Electrical Distribution Industry – Problems: Case of Akwa Ibom State, Nigeria.

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ABSTRACT

The importance of the electricity distribution industry in the power sector cannot be over emphasized, as it helps in providing efficient and reliable power. The rapid rate of technological developments as well as technological integration have continued to pose challenges to the effective management of distribution.

This paper addresses the defects identified in the distribution network, including injection substations, distribution transformers, existing in the network, record of load measurements and load estimation carried out in three major towns in Akwa Ibom state: Uyo, Ikot Ekpene, and Eket. Recommendations on the maintenance of these electrical facilities by the federal and state government and other stack holders were made.

(Keywords: electricity distribution, distribution networks, transformers)

INTRODUCTION

The power supply situation in Nigeria, and Akwa Ibom State in particular, is very poor and it is expected that the state will derive maximum benefit from the 191MW Power Station being built at Ikot Abasi, hence there is the need to assess the existing situation of the power supply and distribution in three major towns of Akwa Ibom state. The three towns are Uyo, Ikot Ekpene and Eket.

Electricity distributing utility management can be defined as a system process of cost-effectively, operating, maintaining and upgrading of electrical assets by combining engineering practices and economic analysis with sound business practice (Davidson, 2005). The distribution of electricity is a natural monopoly (i.e., it is not economically realistic with parallel infrastructures) (Wallnestrom, 2008).

For the case of Akwa Ibom State, the scope of the assessment includes survey of the existing distribution network, survey of areas not connected which can be considered for future expansion, survey of major supply into the towns, load management and collaboration with local Power Holding Company of Nigeria to confirm if any expansion program is in the offing.

This paper present detailed record of the defects identified in the distribution network including injection substations, detailed network of distribution transformers existing in the network, record of load measurements carried out in Uyo, Ikot Ekpene, and Eket were discussed including the load estimation for the three towns.

For the Akwa Ibom case, having know some of the problems and defects in the distributions network such as broken or bent poles, depland damages, tie straps, feeder pillars, snapped strays, cross arm, overloaded transformers, leaking transformers, and bushy distribution substations.

A load forecast, study of the existing capacities of injection and distribution substations based on engineering design to accommodate expansion of load in Uyo, Ikot Ekpene, and Eket was done in order to make a way forward in the electrical distribution industry.

DATA COLLECTION

Data collections were based on all 132/33kV substations, 33/11kV injection substations and distribution substations to ascertain what are on ground by visiting every street of the three towns, inspecting all distribution substations and the network.

ASSESSMENT AND DISTRIBUTION NETWORK DEFECTS

The assessment focuses on the KVA rating and voltage rating of the transformers, details of uprisers (number and sizes), name and location of the substation, whether street is highly is connected to the substation or not and the general conditions of the substation. The summary of the record of the assessment for each of the distribution substations is shown in Table 1 and 2. The total number of the distribution substations for the three towns are Uyo:-364, Ikot Ekpene:- 53, and Eket:- 94 (Ibom company, 2007). Also, the conditions survey of the 33kV, 11kV and 0.415kV distribution network was carried out in detail, noting the defects.

The defects were based on the pole condition, displaced/damaged tie straps, broken cross arms, broken insulators, snapped stays, damaged feeder pillars, leaking transformers, overloaded transformers, bushy distribution substations and broken conductors. The details of the defects in the three major towns are summarized in table 3. The total number of defects recorded for each town are Uyo-98, Ikot Ekpene-20, and Eket 18 (Ibom Power Company, 2007).

The items listed in table 3 include the following: Undersized conductor for LT network, Undersized conductor for HT, Overloaded transformer requiring relieve (Power Holding Company of Nigeria).

LOAD READINGS

One of the major problems with load measurement is the hostility of the consumers who see anybody by the transformer as hostile visitor who is trying to pilfer the transformer (PHCN, 2006). The timing of the peak periods for most of the transformers is around 7.00pm which does not help the situation as the stations are generally dark by this time. Another problem is the limitation of the load allocated to each town due to generation problem all over the country. In fact all the 11kV feeders at the only functional injection substations at Uyo in particular could not be switched on at the same time and the operations resulted to switching on the particular feeder to the transformers whose turn it was for the load to be measured. Most of the loads measurement were carried out during the day time and it was difficult to confirm if the load measured were the actual peak load or not.

