Simulating Power Distribution Network In Nigeria – The Ikpoba-Hill District Network As A Case Study

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ABSTRACT:- The difficulty encountered by the Power Holding Company of Nigeria (PHCN) in the distribution of the insufficient electrical energy generated, has led to this research. Ikpoba-hill network is one of the busiest and high demand networks in Nigeria. It is a 33/11 KV substation which experiences blackout especially with the many industries within its area of jurisdiction. The non availability of proper location as well as details about the transmission lines, poles and transformers calls for concern. To simulate the power distribution network, the Geographical information system (GIS) and the Global positioning system (GPS) techniques were used. Through the use of the GIS, consumer indexing (CI) can effectively be made to manage information on distribution of electricity to consumers and information describing the attributes of each consumer such as location, consumption pattern, the various circuit connections, feeders, etc. Both the geometric data and attribute data collected are entered into the system through MS Excel and later exported into Arc View. Results of the study, show how low loss reduction strategy can be formulated for the Ikpoba-hill network and hence for Nigeria.

Keywords:- data, distribution, GIS, GPS, map, network.

1. INTRODUCTION

Electricity generation in Nigeria is generally regarded to be below the demand. This has therefore resulted in energy supply crisis which the PHCN and government are trying to resolve. This situation is worsened by the network distribution problems which are due to the absence of up to date information about the facilities of the PHCN. Distribution systems network carries electricity from the transmission system and delivers it to the consumer. Such network would include medium voltage power lines, substations, pole monitored transformers and low voltage (less than 1 KV) distribution wiring meters. All modern distribution systems starts as the primary circuit leaves the substation and ends as the secondary services enter the consumers meter sockets. Initially energy leaves the substation in a primary circuit usually with all three phases [1]. Since the pre-independence era, most Nigerian power supply through the few towns that had electricity saw poles at long distances that carried electrical energy through forest/villages or without proper protection and connections which were made both legally and illegally. There was no functional geo-database of the available facilities. The injection substations, transformers and even the poles were not properly documented. At times some facilities could be dumped and not even documented. In cases where such facilities were documented, access to the areas was difficult to locate. Problems of identification of amenities in the feeders were also very difficult if not impossible to locate. Issues of broken down facilities which were not known to the PHCN also affected distribution.[2] Currently with the privatization in the power sector, some towns and cities can get power though majority of the towns still have epileptic power supply which are still due to the mode of distribution. The Ikpoba Hill 33/11KV substation which is part of Benin City in Edo State has four feeders namely, Asaba road feeder, (public) Federal Housing estate feeder (public), BDPA (Bendel Development Property Authority) feeder (public) and the new Auchi road feeder (public). From this 33/11 KV substation consumers can directly take electricity through the transmission network system. To improve on this distribution performance, this write-up tends to discuss the result of its simulation using the GIS and the GPS [3] systems and hence to formulate a possible policy for electricity distribution.

2. MATERIALS AND METHODS

The GIS technique (which is a computerized tool for capturing, storing, checking, integrating, manipulating, analysing and displaying geographical information) and the GPS device (which has the capability to calculate both latitudes and longitudes of locations thereby showing available paths, roads or paths leading to utilities) work hand in hand. While one locates, the other integrates such information on the events [4]. This simulation process includes the following stages:-

- Collecting information of the existing electrical distribution network
- Creating of an electrical network using the GPS data
- Using existing GIS packages for customizing of electrical network application
- Understanding the business process flow of power distribution network
- Design of a database to minimize the data redundancy and effective functioning of the application
- Customization of the software to fulfil the application needs.

With the values of the tables for the various feeders as indicated, the study concentrated into three areas to summarise the process of simulation. First geometric and attribute data for the various feeders, transformers, electric poles, cables etc were captured with the help of the Garmin 76S map GPS in differential mode. A participatory approach was used in the GIS mapping with the PHCN lines men involved as they were better informed in identifying the properties. Guidelines and assistance from the surveyors were strictly adhered to as the instruments are controlled and used only by them. The next stage involved the development or generation of network (point and line) using the GIS software. After this important stage, an application programme was developed using Visual Basic and Map objects. This involved the planning stage, which is segmented into five phases:

- a) data acquisition
- b) data processing
- c) database design and formulation
- d) database implementation
- e) information presentation

