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ANALYSIS OF FEEDERS OUTAGES ON THE DISTRIBUTION SYSTEM OF ZARIA TOWN

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Abstract

The paper is aimed at analysing the outages on the feeders of the distribution system, in Zaria Town, Kaduna State, Nigeria. The 11 kV feeders are the NNPC feeder, Gaskiya feeder, Sabon Gari feeder, NTC/RLY feeder and the Canteen feeder. The 33 kV feeders, on the other hand, are the Shika feeder, Giwa/Makarfi feeder and the Soba feeder. The analysis is based on the daily outage data collected for a period of about one year (April, 2003 to April, 2004 – thirteen months). From these data, the type, number and duration of the outages were identified. The plots of outage distribution of the five 11 kV feeders were obtained. Their forced outages were compared as well. The outage plots of the three 33 kV feeders were also obtained and their forced outages compared. The power losses due to the feeders' outages were considered and the feeders, at each voltage level, were investigated for loss of power. The results obtained were discussed; possible reasons for the causes of the outages were presented and appropriate recommendations were proposed.

1. Introduction

High rate of power demand requires a stable and continuous power supply to consumers, therefore the study and analysis of the various outages on the installations in a power system is necessary for improved performance. These are useful in planning, design, operation and maintenance. Of the National Electric Power Authority, now Power Holding Company of Nigeria (PHCN), grid is the Zaria 132/33/32 kV distribution network.

Electrical power is transmitted from the generating station to consumers by means of transmission and distribution lines. The former are capable of conveying larger quantities of electrical energy over greater distances and higher voltages (330 kV or 132 kV) than the distribution lines (11 kV or 33 kV for primary distribution and 415/240 V for secondary distribution). The 33 kV primary distribution system is also called the subtransmission system. In the distribution system, the conductors are grouped into feeders, distributors and service mains. Feeders radiate power from the bus bar to the distributors, which are characterised by the numerous tapping taken to supply the consumers. The service mains connect the distributors to the consumer terminals. Even though faults can and do occur at each stage of the power system, they are, however, predominant at the distribution level.

Feeders constitute a radial form of distribution system and are, therefore, chosen for investigation. In the Zaria distribution network, there are five 11 kV feeders and three 33 kV feeders; these are carefully analysed and studied in this paper.

A number of works similar to the present one have been carried out in the past. Of concern to this study are the outages on the Zaria feeders. Attempts to identify the causes and effects of the outages on the 11 kV (Adegboye, 1998) and the 33 kV (Adegboye, 1997) feeders,

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respectively were made and possible remedies proposed. Bakare (1990) evaluated the reliability of the 11 kV feeder network in Zaria. The Institute of Electrical and Electronic Engineers (IEEE, 1990) proposed the predictive indices for bulk system reliability in transmission systems. Earlier, the IEEE (1968) had proposed definitions of terms for reporting and analysing outages of electric transmission and distribution facilities and interruptions. For the generating system, however, the IEEE (1979; 1960) discusses the application of probability methods to generating capacity reliability evaluation. Jimoh and Adegboye (1995) applied the frequency and duration (F&D) method to study the performance of the Nigeria's Kainji hydroelectric power station. Xifang *et al.* (1983) discussed the F&D approach earlier. Yahya sampled four Northern states of Nigeria and carried out fault analyses on their distribution networks. Yusuf (1986) evaluated the adequacy and reliability of the 330/132 kV power transmission network of the Nigerian National system.

In this paper, however, the outages on the distribution feeders of the Zaria distribution network are closely considered. Their performance were evaluated in terms of the outages on them between April 2003 and April 2004, being a period considered to be most recent by the management of PHCN as at the time of this research.

The outages are classified as forced or scheduled. For the purpose of this research, the former is, in turn, classified as temporary or permanent depending on whether the outage lasts for less than or more than about thirty minutes, respectively. A scheduled outage, on the other hand, is an outage that results when the feeder is deliberately taken out of service for a specified period of time for a particular purpose. The number and duration of the various outages over the period of investigation are carefully observed.

2. The Zaria distribution network

The Zaria distribution system is separated into two parts, namely, the primary subsystem and the secondary subsystem. The primary distribution subsystem consists generally of a transmission line carrying the three-phase current from the switchyard of the plant to the substation located near the area served. The basic function of this substation is to transform the high voltage necessary for economical long distance transmission to a voltage suitable for lines in areas of residential districts and also for primaries of the light pole top distribution transformer.

