Electrical Network Reliability and Failure Projection With Increase In Installations: Case Study, University of Ilorin

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Abstract

Reliability is a key aspect of power system design and planning. In this research we present a reliability assessment of University of Ilorin electricity network. The focus of this paper is to analyse the contributory effect of electrical installations, majorly domestic and some industrial loads on the reliability of electrical network. This work use data of electrical failure cases from the university of Ilorin community, and categorized the failure reports based on their failure type. It also, gives an insight on how to project the system reliability effect for any consequent electrical faults or unplanned installation. The study here evaluated the reliability over a time period of about two years. The reliability indices for load points and the overall system were obtained using exponential distribution model.

Keywords: Electrical Network, Failure, Reliability.

1 Introduction

Reliability is the probability that a device or system will perform its function adequately, for the period of time intended, under the operating conditions intended. Reliability can be determined through the mathematical concept of probability by identifying the probability of successful performance with the degree of reliability. If a device or system does not fail during the time of service it is said to perform satisfactorily. On the other hand, some devices are expected to fail, be repaired and then returned to service during their entire useful life. In this situation a more appropriate measure of reliability is called availability of the device in question. Therefore, maintaining a reliable power supply is a very important issue for power systems design and operation [1].

Reliability in terms of electrical network takes cognizance of the bulk electrical distribution efficiency within the network and the impact of the failure of sub component on the network. The university of Ilorin electricity network was assessed in terms of fitness of the cables, transformers, control and protection devices and other electrical devices. The load rating of the university was 2.5MVA before it was recently upgraded to 5MVA (with addition of another 2.5MVA) in

march 2011. The network is made up of 30 substations, having various sizes of transformers designated to different loads.

2 Methodology of Data Collection

It is useful to specify the reliability of electrical network by some probability parameters, which give indication of the failure rate of such a system or equipment. In this case it is assumed that the system has a constant failure rate, hence, exponential distribution model is assumed. The system accuracy dependency on data length is ensured by taking system's records of failures for a period of two (2) years, including types, frequency and time of failures. These records of failures for a period of two (2) years from year 2010 to year 2011 were obtained from the University's works department, departmental or units job requests or service records and other related job receipts. The total failure rate of the networks and mean time between failures (MTBF) are the two parameters that is used in determining the reliability of electricity network .

3 Mean Time Before Failure (MTBF)

The length of time that a system will run without failure is of importance to the system users. For a repairable system the mean time between failures is a critical measure. The time distribution is an exponential decay and the mean time between failures (MTBF) is the average of the time a system will function before its failure. It is assumed that electricity network is a repairable system. MTBF can be obtained by operating the system for specified periods of time under specified conditions. The probability density function can thus be expressed as

$$MTBF = \int_0^\infty tf(t)dt.$$

(1)

Based on the assumption that a component has a constant failure rate, equation (1) can be represented by

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

(2)

where λ is the total failure rate of the network. The mean time between failures for the network is obtained by subsituting the total network`s failure rate into equation (2). Microsoft Excel is used in obtaining MTBF. The systems' time between failures and mean time between failures are obtained shown as Figure 1.

4 Failure Rate (λ)

This is the number of failures that occur over a period of two years. Failure rates of the networks are obtained by taking the inverse of networks' MTBF as equation (2) was used to determine the network failure.

Step 1: Convert the dates to text
Step 2: Determine the time between failures
Step 3: Determine the maximum time between failures
Step 4: Determine the minimum time between failures
Step 5: Count the number of time between failures
Step 6: Count the blank spaces
Step 7: Get the difference between numbers of times between failures and blank space
Step 8: Determine the interval N
Step 9: Determine the delta
Step 10: Determine the MTBF

Figure 1: Determination of MTBF for the University of Ilorin Electricity network.

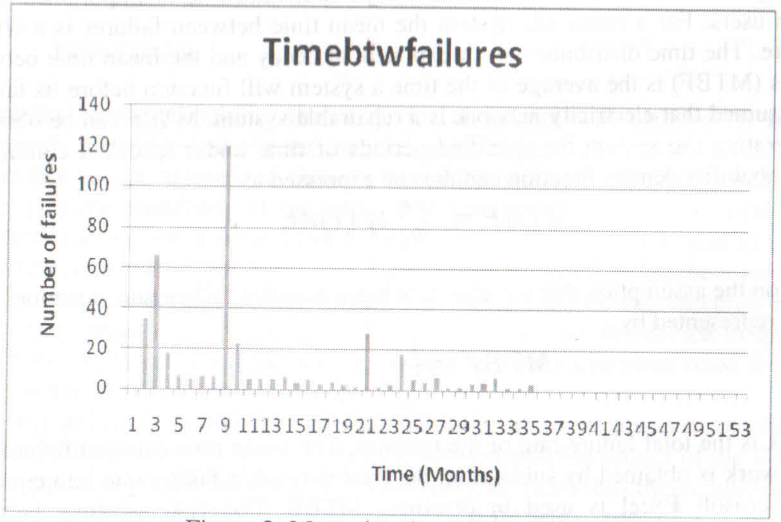

Figure 2: Mean time between failures

It can be seen from Figure 2. that, University of Ilorin Electricity network experienced low mean time between failures during the rain seassion. This is because the aging distribution network in the University which is in both surface and underground cabling. Samples of two components contributry effect is shown by figure 3. Therefore, the university need to reduced the increase mean time between failure (reduced the failure rates) and upgrade the distribution network.