In summary, placing the GPS instrument at the bottom of each electric pole, the coordinates was obtained. This was done street by street in relation to the transformer that served them. Similarly the coordinates for the transformer as well as the feeders were found and documented. During the geometric data acquisition, the attribute data of each entity in each of the feeders (Poles, cables, transformers injection substation, etc) were captured. To achieve the purpose of this work, the relational data structure was used. The data are stored on a simple manner such as tables. Each table contain items called fields about a particular object. The data structures were executed using Arc view 3.2a In this case the entities identified are: i) Low tension electric poles, ii) High tension electric poles, iii) Low and High Tension (dual) electric poles, iv) High Tension cables, v) Low Tension cables, vi) High and Low tension cables, vii) Underground cable, viii) Transformers, ix) Feeders. When a relation database was formed in Arc view 3.2a the following was achieved:-

LT Poles (Pole _ ID, Easting (m), Northing (m), Location, Type, Status, Cable Size, Remark)
HT Cable (Street name, Cable Size (mm), Length _ meters)
Dual Cable (Street Name, Cable size (mm), Length _ meters)
LT Cable (Street Name, Cable Size (mm), Substation Attached, Length _ meters)
Transformer (Trans _ ID, Easting (m), Northing (m), Substation Name, Location, Make, Year Made, Impedance, Capacity, Remarks)
Injection Station (Name, Location, Make, Capacity, Year _ Installed, Max. Load)

3.0 RESULTS

From the simulation, the results obtained are always displayed in form of **reports, queries, charts etc.** These are provided by the customer information services through an established electrical call centre (ECC). However the overall information using Arc view 3.2a is shown in Fig 3.1 where entities are organized into themes. The spatial space operation during this simulation was carried out through **query** generation. By this, information stored in the data base was retrieved pertaining defined attributes to answer spatial related questions using structured query Language (SQL). One of such queries was on the determination of concrete Electric poles carrying High Tension Cable.

Query
Type of analysis:- Database Extraction
Syntax Model: ([Type] = "concrete") and ([Cable_ Type] = "HT")

Result to Query
Total no. of RMU,S = 0
Total no. of HT concrete poles = 226
Total no. of HT wooden poles = 6
Total no. of dual concrete poles = 122
Total no. of dual wooden poles = 4
Total no. of LT concrete poles = 629
Total no. of LT wooden poles = 497
Total no. of Transformers – Public = 227
Total = 42

Total length of Cables
Total length of HT cable = 7156.255 m
Total length of LV cable = 32594.161 m
Total length of HT + LV cable = 4412.525 m
Where: HT – High Tension
LT – Low tension
LV – Low voltage

