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ORIGINAL ARTICLE

A review of some of the operations of power holding company of Nigeria

A. O. Odior · F. A. Oyawale

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Abstract Electric power supply is the most important commodity for national development in any nation. The Power Holding Company of Nigeria (PHCN) is responsible for generating, transmitting, distributing and selling electric power to the various consumers throughout the country. Although regular power supply is essential to the rapid development of any society, power supply in Nigeria is erratic and unreliable. The paper presents the results of an investigation conducted on some of the operations of the generating department, transmitting department and distributing department of PHCN. The paper also examines the various stages of power generation and some of the factors responsible for power outages. These factors include: overcurrent fault, earth fault, planned outages and load shedding. These problems were found to span the various stages of power generation and they also included generation capacity; insufficient and old equipment, unsuitable transmission structure, long, fragile network with lack of loops as well as high transmission and distribution losses.

Keywords Electric power · Major factors · Operating transformers · Percentage loading

A. O. Odior (✉)
Department of Production Engineering, University of Benin, Benin City, Nigeria
e-mail: waddnis@yahoo.com

F. A. Oyawale
Department of Industrial and Production Engineering, University of Ibadan, Ibadan, Nigeria

1 Introduction

Power supply is the real engine of economic growth and development of any nation in the world. It is a key index for measuring the advancement and the development status of any nation. Power supply is an important variable for the socio-economic and technological development of any nation. With electrical energy, the people are empowered to work from the domestic level and the cottage industries, through the small-scale and medium-scale industries to employment in the large-scale manufacturing industries. Actually, depriving people of electric power supply is tantamount to castration. The Power Holding Company of Nigeria (PHCN) is responsible for generating, transmitting, distributing and selling electric power to the various consumers throughout the country. A major objective of PHCN has been to provide regular and uninterrupted power supply to the consumers of electricity nationwide.

Nigeria abounds in numerous energy resources in the form of oil, natural gas, coal and hydroelectric potential. The country ranks the sixth largest exporter of crude oil in the world and has an unlimited supply of natural gas (Okoro and Chikuni 2007). According to Musa (2010), electric power generation may be through one of the following sources of energy: coal, oil or natural gas, hydro power (water turbine), nuclear power (steam turbine), solar-wind or water-wave turbine, solar thermal generator and solar voltaic generator. Coal, oil, gas and hydro power are abundant in the country. Nigeria mostly employs gas-fired and hydroelectric turbines for bulk generation at present, oil being too expensive, while coal-fired stations have almost disappeared (Musa 2010). Maximum power consumption or peak power demand depends on the population and industrialization of a country.

With a population of over 140 million people and over 9,000 villages, the rural electricity consumption is less than 20 % and only about 40 % of the entire populace has access to electricity on the national grid. Yet that fraction depends on less than 3,000 MW of electricity and this is why the Nigeria's economy is described as a "Diesel Generator Economy" (Adenikinju 2005). Electricity supply and demand are closely related and if the maximum supply meets the peak demand, there is a surplus otherwise there is a shortfall. Supply, demand and losses are related by the following equation (Musa 2010):

$$\text{Supply} - \text{Demand} = \text{Supply} - \text{Actual needs} - \text{Losses} = \text{Surplus, and}$$

$$\text{Losses} = \text{Heat losses} + \text{Wastages} + \text{Diversions}$$

However in Nigeria, the power supply system is run with a shortfall where demand exceeds supply.

The capacity in Kilowatt generated by each of the generating units in various parts of the country has also been studied by Oyeyele (1987). The work also examined the Nigerian electricity market and found that the annual growth rate of electricity sales averaged about 18 % in the period of 1950/52–1976/77. It concluded that Nigeria still has a low electricity consumption of 60 kWh/Capita (1,979 figures), which is less than 1 % of that of industrialized countries. It was discovered that developing countries like Liberia, Ivory Coast and Guinea have per capital electricity of about ten times, four times and two times respectively than that of Nigeria. The solar and wind energy resource in Nigeria has also been studied (Sambo 1987). He stated that the annual mean of solar energy received in Nigeria is 2,300 kWh/m^2 and global radiation is as high as 24 MJ/m^2/day due to its good geographical location between latitude 4 and 14° north of the equator.

