



POWER SECTOR REFORM AND AVAILABILITY OF ELECTRIC POWER ON THE AKURE 33KV NETWORK

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ABSTRACT

The study examines the effect of power sector reform on energy supply in Nigeria using Akure 33kV distribution Network as a case study. The study employed Average Service Availability Index (ASAI), System's Average Interruption Duration Index (SAIDI), Network's failure rate and the overall system reliability. The analysis was divided as pre and post privatization; (2010-2012 and (2013-2015), respectively. The result showed decrease in the service availability rate by 1%, and 7.6% increase in the average interruption duration index from 2010 to 2015. The network's failure rate increased by 8% while the system's reliability index decreased by 1.1%.
Keywords:

Keywords: *Power sector reform, Availability, Failure rate, Reliability.*

INTRODUCTION

Electricity is an essential feature for economic development (Nkiruka, 2009). Considering its role on a nation's economy, both developed and developing nations aim towards establishing an efficient electricity sector. Since the first power outage in the 1960s (Ebegbulem, 2009) till date, Nigeria's Electric power sector has been characterized by epileptic and unreliable power supply (Joseph, 2014; Ale and Odesola, 2015) creating an unconducive investment atmosphere. The cost of doing business in Nigeria was increased due to power systems (Okolobah and Ismail, 2013), and industries had to provide their own means of power generation. Many homes and small scale businesses also operate on standby electricity generating sets. These led to a number of reforms in the Nigeria's electricity sector. The reforms were aimed at creating an efficient electricity industry which in turn would boost the Nigerian economy. One of these reforms being the Electric Power Sector Reform (EPSR) Act of 2005, which restructured the power sector from a vertically integrated structure into eighteen unbundled autonomous companies comprising; a single transmission company called TransCo, six generation companies known as GenCos and eleven distribution companies- DisCos (Okolobah and Ismail, 2013).

After its implementation, availability of regular power supply still remains a major challenge to consumers in Akure, the Ondo state capital, as most businesses rely on alternative power supply. An average Akure residence remain sceptical about the reform achieving its objectives. It is however expedient to evaluate the performance of the electric power sector reform programme, so far, in the provision of a stable, reliable and efficient electricity supply. Consequently, this study is undertaken to compare the level of electric power supply availability in Akure few years before and after privatization, and also identify the probable causes of supply unavailability in this area.

POWER SYSTEMS EVALUATION AND AVAILABILITY

The research examined the current reform in Nigeria with respect to the principle of availability. However, the knowledge of reliability engineering discussed in the work of Pabla, 2000; is very useful in this research. Network Availability: The availability of an item is the probability that the item will be in an operational and committable state at the start of a mission, and when the mission is called for at a random time (Hoda and Azad, 2014). It is the degree to which a system, subsystem or equipment is in a specified operation. A system's availability is the proportion of time the system is in a functioning condition (Hoda and Azad, 2014). Availability is expressed as the ratio of the total time a functional unit is capable of being used during a given interval to the length of the interval.

The concept of availability and reliability discussed by (Dhiraj, 1996; Vargas and Blueprint, 2000; Tom, 2017) was very useful in achieving the aim of this study. Availability within a system could be determined as follows:

Inherent Availability (A_i): This is the probability that an item will operate satisfactorily at a given time when used under an ideal environment. This exclude logistics time, administrative, and preventive maintenance downtime before and during operation but includes corrective maintenance downtime. Inherent availability is generally derived from the analysis of an engineering design (Pabla, 2000) and is calculated as;

$$A_i = \frac{MTTF}{MTTF + MTTR} \quad (1)$$

Where MTTF is the mean time to failure and MTTR is the mean time to repair.

Achieved Availability (A_a): This expresses the probability that an item will operate satisfactorily at a given time when used under stated conditions in an ideal environment which includes personnel, tools, spares, etc. It includes active preventive and corrective maintenance downtime (Pabla, 2000).

Operational Availability (A_o): The probability that an item will operate satisfactorily at a given time when used in an actual or realistic operating and support environment. This includes logistics time, ready time, and waiting or administrative downtime, and both preventive and corrective maintenance downtime (Pabla).

$$A_o = \frac{MTBF}{MTBF + MDT} \quad (2)$$

Where, MTBF is the mean time between failures and MDT is the mean downtime.

Average Service Availability Index (ASAI)

This is a measure of the overall reliability of the system. It represents the percentage of time during the year (8760hours) or month (720hours) or day (24hours) that the average customer has power supply (Lina and Carl, 2007).