Table 4a shows the record of the loading readings in Uyo.

Measurement could be carried out only at three locations in Ikot Ekpene, because the town was without power most of the time of visit. The records are shown also in Table 4b.

There was massive load shedding going on in Eket due to the damage of one of the 2 x 15 MVA 33/11kV transformers. Because of this, there was very little possibility of any of the transformers being loaded any where to full capacity, hence it was decided not to embark on load measurement exercise as it might not lead to any meaningful deductions.

POWER SUPPLY

The only 132/33 kV substation in Uyo is supplied from Itu 132/33 kV substations which in turn is supplied from Aba 132/33kV substation. Uyo substations was completed in late 80s and it consist of: 1 incoming and 1 outgoing 132kV lines, 2 x 30/40 MVA 132/33 kV transformers, 6 x 33 kV feeder.

The main supply to Ikot Ekpene is from 33kV line from Aba 132/33kV substation passing through to Uyo. This line had been the main source to both Uyo and Ikot Ekpene in the past prior to the completion of Uyo 132/33kV substation but it is now used to back feed to Ikot Ekpene on completion of 132/33kV substation at Uyo. This line is feed-off to the only injection substation at Ikot Ekpene.

The main supply to Eket is through the 132kV line form Uyo. The substation consist of 1 incoming 132kV line from Uyo, 1 x 30/45 MVA 132/33kV transformer, 1 x 45/60MVA 132/33kV transformer and 4 x 33kV feeders (Jiyoda Engineering, 2007).

One of the 33kV feeders is connected to 2 x 15 MVA 33/11kV transformers feeding Eket township. This is the end of the Spur 132kV feeder from Itu on Aba-Calabar 132kV line and this substation suffers from serious low voltages most of the time.

Table 1: Summary of Uyo Distribution Substations Assessment Record.

	Transformers	Size of conductors	Remarks
FIRST ZONE	500kVA 11/0.415kV (87)	Range of 70mm-150mm	Burnt up rises cable, oil leakage, no J & P Fuse etc.
	300kVA 11/0.415kV (73)	100mm	No fuse holder weed over grown, bad up riser cable etc.
	200kVA 11/0.415kV (41)	70mm	No J & P fuse holder, breeder bad, oil leakage, weedy substation etc.
	100kVA 11/0.415kV (5)	70mm	J & P fuse absent
	750kVA 11/0.415kV (14)	100mm	Bushy not in service indoor type
	750kVA 11/0.415kV (4)	100mm	Not accessible, no J & P fuse weedy
SECOND ZONE	500 kVA 11/0.415kV (1)	70mm	Pole mounted
	500 kVA 11/0.415kV (9)	100mm	Weedy, not connected J & P fuse absent etc.
	300 kVA 11/0.415kV (31)	70-100mm	Weedy, fuse linked, silica gel bad etc.
	200 kVA 11/0.415kV (4)	70-100mm	Weedy, no J & P fuse, fuse linked etc
	100 kVA (1)	100mm	Neat
	2.5MVA(2)	Underground cable	Ok
THIRD ZONE	500 kVA 11/0.415kV (15)	100mmm	s/s bushy silica gel bad, no J & P fuse etc
	300 kVA 11/0.415kV (21)	100mm	No J & P fuse some ok, etc.
	315 kVA 11/0.415kV (2)	100mm	No J & P fuse
	200 kVA 11/0.415kV (4)	70mm	Bushy, no J & P fuse, weedy, etc.
FOURTH ZONE	500 kVA 11/0.415kV (11)	100mm	No J & P fuse,weedy etc.
	300kVA 11/0.415kV (24)	100mm	Weedy, no J & P fuse, etc.
	200 kVA 11/0.415kV (4)	70mm	No J & P fuse
	1000 kVA 11/0.415kV (2)	-	Ok
	1250 kVA 11/0.415kV (1)	-	Ok
	2500 kVA 11/0.415kV (1)	-	Ok

Table 2: Summary of Ikot Ekpene and Eket Distribution Substations Assessment Record.