2 Historical overview of electric power generation in Nigeria

The history of electricity in Nigeria can be traced back to 1896 when electricity was first produced in Ijora, Lagos. This was just 15 years after its inception in England (Niger Power Review 1995). In 1929, the Nigerian Electricity Supply Company (NESCO) commenced operation as an electric utility with the construction of a hydro electric power station in Kuru, Jos (Niger Power Review 1995). By 1951, the Electricity Corporation of Nigeria (ECN) was established as a body responsible for electricity supply and the first 132 kV line was constructed in 1962 linking Ijora Power to Ibadan Power station (Niger Power Review 1995). In 1962, Niger Dams Authority (NDA) was established by an act of parliament, due to rapid urbanization and increasing demand that led to the exploitation of the country's water resources with a mandate to develop hydro power stations. The NDA was responsible for the construction and maintenance of dams and other works on the River Niger and elsewhere, generating electricity by means of water power, improving and promoting fish brines and irrigation (Manafa 1995). The NDA and NESCO had licenses to produce electricity in some locations in Nigeria and the energy produced by NDA was sold to the ECN for distribution and sales at utility voltage (Niger Power Review 1995). By 1970, the Military Government appointed a Canadian Consultant firm "Showment Ltd" to look into the technical details of the merging ECN and the NDA. The report was submitted to the government in November 1971. In 1972, the ECN and the NDA, which were 100 % wholly government-owned public utilities were merged by Decree No. 24 to become the National Electric Power Authority (NEPA) with effect from the first of April 1972 with a mandate to carry out the business of generation, transmission, distribution and marketing of electric power to the generality of the country (Niger Power Review 1989). The Electricity Act and the NEPA Act guided NEPA's activities and operations as it started with four major power stations namely: Delta and Afam thermal power stations, Ijora Gas Turbine power station and Kainji Hydro power station serving more than two million customers nationwide as at then (Niger Power Review 1989).

The NEPA had monopoly of generation, transmission and distribution of electricity until 2005 when the electrical power sector reform (EPSR) act repealed the NEPA act and PHCN was formed from NEPA to serve as a transitory holding company prior to the unbundling of the sector (Ibe and Okedu 2009). At the inception of NEPA in 1973, only five of the then 19 state capitals were connected to the national transmission grid system, but today, practically all state capitals are being served from the national grid, although haphazardly. In March 2005, the Power Sector Reform Act was enacted and this repealed the statute establishing the NEPA which is now known as PHCN. The law paved the way for the unbundling of NEPA into the 18 companies: six generating companies, one transmission company and 11 distributing companies. The generating companies are made up of two hydro and four thermal (gas based) stations (Ibe and Okedu 2009).

2.1 Comparative study of electricity consumption

The poor electricity supply in Nigeria is perhaps the greatest problem confronting the business sector in the nation. A typical firm might experience power failure or voltage fluctuations about seven times per week, each lasting for about 2 h, without the benefit of prior warning (Adenikinju 2005). This imposes a huge cost on the firm arising from idle workers, spoiled materials, lost output,

Table 1 Electricity consumption per capita in kilowatt hours per person

S/no	Country	Electricity consumption per capita (kWh per person)	
		1990	2003
1	Egypt	683.4	1,173.1
2	China	511.1	1,378.5
3	India	275.8	434.8
4	Indonesia	161.4	440.1
5	Malaysia	1,194.3	3,060.5
6	South Africa	4,431.5	4,756.8
7	*Nigeria	91.6	106.3

The asterisk emphasizes Nigeria with poorest electricity consumption per capital all round

damaged equipment and restart costs. The overall impact is to increase business uncertainty and lower returns on investment. This has seriously undermined Nigeria's growth potential and the attractiveness of the economy to investors. The failure of PHCN to provide adequate and reliable electricity to consumers despite billions of naira of investment has generated a confidence crisis in the industry. Public confidence in PHCN's ability to supply uninterrupted and stable electric power is very low.

The generation, transmission and distribution of electrical energy have always been a challenge and hurdle for Nigeria. Between 1999 and 2007 the federal government spent excess of thirteen billion dollars on the energy and power sector alone and the recent 2010 budget saw an allocation of $1.005 billion to the sector. No major improvement was noticed, instead, till date, efficient generation and supply of electrical energy for the consumption of Nigerians has been a serious problem to authorities, industries, and individuals (Osaghae 2009). Table 1 shows comparative figures of electricity consumption per capita per person in selected countries.

