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LIGHTING DISCHARGE ON POWER LINES- CASE STUDY OF AFAM POWER PLANT, NIGERIA

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ABSTRACT: *This study reports on the effects of lightning discharge on power lines in Afam Power Plant, Nigeria. Unstable electrical power transmission is one of the myriads of problems facing the energy sector in Nigeria. The possible consequences of the lightning effect on the consumers are felt in the increased power blackouts in the affected areas. This leads to loss of revenue from the power transmission companies, consumers and the society at large. This paper x-rays the possible causes, and proffers solution and recommendations on the way forward.*

KEYWORDS: Lightning, power lines, Afam power plant, Nigeria.

INTRODUCTION

It is generally understood that power stations pass the electricity they produce into the distribution network. Overhead power lines are the services route through which the distribution sub-station feed power to their various stations. An overhead power line is an electric power transmission suspended by towers or utilities poles. Overhead lines are routinely operated at voltage exceeding 765,000 volts between conductors and even high voltage possible in some cases. Lightning arresters are devices mostly used on electrical power systems and telecommunications gadgets for the purpose of protecting the insulation and conductors of the system from the effects of lightning attacks. A typical lightning arrester generally consists of a high-voltage terminal and a ground terminal. It is generally understood that lightning can be seen as an atmospheric discharge of electricity, occurring from the accumulation of static charges, usually during a thunderstorm incident. Lightning mostly occurs when there are enough charge separation inside the cloud to cause a localised electric breakdown of the air. Lighting activity are mostly described by the “keraunic number”. Accordingly, the keraunic number is the mean number of days per year when thunder can be heard in a given area, and the likelihood thereby of a thunderstorm (Punekar and Kandasamy, 2011). Lightning and thunderstorm are the most significant cause of interferences in the transmission and electrical power distribution systems. Most terrestrial based electrical

systems such as power lines, telecommunication exchanges stations, global system for mobile communications (GSM) base stations as well as tall structures that are not shielded with thunder protectors are all susceptible to the damaging forces of lightning strikes. One way to improve the quality of transmission services by the power transmission companies is to reduce the number of power line interference.

In Nigeria currently, Afam 4 and Afam 6 power plants generate 45MW/hr and 123-125MW/hr respectively on daily basis. Afam IV-V Generating Power Station ($4^o 51^/$N, $7^o 15^/$E) and Afam VI ($4^o 50^/$N, $7^o 15^/$E) Generating Power Station Nigeria is located at Oyigbo Local Government Area, Okoloma, Rivers State, Nigeria (Menakaya, 1980;

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https://en.wikipedia.org/wiki/List_of_power_stations_in_Nigeria). The major aim of this research is to;

(i) Investigate the possible causes of power outage in the study area,

(ii) Contributions of lighting strike to poor power availability,

(iii) Proffer possible solutions and recommendations

MATERIALS AND METHODS

In this study, available data were obtained from the Transmission Company of Nigeria, Afam Power Plant. The data included information extracted from the lightning arresters installed on their transmission plants. The information consists of the lightning arrester readings and the earthing ratings for a given period of 36 months (2012-2014). The data was then analysed using software packages (Origin Pro 8, Trial Version), and useful deduction were made from the outputs.

RESULTS AND DISCUSSION

Table 1 gives the distribution of sub-stations with lightning protection within the study area, and their respective compositions, while Table 2 show the earthing rating within the study periods (2012-2014). According to Table 2, there was a remarkable increase in the earthing rating in all the sub-stations. However, a major increase was recorded in 2014, compared to the previous years (2012 and 2013). The most marked increase was observed in the Garden City Centre (GCC) and Garden City Industrial (GCI) stations. This could be attributed to the effects of weather and other atmospheric variables in that area, load shedding effects, or to other associated effects. Research work by different authors (Güemes et al, (2012), indicate that natural phenomena such as the "corona discharge" can adversely affects electric power transmission lines thus leading to serious power loss, audible noise, interference with communication systems/signals, ozone production, and insulation damage amongst others.