The secondary distribution subsystem emanates from the substation to the consumer's meter through the transformer, located with respect to a small group of customers, which each one supplies. This, if large, may require two or more step-down voltage transformers.

The Zaria distribution network comprises of the 132/33/11 kV substation having two 15 MVA, 132/11 kV transformers and one 45 MVA 132/33 kV transformer. The schematic diagram is shown in Figure 1. On the 132/11 kV line, there are five feeders and a bus section. These include the Ahmadu Bello University (ABU) feeder, Dam feeder, Nigerian National Petroleum Corporation (NNPC) feeder, Feeder 1 and Feeder 2. On the 132/33 kV line, however, there are three feeders: the Shika/Samaru feeder, Giwa/Makarfi feeder and the Canteen feeder.

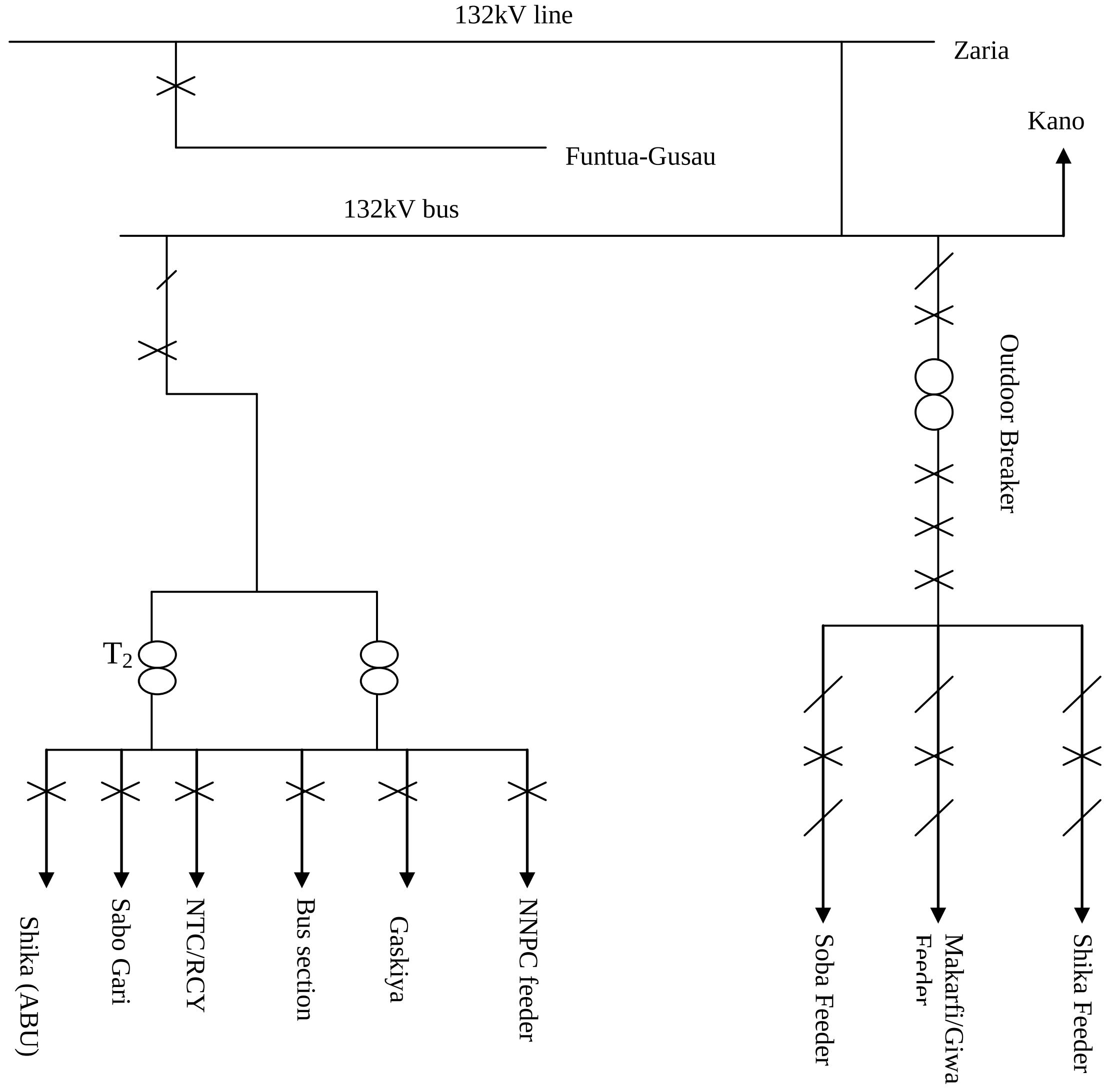

Figure 1: Schematic diagram of the Zaria distribution

Source: PHCN District Office, Zaria

2. Data collection and discussion of results

An outage describes the state of a device or system when it is not available to perform its intended functions due to some event directly associated with that device or system. Outage data were collected from the PHCN district Office, Zaria. They comprise of information on each failure event between April 2003 and April 2004. This gives a period of thirteen months with April 2003 as period 1, May 2003 as period 2 up to April 2004 as period 13. These information were recorded in narrative form. For the purpose of analysis, the records were restructured in such a way that the narrative aspects were highlighted in a manner in which they could be translated into a statistical database. These database and the computations that followed therefrom are given in Figures 2 - 11.

It is observed that failures are generally high on the 11 kV feeders between November and January (or up to February, in some cases). This is the cold (harmattan) season (periods 8 to 11) where there is an increase in the use of weather sensitive devices like heaters. Other appliances that enjoy increased use are electric water heaters in homes and boiling rings on Higher Institution campuses (ABU campuses, Federal College of Education, College of Aviation, Kaduna State Polytechnic, National Institute of Transport Technology, etc). The distribution of the various outage types on the five 11 kV feeders are shown in Figures 2 - 7.