2.2 The cost of alternative electric power supply to various consumers in Nigeria

There are essentially five ways by which firms may respond to unreliable electricity supply. These are choice of location, factor substitution, private provision, choice of business and output reduction (Adenikinju 2005). While all these elements are presently observed among Nigerian firms, the most common approach has been through private provision of electric power. Electricity consumers have responded to PHCN's inefficiency through self-generation. Both firms and households, now find it necessary to provide their own electricity in part or in whole to substitute or complement PHCN supply by factoring generator costs into the overall investment cost, thus raising significantly the set-up cost for manufacturing firms operating in the country. Incidentally, indigenous and small-scale enterprises are worse affected. Lee and Anas (1991) reported that small-scale enterprises spend as much as 25 % of the initial investment on self-provision of generators. Nigeria's electricity market, dominated on the supply side by the state-owned PHCN has been incapable of providing minimum accept-able international standards of electricity supply; reliability, accessibility and availability for the past three decades. According to Okafor (2006), major manufacturing firms experienced 316 outages in 2004. This increased by 26 % in 2005 followed by an explosive 43 % increase between 2006 and 2007. Additionally, in 2005, only 10 % of industries operated and on the average they only functioned at 48.8 % of their respective installed capacities. 60 % of the companies were at almost standstill while another 30 % had completely closed down. The following year, 2006, indicated that most of the industrial areas around the country suffered an average of 14.5 h of power outage per day as against 9.5 h of supply. Over 750 companies (30 %) have closed down out rightly due to the power problem. The alternative power source has forced insistent companies and firms to make huge expenditure on generators. Hence, as at April 2006, Nigeria topped the list of generator-importing countries for the fourth year in a row, having surpassed others since 2002 (Okoro and Chikuni 2007). Nigeria accounted for 35 % or $152 million of the total $432.2 million spent by African countries on generator imports in 2005. These diesel generators of between 2,000 and 5,000 KVA capacity, has placed Nigeria as a country importing three times as many generators than the closest African generator importers—Sudan and Egypt—that spent $40.6 million and $32 million respectively on the product in 2005 (Atser 2006).

A survey conducted in Lagos showed that the British American Tobacco (BAT) Plc spent about $0.433 million in 2005 on diesel and maintenance of its private power generation plant. Dunlop Nigeria Plc similarly spent $0.615 million on annual averages, while West African Portland Cement spent $0.577 million on the average. Others are Friesland Foods Plc: $0.321 million; Nigerite Plc: $0.231 million and Cadbury Nigeria Plc: $0.314 million. Table 2 surmises the extra expenditure in Naira by various sectors in alternate power supply.

3 Power generation

The Nigerian power sector is marked by low generating capacity relative to installed capacity and most of the citizens in the country do not have access to uninterrupted supplies of electricity. At present, electricity generation ranges from between 2,500 MW to about 3,000 (see

Table 2 Extra expenditure in Naira in alternate power supply in Nigeria

S/no	Sector	Expenditure (US dollars)
1	Telecom	0.043 trillion
2	Filling stations	0.282 billion
3	Factories	1.225 billion
4	Banks	0.075 billion
5	Residential	0.050 trillion
6	Insurance companies	0.513 billion
7	Commercial enterprises	0.010 trillion
	Total	0.105 trillion

