

Electricity Distribution Engineering and Geographic Information System (DeGIS).

OLANIYI Saheed Salawudeen, Nigeria and USMAN Rashidat, Nigeria

Key Words: GIS, Electricity Distribution, Geodatabase, Analysis, Arcview 3.2a

SUMMARY

In pursuance of an effective electricity distribution in Nigeria, the Power Holding Company of Nigeria has adopted the Geoinformation Technology in the management of its facilities so as to provide adequate power supply for the resident, industrial and commercial sector of the economy. Because of the need to implement the use of GIS in electricity distribution engineering, Power Holding Company of Nigeria, (PHCN) Plc has entered into partnership with Hafmani Nigeria Limited, a GIS and Mapping Consultant firm.

The aim of the project is to locate and map all the facilities of PHCN. This mapping involves the collection of both the geometric and attributes data of those entities identified. This was done in collaboration with the staff at the distribution department of PHCN.

The GIS technology deployed involves the use of both computer based wares. Both geometric data and attribute data collected was entered into the system via Ms Excel and later exported into Arcview GIS 3.2a. The database was created using Arcview 3.2a. Series of spatial search /query operation was carried out to provide answer to pending questions that will lead to effective management of the facilities. The end products are customized maps, tables, softcopy of the map and project report.

In order to maintain and update the facilities, some staffs of PHCN had been trained on how to use GPS as well how to update the new facilities installed in the feeder.

This paper is about the Planning, techniques and technology deployed for facility mapping of Kubwa II feeder, Abuja. Nigeria.

Electricity Distribution Engineering and Geographic Information System (DeGIS).

OLANIYI Saheed Salawudeen, Nigeria and USMAN Rashidat, Nigeria

Key Words: GIS, Electricity Distribution, Geodatabase, Analysis, Arcview 3.2a

1. INTRODUCTION

It is the talk that Information Technology has come to stay in the 21st century, though it has been in existence for long but little cognizance was paid to it. The aspect of the Information Technology that is saddled with the usage of Computer wares to solve spatial problem is refer to as Geo-Information and Communication technology (Geo-ICT) or Geographic Information System (GIS).

GIS is the computerized tools for capturing, storage, checking, integrating, manipulating, analyzing and displaying of geo-information.

Electricity distribution is the process of transporting electrical energy from the transmission point to the end users points.

Electricity is an essential part of our everyday lives that we often take for granted. We take it for granted, that is, until we have to do without power for one reason or another. We don't often actually see them, but behind the scenes many people are working to ensure that we have a clean, safe, reliable source of power; that we don't have unpredictable or inappropriate current to power our infinite variety of devices; and that the supply is there when we need it; and that it is, more or less, reasonably priced.

The evolution of Geo-ICT has revolutionalized the utility industries. Nigeria is not left out in the race of ICT, so also is Geo-ICT. Power Holding Company of Nigeria, Plc is one of the vibrant utility industries in the West Africa with over five (5) million subscribers. The ever increasing numbers of subscribers to the services of electricity call for the re-engineering of the electricity distribution strategy using the appropriate technology - GIS

2. ELECTRICITY DISTRIBUTION IN NIGERIA

The National Electric Power Authority (NEPA) was established by Decree No 24 of 1st April, 1972, with the amalgamation of Electricity Corporation of Nigeria (ECN) and Niger Dam Authority (NDA). NEPA was empowered to maintain an efficient, coordinated and economic system of electricity supply to all nooks and crannies of the nation.

Major power stations namely: Ijora, Delta and Afam Thermal Power Stations and Kainji Hydro Power Station serving more than two million customers nationwide. That propelled the nation's technological and industrial growth. NEPA has become the fastest and biggest growing electricity industry in Africa and indeed the developing world with a customer population of about five million.