TABLE 1: Stations with Lightning Protection

S/N	AREA/STATION	LIGHTNING PROTECTIVE MEANS			PHASE CONNECTED	VOLTAGE SIDE
		ARRESTER	SHIELD WIRE	EARTHING		
1	T1a	Yes	Yes	Yes	3- Phase	162mVa
2	T1	Yes	Yes	Yes	3 –Phase	162mVa
3	T5	Yes	Yes	Yes	3 –Phase	162mVa
4	Tr10	No	No	No	3 –Phase	162mVa
5	T/ Amadi (TAM)	Yes	Yes	Yes	3 -Phase	162mVa
6	Garden City Main (GCM)	Yes	Yes	Yes	3 Phase	33/11kVa
7	Paradise City (PC)	Yes	Yes	Yes	3 Phase	11/33kVa

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8	Garden City East (GCE)	Yes	Yes	Yes	3 Phase	11/33kV
9	Promise City South (PCS)	Yes	Yes	Yes	3 Phase	11/33kV
10	Promise City North (PCN)	Yes	Yes	Yes	3 Phase	11/33kV
11	Garden City New (GCN)	Yes	Yes	Yes	3 Phase	11/33kV
12	Garden City Centre (GCC)	Yes	Yes	Yes	3 Phase	11/33kV
13	Garden City Industrial (GCI)	Yes	Yes	Yes	3 Phase	11/33kV
14	Promise City Main (PCM)	Yes	Yes	Yes	3 Phase	11/33kV
15	Glory City Main (GACM)	Yes	Yes	Yes	3 Phase	11/33kV

Fig. 1 gives the variation of the arresters counter reading of the red phase at each base stations for the periods of 2012 to 2014. The most significant increase in ARC of the red phase was recorded in Promise City South (PCS) station. It is widely known that when electric charges are built up in thunderclouds to such level that could break atmospheric insulation, an electric discharge eventually occurs between these clouds or between the clouds and the ground. When such incident occurs, an abnormally high voltage generated by direct lightning discharge applied to electric power cables or communication cables at that instance is referred to as a ‘direct lightning surge’. Such scenario are commonly observed around PCS station, hence the increased ARC values are attributed to this effect. Research done by Gallaghar and Pearmain (1983) indicated that the risks of lightning strokes to transmission networks is a measure of the degree of thunderstorm activity within the region in question. Occurrence of thunderstorm, leads to lightning flashes which pose a major risk to electrical and communication installations. It is in this regard that Kuffel and Zaendal, (1988) defined “thunderstorm day” as a day that the sound of thunder is heard independent of the number of times it is heard.

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TABLE 2: Earthing Rating within the Study Periods

S/N	Area/Station			2012	2013	2014
		EARTHING	EARTHING RATING AS AT INSTALLATION	EARTHING RATING	EARTHING RATING	EARTHING RATEING
1	T1A	YES	5Ω	5.5	5.7	6.0
2	T1	YES	5Ω	5.6	5.9	6.0
3	T5	YES	5Ω	5.2	5.9	6.2
4	TR10	NO	5Ω	5.8	6.2	7.0
5	T/ AMADI (TAM)	YES	5Ω	5.5	5.9`	6.5
6	GARDEN CITY MAIN (GCM)	YES	4.5Ω	5.9	6.5	7.0
7	PARADISE CITY (PC)	YES	5Ω	5.8	6.0	7.0
8	GARDEN CITY EAST (GCE)	YES	5Ω	5.8	6.5	7.2
9	PROMISE CITY SOUTH (PCS)	YES	5Ω	5.6	6.0	6.5
10	PROMISE CITY NORTH (PCN)	YES	5Ω	5.2	5.9	6.4
11	GARDEN CITY NEW (GCN)	YES	5Ω	-	5.3	5.5
12	GARDEN CITY CENTRE (GCC)	YES	5Ω	5.9	6.6	7.5
13	GARDEN CITY INDUSTRIAL (GCI)	YES	5Ω	5.9	6.3	7.5
14	PROMISE CITY MAIN (PCM)	YES	5Ω	5.6	5.8	5.9
15	GLORY CITY MAIN (GACM)	YES	5Ω	5.2	5.3	5.4

Increased thunderstorm activities or other lightning associated effects has been recorded in different parts of Nigeria. According to the literature, different research groups (Adegboyega and Odeyemi, 2012), have worked on the development of a data map on the thunderstorm day and flash density in order to ascertain the areas that are prone to high/low risk of thunderstorm/lightning in the northeast region of Nigeria. However reports on thunderstorm activities or other lightning associated phenomena are relatively rare in the study area in the literature. However it also pertinent to note that there was a progressive increase in the ARC-red phase values from 2012 to 2014. It is possible that the insulation in that phase has weakened leading to the observed increase. Another possible scenario could be that of poor maintenance structure, leading to a degradation of the equipments with time.