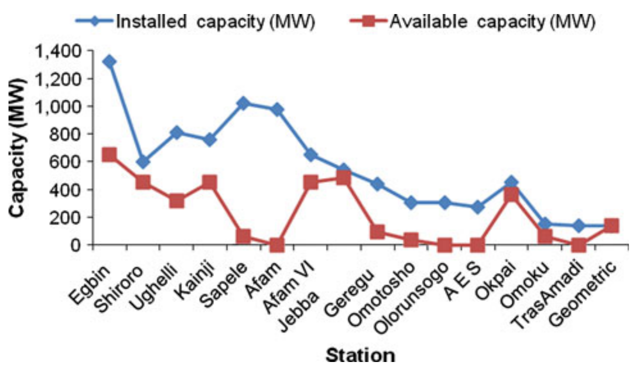

Fig. 1 Generating capacities of power stations

Fig. 1), even with the inclusion of three gas-powered independent power projects in the Niger Delta region, while estimated national consumption is in excess of 10,000 MW. Potential demand in the next few years is estimated at about 15,000 MW despite the fact that Nigeria is endowed with massive reserves of hydro energy, petroleum reserves and one of the largest gas reserve (Babatunde and Shuaibu 2009). Government policy for the sector during the 1980s and the 1990s and until recently, did not properly anticipate national needs. For example, the last major electric generation installation in Nigeria was in 1990 when the Shiroro power station was commissioned. Since then, no new units have come on stream and none of the existing ones have had a major overhaul for 15 years. The Kainji Hydro electric plant in operation since 1968, for instance, was designed to generate 960 MW of power out of its 12 turbines, but only ten of those turbines have been installed. Today the Kainji plant can only generate 760 MW of power. The per capita consumption of electricity is 0.054 kW; only about 5 % of our hydro electric capacity has been developed (Babatunde and Shuaibu 2009).

As at 2005, Nigeria has approximately 6,861 MW of installed electric generating capacity. It was discovered that a wide gap between the installed capacity and total electricity generation capacity started emerging in 1978, thus, making power outages to be frequent and the power sector operates well below its estimated capacity (Babatunde and Shuaibu 2009). The summary of installed and available electricity capacity in Nigerian generating stations are shown in Table 3.

Table 3 Existing power generating plants

Site	Type	Installed capacity (MW)	Available capacity (MW)	Total units
Egbin	Thermal	1,320	650	6
Shiroro	Hydro	600	450	6
Ughelli	Thermal	812	320	20
Kainji	Hydro	760	450	12
Sapele	Thermal	1,020	63	10
Afam	Thermal	980	–	20
Afam VI	Thermal	650	450	3
Jebba	Hydro	540	482	6
Geregu	Thermal	440	92	
Omotosho	Thermal	304	35	
Olorusogo	Thermal	304	–	
A E S	Thermal	270	–	5
Okpai	Thermal	450	361	5
Omoku	Thermal	150	60	
TrasAmdi	Thermal	136	–	
Geometric		140	140	
Total		8,876	3,653	

It is seen from the Table that despite a total grid capacity of 8,876 MW only 3,653 MW were available as at December 5, 2009. Thus 41 % of the installed capacities are unavailable (Emovon et al. 2011).

3.1 Generation capacity of PHCN

PHCN has an installed generation capacity of 4,200 MW; the maximum available capacity is limited to 3,300 MW. The current grid power system of PHCN has a mix of thermal and hydroelectric power plants which generate electricity at 16 kV. In 2008, its three hydro stations had a total installed capacity of 1,938.4 MW, while the 15 thermal power plants had a total installed capacity of 6,199.6 MW. The generating stations generate at 16 kV and feed through transformers into the grid with a primary transmission voltage of 330 kV. The grid feeds a sub-transmission network operating at 132 kV and this network supplies the distribution network at 33 kV, 11 kV and 415/240 V with the national control center (NCC) at Osogbo (Ibe and Okedu 2009). The thermal power plants are generally dual fuelled by oil and natural gas, but are mostly fired by natural gas. Nominal and operational voltages on the distribution system are shown in Table 4.

Table 4 Voltages on the distribution system

Nominal voltage (kV)	Operational voltages	
	Minimum (kV)	Maximum (kV)
33	31	34.98
16	15.2	16.8
11	10.45	11.55
0.415	0.39	0.44
0.23	0.216	0.244

4 Power transmission

Electric power transmission is the bulk transfer of electrical energy, from generating power plants to substations located near the population centers through transmission lines. Transmission lines, when interconnected with each other, become high voltage transmission networks or grid and this is referred to as "national grid" or "power grid". Transmission lines in Nigeria use three phase alternating current (AC) technology. Electricity is transmitted at high voltages (330/132 kV) to reduce the energy lost in long distance transmission (Ibe and Okedu 2009). The transmission system employed in Nigeria is Grid system which is a network that connects all the major power stations and load centres in the country power generation system as shown in Fig. 2.

Power is usually transmitted through overhead power lines in Nigeria. Since overhead transmission lines are uninsulated, design of these lines requires minimum clearances to be observed to maintain safety. Adverse weather conditions of high wind and low temperatures can lead to power outages: wind speeds as low as 43 km/h can permit conductors to encroach operating clearances, resulting in a loss of supply. A key limitation in the distribution of electricity is that, with minor exceptions, electrical energy cannot be stored, and therefore it must be generated as it is needed. To reduce the risk of failures, electric transmission networks are interconnected into regional and national wide networks thereby providing multiple redundant alternate routes for power to flow incase (weather or equipment) failures occur.

