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MAINTENANCE PRACTICES ADOPTED IN ELECTRICAL DISTRIBUTION NETWORK FOR THE REDUCTION OF ELECTRICAL POWER LOSSES IN NIGER STATE

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Abstract

The study investigated the maintenance practices adopted in electrical distribution network for the reduction of electrical power losses in Niger State. two research questions guided the study while two null hypotheses were formulated and tested at 0.05 level of significance. The study adopted a mixed method research design. The targeted population for the study was 134 respondents. There was no sample since the population was manageable. The instrument for data collection was a 106-items questionnaire and an interview guide developed by the researcher. The questionnaire was validated by three expect. Cronbach alpha reliability method was employed to determine the internal consistency of the instrument and a reliability coefficient of 0.93 was obtained. Data collected was analyzed using SPSS. Mean and Standard deviation were used to answer the research questions while Z-test was used to test the hypotheses at 0.05 level of significance. The findings of the study revealed that 17 preventive maintenance practices were constantly adopted while 19 maintenance practices were occasionally adopted by engineers and technicians/technologist for the reduction of electrical energy losses in Abuja distribution network. The hypothesis tested further revealed that there is no significant difference in the mean responses of engineers and technicians/technologist on the preventive maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses. It was recommended amongst others that, there should be regular training and retraining of staffs of Abuja Electricity Distribution Company AEDC Both Engineers and Technicians/Technologist on maintenance practices to be carried out to reduce losses.

Key Words: Energy, Electrical Energy, Distribution network, Maintenance, Corrective Maintenance

Introduction

Energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Energy is the capacity to do work as measured by the capability of doing work as defined by Thumann and Younger (2008). Energy exists in various forms which are light energy, heat energy, mechanical energy, electrical energy to mention but a few. The most important of this form is electrical energy since it can easily be transmitted from one place to another. Electrical energy is a form of energy resulting from the flow of electric charge. Energy is the ability to do work or apply force to move an object. In the case of electrical energy, the force is electrical attraction or repulsion between charged particles. The movement of charged particles through a wire or other medium is called current or electricity. Electricity is derived from electrical power system which is made up of three stages of Generation, Transmission and Distribution system. But this study focuses on electrical power distribution hence

Electrical power distribution is the final stage in the delivery of electric power; it carries electricity from the distribution system to individual consumers. Distribution substations connect to the transmission system and reduce the transmission voltage to medium voltage ranging between 2kV and 35 kV with the use of transformers. Primary distribution lines carry this medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again reduces the voltage to the utilization voltage used by lighting, industrial equipment or household appliances (*Short, 2014*). Commercial and residential customers are connected to the secondary distribution lines through service drops. Customers demanding a much larger amount of power may be connected directly to the primary distribution level or the sub-transmission level. Primary distribution voltages range from 4 kV to 35 kV phase-to-phase (2.4 kV to 20 kV phase-to-neutral) (*Csanyi, 2012*). In Niger state, Abuja Electricity Distribution Company AEDC is responsible for the distribution of electricity. Abuja Electricity Distribution (AEDC) is one of the 11 Electricity Distribution Companies that were successfully privatized and handed over to new investors on 31st October 2013. AEDC franchise area and distribution network currently covers the Federal Capital Territory (FCT), Niger, Kogi and Nasarawa states across an area of 133,000 sq/km. AEDC owns and maintains electrical installations and the distribution network within its franchise area. It is also responsible for the entire meter to cash process (M2C) including but not limited to metering, billing, revenue collection and customer services.

During the delivery of energy to the consumers, a reasonable amount is been lost. Generally, Electric power losses are wasteful energy caused by external factors or internal factors, and energy dissipated in the system (Gupta, 2007). They include losses due to resistance, atmospheric conditions, miscalculations and losses incurred between sources of supply to load centre (or consumers).

Distribution losses occur due to technical and non-technical losses as power flows through the network but technical losses is the focus of this study. Technical losses (TL) are naturally occurring and consist mainly of power dissipated in the system components such as Distribution lines, transformers, power control equipment and measurement systems. Technical power losses are possible to compute and control, provided the power system network consists of known quantities of loads. Some of the reason that could lead to technical losses include: lengthy distribution lines, inadequate size of conductors of distribution lines, too many stage of transformations, and improper load management among others. For these losses to be minimized, maintenance is required.