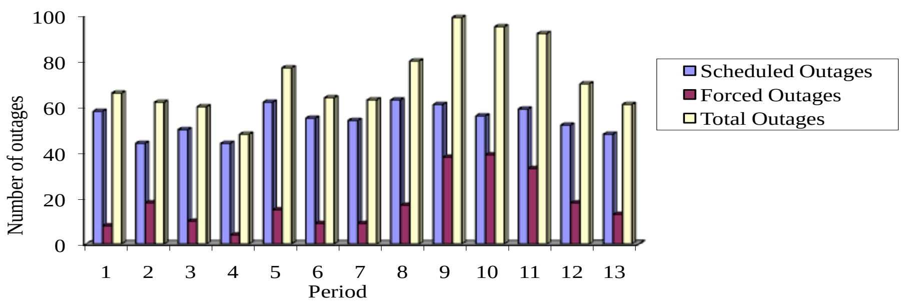

Figure 2: Outage distribution on NNPC 11 kV feeder

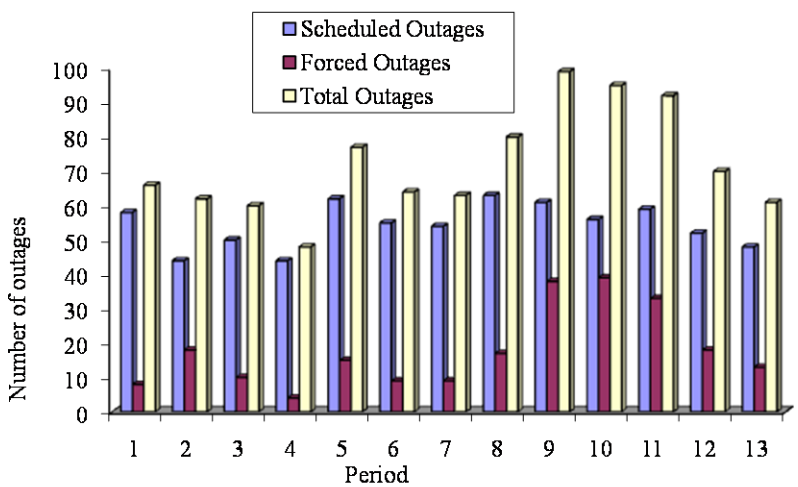

Figure 3: Outage distribution on NNPC 11 kV feeder

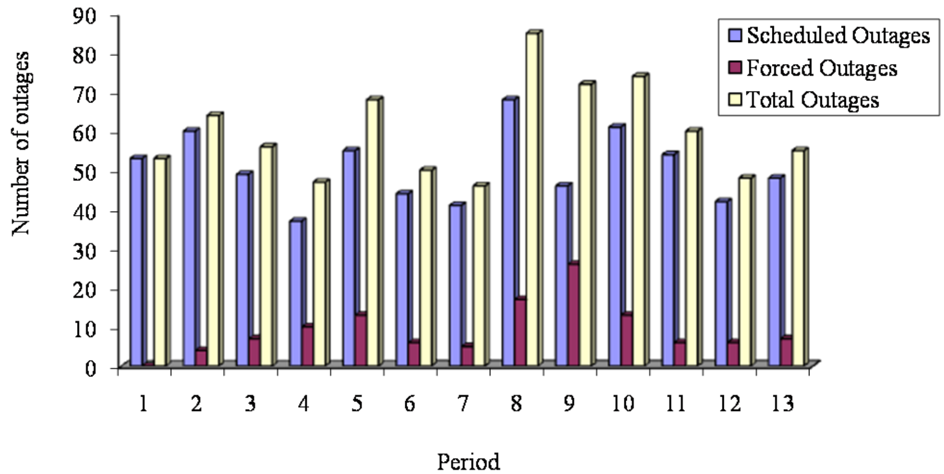

Figure 4: Outage distribution on 11 kV Gaskiya feeder

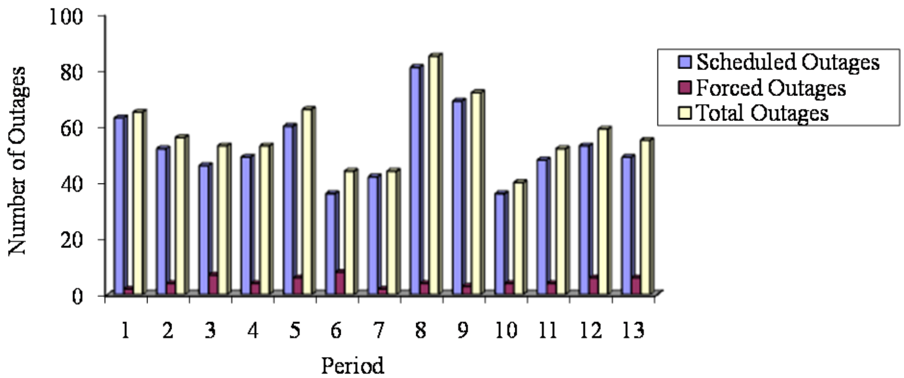

Figure 5: Outage distribution on 11 kV Sabo Gari feeder

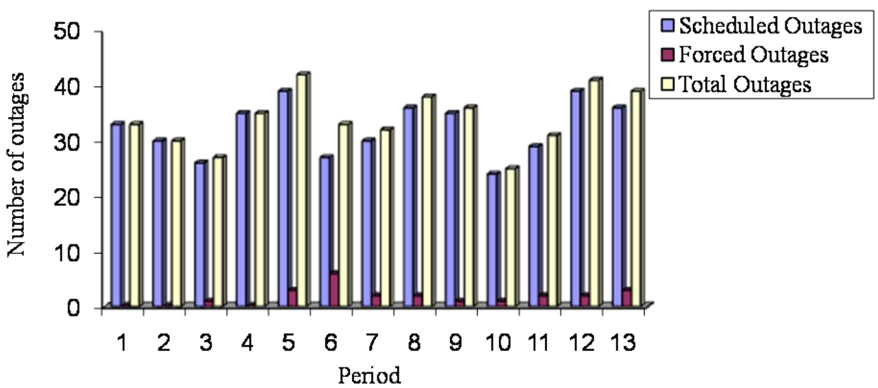

