IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 12, Issue 4 Ver. IV (Jul. – Aug. 2017), PP 34-38
www.iosrjournals.org

Analysis and Development of a Reliability Forecasting Model for Injection Substation

[1]B. O. lkhine, [2]E.A. Ogujor, [3]A.E. Airoboman
[1,2,]Department of Electrical/Electronic Engineering, University of Benin, Edo State, Nigeria.
[3]Department of Electrical/Electronics Engineering,Nigeria Defence Academy, Kaduna.
Corresponding Author: B. O. lkhine

Abstract: *This paper is aimed at analyzing and developing a reliability forecasting model for an Injection Substation; a case study of Ugbowo 33/11kV Injection Substation. This project seeks to determine the current reliability state of the station and suggest realistic as well as possible remedies to ensuring high reliability. In the course of the project, data for a period of three (3) years were collected from Benin Electricity Distribution Company, Ugbowo 33/11kV Injection Substation logbooks. The data consists of the time of power outage, causes of such outage, the load loss and date of occurrence. These data were analyzed using computational techniques and a Non Linear Regression (NLR) was used in order to achieve the aim of this project. The analysis of the data shows that the average reliability was very poor; Ugbowo, 23.68%, Uselu 25.20%, FGGC, 22.30%, Eguadiaken, 22.54% and an average system reliability of 23.43%. This was due to frequent power outages resulting from load shedding, earth fault, over current and loss of power supply from the source. It is therefore recommended that BEDC should either build a new station or expand the existing to one to meet the current load demand of the customer of her customer in other to combat the prevailing problems, more investment in human and financial resources is needed to maintain the above condition as well as adopting an efficient maintenance scheme that will incorporate routine check on equipment and the entire system to prevent breakdown or reduce restoring time during any breakdown or fault in the system.*

Keywords: *Reliability forecasting model, Non linear regression model, Availability and Unavailability, Distribution substation*

Date of Submission: 08-08-2017 Date of acceptance: 05-09-2017

I. Introduction

Energy is the basic necessity for the economic development of a country. The basic necessity of power system is to provide an adequate electrical supply to its customers as economically as possible with high level of reliability. Electric power is generated at far location and transmitted through conductors over long distances to distribution centers close to consumers (Ogujor and Kuale, 2007). Utilities use these distribution systems/centers to serve their customers with reliable quality power.

An Injection Substation aims at meeting the customer's/users demand for energy after receiving the bulk electrical energy from transmission or sub transmission substations. It is the connection between power system supply and the distribution customers.

Reliability is not a recent topic in the Electric Power industry but has become a matter to scientists and engineers in the past decade due to costly blackouts and downtime thus making the Nigeria market a suitable domain for generator dealers around the world (Airoboman, 2017). Reliability is the probability that a device/system will function correctly when required to act, while availability is that, system will be able to perform its required function over a specific period of time (Ubeku, 2015). Analyzing Reliability, maintainability together with availability determines the ability of equipment to achieve an intended task (Kolowrocki, 2003). Forecasting on the other hand is a technique that is used other research fields such as weather forecasting, load forecasting and also in the stock exchange market. Improving distribution reliability is the key to improving customer reliability as the distribution systems record about ninety percent (90%) of all customer reliability problems (Xie*et al*, 2016).

Reliability forecasting of a power system such as an Injection substation shows the system reliability performance that will be realized in the future based on current information (Xie*et al*, 2016). In addition, it can provide information which is able to be used for possible energy interchange with other utilities and is also useful for system security.

Injection Substation component are likely to fail depending on its usage. Being able to proactively predict failure (Airoboman, 2016) and providing counter measures to them will greatly impact positively on Users turnaround time, save cost and reduce downtime intensely.

The system will benefit in the following ways:

- Management- planning of substation and its associated components.
- Customers- the customer which is the society at large will benefit in termsof a well secured and adequate power quality.

II. Aim And Objective

This paper is aimed at using a Non-Linear Regression model to analyze and forecast reliability for an Injection Substation; a case study of Ugbowo33/11kV Injection Substation.

III. Methodology

I INDEX OF RELIABILITY

After quite reasonable amount of data has been collected, the data sets to be used for analysis are hence obtained after filtering of erroneous occurrences. The study employs descriptive statistics which present data using tables, charts and graphs. Based on the non-linear nature of outage data gotten from the case study under review, this research employs the use of Non-Linear Regression model for the analysis and forecasting.

