Survey of Electric Power Supply Outage in Minna Metropolis

E. N. Onwuka, M. David, and G. Jiya
Electrical and Computer Engineering Department
Federal University of Technology Minna
E-mail liztonis@yahoo.com

Abstract:
Nigerians have been both physically and psychologically inflicted by incessant electric power supply interruptions in the country. This situation has several negative effects ranging from economic setback, loss of several man-hour, poor productivity, high average cost of production, impoverishment of individuals, physical discomfort, poor health etc, all of which come together to dampen average individual's morale, and retards his pursuit of civilization. This paper surveyed the power outage rate in Minna metropolis as a case study to gain an insight into the efficiency of electric power supply system in Nigeria. It was found that an average Nigerian suffers 386 times more power interruptions per annum than an average Canadian; and that the average power interruption duration suffered by an average Nigerian is over 392 times longer than that suffered by an average Canadian. The reason for this poor condition is attributable to poor maintenance, and lack of adequate upgrading of the system components. As a result, supply is much lower than demand; the dilapidate systems constantly fails.

Keywords: power supply system, outage, failure, efficiency.

I INTRODUCTION

Frequent and unpredictable outage of electric power supply has adverse effects on modern man and his environment. Due to technological development, man of today has come to depend on electric power for economic and social development and well being. This makes unplanned interruption of power supply an unwelcome event, and frequent interruptions could be described as a seriously unpleasant setback in his life. From sheer physical observations, it is easily seen that it affects him both physically and psychically.

A short period of planned outage of power supply may not cause perceptible problems for a refrigerated storage facility for example, but unplanned and frequent shutdowns may cause millions if not billions of Naira worth of economic waste. Moreover, man's social well-being suffers, his morale lowers, and his environment generally undergoes progressive deterioration. In a medical setup, lives could be lost due to frequent disruptions in power supply. The number of man-hour lost is a considerable economic waste both to individuals, private organizations and the nation as a whole.

Manufacturers Association of Nigeria (MAN) has decried the current incessant power outages across the country, lamenting that in Kano state alone; the problem of frequent power outage has led to the closure of over 350 industrial firms. Whether it is the fault of the Power Holding Company of Nigeria (PHCN) or that of the Federal Government, it is generally observed that electric power supply has become very erratic and unreliable of late in many parts of the country and the Nigerian citizens have undergone many debilitating outages leading to loss of economic man-hours, destruction of industrial and domestic equipment and many other inconveniences. [1, 2]

Failure rate of a power supply system is mathematically expressed as F (t) =1 - R(t), where R (t) is the reliability of the power system i.e. the degree to which an electrical system can deliver power to customers at contract specifications, or acceptable regulatory standards. Reliability may be measured by the frequency, duration, and magnitude of adverse effects on the electric supply. It is usually considered for two primary elements: adequacy of supply and security of supply." [3,4]

It is generally known that there is frequent interruption of power supply in Nigeria, but as far as we know, the causes and the rate of these outages have not been studied well enough. A related work is presented in [5] where Benin-city in Edo state of Nigeria was taken as a case study. The authors collected power outage data from different feeders in Benin, it was a good attempt however, the authors did not draw any reasonable inferences from the collected data.

This paper presents the survey of electric power supply outage in Minna metropolis. Minna the capital of Niger state, which lies within the physical/cultural zone of transition described as the middle belt of Nigeria is chosen as a case study for the following reasons: Minna is moderately populated with a population of about 50,000 people, it is not an industrial or commercial city which means that it has relatively low power consumption/demand. In addition, Minna has a hydropower generating station – the Shiroro power station, on its outskirts. The authors believe that an estimate of outage rate in Minna will be a good representative of power failure rate in Nigeria. Samples taken from places like Abuja, Lagos, or Kano may represent worse cases as these cities are heavily industrialized and the teledensity is relatively high. The rest of the paper is organized as follows: Section II discusses the brief history of power generation and supply in Nigeria, in Section III we present the Methodology adopted for this work, Section IV presents results and discussion while the paper is concluded in Section V.