Figure 6: Outage distribution on 11 kV NTC/RLY feeder

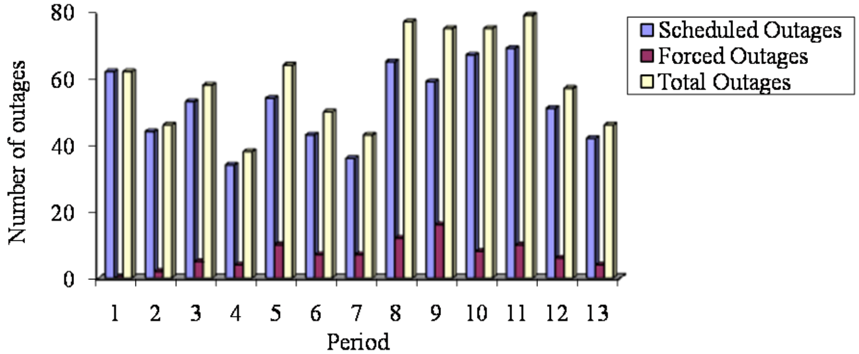

Figure 7: Outage distribution on 11 kV Canteen feeder

In Figure 8, comparison made of the five feeders reveals that the Gaskiya feeder has the greatest forced outage in period 9 followed by the Canteen feeder within the same period; this feeder attained a high level in period 10 as well.