Failure Rate (λ): This relates to repairable systems and expressed as the number of failures which occur per unit in a given time interval. It is expressed as:

Failure rate(λ) = $\frac{numberoffailure}{totaloperatingtimeofunits}$ 1

Total operating time of units = number of unit – hour of operation

Mean Time To Repair (MTTR): It is the average time required to bring a system back to its normal operation. Hence a low MTTR shows a good maintainability skill.

MTTR = $\frac{totaldowntime}{totalnumberoffailures}$ 2

Availability (A): It is the performance of individual components or to a system. It is also the long-term average fraction of time that a component or system is in service satisfactorily performing its intended task.

Availability = $\frac{uptime}{Expectedti\ me}$ 3

Expected time = Uptime + Down time

Reliability: Reliability is the likelihood that a device/system will function correctly when required to act, (Ubeku, 2015). Reliability is closely associated with outages, interruptions, failure, availability etc.

Reliability (R) = $e^{-\lambda t}$ 4

Where λ = Failure rate

t = time of outage

IV. Data Collection

The data that is used for the model in this research are the daily Electric power supplied over the period of three years (January 2014 – December 2016) in Ugbowo33/11kV injection substation Benin City. The summarized data however is stated below:

Names of feeders		YEARS		
		2014	2015	2016
Ugbowo	Frequency of outages	1378	866	1006
	Uptime(Hours)	6219	5601	7039
Eguadiaken	Frequency of Outages	1315	1009	989
	Uptime(Hours)	6607	6019	5513
Uselu	Frequency of Outages	1322	862	925
	Uptime(Hours)	5728	5163	5708
FGGC	Frequency of Outages	1396	979	984
	Uptime(Hours)	6734	6070	6180

The table 1.0 shows the total frequency and duration of outages of the 11/33kV feeders

V. Results

The data above is used in this paper for the period of three (3) years (36 months) for the four (4) feeders which are Ugbowo, Uselu, Fggc and Eguadiaken feeders on a daily basis to analyses, develop and determine the reliability to time of the model. These are recorded in terms of their frequency of outages, uptime, mean time to failure (MTTF), failure rate, Availability, unavailability, repair rate and reliability as shown in the overleaf. The formulas used in achieving results are stated above.

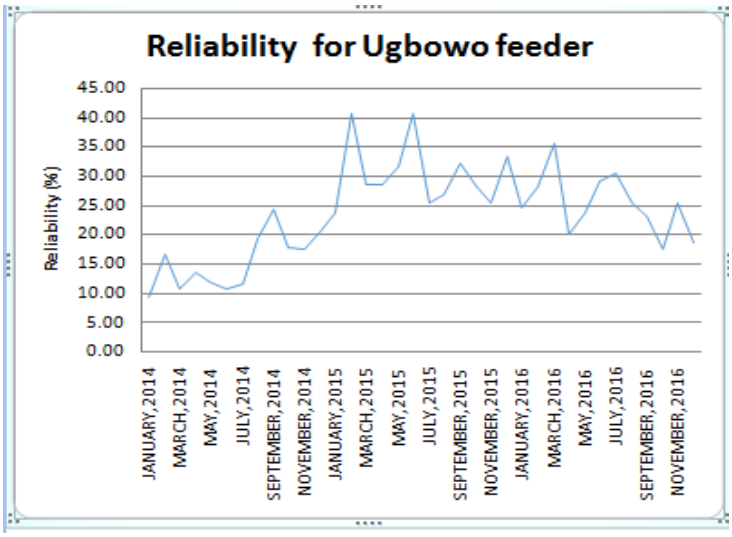

Figure 4.1: Reliability versus Time (Months) for Ugbowo 2014 - 2016

Figure 4.1, 4.2 and 4.3 are charts of reliability against time for Ugbowo feeder which showed January 2014 having the lowest reliability of 9.38% and February and June 2015 having the highest reliability of 40.66% and an average reliability of 23.68%.