The table below is the comparative status of the electricity supply systems from inception of NEPA in 1972 and 1997

Table 1: Status of Electricity Supply in Nigeria between 1972 and 1997

ELECTRICITY SUPPLY SYSTEM	1972	1997
Total Installed generating Capacity	532.6MW	5,958MW
Nation's Peak Demand	390MW	2,446MW
Length of 330KV Lines	1,262KM	5,000KM
Length of 132KV Lines	1,012KM	6,000KM
415 Volts Net-work	15,000KM	55,143KM

NEPA has made giant stride in the production and marketing of electricity to the nation and beyond. A principal beneficiary of NEPA's extended electricity programme is the Republic of Niger under the agreement with NIGERLEC (Niger Electric Company), that country's electricity monopoly.

Similarly, in September 1996, an undertaken was signed between NEPA and Communaute Electrique Du Benin (CEB) which is responsible for the production of and transportation of electric energy in the Republic of Benin and Togo.

NEPA has nine zones (Abuja, Benin, Enugu, Ibadan, Jos, Kaduna, Kano, Lagos, Yola) and 49 districts.

Nigeria has numerous sources of energy generation such as;

- Firewood
- Oil Products
- Liquefied Petroleum Gas (LPG) or Cooking Gas
- Natural Gas
- Hydroelectric Potential
- Wind Energy
- Solar Energy
- Biogas
- Nuclear and Geothermal Energy Sources
- Coal/smokeless coal briquette

With the present state of the technological advancement in Nigeria, much emphasis was placed on power generation through Hydroelectric and thermal sources. Nigeria has three hydroelectric stations and four thermal stations.

Table 2: Power Stations in Nigeria

S/No	Name	Type	Year_Construction	Output	Cost	Remark
1.	Kainji Station	Hydro	1968	760MW	N175 Million	
2.	Jebba	Hydro	1985	578.4MW	N800 Million	
3.	Shiroro	Hydro	1990	600MW	N800 Million	
4.	Afam	Thermal	1963	699MW	-	
5.	Lagos	Thermal	-	1320MW	-	Biggest in West Africa
6.	Delta IV	Thermal	1991	200MW	N2.2 Billion	
7.	Sapele	Thermal	1976	1020MW	-	

In 2005, National Electric Power Authority (NEPA) change its name to Power Holding Company of Nigeria (PHCN), Plc with the aim and objectives of providing effective power supply to the nooks and crannies of the country.

3. STATEMENT OF PROBLEM

Absence of up to date information about the facilities of the Power Holding Company of Nigeria, Plc is a great hindrance towards delivering effective power supply to the citizen of the country. The production of digital map and a functional geo-database of the facilities would assist in the adequate distribution of electricity in the following areas;

- i.) Updating and modification of information concerning facilities for electricity distribution such as injection station, transformers, electric poles, electric cable, etc.
- ii.) Faster and easier retrieval of information for instantaneous use in the area of planning, managing and monitoring of the facilities.
- iii.) Identification of the amenities in the Feeder so as to ascertain their condition and to know which one is due for replacement or repair.

4. AIM OF THE PROJECT

The main aim of the project is to use Geographic Information System to manage the facilities in each of the feeders towards effective distribution of electricity.

5. OBJECTIVE

The processes that led to the achievement of the aim stated above are as follows;

- i.) Capturing of the geometric and attribute data for feeder's injection station, transformers, electric poles, RMU, electric cables, underground cables, etc
- ii.) Creation of database (spatial/attribute) for the features in each of the feeder for updating based on their conditions.
- iii.) Performing spatial analyses on the electricity facilities geodatabase created as a sine qua non of the information need.
- iv.) Information presentation based on the analyses performed.

6. SCOPE

The scope of the project covered the following operations;

- i.) Reconnaissance
- ii.) Geometric data acquisition using GPS
- iii.) Attribute data acquisition
- iv.) GPS data downloading
- v.) Design and creation of spatial database using Microsoft Excel and Arcview GIS 3.2a
- vi.) Perform spatial analyses i.e. query generation using Arcview GIS 3.2a based on information need.
- vii.) Presentation of the required information in form of customized map and table.

7. METHODOLOGY

The GIS-mapping involved a participatory approach, which included collaborative effort with the Lines men of the Power Holding Company of Nigeria, Plc in each of the feeders.
These Lines men follow the Surveyors to identify the facilities in each of the feeders.