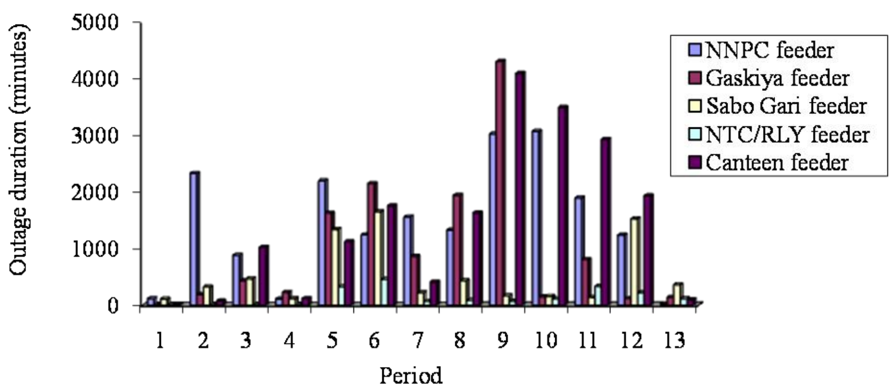

Figure 8: Comparing forced outages on the five 11 kV feeders

Due to these outages, however, some powers are lost. These are calculated and plotted as shown in Figure 9. It is observed that the NNPC and Gaskiya feeders have the same power loss within the first nine periods. During the entire period of investigation, however, the Gakiya feeder accounts for the highest power loss (34.6% of the total power lost to the outages). The NNPC, Sabon Gari, Canteen and NTC/RLY feeders occupy 34.2%, 26.8%, 2.6% and 1.8%, respectively.

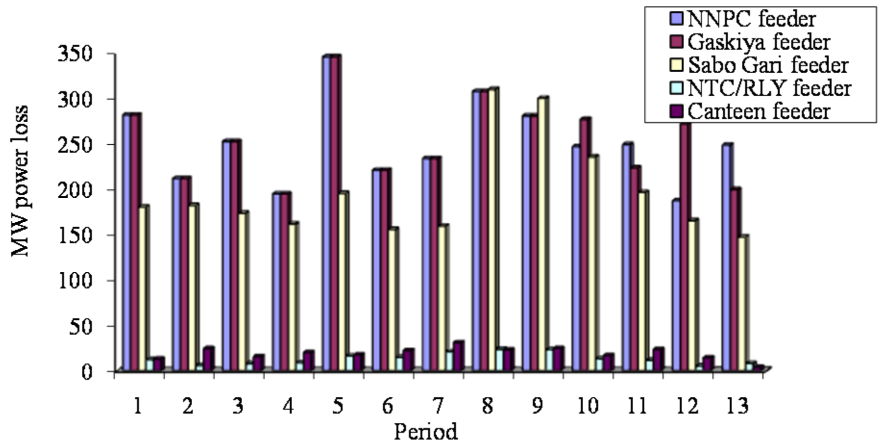

Figure 9: Comparing total power losses to the 11 kV feeders

On the 33 kV feeders, however, it is observed that outage levels are quite high and generally consistent. Different weather sensitive devices are available for either hot or cold seasons. Most commercial organisations, institutions and, even, homes use air conditioners during heat, for instance. The duration of the scheduled outages and the forced outages on the three 33 kV feeders are shown in Figures 10 - 12.

