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REACTIVE AND RELIABILITY-BASED MAINTENANCE PRACTICES ADOPTED IN ELECTRICAL DISTRIBUTION LINE NETWORKS OF ABUJA ELECTRICITY DISTRIBUTION COMPANY

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Abstract
The study sought to identify Reactive maintenance (RM)) practices adopted in electrical distribution line networks of AEDC. Two research questions guided this study and two hypotheses were formulated and tested at 0.05 level of significance. The instrument for data collection was a 25 items Reactive Maintenance Practices Questionnaire developed by the researcher. The instrument was validated by three experts. The population for the study was 702 subjects. Simple Random Sampling Technique (SRST) was adopted to select four out of the six regional offices to represent the entire population of 245 respondents for the study. The reliability coefficient of the instrument was obtained using split-Half Method and Pearson Product Moment Correlation and yielded an index of 0.86. Data collected for this study were analyzed using Mean and z-test statistics. Mean was used to answer the research questions while z-test was used to test the hypotheses at 0.05 level of significance. Findings for research question one revealed that, 10 out of 15 items were the reactive maintenance practices adopted in electrical distribution line networks of AEDC. Findings for research question two revealed that all the 10 items are the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC. Findings for hypotheses one and two revealed that, there was no significant difference between the mean responses of distribution line engineers and technicians/technologists based on each research question. It was therefore concluded that AEDC must move away from the traditional maintenance mode to modern and improved reactive maintenance practices.

Introduction

Electrical distribution line network is the final stage in the delivery of electric power to consumers at residential, industry, commercial, and administrative areas. The delivery or supply of adequate and stable electricity to consumers is the back born of socioeconomic development of any nation. The distribution line network carries electricity produced from the generation stations, transmitted through the transmission line network and then to the distribution Centre's to the final consumers. Electricity generation is the process of producing electric power from sources of primary energy.

It is the first stage in the delivery of electricity through the transmission, distribution and then to the end users (Wood, Wollenberg & Sheble, 2013). Electricity is most often generated at a power plant by electromechanical generators, primarily driven by heat engines fueled by combustion or nuclear fission but also by other means such as the kinetic energy of flowing water and a wind which requires equipment and devices such as turbines, generators, transformers circuit breakers relays and many more with Nigeria present power generation at about 4,025MW. The electricity produced at the generation station passes through the transmission line networks.

Electrical transmission line network is a system that convey electrical power generated from the power generation stations to the substations through the distribution lines and finally to the point of utilization. It is an interconnected line which facilitate the movement of electrical energy produced from the generation station to the substation or to place where it is applied to perform useful work (Uslar, Specht, Rohjans, and Gonzalez, 2012). The transmission line networks in Nigeria has an installed capacity of about 7000MW. It is from this level that electrical power is transmitted for onward distribution to the consumers end.

In Nigeria, electrical power transmission begins with transportation of a very high voltage over some distance from generation station along transmission line network. The voltage is then stepped down by a transformer to 132kV at the transmission substation, this voltage is then further transported along transmission lines to injection substation and stepped down to either 33kV or 11kv. The transmission of electricity in Nigeria is vested on Transmission Company of Nigeria (TCN). The electrical power transmitted gets to the consumers through the distribution line networks.

Electrical distribution line network is a system which facilitate the delivery of electrical power at lower voltages of 12kV to 44kV and is used to distribute power drawn from high-voltage transmission systems to end-use customers. Distribution substations connect to the transmission system and lower the transmission voltage to primary medium voltage ranging between 12 kV and 35 kV with the use of transformers (Short, 2004). In this system, secondary distribution lines carry medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again lower the voltage to the utilization voltage used by lighting, industrial equipment or household appliances. Short posited that, distribution line network comprises of those parts of electrical power system between sub-transmission and consumers service switches. These among others include; primary distribution line, transformers, circuit breakers, insulators, poles (concrete or wooden), line separators, busbars, reclosers and many more. Primary distribution line are medium-voltage circuits, normally thought of a 240V to 415V. At a distribution substation, a substation transformer receives the incoming transmission level voltage (11kV to 33kV) and then steps it down to several distribution primary circuits, which goes out from the substation. A distribution transformer then takes the primary distribution voltage and steps it down to a low-voltage secondary circuit normally

about 240V. From the distribution transformer the secondary distribution circuits connect to the end user where the connection is made at the service entrance which in turns lead to the supply of electricity to the customers end. Service connections are made to individual consumers by service cables from the network feeder lines. The distribution of electricity in Nigeria is carried out by the Distribution Company of Nigeria (DisCos). Generally, the aim of every electrical distribution line network is to enhance and facilitate constant electricity supply Twenty four hours daily (AEDC, 2016). The key to realization of this is the adoption of proper maintenance of electrical distribution line networks.