Maintenance is defined as the combination of all the technical and administrative actions, including supervision, intended to retain an item in, or restore it to a state in which it had been and can perform its required function effectively. It includes inspection, testing, servicing, repair and reclamation. Mohammed and Abbas (2001) classified maintenance into three groups which are preventive, predictive and corrective maintenance. But this work focus on corrective maintenance therefore Corrective Maintenance is defined as any maintenance activity which is required to correct a failure that has occurred or is in the process of occurring (Amelia et al., 2005). According to Moayed and Shell (2009) it is one that occurs after the identification and diagnosis of a problem. It is maintenance identified by a condition monitoring system or due to breakdown. Turki *et al.* (2014) also stated that corrective maintenance are practices where systems are maintained only after failure mostly of a critical nature. Equipment is allowed to run till it fails. The action taken to restore the equipment into use can be servicing, repairing, replacement or overhaul.

Maintenance practices are mostly carried out by engineers and technicians working in Distribution Stations (AEDC) who are trained and possess the competent skills required in the field so as to reduce losses. These groups of persons carry out these practices either on daily or routine bases.

Statement of the Problem

In developed countries, it is not greater than 10%. However, in developing countries like Nigeria, it is still over 20%, (Ramesh, *et al.* 2009). Nigeria is a highly populated Western African country. On a rough evaluation only about 40% of Nigerians are connected to the national energy grid. This percentage of Nigerians who actually have electric power supplied to them still suffer electric power problems around 60% of the time (Aliyu, Ramli & Saleh, 2013). Oyedepo (2011) observed that Niger state and the country at large consistently suffers from energy shortage due to poor maintenance practices adopted by the maintenance personnel of the electrical power distribution stations in the state. Also, Agbata (2000) observed that most modern electrical equipment suffer disrepair (poor repair) in the hands of maintenance personnel. Out of ignorance, minor faults are complicated to cause further damage in the electrical system. The impact of these is that distribution stations will continue to lose a lot of resources because of poor supply of electrical energy and the existing plants may not operate at their maximum installed capacities towards providing stable electrical power to the consumers in Nigeria. This reduction can effectively be done if appropriate maintenance practices are carried out in distribution network hence the need for this study.

Purpose of Study

Specifically, the study is set to:

1) Examine the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses.
2) Identify the maintenance strategies that can reduce electrical energy losses in an electrical distribution network.

Research Questions

The following research questions are formulated to guide the study.

1) What are the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses?
2) What are the maintenance strategies that can reduce electrical energy losses in an electrical distribution network?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

HO_1 There will be no significant difference in the mean responses of Engineers Technicians/Technologist on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses.

HO_2 There will be no significant difference in the mean responses of Engineers Technicians/Technologist on the maintenance strategies that can reduce electrical energy losses in an electrical distribution network.

Research Methodology

Mixed method research design was adopted for the study. Mixed methods research according to Johnson, Onwuegbuzie and Turner (2007), is a design in which a researcher or team of researchers combines elements of quantitative and qualitative research approaches (for instance use of quantitative and qualitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. Quantitative data will be obtained from descriptive survey research design which involves the use of questionnaire to seek information from Technicians/Technologist and Engineers while qualitative data will be obtained from interviews. The study was carried out in AEDC Area Offices in Niger State. The population for the study comprises of 134 subjects: 18 maintenance engineers and 116 maintenance technicians/techonologist from the six area offices in Niger State. There was no need for sampling since the population was manageable. Data was collected using a 106-items questionnaire developed by the researcher. Part A was used to seek for personal information about the respondents and Part B (Section A, B, C and D) were used to solicit information to answer research question 1, 2. The questionnaire was validated by three expect, two from the Department of Industrial and Technology Education, Federal University of Technology Minna and one from Abuja Electricity Distribution Company (AEDC).
The instrument was pilot tested in AEDC, Nasarawa State and the reliability coefficient was found to be 0.93. The questionnaire was administered by the researcher with the help of five research assistapt. The data obtained from the respondents was organized and analyzed on the basis of the research questions and hypotheses. Mean and standard deviation were used to answer research questions while z-test was used to test for hypotheses at 0.05 level of significance.