ASAI can be expressed as follows:

$$ASAI = 1 - \frac{\sum U_i N_i}{N_i \times 8760} \quad (3)$$

Where N_i is the number of customers, and U_i is the annual outage time (in hours) for location i . ASAI can be represented in relation to SAIDI (when the annual SAIDI is given in hours);

$$ASAI = 1 - \frac{SAIDI}{8760} \quad (4)$$

System Average Interruption Duration Index (SAIDI)
System Average Interruption Duration Index (SAIDI)

is a commonly used as reliability indicator in electric power utilities and management. SAIDI expresses the average outage duration for each customer served. This is deployed to determine the average customers without power supply during period of time (Lina and Carl, 2007).

$$SAIDI = \frac{\sum N_i d_i}{N_t} \tag{5}$$

Where N_i is the number of customers affected by the outage, $d_{(i)}$ is the total outage duration, and N_t is the total number of customers served (registered).

To determine SAIDI with respect to duration interruption and number of customers served, equation 6 is revealed by;

$$SAIDI = \frac{\text{sum of all customers interruption durations}}{\text{Total number of customers served}} \dots\dots (6)$$

SAIDI is measured in units of time, often minutes or hours. It is usually measured over the course of a year.

RELIABILITY AND ITS INDICES

This is the probability that a unit system will perform its required function over stated period of time which is expressed in terms of failure rate of the system (Pabla, 2000).

Failure Rate

The frequency at which a system or component fails, expressed in failures per unit of time (Bhavaraju et al, 2005). It is often denoted by λ and used in reliability engineering. The failure rate of a system depends on time, and the rate varying over the system's life cycle. The failure rate of a system increases as the components of the system ages.

Power System Reliability

The Reliability of an Electric power system is expressed as probability that the power system will perform its required function of delivering electric energy to customers on a continuous basis at acceptable service quality (Pabla, 2000). In electric power distribution systems, it is the probability that an item or collection of items such as feeders, transformer, insulation, feeder pillar, distribution line, poles, fuse, isolator, and connections will perform satisfactorily, under stated conditions, for a given period of time (Pabla, 2000). The overall reliability of a distribution system could be affected by physical factors such as: System voltage, Feeder's length, exposure to natural elements (overhead or underground conductor routing), redundancy, conductor type/age, and the number of customers on each feeder.

MATERIALS AND METHODS

The Akure district 33kV feeder network was carefully studied as shown in Figure 1. The Network consist of seven 33kV distribution feeders fed by a single 132kV sub-transmission line from Oshogbo through three numbers of 132/33kV Power transformers (T1A=30MVA, T2A=30MVA and T3A=60MVA). Transformer T1A conveys power to Igbara-Oke and

Owena 33kV distribution feeders, T2A feeds T2B and T2C 33kV feeders and T3A delivers power to Owo, Iju and Obaile 33kV feeders. Outages as a result of faults were recorded from the substation's daily reading sheets and log entry books from 2010 to 2015. The data recorded include date and time a particular fault occurred, time restored, number of customers affected, duration of outage, frequency of outage and the customer population on each feeder. The data were collated, and analysed and depicted graphically. Average Service Availability Index (ASAI), System Average Interruption Duration Index (SAIDI), Failure rate and the System's Reliability index were computed. The result analysis was divided into a Pre-Privatization (2010-2012) and Post-Privatization (2013-2015) periods.

RESULTS AND DISCUSSION

The overall result of service availability study on Akure 33kV distribution network is shown in Table 1 with graphical Figures 1 to 8.

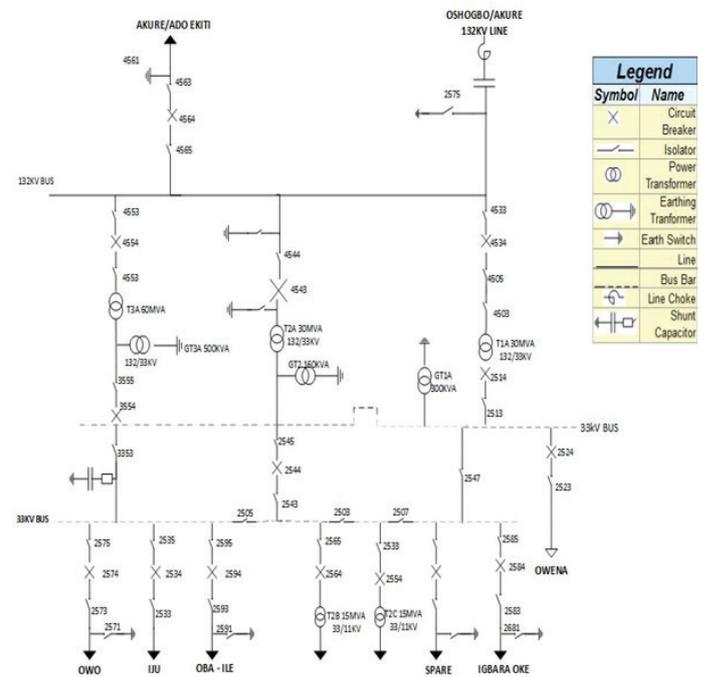


Figure 1: Single Line Diagram of Akure 132/33kV Transformer Sub-station (Source: 132/33kV Sub Transmission Office Akure)

Table 1: Research Result of Availability Study on Akure 33kV Feeder.