II BRIEF HISTORY OF ELECTRIC GENERATION IN NIGERIA

Electric power generation in Nigeria began in 1896.The sector started with the development of electricity in Nigeria when in 1898 the first generating plant was installed in the city of Lagos under the Public Works Department. In 1929, the Nigerian Electricity Supply Company (NESCO) was established and commenced operation as an electric utility company in Nigeria with the construction of a hydroelectric power station near Jos. Subsequently, with the rise in demand for electric power, the Electricity Corporation of Nigeria (ECN) was established in 1951 while the first 132KV line was constructed in 1962 to link Ijora and Ibadan Power Stations. In 1962, the Niger Dams Authority (NDA) was established with the mandate to develop the hydropower potentials of the country. However, in 1972, ECN and NDA were merged to form the National Electric Power Authority (NEPA). NEPA was mandated to generate and supply electricity power to the nation [6].

NEPA was established through Decree No. 24 of 1st April 1972, which amalgamated ECN and NDA with a mandate to maintain an efficient, coordinated and economic system of electricity supply to all parts of the nation and to propel the nation's technological and industrial growth. The sector currently operates and maintains eight power stations (with 72 generating units in which 20 units are overdue for rehabilitation, 19 units for overhaul and 6 units need outright replacement), which are located in close proximity to the energy resources [4]. These are:

- The three hydro stations at Kainji, Jebba and Shiroro, which take advantage of the geo-topography of the rivers Niger and Kaduna respectively.
- The thermal stations at Sapele, Afam, and Ughelli (Delta), which harness the rich oil and gas deposits of the Niger Delta.
- The load center derived thermal stations at Ijora and Egbin, which were built to serve Nigeria's industrial and commercial center, Lagos.

Other smaller installations include the following:
Oji power station in Enugu state, the only coal-fired power station, commissioned in 1956 (due to obsolescence and aging, the four steam plants have been recommended for scrapping). The isolated stations at Calabar, Kaduna, Makurdi, Mubi, Maiduguri, Minna and Suleja (these diesel units operated off-line to serve specified cities) [6]. According to available statistics, the status of electricity supply in Nigeria in 1972, when NEPA was established, and 20 years later (in 2002) is summarized in Fig.1.

It is striking that Nigeria with a population of about 140 million has a total installed capacity of only 55,795 MW of which 36% is over 20 years old. While South Africa with a population of 30 million has a total installed capacity of 37,404MW [15].

NEPA operates a grid system, where the various generating substations are linked up together to form a single power system. Recently, the Federal Government of Nigeria, due to her on-going privatization policy, has decided to privatize NEPA. As a result, in 2005, the name has been changed from National Electric Power Authority to Power Holding Company of Nigeria (PHCN).

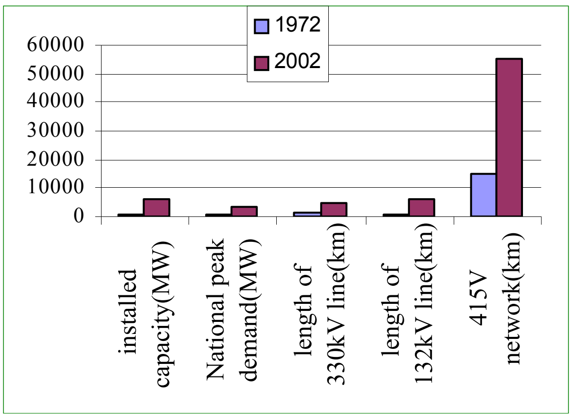

Fig.1 Status of electricity supply in Nigeria in 1972 and 20yrs later

III METHODOLY

Faults associated with power systems are divided into symmetrical faults and non-symmetrical faults. While symmetrical faults are three phase faults and three phases to earth faults, non-symmetrical faults are single phase to earth faults and phase-to-phase faults and double phase to earth faults [7,8].