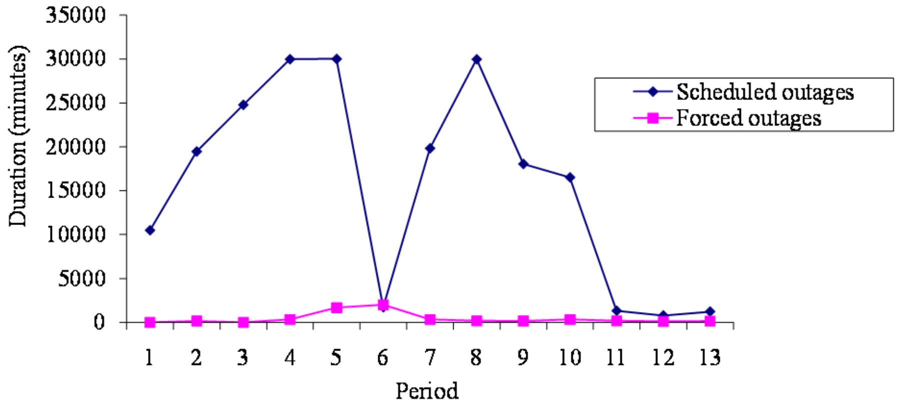

Figure 10: Outages on the Shika 33 kV feeder

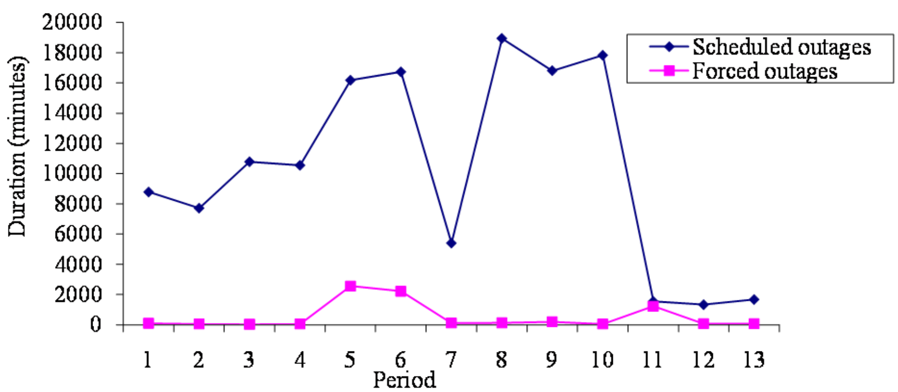

Figure 11: Outages on the Makarfi/Giwa 33 kV feeder

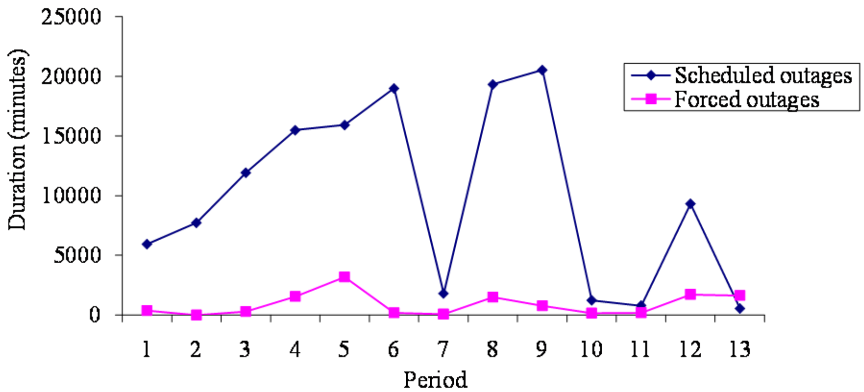

Figure 12: Outages on the Soba 33 kV feeder

A comparison made of the three 33 kV feeders (see Figure 13) shows that the Soba feeder has the greatest forced outage in period 5 followed by the Makarfi/Giwa feeder within the same period; this feeder attained a high level in period 6 as well.

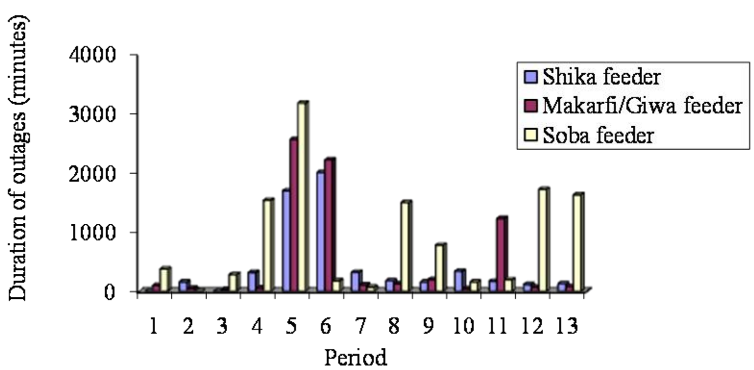

Figure 13: Comparing the forced outages on the three 33 kV feeders

At the 33 kV level also, power is being lost to these outages. These are calculated and plotted as shown in Figure 14. It is observed that the power loss to the Makarfi/Giwa feeder increased greatly between period 6 and period 9 and this feeder accounts for the highest power loss over the period of investigation while the Shika feeder has the least power loss.