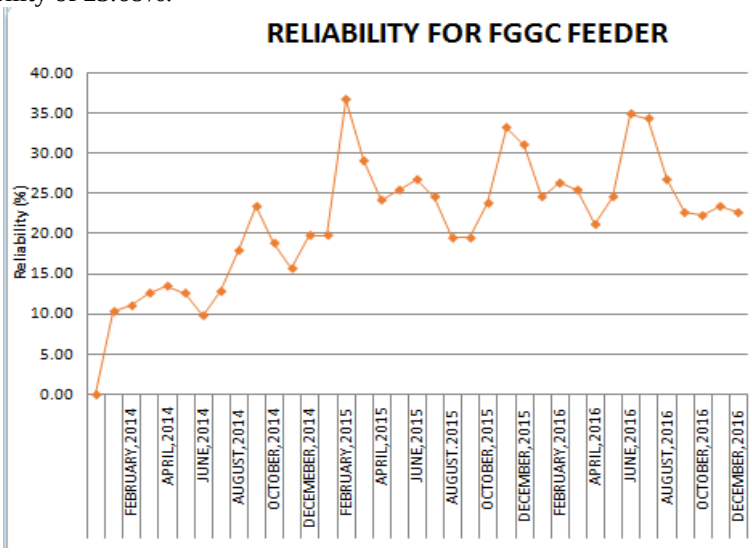

Figure 1: Reliability versus Time (Months) for FGGC 2014 - 2016

Figure1 is the chart of reliability against time for FGGC feeder which showed June 2014 having the lowest reliability of 9.86% and February 2015 having the highest reliability of 36.78% and an average reliability of 22.30%.

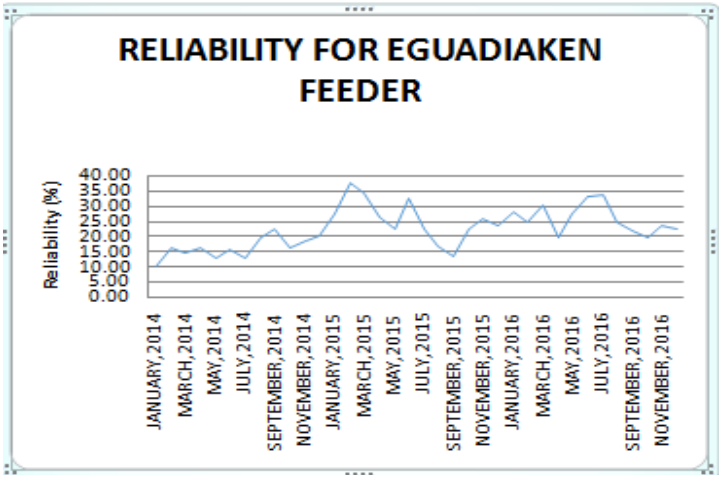

Figure 2: Reliability versus Time (Months) for Eguadiaken 2014 - 2016

Figure 2 is the chart of reliability against time for Eguadiaken feeder which showed January 2014 having the lowest reliability of 10.36% and February 2015 having the highest reliability of 37.4% and an average reliability of 22.54%.

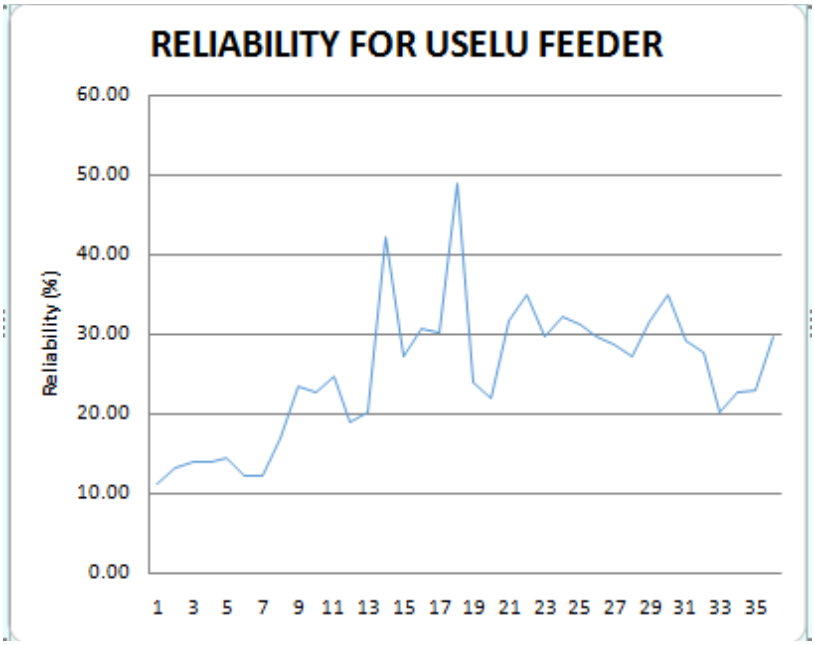

Figure 3: Reliability versus Time (Months) for Uselu 2014 - 2016

Figure 3 is the chart of reliability against time for Uselu feeder which showed January 2014 having the lowest reliability of 11.26% and June 2015 having the highest reliability of 48.83% and an average reliability of 25.20%.

