International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 3 Ver. 3 || March 2018 || PP01-06

Optimizing the Effectiveness and Efficiency of Electricity Distribution in Nigeria

V.K.Abanihi[1]AndS. O.Ikheloa[2]
[1]Electrical/Electronic Engineering, Benson Idahosa University, Nigeria
[2]Electrical/Electronic Engineering, National Institution of construction Technology, Nigeria
Corresponding Author:V. K. Abanihi

Abstract*The aim of this paper is to optimize the effectiveness and efficiency of electricity distribution in Nigeria using IBEDC, Molete Business Unit as a case study. The outage data report for three (3) months is used to calculate the reliability indices of the distribution network. The results showed that the customer hour interruption is ridiculously high and this puts the distribution network in a poor state. It is recommended that new power distribution components such as transformer, circuit breakers should be purchased to replace the worn out ones or to add to the existing network for increased efficiency and effectiveness.*

Date of Submission: 20-02-2018 Date of acceptance: 07-03-2018

I. Introduction

The essence and usefulness of the power sector in the day-to-day economic activities in the nation and the world at large cannot be over emphasized. A weak or poor electric power system can create a fatal loss for not just the electricity company, but the nation as a whole as absence of electricity supply leads to an almost stand-still of all economic activities. Upon the huge investment by the Jonathan administration into the Nigerian power system, it is still plagued by incessant outages. This issue creates a challenge for the Nigerian power system in terms of system effectiveness and reliability. Studies have being carried out by different researchers to propose different methods of improving the Nigerian power system [1].

According to research, less attention has being paid to the optimization of electricity distribution networks as compared to the attention paid to electricity generation and transmission networks [2]. This is due to the reason that the generation and transmission networks are capital intensive and the effects on these networks are widespread while the distribution networks are less costly compared to the other electricity networks and the effects on the network are confined to a particular area or localized.

Great attention should be given to the distribution network as this network deals directly with the end user. Since the adequate analysis of the distribution network leads to increased satisfaction of consumers and also since the demand and supply study of electricity is more prominent in this network as it deals directly with the consumer, it provides adequate and reliable data analysis for improving the power system as a whole(generation, transmission and distribution)[3]. To this end, optimization of the effectiveness and efficiency of the distribution network is essential and also quite important for the increased efficiency of the power sector or electric power system because its mutual and complementary relationship with consumer satisfaction and its effect or influence on the electricity cost is high compared to the other electric power networks (generation and transmission networks).

For analysis of a distribution network, outage reports are required i.e. electricity interruption and the rate of interruption, number of consumers etc. Outages happen because of maturing of supplies/defects, lightning, vandalization, poor maintenance [4]. From the outage reports, two methods can be used to improve the distribution network or system. One of the methods is to reduce the duration of outage on the distribution network when a fault or faults occur and the second method is to reduce the frequency of customer or service interruption. Installing fault indicators in the primary feeders of the distribution network reduces outage duration [5].

These outages could be planned or forced. Forced outages are as a result of faults while planed outages are deliberate actions disconnecting electricity supply for the purpose of maintenance.

Faults are a norm on a distribution network. The circuit breaker on the 11KV feeder with the fault trips on the event of a fault occurrence. This fault occurrence causes a disconnection of electricity supply to the consumers connected to that particular feeder. For rectification of this fault, the faulty component has to be located, isolated and then repaired for electricity supply to be restored to the affected consumers. If the fault clearing period exceeds a particular period of time (threshold time), it becomes a loss for the electricity supply company.

An electric power system is supposed to adequately satisfy the load requirements of the system at the maximum possible quality and with the promise of reasonable continuity. Inability of the electric power system to provide this could lead to excess and costly outages on the network.

The power system in Nigeria is suffering from an almost collapsed or almost dead system. The demand for electricity is increasing daily and the supply growth or rate is crawling. The aim of this paper is to optimize the effectiveness and efficiency of distribution networks in Nigeria by analysing its reliability.