Results

Research Question One: What are the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses?

Table 4.1:
Corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses

S/N	ITEMS	$\bar{X}_A$	SD_A	Remark
	Supply lines			
1	Repair distribution lines and towers	4.64	0.50	CA
2	Replacement of damaged poles	4.68	0.64	CA
3	Replacement of all damaged conductors	4.67	0.68	CA
4	Distribution line stringing	4.43	0.70	OA
5	Replacement of insulator and hardware	4.34	0.65	CA
	Transformers			
6	Tighten every loosen nuts and other parts of the transformer	4.67	0.60	CA
7	Replacement of bushings	4.64	0.61	CA
8	Replacement of the sealing (gaskets)	4.58	0.65	CA
9	Replacement of transformer accessories	4.60	0.66	CA
10	Maintenance of the cooling system	4.51	0.77	CA
11	Stopping of oil leakage from the transformer	4.56	0.70	CA
12	Replacement of oil	4.53	0.55	CA
	Busbars			
13	Refurbish tools, parts and equipment when damaged	4.52	0.90	CA
14	Replace worn out parts of the busbars	4.53	0.67	CA
15	Repair damaged parts of the busbars	4.42	0.90	OA
	Switch gears/switching apparatus			
16	Correct any faulty, damaged, discolored and worn components using site spares.	4.37	0.81	OA
17	Spot check and correct any loose components or connections	4.49	0.75	OA
18	Replace any faulty battery, fuse, or switch.	4.58	0.63	CA
19	Examine insulators for cracks, chips, breaks, and evidence of flashover.	4.54	0.59	CA
	Surge voltage protection			
20	Replace only with identically rated components.	4.61	0.56	CA
21	Components should be inspected for damage and replaced if necessary.	4.54	0.59	CA
	Grounding (Earthing)			
22	Damaged cable lugs are replaced.	4.58	0.64	CA
23	Check for signs of excessive damage to contact surfaces on Line clamps Earth clamps.	4.61	0.67	CA
24	All damaged cable (strand breakage) is replaced.	4.55	0.67	CA
25	Replace all damaged fittings with new ones.	4.53	0.67	CA
	Grand Total of $\bar{X}_A$ and SD_A	**4.56**	**0.76**	**CA**

N_1 = Number of Engineers, N_2 = Numbers of technicians/technologist, $\bar{X}_A$ =Average mean of Engineers and Technicians/technologist, SD_A = Average Standard Deviation of Engineers and technicians/technologist, CA = Constantly Adopted, OA = Occasionally Adopted.

Table 4.1 shows the analysis of responses of the respondents on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses. The score shows that items 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24 and 25 have their mean values within the range of constantly adopted (4.50 - 5.00). But items 4, 15, 16 and 17 have a mean value within the range of occasionally adopted (3.50 - 4.49). The table also shows that the standard deviations (SD) of all items are within the ranges of 0.25 to 0.90 and are positive which indicates that respondents were not too far from the mean of their responses on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses.

An interaction with engineers and technicians/technologists shows that corrective maintenance majorly involves replacement of damaged parts. One of the engineers said: "corrective maintenance is carried out whenever there is a break down and it involves complete replacement. For example, Improving or replacement of the earthing system when it is more than 5Ω, replacement of broken cross arm, replacement of under sized cables, wooden poles, replacement of transformer oil when bad, tightening of transformer part" (Engineer 5 Interview, April 29, 2019).

Research Question 2

What are the maintenance strategies that can reduce electrical energy losses in an electrical distribution network?