Maintenance could be seen in the context of this research as a work that is done regularly to keep a machine, item, or piece of equipment in good condition. It is an integral part of the operation for the well-being of any equipment, items and facilities which requires frequent services in order to ensure reliability. According to Abdullahi (2002), maintenance is the art of performing systematic supporting services on any device or equipment which may involve the systematic supply of necessary materials for routine servicing, diagnosis and repairs of faults in a system. It is commonly known that constant load shedding, incessant trips on power equipment, breakdown of power distribution facilities to mention but a few have become a norm rather than an exception in Nigeria. Some of these power demand problems could largely be traced to maintenance of existing facilities including distribution line networks (Mbendi, 2007). Maintenance of electricity utilities is a combination of any action carried out to retain the utilities in order or restore them to normal operational standard (Short, 2004). Therefore, in order to improve and sustain efficient and constant electricity supply, proper maintenance practices need to be adopted.

Maintenance practices are activities carried out by experts in an organization to repair, broken down equipment's, preserve equipment conditions and prevent their failure, which ultimately reduces production loss and down time. These are series of procedures, steps and actions adopted by the maintenance personel with aim of restoring an equipment to its operational condition. Good maintenance culture could lead to availability of electricity to consumers almost all the time (Oroge, 2008). Good maintenance culture is very essential in keeping any physical systems, such as electricity distribution networks in operational readiness. Some of the maintenance practices on distribution line networkswould include visual confirmation of the general condition of switchgear, earthing mechanisms, transformers, insulating liquid levels in transformers, lightning arrestors, circuit breakers, insulators, towers, poles, line seperators, trimming of tree branches and many more. As the electrical power facilities and equipment evolved and became increasingly complex and expensive, the expectations on maintenance increased as well. Yusuf, (2019) opined that Abuja Electricity Distribution Company (AEDC) carries out these maintenance practices among others on electrical distribution line networks which includes; Reactive

maintenance (RM), Proactive Maintenance (PM) and Reliability-Based maintenance practices;

Reactive maintenance (RM) also called Run-to-Failure (RTF) Maintenance practices are type of maintenance that takes place when breakdown occurs. RM is sometime referred to as corrective maintenance. RM involves the repair or replacement of equipment and components after they have failed (Staller, 2009). This may entail replacement of components with identical parts, replacement of components with improved design or materials, replacement followed by changes in operating procedures, or replacement of an entire assembly or system that includes the failed component. In order to avoid or reduce sudden breakdown of electrical system, proactive maintenance is carried on the system. An effective maintenance strategy is essential in delivering safe and reliable electric power to consumers. Maintenance practices are carried out by electrical engineers and technicians technologists.

Electrical engineers are trained personel who carry out the maintenance of electrical distribution line networks facilities and equipments. They coordinate, guide and direct the technologist/technicians on field. An electrical technician is an individual skilled in electrical installation work, repairs of electrical equipment and facilities including distribution line networks. Electrical technicians maintains AEDC power facilities for sufficiency and availability of electricity to the consumers. Electrical technicians helps maintain and repair power equipment's and facilities to keep them running correctly.

Electrical technicians are assisted by technologist in the maintenance of distribution line. Technologists are trained individual who assist in the maintenance and installation of electrical and electronics facilities. They work collectively together in the maintenance of AEDC distribution line networks and other auxiliary power facilities. Both engineers, technicians and as well technologists work together in carrying out maintenance and installation of electrical facilities of AEDC.

Abuja Electricity Distribution Company (AEDC) is one of the 11 power distribution companies that were successfully privatized and changed its name from Power Holding Company of Nigeria (PHCN) to AEDC on November 1, 2013. AEDC has a franchise for the distribution and sale of electricity across the Federal Capital Territory, Niger State, Kogi State and Nassarawa State. Within its franchise area, AEDC is responsible for owning and maintaining the distribution networks and supporting equipment. In addition, AEDC manage meter installations, carry out servicing and billing, coordinating consumer credit and revenue collection. It is for this reason that the company has placed, as a priority, plans to improve power supply, maintenance of existing facilities including electrical distribution line networks to improve and sustain electrical power supply in the country.

Objectives of the Study

The study seek to determine the:

1. Reactive maintenance practices adopted in electrical distribution line networks of AEDC
2. Challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC.

Research Questions

The following research questions guided the study:

1. What are the reactive maintenance practices adopted in electrical distribution line networks of AEDC?
2. What are the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC?