YEARS	ASAI	SAIDI (days)	Failure rate (failures/hour)	Reliability $R=e^{-\lambda t}$
2010	0.8492	55.05	0.1152	0.8917
2011	0.9213	28.73	0.1280	0.8806
2012	0.9321	24.77	0.1092	0.8970
2013	0.9152	30.94	0.1436	0.8667
2014	0.8554	52.77	0.1734	0.8410
2015	0.8292	62.36	0.1586	0.8537

The result in Table 1 shows an increasing state of energy supply availability from 2010 to 2012 and a decreasing trend from 2013 to 2015. The same pattern of result was obtained for the reliability index while

the failure rate and the interruption duration index results were in the reverse order.

Network’s Average Service Availability Index (ASAI)

The obtained Availability Index of the feeders and the entire network is presented in Figures 2 and 3.

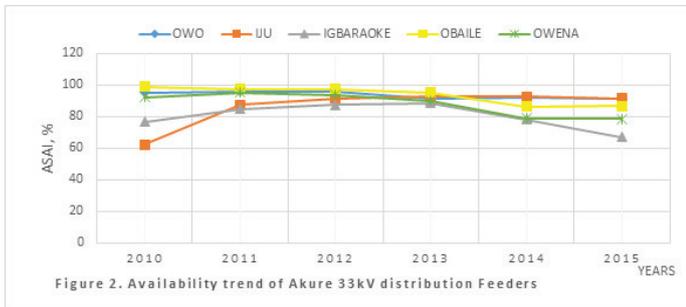


Figure 2. Availability trend of Akure 33kV distribution Feeders

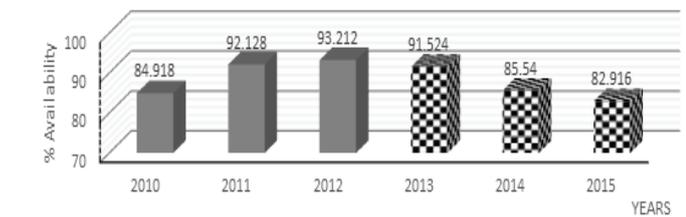


Figure 3 Yearly Percentage Service Availability Index values of Akure 33kV Distribution Network

The result shows an increasing trend before the privatization. Obaile feeder has the highest availability index value of 98.71% in 2010, which decreases gradually to 97.45% in 2012. The least availability value of 62.34% was recorded by Iju feeder before the privatization. Only Iju feeder has an increasing trend of availability index after the privatization. As depicted in figure 3, a yearly increasing availability rate is obtained before the privatization, and decreasing availability rate after the privatization. The Network’s ASAI decreases from 84.92% in 2010 to 82.92% in 2015. The result indicates that the network has a higher availability index before than after privatization.

Network’s System Average Interruption Duration Index (SAIDI)

The obtained SAIDI of the Feeders and Network is presented in Figures 4 and 5.

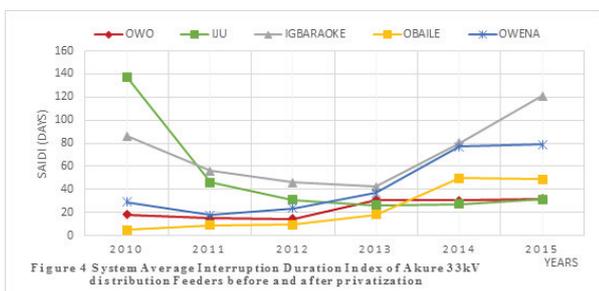


Figure 4 System Average Interruption Duration Index of Akure 33kV distribution Feeders before and after privatization

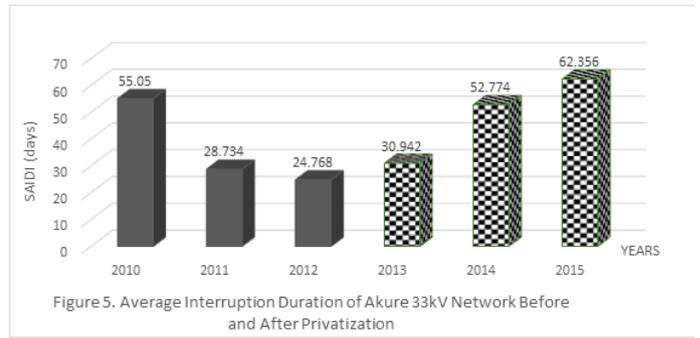


Figure 5. Average Interruption Duration of Akure 33kV Network Before and After Privatization