5 Power distribution

Electricity distribution is the final stage in the delivery of electricity to end users. A distribution system's network delivers electricity from the transmission system to the consumers. Typically, the network would include power lines, electrical substations and distribution transformers as well as low-voltage distribution wiring and electricity meters. The distribution system begins as the primary circuit leaves the sub-station and ends as the secondary service enters the customer's meter socket. It is important to note that the demand for electricity in Nigeria is growing but the development of the energy sector is not keeping pace with the provision of electricity and related expanding economic activities (Osaghae 2009). A comparism of worldwide electricity consumption is presented in Table 5 and it is seen that Libya with a population of only 5.5 million has generating capacity of 4,600 MW, approximately the same as Nigeria which has a population of about 140 million. Also South Africa with a population of only 44.3 million has a generating capacity of 45,000 MW, almost eleven times the generation capacity in Nigeria which has three times the population of South Africa (Agbo 2007). According to Osaghae (2009), the nation's energy demand is estimated at 10,000 MW.

However, existing power stations and their installed capacities are shown in Table 6. With the installed capacity of about 6,000 MW, the country manages to generate only a meager 4,000 MW of electricity.

The results above shows that power generation in the country has been declining and unable to compare with

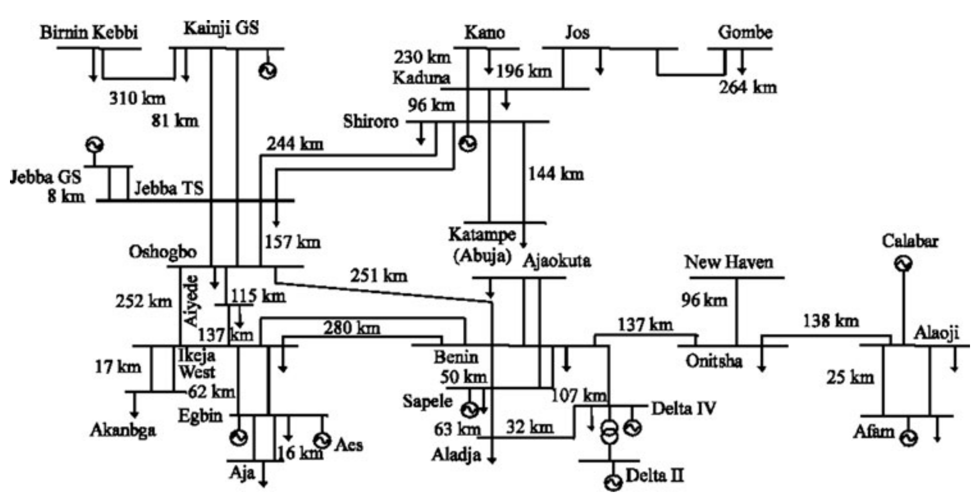

Fig. 2 Nigerian 330 kV transmission grid showing the single loop (PHCN 2006)

Table 5 A comparism of worldwide electricity consumption

Country	Population (million)	Power generation (MW)	Per capital consumption (kW)
United States	250.00	813,000	3.20
Cuba	10.54	4,000	0.38
UK	57.50	76,000	1.33
Ukraine	49.00	54,000	1.33
Iraq	23.60	10,000	0.42
South Korea	47.00	52,000	1.09
South Africa	44.30	45,000	1.015
Libya	5.50	4,600	1.015
Egypt	67.90	18,000	0.265
Nigeria	140.00	4,000	0.03

Table 6 Power plants and their generation capacities

Station	Type	Inauguration date	Installed capacity (MW)	Current output (MW)
Oji	Thermal	1956	30	–
Delta	Thermal	1966–1999	900	366
Ijora	Thermal	1978	60	–
Sapele	Thermal	1978–1981	1,020	62
Kainji	Hydro	1968–1978	760	445
Jebba	Hydro	1983–1984	578.4	339
Afam	Thermal	1978–1982	969	85
Egbin	Thermal	1985–1987	1,320	241
Shiroro	Hydro	1989–1990	600	281
Total			6237.4	