8. PLANNING

The project planning was carried in five (5) different phases as follows;

- i.) Data acquisition phase
- ii.) Data Processing Phase
- iii.) Database design and creation phase
- iv.) Database implementation phase
- v.) Information presentation phase

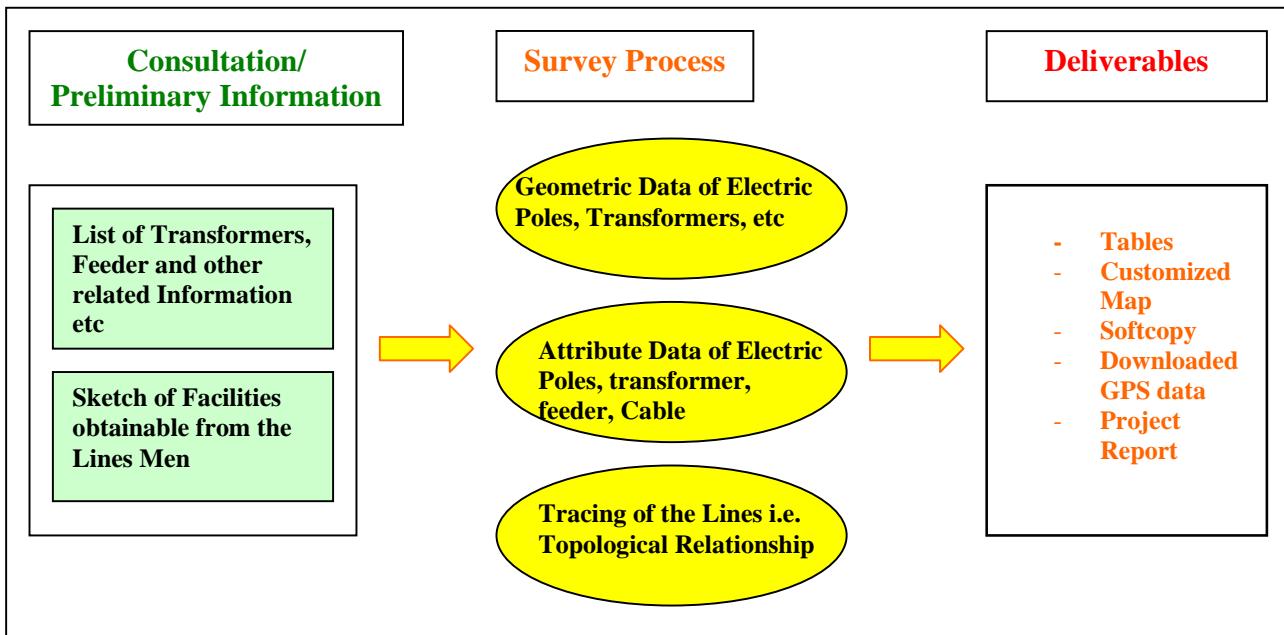


Fig. 1: Project Survey Process

9. HARDWARE AND SOFTWARE USED

The hardware used is basically digital hardware with the data downloading ability. The major hardware used are the Garmin 76S Map Global Positioning System in differential mode and the Computer system

The software used area as follows;

- i. Microsoft Excel for attribute data entry and Analysis
- ii. ArcView 3.2a for database creation, Visualizing Geo-information and Presentation.
- iii. Microsoft word for FrontPage Analysis

10 DATA ACQUISITION

10.1 Geometric Data Acquisition

The geometric data was acquired using Garmin 76S GPS in a differential mode. The GPS was placed at the bottom of each of the electric poles to obtain its X,Y Coordinate in UTM coordinate system. The Coordinate was obtained serially according to how the poles exist on the ground with the assistance of the linesmen. The coordinates of each pole was obtained street by street in relation to the transformer that serviced them. The coordinates of each of the transformer's locations were collected as well as that of the feeders.

10.2 Attribute Data Acquisition

During the geometric data acquisition, the attribute data of each of the entities in each of the feeders were also captured. The entities are Pole, cable, Transformer, Injection substation, etc. This was recorded in a notebook against the point identification number of each of the pole as well as their street name and the transformer that service each of poles and taken into consideration, the way the cable join (topological relationship), the cable size, etc.