Iju feeder experienced the highest interruption duration of 137 days before privatization. Igbaraoke also experienced high interruption duration value of 85.97 days, while Obaile recorded the least interruption duration before the privatization. Obaile, Owo, and Owena feeders maintained low value before 2013, and a high value after 2013. Igbaraoke feeder also showed a decreasing trend from 2010 to 2013 before increasing rapidly after year 2013. After the privatization, the highest value of interruption duration was recorded by Igbaraoke. The total network’s interruption duration index increased from 55.05 days in 2010 to 62.36 days in 2015. The result indicates that the network experienced high interruptions after privatization.

Failure Rate of the Network

The obtained failure rate of the feeders and the network are presented in Figures 6 and 7.

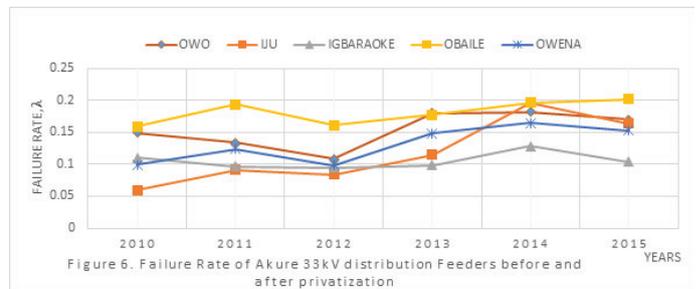


Figure 6. Failure Rate of Akure 33kV distribution Feeders before and after privatization

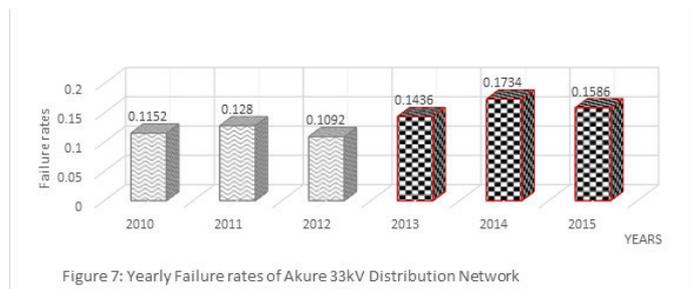


Figure 7: Yearly Failure rates of Akure 33kV Distribution Network



Figure 8: Reliability and Availability Plot of Akure 33kV Distribution Network

The plot in figure 6 shows a decreasing trend in failure rates of the feeders from 2010 to 2012. Obaile feeder recorded the highest failure rate before the privatization while the least failure rate occurred at Iju feeder. The failure rate of the feeders increased from 2013 to 2015 with Obaile also recording the highest failure rate after the privatization. As depicted in figure 7, the overall failure rate of the network increased from 0.115 failures/hour in 2010 to 0.159 failures/hour in 2015. The result indicates that the network experienced higher failure rate after privatization.

Figure 8 shows that Akure network has a reliability value of 89% at a low Service Availability index value of 0.85 in 2010. At an increased availability index of 0.93, the network's reliability is kept at 90%. This reveals possible weakness that might be associated with the network before privatization such as system overloading and line losses. However, both system reliability and service availability indices decreased after privatization. Service availability index decreased at the rate of 4.9% from 2013 to 2015, with system reliability kept within 85% to 87%, making network operation less economical.

CONCLUSION AND RECOMMENDATIONS

The rate of electric power supply availability before and after Privatization has been studied on Akure 33kV distribution network. The obtained results reveal a decline in network performance after the privatization in terms of power supply availability, average interruption duration experienced by customers and the network's failure rate. Supply availability shows

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a contributing factor to poor system reliability and availability indices after privatization. The study revealed network overload and high losses, which could be addressed by creating more 132kV Injection substation.

Having carried out this research, the following is recommended;

Feeders Reinforcement

The availability and reliability result reveals a possible weakness in the network resulting from line losses and overloading. It is therefore recommended that the overloaded lines be reinforced with additional lines.

Adequate staff motivation

With salaries based on commission of percentage revenue generated, the staff of the distribution companies are not adequately motivated. This condition reflects in their response rate to fault calls, as they feel safe when lesser energy is being consumed. This has also contributed to increased interruption duration periods.

Increased Repair Facilities

Sufficient repair facilities should be made available at all times for the purpose of both preventive and corrective maintenance works, this will help in reducing the interruption duration and system downtime periods.

Proper monitoring and sanctioning of defaulting Discos

Adequate monitoring and supervision by the Nigerian Electricity Regulatory Commission (NERC) is required to checkmate the activities of the distribution companies, and necessary sanctions meted out to any defaulting distribution company.