VI. Conclusion

This project discusses the analysis and development of reliability forecasting model for Ugbowo Injection Substation using historical data that can help the utility in preparing for future electricity demand requirements with a high reliability percent. The overall goal of the project was to use a regression model to predict three years (36 months) reliability values given large amount of historical data. Historical data ranging from 2014 – 2016 is used to train and test the model for future predictions. Having determined the reliability and identified the various causes of poor availability of power supply and frequent faults some efficient recommendations were made on how to improve in the availability as well as the reliability of power supply at Ugbowo 33/11kv injection substation. To this end, we can say that the objectives and aim of this project work have been achieved.

References

[1] Airoboman A.E, Ogujor E.A and Okakwu, I.K (2016) "On the Centralization of Reliability in Maintenance Practices in the Nigeria Power System Network: A Review". International Journal of Engineering Works Vol.3, No. 9 pp.68-72
[2] Airoboman A.E, Ogujor E.A and Okakwu I.K (2017) "Reliability Analysis of Power System Network: A Case Study of Transmission Company of Nigeria, Benin City". IEEEPES-IAS Conference Accra Ghana June 27-30. pp.99-104
[3] Ali Chowdhury and Don Koval (2009)."Power Distribution System Reliability". Published by John Wiley and Sons Inc., Hoboken, New Jersey.
[4] Adoghe U.A, Awosope C.A. and Joseph C.E, (2013)."Asset Maintenance Planning in Electric Power Distribution Network Using Statistical Outage Data".Electric power and Energy Systems, 47(2013) 424-435.
[5] BEDC (2014-2016). BEDC daily operational log books of UgbowoInjection Substation, Benin City, Nigeria.
[6] Elizabeth Amuta, Adejumobi I.A, Wara, S.T, Abiala I.O, (2014). "A critical Analysis of the Reliability of Power Holding Company in Nigeria Protection Schemes".International Journal of Engineering and Technical Research (IJETR), Vol. 2(5), Pp 369-372.
[7] Ignatius K.O, Oluwasogo E.S (2015). "Reliability Study of 11kV Distribution
[8] Feeders: A case study of Idi-Araba PHCN injection Substation". IOSR journal of Electrical and Electronics Engineering, Vol.10 (1), Pp58-65.
[9] Kaigui X, Hua Zand Chanan S (2016)
[10] "Reliability forecasting models for electrical distribution systems considering component failures and planned outages," International journal of Electrical Power and Energy System Vol 79, Pp. 228-234.
[11] Luiz F., Jefferson L., Tiago R., Marcelo L., Eduardo L. and Renato V., (2011). FaultDetection, Diagnosis and Prediction in Electrical Valves Using Self-Organizing Maps.Journal of Electronic Testing. Vol. 27(4), Pp 551-564.
[12] Musa B.U., Ngaja T.B, Kali B.M and Tijani B.U. (2015)."Outage Analysis onDistribution Feeder in North East Nigeria".Journal of Multidisciplining Engineering Science and Technology (JMEST) Vol.2 issue 1 Pp149-152.

[13] Ogujor, E.A. and Kuale, P.A. (2007) "Fault Events Reduction in Electric Power Distribution Reliability Assessment using Pareto Analysis," International Journal of Electrical andPowerEngineering.Vol. 1 No. 4 Pp 463-467.
[14] Ogujor, E.A. and Kuale, P.A. (2007) "Using Relaibility Indices-Markov Model in Electric Power Distribution Reliability Assessment".International Journal of Electric and Power Engineering (IJEPE), 1(4), 416-420.
[15] Okakwu I.K., Ade-Ikuesan and Oluwasogo E. (2015). "Reliability Improvement through Identification of few Significant Faults in a Distribution Feeder".American International Journal of Science, Technology, Engineering and mathematics, 11(2), Pp 108-114.
[16] Okorie P.U and Abdu A.I (2015)."Reliability Evaluation of Power Distribution Network System in Kano Metropolis of Nigeria".International Journal of Electrical and Electronic Science, Vol.2 No. 1 Pp1-5.
[17] Onime, F. and Adegboyega G. (2014). "Reliability Analysis of Power Distribution System in Nigeria: A case study of Ekpoma Network, Edo State," International Journal of Electronics and Electrical Engineering, Vol. 2, No. 3, Pp 175-182.
[18] Sule A.H (2010). "Major Factors affecting Electricity Generation, Transmission and Distribution in Nigeria".International Journal of Engineering and Mathematics Intelligence, Vol.1, Nos 1&3, Pp 159-164.

B. O. lkhine. "Analysis and Development of a Reliability Forecasting Model for Injection Substation." IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), vol. 12, no. 4, 2017, pp. 34–38.