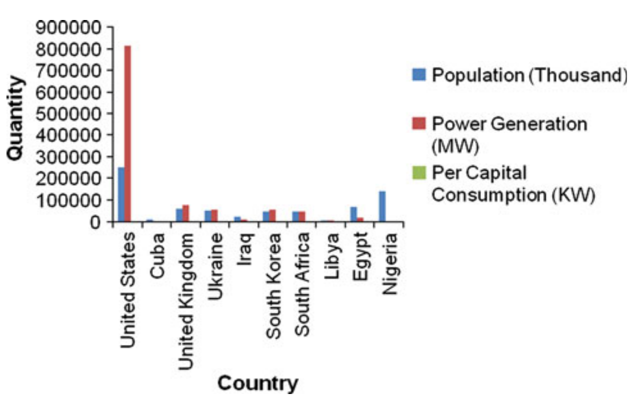

Fig. 3 power generation and consumption in some countries

what obtains even in smaller countries, with far smaller population, as presented in Fig. 3. Consequently, power supply in virtually all the sates in the country have been very poor. For instance, in Edo/Delta zone the average

Table 7 Average total outages in 11 kV feeders

Month	11 kV Feeders				
	Asaba	BDPA	New Benin	New Auchi	F.H. Estate
January	120.02	29.02	52.02	82.06	80.06
February	12.8	51.12	82.05	89.44	84.25
March	120	35.29	57.35	83.07	94.31
April	112	28.30	43.19	96.21	73.34
May	130.02	44.05	61.02	88.08	78.82
June	128	42.08	80.05	82.46	84.25
July	122	50.02	47.30	93.07	96.41
August	118.24	32.60	45.19	79.28	83.34
September	130.02	51.12	82.05	89.44	84.25
October	133.8	35.29	57.35	83.07	94.31
November	100.43	28.30	44.19	96.21	73.34
December	112.04	27.06	50.06	90.02	76.04

power supply to industrial area is put at 4.4 h/day. The Ikeja industrial area of Lagos enjoyed power supply for 12.5 h/day and this is the highest in the country. Industrial estates in Bauchi, Benue and Plateau zone receive power supply for 4.5 h/day which amounted to near blackout in real sense (Nwaoshai 2006).

The current per capita consumption of electricity in Nigeria is about 106 kWh/person compared to Ghana's 430, India's 470 and Brazil's 1,800. Expected increase in consumption is 379 MW annually at 2.5 % population annual growth rate and five % annual growth of the economy (Nwaoshai 2006).

6 Electric power outages from feeders

Electric power outages occur frequently in Benin City and the outages recorded occurred directly from feeders at injection substations. The frequency of power outages during the period under study are presented in Tables 7 and 8.

Most of the outages were as a result of faults from incoming power lines.

The mean power outages from 11 kV feeders are presented in Fig. 4 while the mean power outages from 33 kV feeders are presented in Fig. 5.

7 Electric power outages from injection substations

Electric power outages also usually occur directly from the injection substations and some of the factors responsible for such outages were also studied for Siluko and GRA

Table 8 Average total outages in 33 kV feeders

Month	33 kV Feeders	
	Guinness	Ikpoba Dam/koko
January	124.04	114.08
February	132.82	118.26
March	188.06	121.14
April	165.04	122.02
May	98.08	186.56
June	201.04	178.02
July	168.24	188.02
August	186.24	204.36
September	149.41	211.40
October	95.40	112.42
November	220.47	167.57
December	202.22	180.02