Table 4.2:

Mean Responses of Maintenance Engineers and Maintenance Technicians/Technologist on the Maintenance Strategies that can Reduce Electrical Energy Losses in an Electrical Distribution Network N1 = 18, N2 = 116

S/N	ITEMS	$\bar{X}_A$	SD_A	Remark
1	Regular training and retraining of Technical staff	4.54	0.72	SA
2	Ascertaining the quality of Aluminium conductor	4.75	0.44	SA
3	Making fund available in case of casualty	4.66	0.57	SA
4	Regular Staff motivation	4.66	0.57	SA
5	Holding Staff responsible of failures in their part	4.68	0.54	SA
6	Assigning Staff to their area of Specialization	4.76	0.43	SA
7	Installation of alarm system in case of short circuit	4.76	0.45	SA
8	Inculcating team spirit among workers	4.52	0.72	SA
9	Educating energy users on power factor and power factor correction	4.74	0.51	SA
10	Setting up of maintenance practices monitoring team	4.80	0.40	SA
11	Installation of closed circuit television CCTV to check distribution equipment	4.68	0.75	SA
12	Regular evaluation of maintenance practices	4.70	0.46	SA
13	Ensuring adequate load distribution among electrical users	4.77	0.52	SA
14	Setting up a task force for monitoring illegal connections	4.74	0.45	SA
15	Use of proper jointing techniques such as western union splice joint, rattail joint, fixture joint, knotted tap joint and split bolt connector	4.64	0.48	SA
16	Keeping the number of joints to a minimum	4.64	0.49	SA
	Grand Total of $\bar{X}_A$ and SD_A	**4.69**	**0.53**	**SA**

N_1 = Number of Engineers, N_2 = Numbers of technicians/technologist, $\bar{X}_A$ = Average mean of Engineers and Technicians/technologist, SD_A = Average Standard Deviation of Engineers and technicians/technologist, SA = Strongly Agree

Table 4.2 displays the analysis of responses of respondants on the maintenance strategies that can reduce electrical energy losses in an electrical distribution network. The result shows that all the items have their mean values within the ranges of strongly agree (4.50 - 5.00). The table also reveals that the standard deviations (SD) of all items are within the range of 0.40 to 0.75 and are positive which indicates that respondents were not too far from the mean of their responses on the maintenance strategies that can reduce electrical energy losses in an electrical distribution network.

The interview conducted with the engineers and technicians/technologists displays that for electrical energy losses to be reduced standard materials must always be use to draw lines. One of the engineer said, "For electrical energy losses to be reduced, standard conductors should be used, bad fuse should be replaced, joints in a conductor should be reduced to a minimum, constant evaluation of maintenance practices should be carried out

4.3 Hypothesis One

There will be no significant difference in the mean responses of Engineers, Technicians/Techoologist on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses.

Table 4.3
Z-test Analysis of Mean Difference between Responses of Maintenance Engineers and Maintenance Technicians/Technologists on the Corrective Maintenance Practices Adopted in Electrical Distribution Network for the Reduction of Electrical Energy LossesN1 = 18, N2 = 116

	Hartley Test for Equal Variance		z-test for Equality of Means						
								95% Confidence Interval for Difference	
	F	Sig.	Z	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	5.14	0.00	0.21	118	0.83	0.04	0.19	0.41	0.33
Equal variances not assumed			0.12	14.79	0.91	0.04	0.33	0.75	0.67

Table 4.3 shows the z-test analysis of differences in the responses of engineers and technicians/technologist on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses. The table discloses that from Hartley test for equality of variance, the significant criterion (sig. 2-tailed) was found to be 0.91 which is greater than the probability value of 0.05 in comparison hence; the null-hypothesis was accepted. Therefore, there is no significant difference in the mean responses of engineers and technicians/technologist on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses.

4.4 Hypothesis Two

There will be no significant difference in the mean responses of Engineers Technicians/Technologist on the maintenance strategies that can reduce electrical energy losses in an electrical distribution network

Table 4.4
Z-test Analysis of Mean Difference between Responses of Maintenance Engineers and Maintenance Technicians/Technologists on the Maintenance Strategies that can Reduce Electrical Energy Losses in an Electrical Distribution Network(N1 = 18, N2 = 116

	Hartley Test for Equal Variance		z-test for Equality of Means						
								95% Confidence Interval for Difference	
	F	Sig.	Z	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.04	0.42	0.14	118	0.89	0.02	0.14	0.27	0.31
Equal variances not assumed			0.14	18.07	0.89	0.02	0.15	0.29	0.33

Table 4.4 shows the z-test analysis of differences in the responses of engineers and technicians/technologist on the maintenance strategies that can reduce electrical energy losses in an electrical distribution network. The table shows that from Hartley test for equality of variance, the significant criterion (sig. 2-tailed) was found to be 0.89 which is greater than the probability value of 0.05 in comparison hence; the null-hypothesis was accepted. Therefore, there is no significant difference in the mean responses of engineers and technicians/technologist on the maintenance strategies that can reduce electrical energy losses in an electrical distribution network.