Hypotheses

The following null hypotheses, tested at 0.05 level of significance were further used to guide the study:

HO_1: There is no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on reactive maintenance practices adopted in electrical distribution line networks of AEDC

HO_2: There is no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC

Research Methodology

A descriptive survey research design was employed for this study. The population for the study consist of 245 respondents: comprising 49 maintenance Engineers and 196 maintenance Technologists/Technicians from the four selected regional offices in some North Central States, Nigeria including FCT. A structured questionnaire for assessing the reactive maintenance practices adopted in electrical distribution line networks of AEDC developed by the researcher was used for data collection. The instrument consist of two Parts. Part ONE seek for information on the personal data of the respondents Part TWO of the questionnaire was divided into two Sections (A-B). Section A was concerned with the reactive maintenance practices adopted in electrical distribution line networks of AEDC with 15 items. Section B was concerned with the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC with 10 items. The distribution line network engineers and technologists/technicians from each AEDC regional offices of the study areas responded to both section A and B of the instrument. A five point rating scale of measurement was used ranging from Always Adopted (AA) 5 point, Adopted (A) 4 point, Uncertain (U) 3 point, Rarely Adopted (RA) 2 point and Not Adopted at All (NAA) 1 point for research question 1. While, Strongly Agree (SA) 5 point, Agree (A) 4 point, Undecided (U) 3 point, Disagree (D) 2 point, Strongly Disagree (SD) 1 point

for research questions 2. The draft copies of the instrument was validated by three experts; two lecturers from Electrical/Electronics section in the Department of Industrial and Technology Education, Federal University of Technology, Minna, one Engineer from Abuja Electricity Distribution Company, Minna regional office and their comments and suggestions were considered in preparing the final draft of the instrument. The instrument was trial tested at Kaduna Eelectricity Distribution Company (KAEDCO) in Kaduna State (outside the study area), data collected was used to determine the internal consistency of the items and the generated data was analyzed using the Cronbach's Alpha and the reliability coefficient was found to be 0.86 using Statiscal Package for Social Science (SPSS) Version 23. The data collected for this study were analyzed using Mean and z-test statistics. Mean was used to answer the research questions while z-test was used to test the hypotheses at 0.05 level of significance. Any item with a mean of 3.49 and above was considered Adopted while any item with a mean below 3.49 was considered Not Adopted. Z-Calculated value above the Z-critical value shows significance difference between the mean responses of the respondents and the null hypothesis was not retained. Z-calculated value below the Z-critical value shows no significance difference between the mean responses of the respondents and the null hypothesis was retained.

Results

Research Question one

What are the reactive maintenance practices adopted in electrical distribution line networks of AEDC?

Table 1:

Mean Responses of Maintenance Engineers and Maintenance Technologists/Technicians on the Reactive Maintenance Practices Adopted in Electrical Distribution Line Networks of AEDC N1=49, N2 = 196

S/N	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_t$	REMARK
1.	Replacement of electric poles (wooden/concrete)	3.31	3.58	3.85	Adopted
2.	Ensure that bolts, nuts, washers, and terminal connections are in place and tight.	3.77	3.48	3.89	Adopted
3.	Repair faulty component or parts.	3.62	3.58	3.84	Adopted
4.	Replacement of circuit breaker contacts if badly worn or burnt	3.38	3.58	3.89	Adopted
5.	Load balancing in the transformer based on line phases	2.34	2.40	2.78	Not Adopted
6.	Replacement of component or parts with improved design	3.38	3.65	3.83	Adopted
7.	Change or replace transformer oil with a new one at the specified period of operation.	2.38	2.52	2.72	Not Adopted

8.	Replacement of burnt fuses in the feeder pillars units	3.23	3.28	3.87	Adopted
9.	Replacement of burnt or damaged line conductors	3.85	3.57	3.88	Adopted
10.	Replacement of lightening arrestors	3.00	3.23	3.89	Adopted
11.	Replacement of busbars in the feeder pillars	3.85	3.78	3.84	Adopted
12.	Replacement of burnt component with same rating	2.23	2.48	2.89	Not Adopted
13.	Replacement of obsolete energy meter with modern ones	2.39	2.87	2.82	Not Adopted
14.	Replacement of burnt or damaged Miniature Circuit Breakers(MCB).	3.31	3.30	3.86	Adopted
15.	Remove and replace weaken conductors on the line	2.31	2.37	2.87	Not Adopted
	Grand Mean		3.52		Adopted

Keys

N_1 = Numbers of maintenance engineers, N_2 = Numbers of maintenance technologist/technicians

$\bar{X}_1$ = Mean of maintenance engineers, $\bar{X}_2$ = Mean of maintenance technologist/technicians

$\bar{X}_t$=Average mean of maintenance engineers and maintenance technologist/technicians.