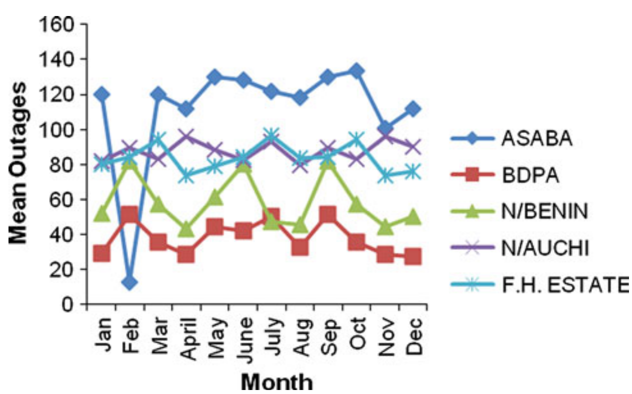

Fig. 4 Mean power outages from the 11 kV feeders

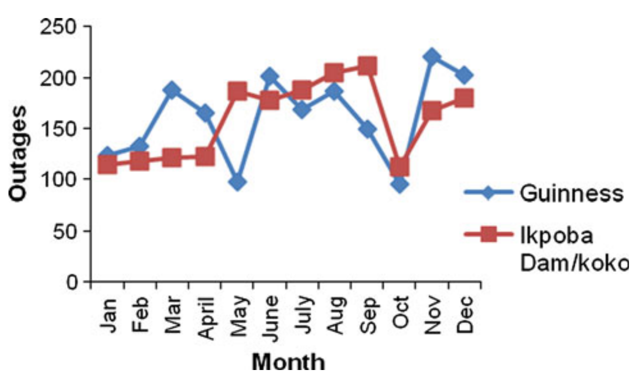

Fig. 5 Mean power outages from the 33 kV feeders

injection substations. A summary of the results is presented in Table 9. It is observed that GRA is more under control than the Siluko injection substation, while the daily peak load readings for the stations are shown in Tables 10 and 11. [rating = 7,500 KVA and voltage = 33/11]. Factors responsible for electric power outages are presented in Fig. 6.

Table 9 Major factors for electric power outages

Factors	Numbers of outages		Total	Percentage
	SILUKO	GRA		
Man-made	64	28	92	40.9
Earth fault	40	15	55	24.4
Over current	19	15	34	15.1
Natural fault	15	12	27	12.0
Transient fault	12	5	17	7.6

Table 10 Mean daily peak load readings for GRA injection substation

Days	Time (h)	Peak load readings (AMPS)			Percentage loading (%)
		R	Y	B	
1	20.00	340	340	340	75
2	19.30	357	357	357	61
3	22.30	330	330	330	64
4	20.00	380	380	380	76
5	21.00	350	350	350	69
6	20.00	350	350	350	69
7	19.30	370	370	370	74
8	19.30	300	300	300	76
9	19.30	340	340	340	76
10	20.00	384	384	384	67
11	21.30	360	360	360	81
12	20.00	370	370	370	84
13	19.30	360	360	360	81
14	19.00	340	340	340	66
15	22.00	340	340	340	76
16	19.30	380	380	380	76
17	19.30	386	386	386	76
18	21.30	330	330	330	68
19	20.00	358	358	358	71
20	19.00	380	380	380	76
21	21.30	320	320	320	71
22	23.00	320	320	320	71
23	20.30	380	380	380	66
24	19.30	370	370	370	64
25	19.30	380	380	380	66
26	19.30	360	360	360	71
27	22.00	380	380	380	76
28	19.30	380	380	380	76
29	22.30	320	320	320	71
30	23.00	350	350	350	69
31	19.30	380	380	380	66

The mean %age loading for the injection substations are presented in Fig. 7. It is clearly seen that Siluko injection substation is over loaded than the GRA injection substation.

Table 11 Mean daily peak load readings for Siluko injection substation [rating = 7,500 KVA and voltage = 33/11]

Days	Time (h)	Peak load readings (AMPS)			Percentage loading (%)
		R	Y	B	
1	21.00	310	310	310	79
2	20.30	350	350	350	89
3	21.30	380	380	380	99
4	20.30	320	320	320	80
5	22.30	300	300	300	76
6	20.00	350	350	350	89
7	22.00	340	340	340	86
8	20.00	340	340	340	86
9	20.30	350	350	350	89
10	20.30	350	350	350	89
11	19.30	380	380	380	96
12	20.00	370	370	370	94
13	19.30	350	350	350	89
14	22.30	310	310	310	79
15	19.30	350	350	350	89
16	19.00	380	380	380	96
17	20.30	390	390	390	97
18	19.30	380	380	380	96
19	19.30	360	360	360	91
20	19.30	90	90	90	23
21	19.00	350	350	350	89
22	19.30	370	370	370	94
23	19.30	370	370	370	94
24	20.00	380	380	380	96
25	19.30	350	350	350	89
26	21.30	350	350	350	89
27	20.00	350	350	350	89
28	20.00	370	370	370	94
29	20.00	360	360	360	94
30	19.00	90	90	90	23
31	20.00	270	270	270	61