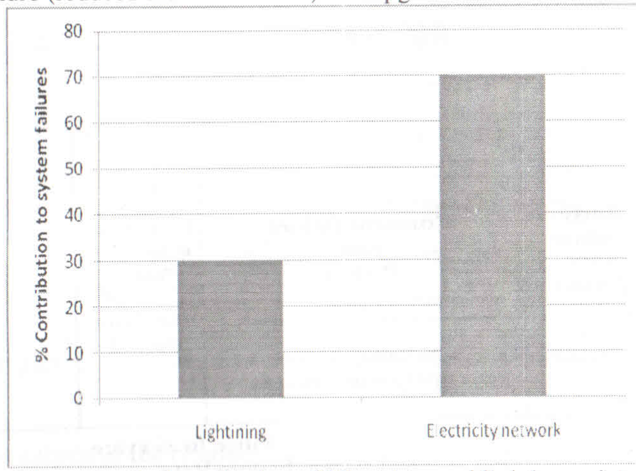

Figure 3 : % Contribution of Electricty and lighting points to system failures

5 System Reliability

In operational situation a more appropriate measure of reliability is called availability of the device in question. Availability of a repairable device is the proportion of time, during the intended time of service, that is the device is in, or ready for service. Thus, network availability analysis considers the problem of evaluating such a measure; this is often termed as the network reliability analysis [2]. In [3] a distinction between predicted and estimated or assessed reliability is addressed. The first one is calculated on the basis of the item's reliability structure and the failure rate of its components, the second is obtained from a statistical evaluation of reliability tests or from field data by known environmental and operating conditions. In this work the reliability of the system is calculated based on the field data.

Reliability figures are obtained by using exponential distribution. It is one of the simplest distribution forms to actually calculate reliability value. The exponential distribution model is given discuss in detail in [4] and [5]. For system reliability the exponential failure density function $f\ (t)$ is defined by

$$f\ (t) = \lambda e^{-\lambda t} \qquad t \geq 0 \& t > 0$$

(3.1)

where λ is constant failure rate, and t is operating time. The reliability function $R(t)$ is given by

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

(3.2)

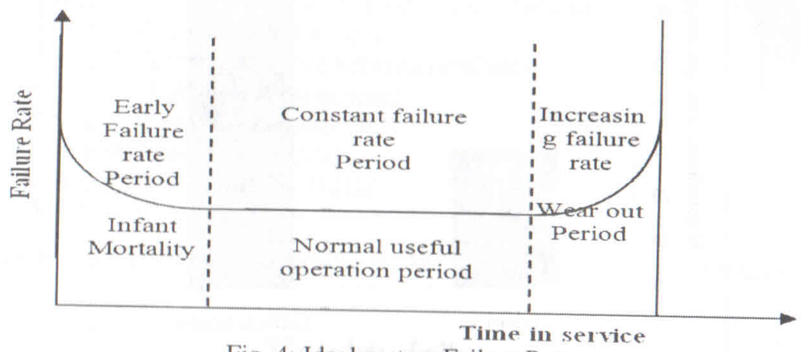

Fig. 4: Ideal system Failure Rate

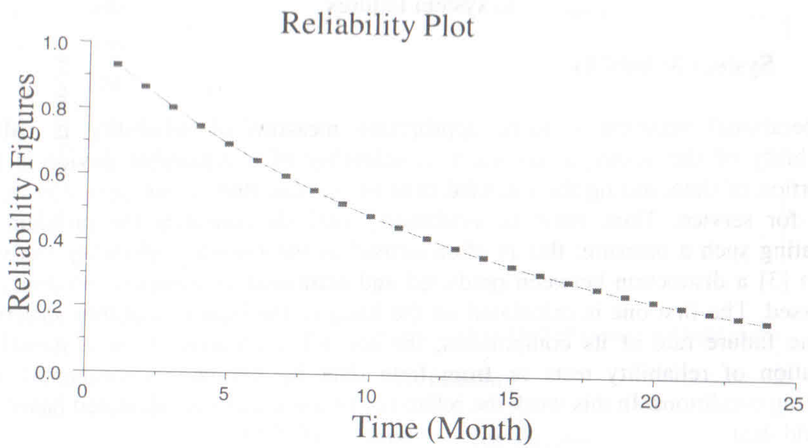

Figure 5: Present System Reliability plot of University of Ilorin Electricty Network

In the next two years, the network reliability is obtained by assuming constant failure rate and using exponential distribution model. The forecasted electricity network reliability is presented in Figure 6.