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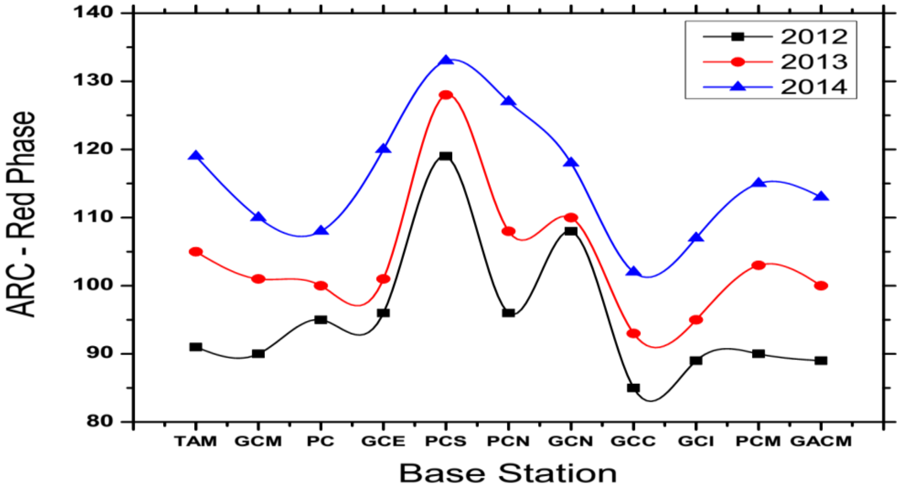

Fig. 1: Variation of ARC-red phase at different base station within the study periods (2012 – 2014)

Fig. 2 gives the variation of the arresters counter reading of the yellow phase (ARC-yellow phase) at each base stations for the periods of 2012 to 2014.

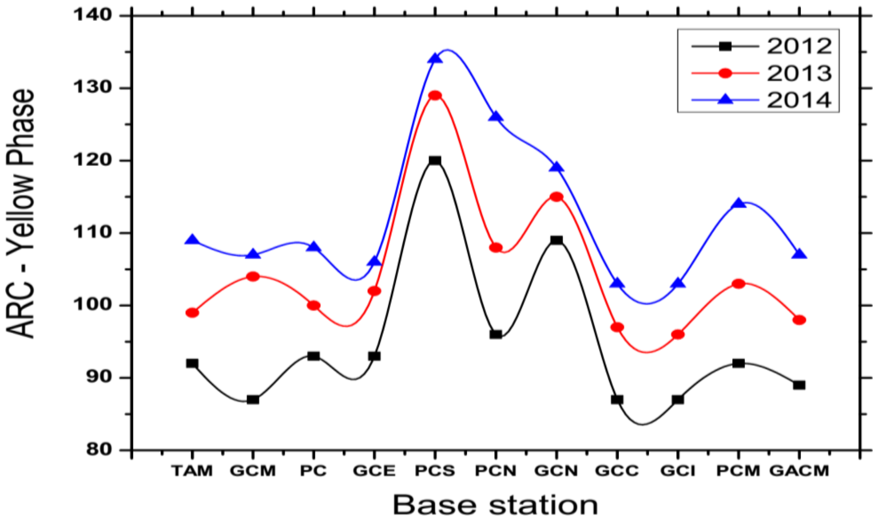

Fig. 2: Variation of ARC-yellow phase at different base station within the study periods (2012 – 2014).

As indicated in Figure 2, there was a maximum rise in the ARC-yellow phase values at Promise City South (PCS) station. This observation is in agreement with of the ARC-red phase, hence similar reasons as indicated before was the cause of such behaviour.

Fig. 3 gives the variation of the arresters counter reading of the blue phase (ARC-blue phase) at each base stations for the periods of 2012 to 2014. The behaviour of the ARC-blue phase

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was quite different from the former, in that the maximum values for the three-year periods of investigation were obtained at GARDEN CITY NEW (GCN) station. This observation implies that the effect of the lightning is not only geographically dependent but also phase dependent.