For the purpose of this paper, Ibadan Electricity Distribution Company (IBEDC), Molete Business Unit would be used as the case study. The monthly electricity report generated by the electricity company will be used to analyse the reliability of the distribution network using the power outage readings for the duration of three (3) months.

This area of study is therefore essential for obtaining reasonable maximum output, satisfaction and profit for the electric distribution network and the electric power system as a whole. The results of this study would proffer solutions to the costly blackouts and will improve our electricity distribution network.

II. Mathematical Models For Reliability Indices.

- System Average Interruption Frequency Index (SAIFI)

The system average interruption index indicates how often an average customer is subjected to sustained interruption over a predefined time interval (i.e. indicates how often the average customer experiences a sustained over a predefined period of time).

It is the sum of the number of interrupted customers (N_i) for each power outage greater than five minutes during a given period, or customers interrupted (CI), divided by the totalnumber of customers served (N_T). This metric is expressed in the average number of outages per year. Major events are excluded. [6]

This is mathematically written as;

$$\text{SAIFI}=\frac{TotalNumberOfCustomersInterrupted}{TotalNumberOfCustomersServed}$$

$$\text{SAIFI}=\frac{\sum \mathrm{N}_i}{N_T} \qquad (2.1)$$

- System Average Interruption Duration Index (SAIDI)

System Average Interruption Duration Index indicates the total duration of interruption an average customer is subjected for a predefined time interval (i.e. this index indicates the total duration of interruption for the average customer during a predefined period of time). It is commonly measured in customer minutes or customer hours of interruption.

The sum of the restoration time for each sustained interruption (r_i) multiplied by the sum of the number of customers interrupted (N_i), or customer minutes interrupted (CMI), divided by the total number of customers served for the area (N_T). This metric is expressed in average minutes per year. Major events are excluded.[6]

This is mathematically written as;

$$\text{SAIDI}=\frac{SumOfCustomersInterruptionDurations}{TotalNumberOfCustomersServed}$$

$$\text{SAIDI}=\frac{\sum (r_i N_i)}{N_T} \qquad (2.2)$$

- Customer Average Interruption Duration Index (CAIDI)

Customer Average Interruption Duration Index represents the average time in the reporting period that customers who actually experienced an interruption were without power.

The sum of the restoration time for each sustained interruption (r_i) multiplied by the sum of the number of customers interrupted (N_i), or customer minutes interrupted (CMI), divided by the sum of the number of customers who had at least one interruption (C_N). This metric is commonly expressed in minutes per outage. Major events are excluded. [6]

This is mathematically written as;

$$\text{CAIDI} = \frac{SumOfCustomersInterruptionDurations}{TotalNumberOfCustomersInterrupted}$$

$$\text{CAIDI} = \frac{\sum (r_i N_i)}{\sum N_i} \qquad (2.3)$$

- Customer Average Interruption Frequency Index (CAIFI)

This index gives the average frequency of sustained interruptions for those customers experiencing sustained interruptions. The customer is counted once regardless of the number of times interrupted for this calculation. [6]

This is mathematically expressed as;

$$CAIFI = \frac{NumberofInterruptions}{TotalNumberOfCustomersInterrupted}$$

$$CAIFI = \frac{N_0}{\sum N_i} \qquad (2.4)$$

III. Materials And Methods

The monthly electricity report generated by Ibadan Electricity Distribution Company (IBEDC), Molete Business Unit will be used to analyse the reliability of its distribution network using the power outage readings for the duration of three (3) months.

The readings were substituted into equations 2.1 to 2.4 to obtain the results.