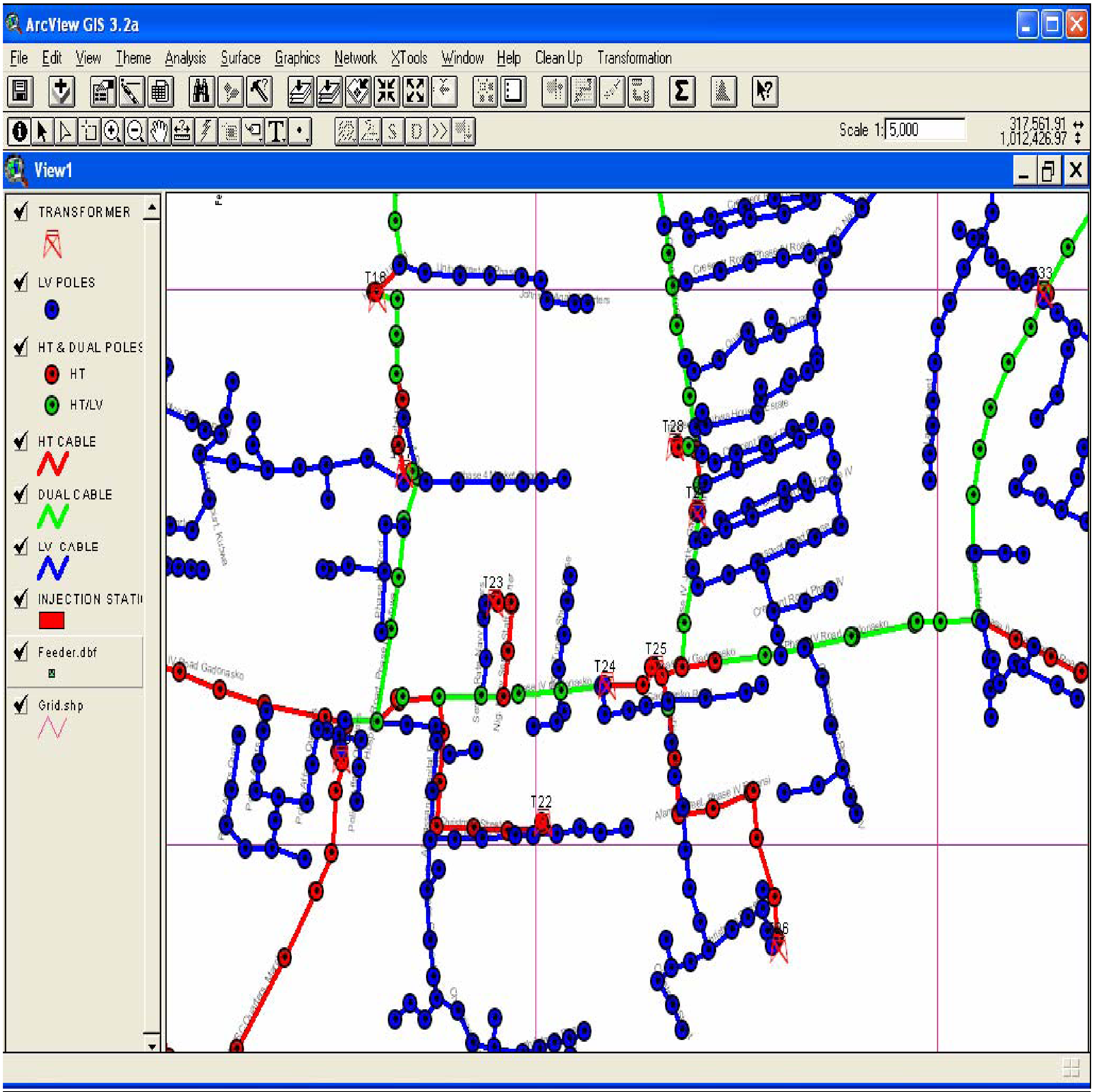

Fig.3.1: Output of electricity distribution in Ikpoba Hill business district.

PHCN – BENIN DISTRIBUTION ZONE
TRANSFORMER LOAD READING

DISTRICT: IKPOBA HILL

S/NO	NAME OF SUBSTATION/CAPACITY	LOAD READINGS				TRANSFORMER MAXIMUM LOAD	PERCENTAGE LOADING	REMARKS
		R	Y	B	N			
1	Zico 300kva	005	119	174	144	278.24	52.95%	*
2	Aduwawa I 500kva	425	508	307	106	659.60	64.50%	*
3	Ojo 300kva	96	96	92	23	417.36	247.52%	
4	Survey 300kva	337	216	198	101	417.36	68.05%	*
5	Ivav 500kva	155	143	140	23	695.60	22.09%	
6	N S O 500kva	245	262	352	93	69560	45.62%	*
7	Igbinosun 500kva	502	248	379	195	695.60	63.45%	*
8	Big Joe 500kva	432	691	382	152	695.60	79.40%	*
9	Ahanor 500kva	233	149	280	102	695.60	36.61	*
10	Evbuomodu 300kva	327	319	211	126	417.36	78.51%	*
11	Aduwawa II 500kva	366	228	420	204	695.60	56.93%	*
12	Adima 300kva	168	221	160	065	417.36	49.04%	*
13	Omogiate 300kva	138	145	053	093	417.36	34.26%	*
14	Urora I 500kva	427	315	345	100	695.60	56.88%	*
15	Urora II 500kva	407	516	472	072	695.60	70.01%	*
16	Imosuen 500kva	241	285	170	084	695.60	37.38%	*
17	Okpagha I 300kva	479	333	392	052	417.36	106.54%	*
18	Okpagha II 300kva	320	247	249	052	417.36	69.32%	*
19	P I S H S 200kva	008	012	000	011	278.24	3.715	*
20	Cattle market 300kva	567	489	583	091	417.36	138.17%	*
21	Enoguie palace 200kva	004	133	000	146	278.24	33.90%	*
22	Pipeline 300kva	252	269	154	111	417.36	62.78%	*
23	Sunny my son 500kva	122	115	381	245	695.60	41.365	*
24	2 + 2 500kva	307	336	559	207	695.60	67.52%	*
25	Urora III 300kva	164	202	116	066	417.36	43.77%	*
26	Azogba 300kva(331.415)	001	028	022	020	417.36	5.67%	*
27	Idokpa 200kva(331.415)	082	016	135	040	278.24	41.09%	*
28	Ayen 300kva(331.415)	000	000	070	070	417.36	65.01%	*
29	Army Signal I 300kva	273	296	128	117	417.36	45.44%	*
30	Army Signal II 300kva	246	144	057	122	417.36	45.44%	*
31	Hollow Block 300kva	93	78	50	63	417.36	22.68%	*
32	Omoruyi 300kva	087	337	202	171	417.36	63.65%	*
33	Erhamwen 300kva	027	025	024	028	417.36	10.46%	
34	nabteb i 500kva	292	250	283	042	695.60	41.55%	*