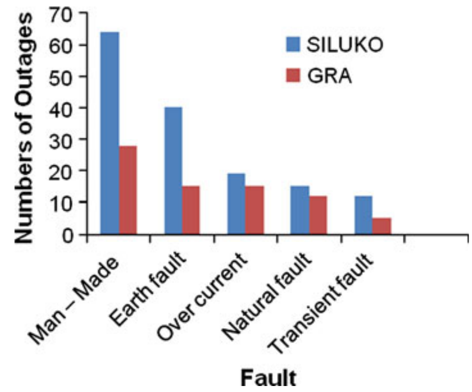

Fig. 6 Problem of electric power outages

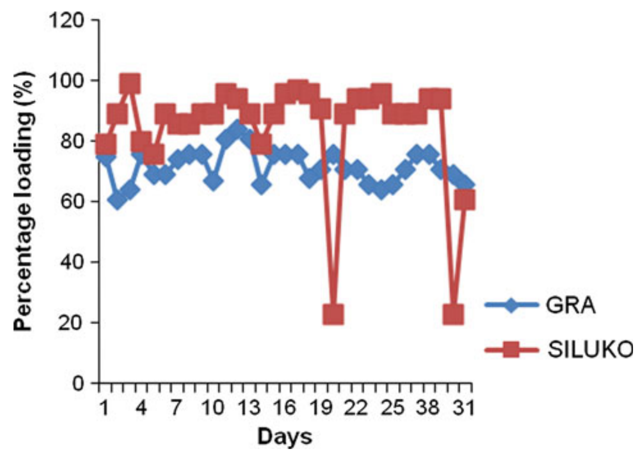

Fig. 7 Mean %age loading for the injection substations

8 Discussion

Electric power outages were found to be very frequent in Benin City area of Nigeria and were due to various factors among which are the following: Planned outages which were normally arranged to permit planned maintenance, repair or modification work on in—service equipment and also to enable new equipment to be installed and put into service. Automatic or forced outages are outages caused by different types of inadvertent or unintentional faults in the power supply system. Such faults were found to occur fairly frequently due to storm, lightening, strike action, contractors excavating PHCN underground cables, vehicles hitting PHCN poles and overhead circuits, earth—faults, and human errors. Emergency actions leading to outages, such as load shedding, were sometimes embarked upon in order to save the equipment or system from imminent danger or failure. At a high winding temperature of about 78 °C, the transformer trips off automatically to prevent transformer's explosion. Accordingly, whenever the need arose, load shedding was embarked upon to reduce the load on the transformer, and hence, the temperature, so as to save the life of the transformer. Forces external to the system were found to be the common problems to power supply as a result of the fact that people embarked upon individual construction work without informing the PHCN authority thereby damaging power equipment. Also illegal power connection, vandalization and stealing of electric power facilities with insufficient and old equipment also contribute to frequent power failure in Nigeria. Corruptions among the staff of PHCN whom sometimes embarked upon illegal power connections also affect power supply as it often leads to overloading of the facilities of PHCN.

8.1 Improvement on electric power supply in Nigeria

It is proposed that the following steps should be taken to improve on electric power supply in the country.

i. It is suggested that government should up-grade the performance of major electrical infrastructural facilities by replacing the over aged electrical facilities with new ones.
ii. The staff of PHCN should be discouraged from indulging in illegal power connections to prospective consumers.
iii. Illegal sales of electricity metres to prospective consumers by the staff of PHCN should be discouraged.
iv. Vandalisation of power holding equipment and reselling of power holding equipment, in most cases to public and private electricity institutions should be discouraged.
v. There should be regular maintenance of electric power lines by cutting down the over grown trees to avoid the bridging of the power lines by the over grown trees.
vi. People should be discouraged from illegal connection which usually lead to overloading of power transformers by penalizing anyone caught in the act.

9 Conclusion

The perennial problem of electric power supply in Nigeria has adversely affected every sector of the nation economy. The study has identified and discussed some of the factors that are responsible for inadequate and irregular supply of electric power in the Benin City area of Nigeria. It was found that most of the major factors affecting the availability of power supply in Nigeria could be grouped into two major classes. The first consists of those arising from policy actions, which are deliberate in nature and they are usually taken to safeguard the equipment. They include such actions that are taken during emergency outages, planned or pre-arranged outages as well as load- shedding. On the other hand, the other category includes those arising from forces external to the system, and they include over-current, earth fault, high peak load, as well as forced or automatic outages. However, some of the latter may lead to the former.

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