IV. Result And Discussion

4.1 Result

Table 1: Reliability Indices for July

AVERAGE SYSTEM INDICES FOR THE MONTH OF JULY					
PERFORMANCE INDICATOR	WEEK 1	WEEK 2	WEEK 3	WEEK 4	MONTHLY AVERAGE
SAIDI	5.109134	1.840665	2.999537	0.931703	2.720259529
SAIFI	0.965402	0.932266	0.932338	0.936399	0.941601393
CAIDI	5.292234	1.974399	3.217219	0.994985	2.86970912
CAIFI	0.00028	0.000387	0.000658	0.001137	0.00061573

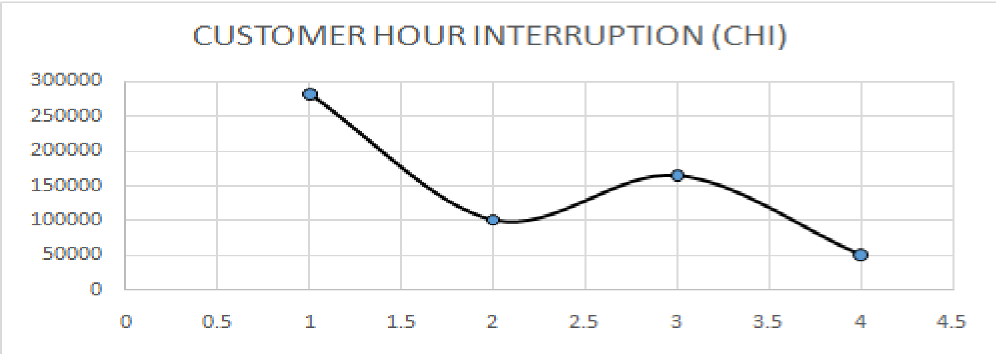

Fig.1: customer hour interruption characteristics for july

Table 2: Reliability Indices for August

AVERAGE SYSTEM INDICES FOR THE MONTH OF AUGUST					
PERFORMANCE INDICATOR	WEEK 1	WEEK 2	WEEK 3	WEEK 4	MONTHLY AVERAGE
SAIDI	1.47597	3.929306	2.015176	4.365705	2.946539218
SAIFI	0.902126	0.979082	0.729263	0.998249	0.902180191
CAIDI	1.636101	4.013254	2.763305	4.373361	3.196505373
CAIFI	0.00084	0.000332	0.000247	0.000434	0.000463362

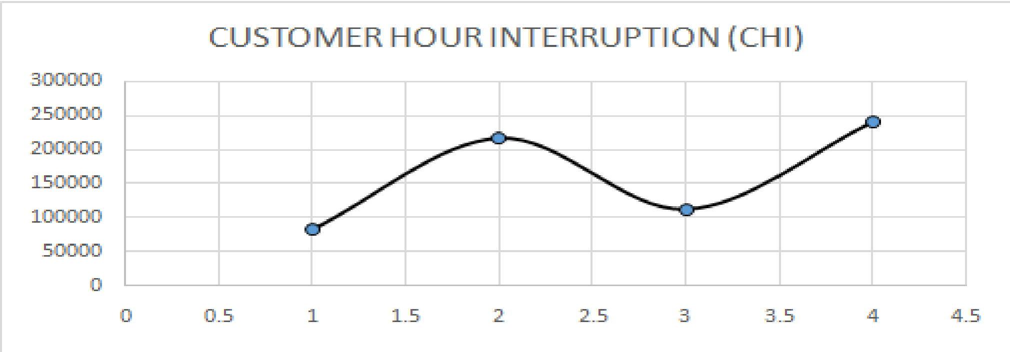

Fig.2: customer hour interruption characteristics for august

Table 3: Reliability Indices for September

AVERAGE SYSTEM INDICES FOR THE MONTH OF SEPTEMBER					
PERFORMANCE INDICATOR	WEEK 1	WEEK 2	WEEK 3	WEEK 4	MONTHLY AVERAGE
SAIDI	2.827347	1.6858	0.903076	5.152183	2.642101502
SAIFI	0.877455	0.906313	0.891712	0.919254	0.898683403
CAIDI	3.222215	1.860063	1.012743	5.604747	2.924942091
CAIFI	0.000617	0.001294	0.000972	0.000746	0.000907251