11. GEODATABASE DEVELOPMENT/IMPLEMENTATION

A database is an organized, integrated collection of non-redundant data stored so as to be capable of use by relevant applications with the data been accessed through some logical path. Database referred to is a spatial database (Geodatabase) and it is the heart of GIS. This is the process whereby real world entities and their interrelationships are analyzed and modeled in such a way that maximum benefits are derived while utilizing minimum amount of data.

The geodatabase

The geodatabase supports an object-oriented vector data model. In this model, real-world entities are represented as objects with properties, behavior, and relationships. The object types include simple objects, geographic features (objects with location), network features (objects with geometric integration with other features), annotation features, and other more specialized feature types. The model allows you to define relationships between objects, as well as rules for maintaining the referential integrity between related objects.

Its purpose

The purpose of the geodatabase data model is to let you make the features in your GIS datasets smarter by endowing them with natural behaviors, and to allow any sort of relationship to be defined among features.

Its benefits

A principal advantage of the geodatabase data model is that it includes a framework to create intelligent features that mimic the interactions and behaviors of real-world objects.

A geodatabase stores geographic data in a commercial relational database. This means that geographic data can be administered centrally by information technology professionals and Arcview can take advantage of developments in database technology.

12. LOGICAL DESIGN

In order to implement the database design as defined by the system independent conceptual model, it is necessary to map in a system-specific model. Logical data modeling is the process by which the conceptual schema is consolidated, refined and converted to a system-specific logical

schema. It could also be termed as a database structure. Generally, there are several approaches to the structure, they are hierarchical structure, network, relational and object oriented approach. In this project, relational database structure was used. The data are stored in a simple record known as tables. Each table contain item of data called fields about a particular object. The objects area arranged along the rows and the field (attribute values) arranged along the column. The data structure was executed using Arcview 3.2a.

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 Cable
- v. Low tension Cable
- vi. High and Low Tension Cable
- vii. Underground Cable
- viii. Transformers
- ix. Feeder

The entities identified are used to form a relation database in Arcview 3.2a. The relation name and its attributes are as follows;

LT Poles (Pole_Id, Easting (m), Northing (m), Location, Type, Status, Cable Size, Transformer Attached, Remark)

HT & HT +LV 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_Man., Impedance, Capacity, Remarks)

Injection Station (Name, Location, Make, Capacity, Year_Installed, Max. Load)

The entities were organized into themes in Arcview 3.2a.