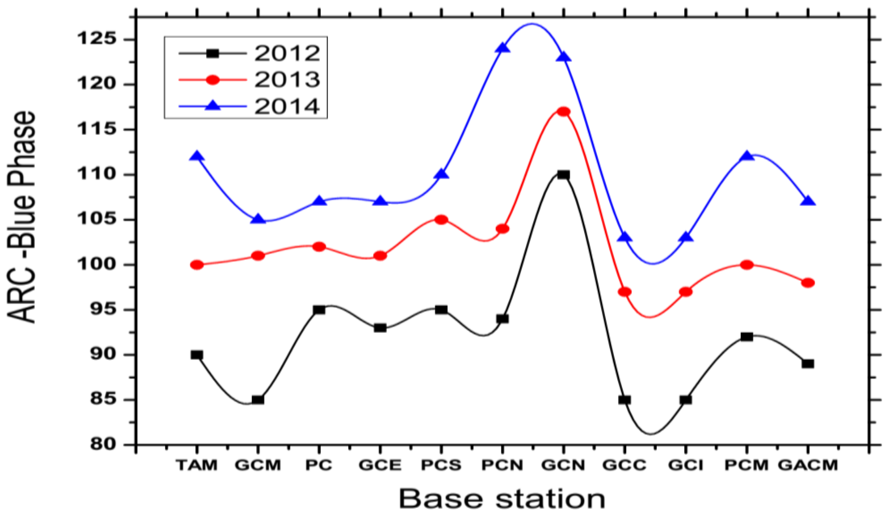

Fig. 3: Variation of ARC-blue phase at different base station within the study periods (2012 – 2014).

IMPLICATIONS

The effect of the lightning discharge amongst other factors (poor maintenance culture on transformers, over loading, use of sub-standard materials (cables), and environmental factors) in the study area is manifested in the poor power availability to consumers. Fig. 4 gives a typical power availability in hours in December 2014 in the respective base stations. As indicated in Fig. 4, only one station had an average power availability for 14 h while more than 50 % of the station investigated, had average power availability < 9 h. This scenario is typical of most power generating companies in

Nigeria. Other research group has reported similar findings in the literature (Nwulu and Agboola, 2011; Nwofe 2013[ab] ; Nwofe 2014[ab]; Nwofe and Ekpe, 2014; Awogbemi and Komolafe, 2011). From Fig. 4, it could be inferred that the stations that offered least power availability are GARDEN CITY CENTRE (GCC), and PROMISE CITY MAIN (PCM) while PROMISE CITY NORTH (PCN) offered maximum power to her customers.

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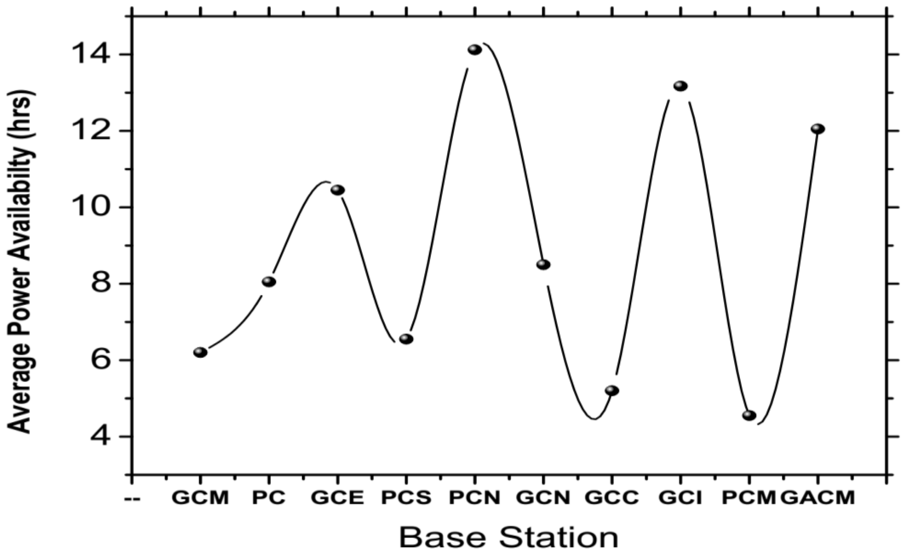

Fig. 3: Typical variation of average power availability at different base station in December 2014.

RECOMMENDATIONS

In view of the foregoing discussions, it is strongly recommended that;

a) There should be proper earthing of the surge arrester and shield wire which when not properly earthed may pose more treat.
b) Arrester and shield wire should be employed appropraitely.
c) Preventive maintenance of the equipments should be adopted more frequently in the respective stations.
d) Increased R & D (research and development) will enhance better understanding of areas prone to lightning surge.

CONCLUSION

The effects of lightning discharge on power lines in Afam Power Plant, Nigeria is investigated for a three-year period (2012-2014). The results show that lightning activities play a significant role in reducing power availability to customers at the respective base stations that were investigated. The results also indicate that the effect of the lightning is not only geographically dependent but also phase dependent. The work reported herein is a fundamental step to improving power availability in the study area.

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