To carry out this study we visited Minna power distribution office, and interviewed the staff in the record office and also collected useful data from their fault logbook. The collected data was studied, from it the following information was derived:

Faults experienced in Minna (Niger state) are basically associated with:

- Underground cable faults due to bad joint
- Cables sparked by diggers
- Poles and equipment damaged by vehicles
- Failure of lines due to jumper or cross arm
- Trees falling on a line
- Faulty transformers, switchgears /panels and tripping unit
- Earth faults
- Over current caused by short circuit or load demand
- Broken or cut conductors
- Short circuits by animals such as reptiles
- Adverse weather conditions
- Vandalism of PHCN equipments
- Transformer faults

The different types of fault itemized above result in outages, which may either be forced outages or planned outages. Forced outages, as the name implies, is not planned and can occur at any time. Its causes could be natural (heavy rain fall, strong wind, thunder strikes, erosion etc),or artificial by human/animal activities (vandalism, short circuits by reptiles etc). On the other hand, planned outages are planned by the authorities concerned. In such cases the public is often informed through the public media before the outage occurs. Planned outages are necessitated by factors such as:

- Load shedding
- Maintenance work to be carried out
- Under frequency and over frequency
- Too much load on a transformer, etc

The fault logbook recorded a total of 4,257 faults on the 11KV and the 33KV transmission lines between the year 1999 and the end of 2005 (these are faults that were not cleared between 0-30 minutes of their occurrence). Note that any fault that was located and cleared within 30 minutes of its occurrence was not recorded. In addition to this, a total of 16,948 and 16,896 low tensions faults were recorded in the same zone in 2004 and 2005 respectively. Some of these fault data were categorized according to the following category:

- Types of outages
  - Force outages
  - Request outages
  - Load shedding
- The different feeders in Minna system
  - Bosso
  - Chanchaga
  - Parliamentary
  - Piggery
  - Shiroro
- The customer population of the different locations listed above. Minna has a total customer population of 28,254 customers, that is to say, the total number of meters in Minna town. With this, the total number of customer-interruptions can be obtained
- The total durations of outages per annum.

IV RESULTS AND DISSCUSSION

The distribution of 11kV- and 33kV-line faults that led to outage, for a 6-year period is shown in Fig.2. This result shows no particular trend in the failure pattern except that there are, on the average, more faults on the 11kV line. Fig.3 shows the distribution of feeders in Minna and the number of people served by each feeder. The PHCN estimates these numbers based on the number of registered meters. It should therefore be noted that these figures represent estimates and may not be taken for accurate figures. This is because there are people who are served through direct connection (i.e. without meter) and there are illegal connections also. The real number of people served is expected to be lager.

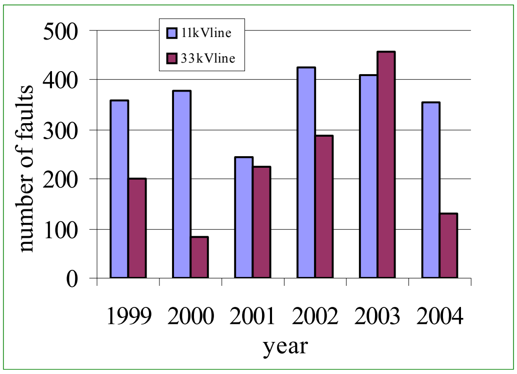

Fig.2: Fault statistics for a six-year period in Minna zone

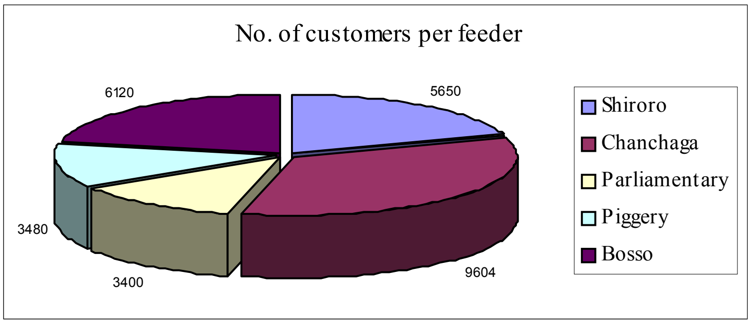

Fig. 3 Number of customers served by each feeder

Tables 1-3 show the different outage data collected from the PHCN Minna district office for the year 2004. The data presented are for the year 2004 and are grouped according to the number and duration of forced outages, request outages and load shedding for a 1-year period. Some striking facts are elicited from these Tables. One such fact is that, as shown in Fig.4, of the three major types of outages, customer interruption due to forced outage is far greater in number than the other types of outage. This points to poor reliable state of our