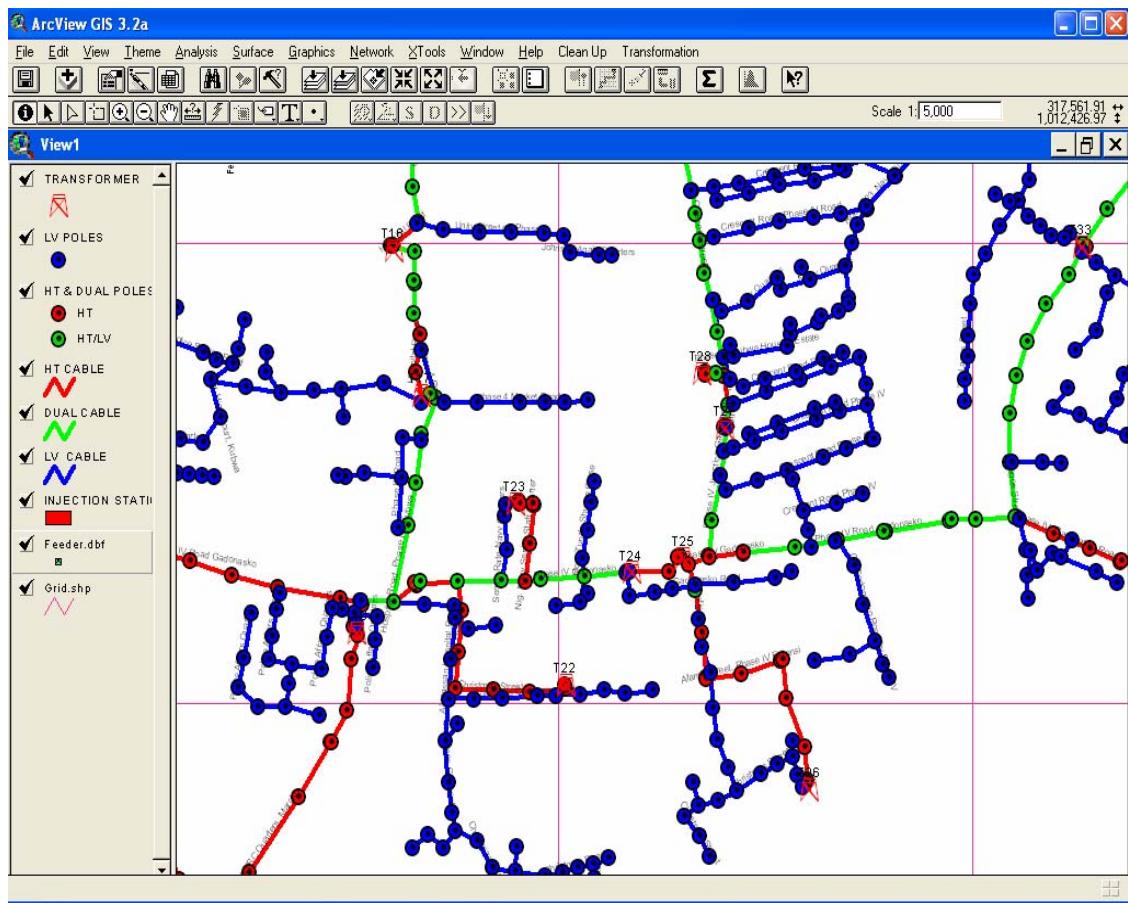


Fig. 2: Output of Electricity Distribution of Kubwa II Feeder, Abuja, Nigeria.