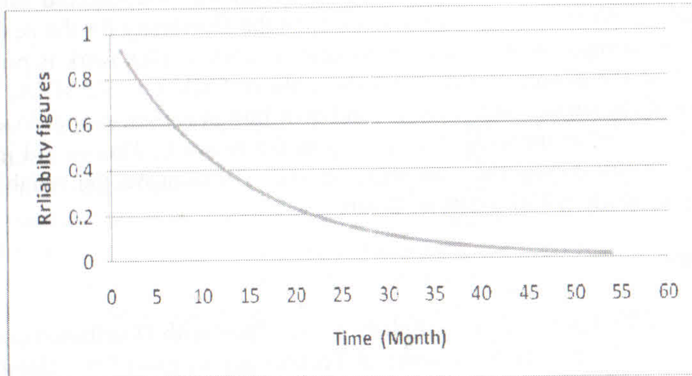

Figure 6: Forcasted System Reliability plot of University of Ilorin Electricty Network

5 Analysis of the results

The present system reliability when compared with the ideal situation, the present electricity network reliability is nearly exceeding the useful life span of the network. The electricity distribution network in the University experience high failure rate during rain seasons, examination periods and registration periods. Comparing the present system reliability with the forecasted system reliability, it was observed that the electricity network in the next two years is entering its wear out period. By upgrading the network, results shows reduction in percentage contribution of the distribution network failure to the total system failure espicially during rain seassion.

Also, inferred from the data collected, it was observed that most of the electricity failures in the network during dry seassion are as a result of system failures not lightining equipments. To decrease failure rate, there is need to use the stanadard equipment at all times. These would decrease the system failure rate, espcially during exams periods when the students need the electricity most.it can be seen in Figure 3. that the system contributed highest electricity failure compared to the lightitng points. Lightining points contributed only 30% to the electricity failure as against the main electicity network which account for 70% of the system failures for the last two years.

6 Conclusion and recommendation

In the course of this work it was found that each sub-unit within the network carried out independent maintenance and upgrading without recourse to the impact on the capacity of the power source (feeder). Also, the infrastructural growth of the university in the last decade has not been matched with the required source power. The calculated electricity network reliability in the University for the next two years are very low compared to the present system reliability. This work is proposing the upgrading of the power source from the present 5MVA to 7.5MVA, as well as upgrading of the surface and underground distribution cables, proper load matching of the control and monitoring devices within the network. This would incresae the system reliability during the rain seassion and will improve the reliability of the electricity network in University of Ilorin.

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Public - Private Partnership: a Solution to the Failure Menace of the Road Infrastructure in Nigeria

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Abstract

This paper is a contribution towards proffering a solution to the deplorable state of most of the road network in Nigeria. It traces the origin of the problem to the lack of application of Adam Smith's principle of increasing the expenditure on the road sector in parallel with the Gross National Product and the traffic volume. The paper goes on to examine the legal and policy framework for road maintenance in other developing countries vis-à-vis what obtains in Nigeria, and shows up the need for reforms in our present system of funding the maintenance of the road network. It concludes by making definite recommendations on the specific reforms necessary for the attainment of a sustainable maintenance of the nation's road infrastructure through Public-Private Partnership.

1. Introduction

The annual public expenditure for the road sector must increase in parallel with the Gross National Product GNP and with the traffic volume". This quotation paraphrased from Adam Smith's work (Heggie 2001) is as true now as it was 233 years ago. Continued failure to apply this principle in the planning and budgeting for our national infrastructure is largely responsible for the sorry state of our roads. Yet the importance of road transport infrastructure to the economic growth, citizen mobility and national competitiveness of any nation is not in doubt. This is even more so in present day Nigeria where alternative modes of transportation have either collapsed, like the rail system or are, underdeveloped like water transport. Since the virtual collapse of our rail system in the early 1980s, the road network has become the backbone of the transport system, such that heavy freight more suitable for the rail system such as fuel oil, fertilizers, cement, iron blooms etc. are now transported through the road network. This combination of heavy axle loads and increased traffic volume resulted in a rapid deterioration of the national road network, some 200,000km long with a replacement value of $23 billion (Tomori, 2001).

The Central Bank of Nigeria (2003) quoting from a Federal Ministry of Works and Housing report, estimates the annual loss due to bad roads as N133.8 billion made up of N80 billion deterioration of the roads, and increased vehicle operating cost of N53.8 billion, not counting the man hour losses in traffic.

Inspite of these colossal losses, the traffic volume has continued to increase, 1.2 million passenger cars and almost 400,000 commercial vehicles (Metschies