	Transformer	Size of conductors	Remarks
IKOT EKPENE TOWN	500 kVA 11/0.415kV (18)	100mm	No J & P fuse carrier silical gel saturated etc.
	300 kVA 11/0.415kV (19)	70-100mm	Bushy, No fuse holder etc.
	100 kVA 11/0.415kV (4)	70-100mm	No J & P fuse etc.
	200 kVA 11/0.415kV (6)	70-100mm	No J & P fuse carrier bushy
EKET TOWN	500 kVA 11/0.415kV (17)	100mm	No fence, burnt up riser cable, no J & P fuse etc.
	300 kVA 11/0.415kV (11)	70-100mm	No fuse holder etc.
	200 kVA 11/0.415kV (13)	100mm	No J & P fuse carrier
	315 kVA 11/0.415kV (1)	70mm	Ok
	100 kVA 11/0.415kV (4)	70-100mm	J & P fuse carrier present etc.
	100 kVA 11/0.415kV (4)	70-100mm	Name plate removed, etc.

Table 3: Summary of Distribution Network Defects in Uyo, Ikot Ekpene and Eket.

Towns	Defective cross arm (unit)	Tie strap (pair)	Sag conductors	Insulator unit	Poles	Unkept. Substation	Stay to be replaced	Undersized conductors (spans required)		
								LT	HT	
									33kV	11kV
Uyo	55	31	24	26	6	39	2	238	50	22
Ikot Ekpene	17	7	-	16	1	16	2	569	-	-
Eket	19	11	-	13	7	7	372	372	-	-

Source (PHCN, 2007)

Table 4a: Summary of Load Reading for Uyo City (First to Forth Zone).

	S/N	Substation Name	Transformer raking (kVA)	Measured load (kVA)	Percentage loading [%]
FIRST ZONE	1	Uyo control station	500	192.1	38
	2	Enwe street	300	110	36
	3	Atim Atakpo	300	54.6	18
	4	52 Ikot Ekpene rd	500	156.2	31
	5	Opp Mr. Bigg's	500	247	49
	6	Iboko Street	300	161	53.6
	7	Akpan Essien	300	128.8	43
	8	Beside Oceanic bank	500	165.2	33
	9	Shopping centre	500	173.2	34
	10	Auditor general	500	78	15
	11	Mberibe Atan rd	300	84	28
	12	B. M. substaions	500	244	48
	13	Police s/s, EHE	500	99	19.8
	14	Stallion II	300	90	30
	15	4.2	500	132	26
	16	SSG II	500	40.7	8
	17	Agaha Gardens	300	41	13.7
	18	De Castle	500	122	24
	19	Akpan Ekpo	300	132.5	44
	20	K line I	300	99	33
	21	Ambassador Edem	500	0.3	0.0006
	22	Ultra fit	500	159.6	32
	23	Lamuta	500	118.5	23.7
	24	G. M. Okon	500	103.6	21
	25	Etiebet II	300	97	32
	26	D. Line	300	92	30.6
	27	Etiebet I	300	55	18
	28	Engineer Udoh	500	56	11
	29	B. Line II	500	58	11
	30	B. Line I	300	108.6	36
	31	SSG I	300	123	41
	32	Akpan Isemin	500	72	14
	33	K. Line II	300	95	31.7
2nd Zone	1	Use Offot I	500	211.4	42
	2	Ekpri Nsukara I	300	183.6	61
	3	Anglican	500	337	67
	4	Ibiaku Offot	300	178.4	59
	5	Adiaha Obong	300	210.4	70.1
	6	Awua Hospital	500	316.7	63.3
	7	Akpan Etuk	500	332.4	66
	8	Chattered Bank	315	248.6	79
	9	Barracks road II	500	208.1	41
3rd Zone	1	Osongama II	500	76	15
	2	Osongama II	300	92	30.7
	3	Osongama I	500	184	36
	4	Fiver star	500	292	58
4th Zone	1	Water works, Legislators	500	99	19
	2	Uyo tech. incubation centre	500	4	0.008
	3	Idak-Eyop	500	360	66
	4	St. Phillips African church	500	167.6	3
	5	St. George Catholic church	500	142	28
	6	Johnson	500	215	43
	7	IDC(ministry of industry)	500	5.6	0.01

Source : Jiyoda Engineering Limited, 2007.