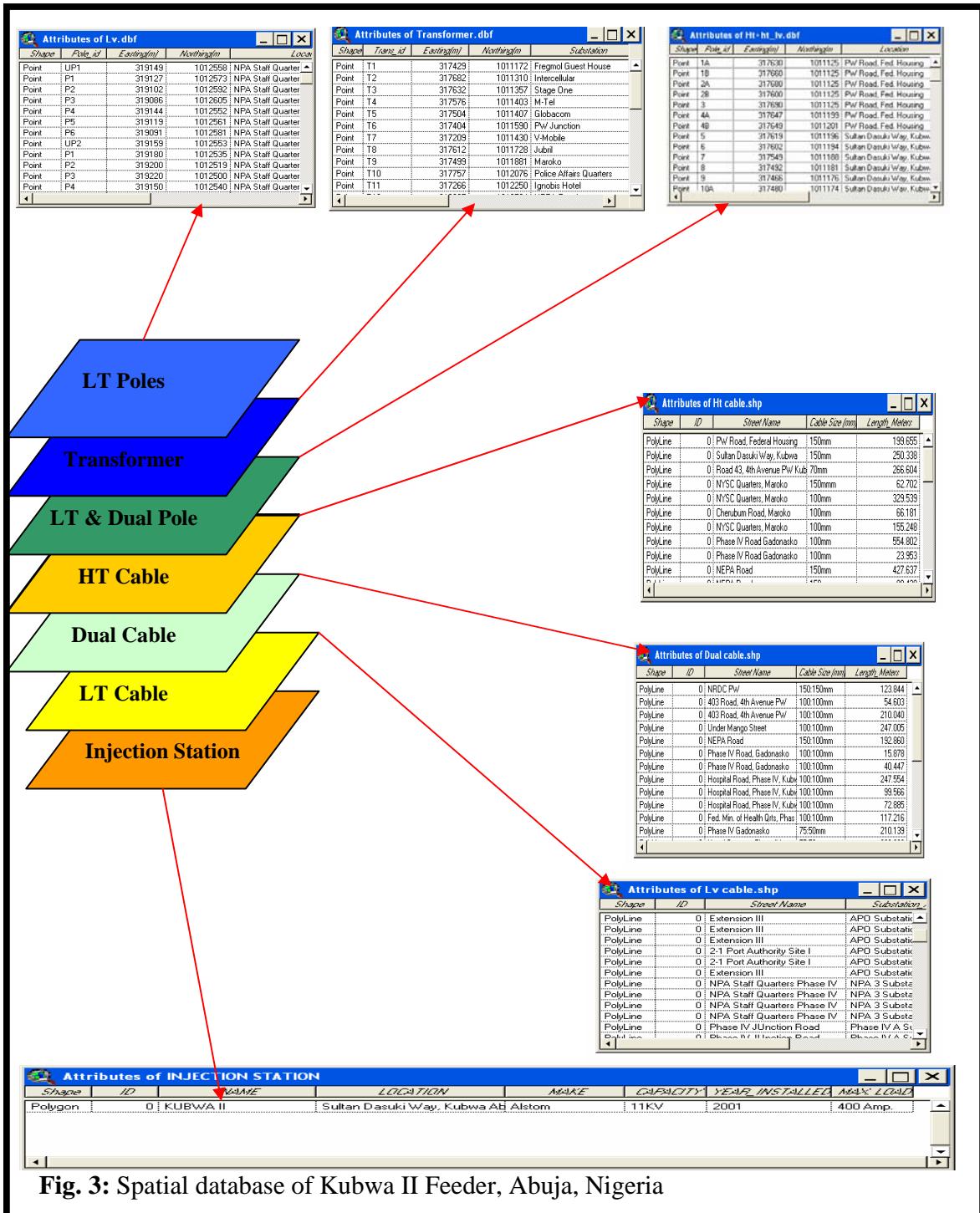


Fig. 3: Spatial database of Kubwa II Feeder, Abuja, Nigeria

13. SPATIAL SEARCH/QUERIES GENERATION

The distinction between Geographical information System and other Information Systems is in the area of spatial search/spatial analyses. Search operation is a GIS tool that is essential for processing or manipulating of data to suit user's need.

The spatial search operation for this project was carried out through query generation to retrieve information stored in the database pertaining to certain systematically defined attributes within the database to answer some spatially related questions. This operation involved the link between the database and the composite map of the project area. Queries were generated to provide answer to the application use of GIS in managing PHCN facilities and the results displayed in form of hardcopy map.

14. QUERIES AND PRESENTATION

Database query can be referred to as the selection of various combinations of various tables for examination; it involves the retrieval of information stored in the database using structured query language (SQL). However, the queries generated are basically through database extraction in Arcview 3.2a. Below is a sample of the queries generated.

Query

Type of analysis: - Database Extraction

Syntax Model: ([Type]= "Concrete") and ([Cable_Type]= "HT")

Explanation:

The query enables the determination of Concrete Electric poles that carries the High Tension cable.

The results of the queries generated to provide answer to some questions in Kubwa II Feeder is shown below;

ANALYSIS OF FACILITIES OF POWER HOLDING COMPANY OF NIGERIA, Plc KUBWA II FEEDER, ABUJA

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 POLE	=	122
TOTAL No. OF DUAL WOODEN POLE	=	4
TOTAL No. OF LT CONCRETE POLES	=	629
TOTAL No. OF LT WOODEN POLES	=	497
TOTAL No. OF TRANSFORMER		
PRIVATE	=	22

PUBLIC	=	20
TOTAL	=	42

TOTAL LENGTH OF CABLES

TOTAL LENGTH OF HT CABLE	= 7156.255m
TOTAL LENGTH OF LV CABLE	= 32594.161m
TOTAL LENGTH OF HT+LV CABLE	= 4412.525m

Some other queries can also be generated based on the user's need.

15. DISCUSSION ON PRODUCT/RESULT GENERATED

The results obtained from the project have assisted the Power Holding Company of Nigeria, Plc in the following areas;

- i. Monitoring the Status of the Facilities in each of the Feeders.
- ii. Information on the Total Length of cable in each of the feeders
- iii. Cost of replacement of cable can be calculated i.e. preparation of bill of quantity (BOQ)
- iv. Since the cable run across the road, it can also serve as a street guide in the absence of street map.
- v. Prioritization of facility replacement based on the available information.
- vi. Up to date information about the facilities.