Table 1: customer interruptions for forced outages

Feeder	No. of Interruptions	No. of Customers	Customer Interruptions	Duration (Hours)
Bosso	53	6120	324360	58.50
Chanchaga	66	9604	633864	73.57
Parliament	110	3400	374000	60.57
Piggery	57	3480	198360	58.50
Shiroro	85	5650	480250	59.18

Table 2: customer interruption for request outage

Feeder	No. of Interruptions	No. of Customers	Customer Interruptions	Duration (Hours)
Bosso	10	6120	61200	8.00
Chanchaga	21	9604	201684	14.58
Parliament	29	3400	98600	25.55
Piggery	29	3480	100920	21.85
Shiroro	39	5650	220350	27.42

Table 3: customer interruption for load shedding

Feeder	No. of Interruptions	No. of Customers	Customer Interruptions	Duration (Hours)
Bosso	28	6120	171360	71.77
Chanchaga	20	9604	192080	64.53
Parliament	25	3400	85000	68.00
Piggery	27	3480	93960	68.42
Shiroro	27	5650	152550	69.78

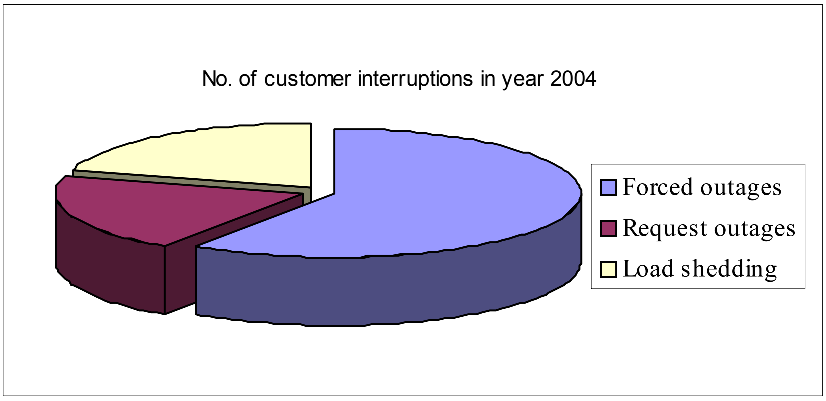

Fig.4 Number of customer interruption due to various types of outages

Power system. The system is far beyond control. This could be as a result dilapidation of the system, which calls for a major overhaul and replacement of many components in the system.

The performance estimate of a power system from individual customer point of view is usually based on the use of certain basic indices most of which are the averages of the basic load point indices [4]. The common indices include:

- System Average Interruption Frequency Index (SAIFI)
- System Average Interruption Duration Index (SAIDI)
- Customer Average Interruption Duration Index (CAIDI)
- Customer Average Interruption Frequency Index (CAIFI)
- Average Service Availability Index (ASAI)
- Average system Unavailability Index (ASUI)

4.1 Customer Satisfaction Estimation based on System Indices Calculations

1. System Average Interruption Frequency Index (SAIFI)

This index is used to estimate the frequency of power supply interruption experienced by each customer, it is defined as

$$SAIFI = \frac{\text{Total no. of interruptions in the year}}{\text{No. of customers served.}}$$

Total number of interruptions is the sum of all interruptions due to forced outages, request outages and load shedding. It is extracted from the Tables as 3388538 interruptions.

Total number of customers served is also extracted from the Tables as 28254 customers.

Therefore:

$$SAIFI = \frac{3388538}{28254} = 119.9 \text{ interruptions/ customer/annum.}$$

2. System Average Interruption Duration Index (SAIDI)

This index gives the average measure of the length of time (in hours) an outage event lasted before supply was restored. It is defined as

$$SAIDI = \frac{\text{sum of all customer interruption-hours}}{\text{Customers served for the year}}$$

Note that customer interruption-hour is given by the number of customers interrupted multiplied by the number of hours that the interruption lasted. These values are also extracted from the Tables. Therefore

$$SAIDI = \frac{4211724}{28254} = 149.07 \text{ hours/ customer/annum}$$

3. Customer Average Interruption Duration Index (CAIDI)

$$CAIDI = \frac{\text{sum of customers sustained interruption duration}}{\text{No. of customer interruption}}$$

$$= \frac{4211724}{3388538} = 1.24 \text{ hour/ customer interrupted}$$

4. Customer Average Interruption Frequency Index (CAIFI)

$$CAIFI = \frac{\text{no. of customers interruption in the year}}{\text{No. of customers affected}}$$