Table 4b: Summary of Load Reading Ikot Ekpene.

S/N	Substation name	Transformer rating (kVA)	Computed load (kVA)	Percentage loading [%]
1	Urua Otoh	300	184.5	61
2	Market Road	500	187	37.4

Source: Jiyoda Engineering Limited, 2007.

EXISTING DISTRIBUTION NETWORK

There is only one functional 33/11kV injection substation in the city of Uyo and this is located along Oron road. It consists of the following: 2 x 15MVA 33/11 kV transformers, 4 x 11kV feeders. This is fed from Uyo 1 33kV feeder from the transmission substation. Another injection substation consisting of 2 x 15 MVA 33/11kV transformers, 2 x 11kV feeders is located by the state secretariat. This substation is completed but not yet commissioned. The third injection substation is located in the industrial area of the city, this consist of: 2 x 7.5 MVA 33/11kV transformers, 2 x 11kV feeders. This is again completed but not yet commissioned. The fourth injection substation is located at the university and it consist of: 1 x 2.5 MVA 33/11kV transformer, 1 x 11kV feeder. The fifth injection substation is located at Le Meridian Hotel and it consists of: 1 x 7.5 MVA 33/11kV transformer, 2 x 11kV feeders (Jiyoda Engineering, 2007).

DISTRIBUTION SUBSTATIONS

There are all together 364 Distribution substations within the metropolis of Uyo and the breakdown can be found in Table 5a (Ibom Power Company, 2007). A breakdown on the basis of the four zones and the details for each network is divided into 4 zones and the details for each network on zone basis are shown in Tables 5 a and b. There is only one injection substation in Ikot Ekpene town and it consists of: 1 x 7.5MVA 33/11kV transformer, 1 x 15MVA 33/11kV transformer and 2 x 11kV feeders (Jiyoda Engineering, 2007). The 15MVA transformer is bad and out of service leaving only the 7.5MVA to serve the town and its environs. In fact the 15MVA was relocated from Eket and was found bad on attempt to energize it.

There are all together 53 distribution substations in Ikot Ekpene and the breakdown can be found in Table 6 all the distribution substations in the town are rated 11/0.415kV. Similarly, there is only one injection substation in Eket and it consists of: 2 x 15MVA 33/11kV transformers and 3 x 11kV feeders. One of these transformers is bad and out of service leaving just one transformer to serve the town.

The total number of distribution substations in Eket is 94. The breakdown can be found in Table 6 of this total, there are 86 x 11/0.415kV substations and the remaining 8 are 33/0.415kV substation.

LOAD SURVEY

Load measurements could only be carried out in 53 substations in Uyo as stated earlier. The maximum percentage loading recorded for any transformer is 79% and this is on the dedicated transformer located at the chartered Bank, Uyo.

The measurement was made during the day time when the bank was fully operational. The transformer size is 314kVA. The two lowest percentage loading recorded are 0.008 and 0.01 respectively and these occurred at a Uyo technical incubation centre which is not yet operational and the Ministry of Industry which was closed due to the national Strike (Ministry of Power and Steel Uyo, 2007).

The entire load on Ambassador Edem 11/0.415kV distribution substation which has a reading of 0.3kVA must have been switched off. The average loading of 34% is applied to the installed distribution transformer capacity in Uyo as shown in Table 5a.

Equivalent load = 34% x 142,560
= 48.47MVA

Assuming a Power factor of 0.9
∴ Equivalent load =43.6 MVA

Only three measurements were made in Ikot Ekpene town and it would be difficult to base any meaningful deductions on these, while no measurement was recorded during the visit in Eket as there was massive load shedding going on.