TABLE 1: ASABA ROAD FEEDER (PUBLIC)
PHCH – BENIN DISTRIBUTION ZONE
TRANSFORMER LOADS READING

S/N	NAME OF SUBSTATATION /CAPACITY	LOAD READINGS				TRANSFORMER MAXIMUM LOAD	PERCENTAGE LOADING	REMARK
		R	Y	B	N			
1	Aduwaika 300KVA	199	241	198	036	417 - 36	53.83%	*
2	Owie 500kva	190	314	280	130	695.60	44.23%	*
3	Palace 500kva	325	314	326	051	695.60	49.55%	*
4	Agbowoii 500kva	183	155	088	070	695.60	24.20%	*
5	Agbowoi 500kva	1800	238	200	048	695.60	31.91%	*
6	Sonowe 300kva	321	300	168	099	417.36	63.73%	*
7	Pipeline 500kva	103	011	071	085	695.6.	12.94%	*
8	Philova junction300kva	103	026	090	090	417.36	24.68%	*
9	D.A.E 100kva	079	096	017	071	139.12	63.02%	*
10	Phiova 500kva	196		484	489	695.60	59.90%	*
11	Liberty 500kva					695.60		
12	Igbinidu 50kva	055	056	077	026	695.60	10.25%	
13	Ebikade 500kva	422	524	346	097	695.60	66.56%	*
14	Ugokpolor 500kva	267	239	288	042	695.60	37.19%	*
15	Unity200kva	085	132 1	166	030	278.24	43.49%	*
16	Adune200kva	152	122	172	052	278.27	59.66%	*
17	Iyobosa 500kva	263	215	224	076	695.60	37.28%	*
18	Goldeoc 500kva	130	174	173	016	695.60	23.62%	*
19	Bulkeve500kva	217	212	182	032	695.60	30.81%	*
20	GT Plaza 300kva	100	065	122	045	417.60	26.52%	*
21	Osasumulen 200kva	158	084	082	064	248.24	46.60%	*
22	Ifosuyi 300kva	186	171	210	050	412.36	49.28%	*
23	Asowata 315kva	331	224	226	060	438.23	62.45%	*
24	Ihase500kva	110	101	125	018	695.60	16.96%	*
25	Airhunmwunde 300kva	336	306	218	125	417.36	78.67%	*
26	Evbadoloyi 300kva	225	197	260	065	417.36	59.66%	*
27	Uwanai 500kva	369	620	507	130	695.60	77.92%	*-
28	Ugbozigue 500kva	319	340	290	085	695.60	50.99%	*
29	Ikhuenirei 500kva	135	165	131	065	695.60	23.77%	*
30	Ikhueniro II 500kva	135	037	096	094	695.60	17.35%	*
31	Nepacord I 500kva	037	033	034	007	695.60	5.75%	*
32	Nepacord II 300kva	007	023	000	018	417.36	3.83%	*
33	Iguomon I 500kva	204	129	123	051	695.60	24.30%	*
34	Iguomon II 500kva	116	004	010	104	695.60	11.21%	*
35	Amufi 300kva	072	062	015	043	417.36	15.33%	*
36	Uyigue 500kva	296	269	362	067	695.60	47.63%	*
37	Eikhame 300kva	382	162	175	199	417.36	73.32%	*

Table 2: Federal Housing Estate Feeder (Public)
PHCN-BENIN DISTRIBUTION-ZONE
TRANSFORMER LOAD READING