Each customer in counted only once. But in this situation the outages are affecting all the customers. Total number of customers affected is 28254.

$$CAIFI = \frac{3388538}{28254} = 119.9 \text{ interruptions/year}$$

5. Average Service Availability Index (ASAI): This is the ratio of the total number of customer hours that service was available during the year to the total customer hours demanded. Customer hours demanded are determined by the total hours in a year which is 8760 hours.

$$ASAI = \frac{(28254 * 8760) - 4211724}{(28254*8760)} = 0.98298$$

6. Average system Unavailability Index (ASUI)

$$ASUI = 1 - ASAI$$

$= 1 - 0.98298 = 0.01701$

Table 4 presents a comparison between these calculated reliability values with that of Monte Carlo in Canada. The comparison of the average frequency and average duration of interruption shows that failure rate is 386 times higher in Minna than in Mont Carlo and last longer by about 392 times. This result is very close to the customer perception of efficiency of supply in Minna and in Nigeria in general. It should be noted that the data upon which these estimations are based are what is found available at Minna district office. The fault data is incomplete due to various reasons ranging from poor observation system to poorly trained staff and nonchalant attitude common in Nigerian public offices. Should the actual number of interruptions be accurately recorded and used for these estimations, a far worse picture will be depicted. If the situation in Minna, which is neither industrialized nor highly populated, is like this, it could be concluded that Nigeria's power supply system is grossly inefficient.

Table 4 comparisons of indices

Indices	Monte Carlo	Minna
SAIFI	0.31 interruptions/ customer	119.9 interruptions/customer
SAIDI	0.38 hours/ customer/annum	149.07hours/customer/annum
CAIDI	1.22 hour/customer interrupt	1.24 hour/customer interrupt
CAIFI	1.06 interruptions/customer	119.9interruptions/customer
ASAI	0.99957	0.98298
ASUI	0.000043	0.01702

V CONCLUSIONS

This paper presented a survey of the electric power outage in Minna metropolis as a window through which the electric power supply situation in Nigerian may be assessed. Fault data was collected from Minna district office of PHCN. The collected data was studied and outage rate was estimated. From the results obtained, it was found that a greater number of power failures were caused by forced interruption than planned interruption. This suggests that the power system is unfit to support the demand placed on it. Also, planned outages, which consist of load shedding and request interruptions are relatively high. The results further revealed that there are far more power supply interruptions than Canada and that the interruptions last very long before power supply is restored.

It is therefore not surprising that most economic and social activities in the country is gradually coming to a halt, and that average Nigerian citizen is sick (both in body and mind) of the frequent and unpredictable interruptions in power supply. This poor situation calls for immediate attention of the Federal Government. Thanks to the privatization program, it will probably be the only way to salvage the Nigerian electric power supply system and make Nigeria a more habitable place for the citizens.

REFERENCE:

[1] http://www.odysen.com/location/main.php?c=Nigeria
[2] http://www.odysen.com/News/list.php?i=//Africa/Reliability/0
[3] http://www.cnie.org/nle/crsreports/briefingbooks/electricity/reliability.cfm
[4] R. Billinton and R.N. Allan. "Reliability Assessment of large electric power system." Kluwer Academic publishers Boston/Doorchecht/Lancaster.
[5] E.A. Ogujor, P. Otasowie, and P.A. Kuale: "Fault analysis of electric power distribution in Benin-city." Journal of elect/elect Eng. Vol 10, No.1, pp. 27-38, Jan. 2006.
[6] "Presidential Research & Communications Unit - Features.htm"(*http://www.nigeriafirst.org/article 4214shtml*)
[7] B.L. Theraja and A.K. Theraja: "A text book of electrical technology, S. Chand and Company Ltd New Delhi 2002.
[8] H. Cotton and H. Barber: The transmision and distribution of electrical energy, Hodder and Stonghton, London 1970.