LOAD ESTIMATION

The installed capacity at 33kV at Uyo 132/133kV substation is 2 x 40 MVA = 80MVA. This capacity is not for Uyo town alone as it includes supply to Abak and Ikot Ekpene. Based on the rating of 150mm^2 conductor at 33kV, the capacity of the three 33kV feeders, Uyo feeder 1, Uyo feeder 2, and the industrial feeder can be up to 3 x 23 MVA = 69MVA

The maximum load recorded on Abak feeder is 11MW. If it is assumed that both Abak and part of Uyo share the load equally, the load for Uyo would be:

$$= \frac{11}{2} MW = 5.5.MW$$

∴ Total of 35MW

I
f the power factor is assumed to be 0.9,
Equivalent MVA = 35/0.9 = 38.8MVA

This load is about 10MVA lower than the estimated load from the survey. The gap could have been more if the loads measured were any where close to the peak loading. The only functional injection substations is the one at Oron Road with 2 x 15MVA=30MVA. The two other new injection substations, one at the state secretariat with 2 x 7.5MVA and another one at the industrial estate with 2 x 7.5MVA are yet to be commissioned (Ministry of Power and Steel, Uyo, 2007).

The total capacity of these two are commissioned and connected to the load would be=75MVA. If the capacities of the 1 x 2.5MVA at Uniuyo and 1 x 7.5MVA at Le Meridian Hotel are added, the total would be equal to 85MVA.

Table 5a: Uyo Distribution Transformers.

Types of Transformer	11/0.415kV		33/0.415kV		Total Quantity	Total Capacity (kVA)
	Quantity	Capacity (kVA)	Quantity	Capacity (kVA)		
50	1	50	0	0	1	50
100	6	600	1	100	7	700
200	48	9600	4	200	52	10400
300	115	34600	35	300	150	45000
315	4	1260	2	315	6	1890
500	114	57000	13	500	127	63500
750	14	10500	0	0	14	10500
1000	3	3000	0	0	3	3000
1250	1	1250	0	0	1	1250
2500	3	7500	0	0	3	7500
	309	**125,260**	**55**	**18,530**	**364**	**143,790**

Source: Ibom Power Company 2007

Table 5b: Uyo Distribution Transformers on Basis of Zone.

Types of transformers	11/0.415kV		33/0.415kV		Total qty	Total capacity (kVA)
	Qty	Capacity (kvA)	Qty	Capacity (kVA)		
1ST ZONE						
50	1	50	0	0	1	50
100	5	500	0	0	5	500
200	41	8200	0	0	41	8200
300	68	20400	6	1800	74	22200
315	4	1260	0	0	4	1260
500	88	44000	1	500	89	44500
750	14	10500	0	0	14	10500
1000	1	1000	0	0	1	1000
1250	0	0	0	0	0	0
2500	0	0	0	0	0	0
	222	**85,910**	**7**	**2,300**	**229**	**88,210**
2nd ZONE						
50	0	0	0	0	0	0
100	1	100	1	100	2	200
200	3	600	1	200	4	800
300	16	4800	15	4600	31	9300
315	0	0	0	0	0	0
500	9	4500	3	1500	12	6000
750	0	0	0	0	0	0
1000	0	0	0	0	0	0
1250	0	0	0	0	0	0
2500	0	0	0	0	0	0
	222	**15000**	**20**	**6,300**	**51**	**21,300**
3rd ZONE						
50	0	0	0	0	0	0
100	0	0	0	0	0	0
200	1	200	2	400	3	600
300	12	3600	9	2700	21	6300
315	0	0	2	630	2	630
500	7	3500	8	4000	15	7500
750	0	0	0	0	0	0
1000	0	0	0	0	0	0
1250	0	0	0	0	0	0
2500	0	0	0	0	0	0
	20	**7,300**	**21**	**7,730**	**41**	**15,030**
4th ZONE						
50	0	0	0	0	0	0
100	0	0	0	0	0	0
200	3	600	1	200	4	800
300	19	5700	5	1500	24	7200
315	0	0	0	0	0	0
500	10	500	1	500	11	5500
750	0	0	0	0	0	0
1000	2	2000	0	0	2	2000
1250	1	1250	0	0	1	1250
2500	1	2500	0	0	1	2500
	36	**17,050**	**7**	**2,200**	**43**	**19,250**

Table 6: Ikot Ekpene and Eket Distribution Transformers.