S/ON.	Name of substations/capacity	LOAD READINGS				TRANSFORMER MAXIMUM LOAD	PERCENTAGE LOADING	REMARKS
		R	Y	B	N			
1	Worker's village 300kv&	053	095	055	044.	404.36	19.73%	*
2	Street 33 500kv&	463	323	254	152.	695.60	57.12%	*
3	Street 24 500kv&	153	146	111	039.	695.60	21.52%	*
4	Street 21 500kv&	233	216	257	044	695.60	35.94%	*
5	Street 3 300kv&	221	283	165	092.	417.36	60.79%	*
6	500kv&	298	275	128	127.	695.60	39.68%	*
7	300kv&	432	524	271	157.	417.36	110.54%	*
8	500kva	777	700	312	338.	695.60	101.93%	*
9	Street 49 500kva	283	222	338	053.	695.60	46.29%	*
10	Integrated 200kva	186	163	055	109.	278.24	61.46%	*
11	Chorale							-
12	Uteh I							-
13	Uteh 11							-
14	Barrack 11 500kva	501	389	399	105.	695.60	66.80%	*
15	Barrack 1 300kva	192	250	50	178.	417.36	53.51%	*
16	Palace 315kv a	104	095	103	012.	438.23	23.89%	*
17	St Jude 300KVA	392	200	262	077.	417.36	70.36%	*
18	Street 2 500kva	417	345	314	039.	695.60	53.43%	*
19	Golden 300kva	211	252	279	074.	417.36	65.17%	*
20	Ogieoba 300kva	223	171	201	047	417.36	51.27%	*

Table 3: B.D.P.A Feeder (Public)
PHCN – BENIN DISTRIBUTION ZONE
TRANSFORMER LOAD READING

S/NO.	NAME OF SUBSTATIONS / CAPACITY	LOAD READINGS				TRANSFORMER MAXIMUM LOAD	PERCETAGE LOADING	REMARKS
		R	Y	B	N			
1	BDPA 1 500kva	347	301	193	126	695.60	46.34%	*
2	BDDA 11 500kva	503	670	454	146	695.60	84.96%	*
3	QUEET Edo 200kva	310	114	199	168	278.24	94.76%	*
4	Ukopghodu 300kva	2969	120	94	137	417.36	49.52%	*
5	Signol 500kva	612	658	439	201	695.60	91.29%	*
6	Igbodaro 300kva	217	233	152	69	417.36	53.59%	*
7	Abasuyi 500kva	878	935	466	308	695.60	23.97%	*
8	Poga 500kva	432	299	520	184	695.60	68.77%	*
9	Poda reliet 200kva	296	188	352	209	278.24	115.61%	*
10	Sunny foam 300kva	437	375	419	056	417.36	102.79%	*
11	Owenaze 200kva	060	131	268	123	278.24	62.54%	*
12	Eweka I 500kva	390	395	396	090	695.60	60.95%	*
13	Eweka ii 200kva	190	132	150	053	278.24	62.90%	*
14	Uruala 300kva	321	380	188	160	417.36	83.78%	*

Table 4: New Benin Town Feeder (Public)
PHCN – BENIN DISTRIBUTION ZONE
TRANSFORMER LOAD READING

S/NO.	NAME OF SUBSTATIONS / CAPACITY	LOAD READINGS				TRANSFORMER MAXIMUM LOAD	PERCETAGE LOADING	REMARKS
		R	Y	B	N			
1	Edokpolor 200kva	96	107	68	25.	278.24	35.46%	*
2	Ugege 500kva	298	344	286	49.	417.36	78.03%	*
3	Jemila 500kva	267	388	237	106.	695.60	51.99%	*
4	Agbowu 500kva	267	138	297	110.	695.60	38.91%	*
5	Oboseki 300kva	93	141	155	64.	417.36	36.18%	*
6	Ogesota 500kva	460	541	246	143.	695.60	66.99%	*
7	Idehen 500kva	107	115	103	020	695.60	16.53%	*

Discussions

From the results shown it is very evident that the company in charge of power distribution in Ikpoba-Hill which is the PHCN and other available companies would be able to monitor the status of the facilities on the ground. Similarly they will be able to account for the total length of cable in each of the feeders. Cost of replacing can be properly calculated for. There will be proper prioritization of facility replacement based in available information. Up to date information about the facilities will be known. Electricity call centres will be able to do proper documentation of problems in the feeders and as such provide solutions when needed. Since cables run across the road, they can also serve as street guide in the absence of a street map.

4.0 CONCLUSION

From the simulation carried it has been found that complete information system for the distribution of electrical energy, can be used to improve planning, maintenance and management standards. This on the other hand can improve on the distribution of the insufficient energy generated. From observed results it shows that a low loss reduction system has been developed for the PHCN. The use of the GIS and the GPS techniques are very important to development. This new approach to Nigeria will provide accountability and erase sharp practices as everything will be accounted for. If a GIS department is established in all zones or district offices of the PHCN then the country will be able to manage all she is generating.

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