Table 1 revealed that 10 out of 15 items had their average mean value range from 3.50 to 3.86. This showed that their average mean value were above the cut-off point of 3.49 indicating that most of the respondents were of the opinion that the listed items were the reactive maintenance practices adopted in electrical distribution line networks of AEDC. The mean score of 3.52 indicated that most of the reactive maintenance practices are adopted in electrical distribution line networks. However, items 5, 7, 12, 13 and 15 had their average mean values 2.78, 2.72, 2.87, 2.82 and 2.87 respectively which are below the cut-off point of 3.49. This indicated that respondents were of the opinions that the items are reactive maintenance pra-ctices which are not adopted in electrical distribution line networks of AEDC.

Research question 2

What are the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC?

Table 2:

Mean Responses of Maintenance Engineers and Maintenance Technologists/Technicianson Challenges faced in Reactive Maintenance

Practices Adopted in Electrical Distribution Line Networks of AEDC N1=49, N2 = 196

S/N	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_t$	REMARK
16.	Poor inspections of the point load transformer in terms humming and appearance	3.85	3.78	3.64	Agreed
17.	Lack of regular inspection of all malfunctioning components.	3.23	3.48	3.59	Agreed
18.	Untimely checking and inspection of switchyards	3.36	3.32	3.87	Agreed
19.	Wrong reading of load using non-sensitive ammeters	3.92	3.40	3.63	Agreed
20.	Poor inspection of the bus bars for overheating and temperature rise	3.23	3.18	3.75	Agreed
21.	Lack of periodic inspection of transformer bushings, gaskets, leakages, silica-gel, and oil level.	3.31	3.30	3.64	Agreed
22.	Poor checking and observation of electrical, mechanical and control system	3.31	3.37	3.69	Agreed
23.	Lack of routine checking of G and P fuse on the line	3.26	3.58	3.54	Agreed
24.	Poor inspection of cable ducts to ensure proper ventilation or heat dissipation	3.15	3.40	3.56	Agreed
25.	Lack of proper inspection of unit auxiliary and substation auxiliary	3.23	3.28	3.57	Agreed
	Grand Mean			**3.64**	**Agreed**

Table 2 revealed that all the 10 items had their average mean value range from 3.50 to 3.86. This showed that their average mean value were above the cut-off point of 3.49 indicating that all the respondents were of the opinion that the listed items were the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC.

However, all the items had the average mean value 3.50 to 3.86 which are above the cut-off point of 3.49. The grand mean score of 3.64 indicated that the respondents were of the opinions that the items were the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC

Hypothesis One

There is no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on reactive maintenance practices adopted in electrical distribution line networks of AEDC

Table 3:

z-test Analysis of Mean Difference between Responses of Maintenance Engineers and Maintenance Technicians/Technologists on the Reactive Maintenance Practices Adopted in electrical Distribution Line Networks of AEDC N1=49, N2 = 196

Respondents	N	Mean	SD	Df	Z-cal	Z-crit	Decision
Engineers	49	3.28	.34	75	.691	.814	Not Significant
Technicians	196	3.32	.14				

Table 3 Revealed that there is no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on reactive maintenance practices adopted in electrical distribution line networks of AEDC. This was indicated by overall calculated z-value of .691which is less than the z-critical value of .814 at 0.05 level of significance. As a result the hypothesis was retained. In other words, Engineers and Technicians/Technologist does not differ significantly in their responses on the reactive maintenance practices adopted in electrical distribution line networks of AEDC

Hypothesis Two

There is no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC

Table 4:

z-test Analysis of Difference between Mean Responses of Maintenance Engineers and Maintenance Technicians/Technologists on the Challenges faced in Reactive Maintenance Practices Adopted in Electrical Distribution Line Networks of AEDCN1=49, N2 = 196

Respondents	N	Mean	SD	Df	Z-cal	Z-crit	Decision
Engineers	49	3.32	.39	75	.678	.920	Not Significant
Technicians	196	3.38	.27				

Table 4 revealed that there is no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC. This was indicated by overall calculated z-value of .678 which is less than the z-critical value of .920 at 0.05 level of significance. As a result the hypothesis was retained. In other words, Engineers and Technicians/Technologist does not differ significantly in their responses on the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC

Findings of the Study

Based on the data collected for this study and the analysis made, the following findings were arrived at:

1. Findings for research question one revealed that, 10 out of 15 items were the reactive maintenance practices adopted in electrical distribution line networks of AEDC.
2. Findings for research question two revealed that all the 10 items are the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC.
3. Findings for hypotheses one revealed that, there was no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on reactive maintenance practices adopted in electrical distribution line networks of AEDC
4. Findings for hypotheses two revealed that, there was no significant difference between the mean responses of distribution line networks engineers and technicians/technologists on challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC

Discussion

Findings of this study presented in Table 1 revealed that replacement of electric poles (wooden/concrete), ensure that bolts, nuts, washers, and terminal connections are in place and tight, replacement of circuit breaker contacts if badly worn or burnt, replacement of component or parts with improved design, replacement of burnt fuses in the feeder pillars units, replacement of burnt or damaged line conductors, replacement of lightening arrestors, replacement of busbars in the feeder pillars, replacement of burnt or damaged Miniature Circuit Breakers (MCB), among others, are the reactive maintenance practices adopted in electrical distribution line networks of AEDC. While load balancing in the transformer based on line phases, changing or replacing transformer oil with a new one at the specified period of operation, replacement of burnt component with same rating are those reactive maintenance practices that are not adopted in electrical distribution line networks of AEDC. These findings are in line with the findings of Au-Yong, Ali and Ahmad (2014) who carried out a study on Operations and Maintenance Practices of Hydropower Stations Planning and Management and discovered that periodic cleaning and replacement of worn out parts, examine state of equipment periodically, repair faulty component/parts, are the common reactive maintenance practices adopted in electrical power generating stations to prevent plants/equipment from failure and ultimately reduces operating costs and increasing electricity generation output.

Finding presented in Table 2 revealed that poor inspections of the point load transformer in terms humming and appearance, lack of regular inspection of all malfunctioning components, untimely checking and inspection of switchyards, wrong reading of load using non-sensitive ammeters, poor inspection of the bus bars for overheating and temperature rise, lack of periodic inspection of transformer bushings, gaskets, leakages, silica-gel, and oil level, poor checking and observation of electrical,

mechanical and control system, lack of routine checking of G and P fuse on the line, poor inspection of cable ducts to ensure proper ventilation or heat dissipation, lack of proper inspection of unit auxiliary and substation auxiliary among others are the challenges faced in reactive maintenance practices adopted in electrical distribution line networks of AEDC. The finding are in line with the finding of Adenuga, Odusami and Oladiran (2006), who carried out a study on Essential Skills for Maintenance Practices in Power Stations and discovered that maintenance practices in electrical power generating stations a number of maintenance would make maintenance technicians/technologists to become good maintenance personnel. The most important maintenance measure among mentioned above is the routine cleaning. Lawal (2005) further revealed that routine cleaning of the power utilities makes the power system equipment function in good working order.

Conclusion and Recommendations

The supply and delivery of adequate and stable electricity to consumers is the back born of socio-economic growth of any nation and Nigeria is not an exception. Reactive maintenance practices adopted in electrical distribution line networks is one of the most important performance parameters which reflect the quality and standards of the present electrical power distribution system. Findings revealed that load balancing in the transformer based on line phases, change or replace transformer oil with a new one at the specified period of operation, replacement of burnt component with same rating, replacement of obsolete energy meter with modern ones, removing and replacing weaken conductors on the line are not adopted. Based on this findings, it can be concluded that the maintenance technicians do not have much knowledge or experience on reliability-based maintenance or they are careless about it. More so, majority of the users of electricity in Nigeria do not have access to any formal training programme on effective use of modern electrical facilities. To achieve these, AEDC must move away from the traditional maintenance mode to modern and improved (reactive) maintenance practices.

Based on the findings of the study, the following recommendations were made in order to improve on the reactive maintenance practices adopted in electrical distribution line networks of AEDC.

1. The Federal Ministry of Power should initiate training and retraining programme for the maintenance personel (engineers, technicians/technologist) on appropriate maintenance procedures in the power system. This will help to improve the efficiency and proper delivery of power system in the country.
2. The management of the power distribution line networks should organize training and retraining programmes, workshop and seminars for the maintenance Engineers and Technicians/Technologist on need for proper load balancing in the transformer based on line phases, change or replacement of transformer oil with a new one at the specified period of operation, replacement

of burnt component with same rating, replacement of obsolete energy meter with modern ones in their good working conditions in order to strengthen their capacities.

3. The loading of power distribution transformers and illegal connections should be discouraged by the electricity power stakeholders on the distribution line networks. This is in order to trim down the number of consumers per transformer to a ratio of about 10 consumers per distribution transformer.

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