Discussion

The findings emanate from the study as presented in Table 4.1 revealed that most of the corrective maintenance practices were adopted in electrical distribution network for the reduction of electrical energy losses. The result from Table 4.1 divulges 21 items such as; repair distribution lines and towers, replacement of damaged poles, distribution line stringing, tighten every loosen nuts and other parts of the transformer, maintenance of the cooling system, stopping of oil leakage from the transformer and so on are constantly adopted with mean value falling within (4.50 - 5.00). While other items such as replacing all damage cable (strand breakage) and fitting new ones falls within the range (3.50 - 4.49) and their standard deviation range disclose low level of dispersion. Hence, the respondents were not too far from the mean of their responses on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses.
From the interview conduct the responses of the engineers and technicians/technologists shows that corrective maintenance majorly involves replacement of damaged parts. the responses from engineers reveals the various step and measure taken in corrective maintenance practices especially when there are breakdown of transformer. For example, Improving or replacement of the earthing system when it is more than 5Ω, replacement of broken cross arm, replacement

of under sized cables, wooden poles, replacement of transformer oil when due, tightening of transformer part.

The outcomes Table 4.3 demonstrations the level of significance of responses of engineers and technicians/technologist on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses at the probability value of 0.05. The significance value of 0.91 affirmed that there is no significant difference in the mean responses of engineers and technicians/technologist on the corrective maintenance practices adopted in electrical distribution network for the reduction of electrical energy losses. The result is inconsonance with the finding of (Turki et al., 2014). He reported that corrective maintenance as a practice where systems are maintained only after failure mostly of a critical nature. Equipment is allowed to run till it fails. The action taken to restore the equipment into use can be servicing, repairing, replacement or overhaul. Gitonga (2014) also noted that most of the manufacturing companies do planned corrective maintenance as opposed to unplanned corrective maintenance. It was found that most of the firms had maintenance staff that was readily available to diagnose and correct problems with equipment, also noted that in most cases the corrective action taken included inspection, cleaning, oiling and adjustment.

The results conveyed on Table 4.2 depict the findings on responses of respondents on the maintenance strategies that can reduce electrical energy losses in an electrical distribution network. The outcome shows that all the items listed: regular training and retraining of technical staff, ascertaining the quality of aluminum conductor, making fund available in case of causality, installation of alarm system in case of short circuit, inculcating team spirit among workers, regular evaluation of maintenance and son on are been accepted with their mean values within the ranges of strongly agree (4.50 - 5.00). The standard deviations (SD) of all items are within the range of positive value 0.40 to 0.75which indicates that respondents responses were close on themaintenance strategies that can reduce electrical energy losses in an electrical distribution network.

Conclusion

The need for adequate maintenance for the reduction of electrical energy losses cannot be overemphasize, as it handles the overall functionality and services offered by electrical distribution network. The present study was able to investigate into the various maintenance practices adopted by the electrical distribution network in Niger State. In the outcome of the investigation it was conclude that preventive, predictive and corrective maintenance are practices that are widely adopted by the electrical distribution network especially the corrective maintenance practices.

Recommendations

The following recommendations were made for implementation based on the findings of this study;

1. AEDC should organize seminars and workshops for Engineers and Technicians/Technologists to improve their maintenances practices in distribution network.
2. Standard equipment should used by AEDC workers during installation and repairs so as to reduces losses in Niger state.
3. Maintenance practices should be constantly carried out on distribution equipment by Engineers and Technicians/Technologist to prolong their lifespan.

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THE DEVELOPMENT AND VALIDATION OF EDUTAINMENT INSTRUCTIONAL PACKAGES FOR TEACHING BIOLOGY AT SENIOR SECONDARY SCHOOL IN NIGERIA

NWOKOCHA Nkiruka Benadeth

Department of Education Foundation and Curriculum