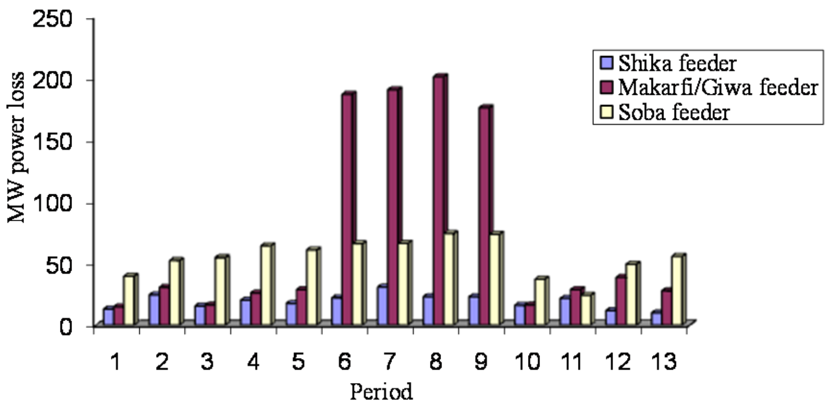

Figure 14: Comparing total power losses to the 33 kV feeders

The outages on the feeders were traced to the damages done to the overhead lines due to heavy winds, thunder strikes, storm and other disturbances associated with rain. Some of the damages are breaking of the cross arm, shattering of the lighting arrestors, cracking of the insulators, explosion of the ring main units, bending or falling of trees. In some situations where the atmosphere is cloudy, dust particles and pollutants on the insulators become conductive, thereby, creating some leakage path to ground for the current and hence flashover occurs.

4. Conclusions

The outages on the feeders of the Zaria distribution network (11 kV and 33 kV) have been studied over a period of thirteen months. There are higher forced outages on the 11 kV feeders between November and February. The Gaskiya feeder recorded the highest forced outage in December. This feeder is characterised by the highest power loss to the outages. As for the 33 kV feeders, the levels of outages are quite high. The Soba feeder recorded the highest forced outage in August while the Shika feeder recorded the least. In addition, too much time is being wasted on scheduled outages, thereby, prolonging the downtime of both the 11 kV and the 33 kV feeders. This, in turn, increases the power loss, which has the following cost implications:

- loss in revenue to PHCN due to unserved load demand;
- loss in perishable goods and in production for industries; and
- alternative power supply, such as standby generators.

The following recommendations would serve to minimise feeder outages and help the PHCN management in general:

1. A standard reporting procedure and record keeping which would give adequate information should be adopted;
2. A form of preventive maintenance to be observed is the cutting down of branches and trees which grow near the overhead lines, so that during the rainy season, they will not damage the lines;
3. It is essential to grease the entire conductor surface periodically to reduce flashovers due to pollution. The surface may also be washed with water from hoses when the line is hot;
4. PHCN Engineers should be trained on the design and maintenance of stations equipment with the aim of producing them locally;
5. The management of PHCN should wake up and see to the discipline of their staff with a view to curbing the high level of corruption within the organisation, especially the distribution staff.
6. Customers should be enlightened on the consequences of thefts and illegal connections;
7. Provision of surveillance installations is highly essential, therefore, there should be commensurate priority in allocation of funds and to enhance adequate training for maintenance personnel;
8. A carefully planned preventive maintenance programme should be adhered to, in which the equipment, lines and other associated substation equipment, such as cross arms, insulators, etc, are maintained routinely with the downtime brought to a minimum;
9. There should be inward integration of ideas by setting up home-based facilities for the maintenance of equipment. This approach could reduce wastage of economic resources;
10. New equipment should be acquired to supplement the old and unserviceable ones since most of the equipment are not manufactured in Nigeria;
11. An effective and workable engineering policy (such as reward of innovation and creativity) is enacted and vigorously pursued as a way of taming the continuous crave for new equipment;
12. Feeders may be constructed in pairs so that when one feeder fails, the other can easily be switched to at various substations. This ensures continuity in supply;

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