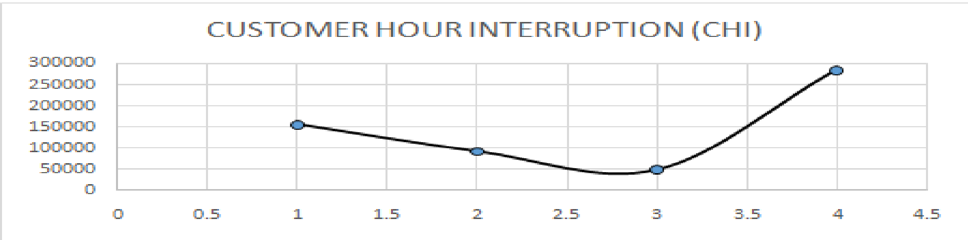

Fig.3: customer hour interruption characteristics for august

4.2 Discussion

Table 1 shows the SAIDI for July. it is observed that week 1recorded the highest average hour for which there was power outage for customers and the CAIDI and SAIFI values also show this (i.e. the probability of having an outage in week 1 is very high as described by the SAIFI and on an average, any customer who experienced outage was out for approximately more than five (5) hours that week).

The customer hour interruption characteristics for July (Fig.1) also showed the same trend under this consideration. Week 1 had the highest amount of customer hour interruption value (approximately 283086 hours-customers).

Table 2 shows the SAIDI for august. it is observed that week 4 recorded the highest average hour for which there was power outage for customers and the CAIDI and SAIFI values also show this (i.e. the probability of having an outage in week 4 is very high as described by the SAIFI and on an average, any customer who experienced outage was out for approximately more than four (4) hours that week).

The customer hour interruption characteristics for August (Fig.2) also showed the same trend under this consideration. Week 4 had the highest amount of customer hour interruption value (approximately 241894 hours-customers).

Table 3 shows the SAIDI for September. it is observed that week 4 recorded the highest average hour for which there was power outage for customers and the CAIDI and SAIFI values also show this (i.e. the probability of having an outage in week 4 is very high as described by the SAIFI and on an average, any customer who experienced outage was out for approximately more than five (5) hours that week).

The customer hour interruption characteristics for September (Fig.3) also showed the same trend under this consideration. Week 4 had the highest amount of customer hour interruption value (approximately 285472 hours-customers).

V. Conclusion And Recommendation

5.1 Conclusion

There are virtually no areas of human endeavours these days that do not require the use of electric energy. As the demand on power distribution system isbecoming greater the problems associated with it are also becoming greater and more complex. The efficiency in power distribution presently in Nigeria is too low. The quality of electricity power supply reaching the consumers is very poor. The urban areaswhere there are a lot of industrial and commercial activities experience the worst. Low voltage and incessant power outages are the order of the day in our entire Nigeriadistribution system. This problem could be eradicated or greatly minimized if the effective Distribution management is employed.

Distribution system management without a continuous analytical assessment of the entire distribution system is incomplete. This is one of the major tools for proper control, management and planning of the distribution system. Calculation of peak loadsvoltage drops and power losses, and the ability to predict how the nature of faults on thedistribution feeders and the nature of demand energy will be in future and knowing the reliability of the system would go a longway to assist the power distribution engineers to forestall eventualities and to plan ahead.

Ibadan Electricity Distribution Company (IBEDC), Molete Business Unit, one of the urban distribution networks in Nigeria hasbeen used as a case study for this paper. Like any other urban electricity supply problems, most of the feeders within the network are experiencing low voltage problems due abnormal voltage drops on them.

Alternate approach to create a stable distribution system in Ibadan metropolis is to create new additional primary (11KV)radial lines but this will attract more materials than the former. The later, however,provides room for future expansion.

Circuit breakers tripping on no fault is an unwelcomed phenomenon. It is a great threat to the stability and security of the entire distribution network. The technical staff expected to champion technical management of the entire distribution centres are not adequately trained. The need for more adequately trained technical staff isundisputable.

Most of the types of maintenance being carried out in our distribution system are corrective. Some were done only when after serious damages have been done. Issues of repairing damaged parts or cannibalizing one to place other as is always done withcircuit breaker copper contacts and transformer windings are not really effectively good. Equipment and materials to make those replacements or repair them locally to design specification are not readily available.