IKOT EKPENE						EKET				
Types of Transformer	11/0.415kV		33/0.415kv		Total Capacity (kVA)	11/0.415kV		33/0.415kV		Total Capacity (kVA)
	Qty	Capacity (kVA)	Qty	Capacity (kVA)		Qty	Capacity (kVA)	Qty	Capacity (kVA)	
100	5	500	-	-	500	5	500	1	100	600
200	8	1600	-	-	1600	14	2800	1	200	3000
300	20	6000	-	-	6000	27	8100	4	1200	9300
315	-	-	-	-	-	-	-	1	315	315
500	20	10000	-	-	10000	37	18500	1	500	19000
1000	-	-	-	-	-	3	3000	-	-	3000
	53	**18,100**	**-**	**-**	**18,100**	**86**	**32,900**	**8**	**2,315**	**35,215**

If the existing maximum load to Abak and Ikot Ekpene (11+16=27/0.9) =30MVA are added to this value, the total would be 115MVA. It is obvious that there is no way the existing supply capacity of only 80MVA at 132/33kV can meet the requirement if the injection stations are anywhere close to full capacity.

ESTIMATION OF CAPTIVE GENERATION AND SUPPRESSED LOADS

The total load could be much higher if the captive generation by industries commercial/business enterprises or individuals is taken into consideration. Almost every household or commercial/business unit has one form of Power generation or the other and this means the captive generation could be as high as 40%.

Suppressed loads are new loads not connected to the system because of the low voltages generally experienced in most areas of the network. This low voltage can stem from over loading of the main power transformers or distribution transformers. This unconnected load could be as high as 20%.

The estimated load = 48.5MVA + Captive Generation + Suppressed load =48.5 + 40% of max. load recorded + 20% of the max. load record.

= 48.5 +60% x 48.5

= 77.6 MVA

There is currently only one functional 7.5MVA 33/11kV tied to Aba-Uyo 33kV line but currently fed from Uyo. To arrest the massive load shedding going on in Ikot Ekpene, an attempt was made sometimes ago to increase the capacity by 15MVA when one transformer was transferred from Eket to Ikot Ekpene. On attempt to commission the transformer, it was discovered that it was bad and nothing has been done about the capacity increase to date. Thus the load in the town is pegged to about 6.5MV.

The situation in Ikot Ekpene is similar to that of Uyo in terms of captive generation, but the level could be higher since the Ikot Ekpene is deliberately under fed with the injection capacity pegged to 7.5MVA since efforts to increase it to 22.5MVA had failed. This means the captive generation in Ikot Ekpene town could be as high as 50% of the existing load. Similarly, the suppressed load in Ikot Ekpene could be as the actual existing load i.e. 100%.

The estimated load at Ikot Ekpene is:

= Existing load + Captive generation +
Suppressed load

= 7.5MVA + 50% +100

=18.75MVA

Finally, there two 132/33kV transformers at Eket, one rated 45MVA and the other 60MVA corresponding to the available capacities on the two halves of the bus bars. The max. load recorded so far on each transformers is T2B = 18MW ad T1B=15MW.

There are altogether 4 x 33kV feeders, one to Abak, one to Onna, One to Mbo and the other to the only 333/11kV injection at Eket. The injection substation has two 15MVA transformers, one of which is bad leaving only one to serve the entire community. Similar to Ikto Ekpene, the load in Eket is pegged to 13MW. The captive generation in Eket town would be more than Uyo because of having to peg the load to a half of the original capacity. In fact, most of the industrial and commercial concerns would be permanently on captive generation. It could be as high as 60%.

Similarly, the suppressed load could be as high as the actual existing load i.e. 100%

Thus the estimated load for Eket could be as high as

=13MW + 60% for captive generation + 10% suppressed load

=34MW (38MVA) at 0.9 power factor

But the installed distribution transformer capacity is 28.40MVA, which only about 75% of the estimated load. It is possible that the distribution capacity is limited to this level because of lack of capacity at the injection substation.

CONCLUSION

Bent or broken poles, displaced and damaged straps, broken cross arms, broken insulators, snapped strays, damaged feeder pillars, leaking transformers, overloaded transformers, bushy distribution substation, and broken insulators are some of the major defects identified in the electrical distribution system in Akwa Ibom state. The total number of defects recorded for each town is Uyo (98), Ikot Ekpene (20), and Eket (18).

The federal government, state government, PHCN, who are the owner of the facilities, and stake-holders involved in utilization of these facilities should endeavor to help in the maintenance of these facilities. The issues observed in paper are responsible for the lack of end-user power supply, even if there is adequate power from the transmission end of the network.

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