fault frequency affected the failure rates and conversely, reduces the reliability of power system in the distribution area. For example in Lagos Road feeder where the number of consumers is about 4,709, the failure rate for the eight years is 0.0017135 failure/hour/customer. This is too high because in a normal circumstance, anywhere in the world, failure rate should be as low as 0.00001459 failure/hour/customer or even lower.

The actual electrical power requirement of customers along Lagos Road feeder is 15.328MW while power supply along the feeder is 6.711MW. This has shown that the quantity of power supply is inadequate in the area. Load demand kept on increasing in the distribution network area. As at December, 2011, load demand of the customers in Ikorodu was 120MW. Beside this increase in load, the network is characterized by the high number of faults and outages which is over 100 occurrences per annum. All these have made power failure and outage problems regular events in this distribution area. For instance, the net failure rate between years 2004-2011 along Lagos Road feeder is 0.001411 failure/hour/customer. It is even worst along Ayangburen 11kV feeder, over there, the failure rate was at the highest level of 0.002172 failure/hour/customer. And along Ijebu Ode feeder, the failure rate was 0.001834 failure/hour/customer. All these are still on the high side. They are therefore reasons for the incessant supply of electric power in this distribution area. Also, Mean Time Between Failure stands at an average of 583.59 hours along Lagos Road feeder. Mean down time along the feeder is 178.1522 hours. The results show that most of the electrical equipment along this feeder are prone to failure as a result of overload, losses, damages and decrease in efficiency of components. Thus, the supply of electricity along all the feeders is not reliable and needs improvement according to the following recommendations.

This research work revealed that the actual electrical power requirement of customers along Lagos Road feeder is 15.328MW. The actual electrical power requirement of customers in Ikorodu Distribution Network is 137.952MW. The actual electrical power requirement of customers in Lagos State is 2,759.04MW. The actual electrical power requirement of Nigeria is 106,774.848MW. If Nigeria must overcome the present incessant power outages, poor power supply which has grounded many activities, destroyed many industrial processes, reduced productivity, increase unemployment and crime among the youths, this is the actual electrical power required by the country.

REFERENCES

A. A. Tawfiq, M. A. Elhameed and A. A. Elgawad, (2017). "Antlion Optimizer for Effective Integration of Distributed Generation in Radial Electrical Distribution Networks," 2017 Nineteenth International Middle East Power Systems Conference (MEPCON), Cairo, Egypt, 2017, pp. 248-262

Adegboyega, G.A, Adu, M.R and Melodi A.O (2010), Power Losses in Distribution System and Solutions; Akure as a Case Study, FUTAJET, vol. 6, No.2, pp 75-80

Burke James J. (1994). Power Distribution Engineering Fundamental and Applications, Marce Dekker Inc. New York, pp 125-127

Bursa, (2017). Electronics Engineering (ELECO), pp. 1485-1490J.

Distribution System and Solutions; Akure as a Case Study, FUTAJET, vol. 6, No.2, pp 75-80

Duncan Glover, Thomas Overbye and Mulukutla S. Sarma, (2016). Power System Analysis and Design, Jan 7, 2016

Gupta B.R (2010). Power System Analysis and Design, S.Chand Company Limited New Delhi pp 593 – 611

Gupta J.B.(2006), A Course in Power System, S.K Kataria & Sons ,New Delhi, part 1, pp 130

H. Suyono, Wijono, R. N. Hasanah and S. Dhuha, (2017). "Power Distribution System Reliability Improvement Due to Injection of Distributed Generation," 2017 10th International Conference on Electrical

James J. Burke. Power Distribution Engineering: Fundamentals and Applications (Electrical and Computer Engineering) 1st Edition

M. K. Giridharan (2015). Electrical Systems Design (Second Edition) Nov 4, 2015

Monterrosa Carlos (2011). Fault Analysis in Electrical works and distribution Lines, Green and co Ltd, London, pp 77

Pabla, A.S (2004) Electric Power Distribution , 5th Edition , Mc Graw – Hill Publishing Company , New Delhi , pp 96,117, 218 and 230

Tawfiq, M. A. Elhameed and A. A. Elgawad, (2017). "Antlion Optimizer for Effective Integration of Distributed Generation in Radial Electrical Distribution Networks," 2017 Nineteenth International Middle East Power Systems Conference (MEPCON), Cairo, Egypt, 2017, pp. 248-262

Z. A. Adetona, M. A. Waheed, I. A. Adejumobi and A. T. Akinwale, (2013). "A Novel Data-acquisition System for Improving Electric Power Distribution Planning," 2013 IEEE International Conference on Emerging & Sustainable Technologies for Power & ICT in a Developing Society (NIGERCON), Owerri, 2013, pp. 191-195.

Z. Li, J. Gu, T. Xu, L. Fu, J. An and Q. Dong, 2017, "Reliability Analysis of Complex System Based on Dynamic Fault Tree and Dynamic Bayesian network," 2017 Second International Conference on Reliability Systems Engineering (ICRSE), Beijing, 2017, pp. 1-6

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