Most distribution substations and injection substation Nigeria transformers have been overloaded. In a situation where some distribution substation transformers areoverloaded while some are underutilized on the same feeder is a poor distribution approach.

5.2 Recommendations

In order to arrest the abnormal situation of poor electric power supplies inthe country and to put an end to the incessant power outages that are disrupting our economics activities, the following suggestions should be considered:

1) There is a need for distribution engineers to be carrying out researches and analysis on continuous basis, which can help to improve on efficiency of distribution of electric power in Nigeria.

2) There are needs to purchase new power distribution equipment such as transformer, circuit breakers etc., to replace the worn out ones or to add more to the existing ones.

3) The present radial distribution system be changed to ring distribution system in order to reduce the voltage drops and to avoid interruption due to outages and maintenance.

4) Preventive maintenance should be adopted in our entire distribution network. Instead of present corrective maintenance operation being carried out on quarterlybases, preventive maintenance on regular basis should be adopted. Worn out components should be replaced instead of repairing them, which of course were not done to specification.

5) Worn out or damaged protective devices such as relays and circuit breakers should be replaced immediately they are detected. This is to avoid undue interruption due to incorrect tripping.

6) There should be strong monitoring team in all our entire distribution centres. Thisbody will be responsible for curbing the activities of all illegal connections andvandalization of IBEDC equipment. New orientation should be given to all workers in the establishments. Honest and hardworking workers should be rewarded. There is need also for public awareness on the risk of attached to illegal tampering with the power systems, and the menace being caused as a resultabusive use of IBEDC equipment. There should be legislation to administer punishment on those people tampering illegally with IBEDC equipment.

7) There should be continuous research and analysis on our entire distribution systems and their components. The analytical behaviour of distribution systemfrom the research work can assist to determine the appropriate control and planning needed for effective management of distribution system.
8) Planning and Construction department in the distribution centre should begiven more power to plan and execute construction of power distribution network. They should always work hand in hand with the town planning authority and possibly industrialists for effective planning and good networkconstruction. This department should be allowed to be installing IBEDCequipment instead of inexperienced personnel.
9) There should be continuous and up to date training of personnel and IBEDCtechnical staff for effective construction, maintenance and monitoring ofdistribution networks. There should be procurement of modern working equipment for the personnel.
10) There is such need for management to always inspect new and old Installation. This is to avoid faulty wiring and the use of substandard materials.
11) The supply authority should always endeavours to work hand in hand with state and local Government to provide adequate rural electrification for rural dwellers. This will reduce urban drift, and therefore help in stable electricity supply.

References

[1]. KenechiAbanihi, Praise Adigo and Patrick Ezonuo (2014) “Outages on Nigerian Integrated High Voltage Transmission Grid”
[2]. Roy Billinton, Ronald N. Allan, Reliability Evaluation of Power System, Second Edition
[3]. TempaDorji (2009) “Reliability Assessment of Distribution Systems-Including a case study on Wangdue Distribution System in Bhutan”, Norwegian University of Science and Technology, Department of Electrical Power Engineering.
[4]. Onohaebi O. S (2009) “Power Outages in the Nigeria Transmission Grid”, Retrieved November 3, 2014 from http://www.medwelljournals.com/fulltext/?doi=rjasci.2009.1.9.
[5]. Tang.Y. (1996) “Power Distribution Planning with Reliability Modelling and Optimization”, IEEE Transactions on Power Systems, Vol. 11, No 1.
[6]. Distribution Reliability Report, U.S Department of Energy, December 2012.

International Journal of Engineering Science Invention (IJESI) is UGC approved Journal with Sl. No. 3822, Journal no. 43302.

V.K.Abanihi and S.O. Ikheloa "Optimizing the Effectiveness and Efficiency of Electricity Distribution in Nigeria "International Journal of Engineering Science Invention (IJESI), vol. 07, no. 03, 2018, pp01-06