16. THE FUTURE OF ELECTRICITY DISTRIBUTION ENGINEERING AND GIS (DEGIS) IN NIGERIA

There is no doubt, Geo-information technology has come to stay and has been helping in the area of facility mapping especially in electricity distribution.

Towards effective electricity distribution, there is need to apply Geoinformation Technology in the country at large. The DEGIS that will cover the whole of the country required the adoption and use of remote sensing technique of data acquisition from a high resolution satellites such as Ikonos, Quickbird, etc. This will cover the whole of the country at once and all the power generation stations can be monitored too. The DEGIS has the potential of forming part of National Geospatial Data Infrastructure (NGDI). Application of GIS in electricity distribution engineering will also provides job opportunities for professionals like Surveyors, Database Administrators, GIS Analysts, etc. With the plan towards the launching of Nigersat-2 and Nigcomsat-1, electricity distribution engineering can function in real time thereby providing effective power supply to all the sector of the economy.

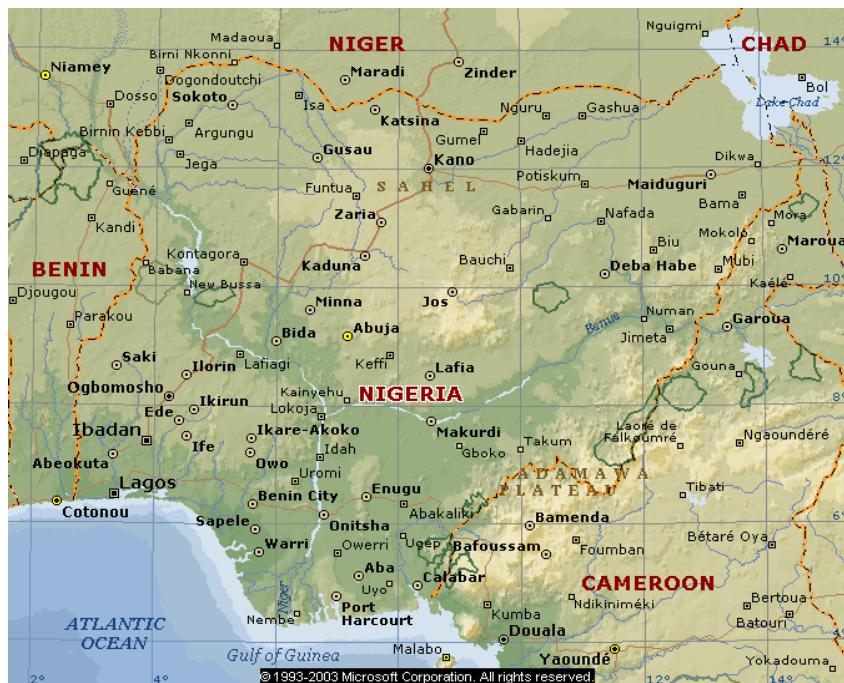


Fig. 4: Map of Nigeria

17. PROBLEMS ENCOUNTERED

- i. Security problem
- ii. Endangering of Life
- iii. Loss of satellite signal in area with high-rise structures
- iv. Inadequate initial information
- v. Access denial in some Residential area.

18. RECOMMENDATIONS

- Training of PHCN staffs on the use of GIS
- The whole of the country should be mapped for effective management of PHCN facilities.
- Establishment of a GIS department in all the zone and district offices of PHCN throughout the country and a surveyors/GIS expert as the head of the department.
- Increase revenue generation as more customers will be captured.

REFERENCE:

ESRI (2001): Electricity Distribution ArcGIS Data Model

NEPA (1998): Fact of the matter, NEPA checking the odds, Pp1-7, Public Relation

Division Electricity Headquaters, Abuja
NEPA (1998): NEPA Press clips (1), Pp 84 - 85, Public Relation
Division Electricity Headquaters, Abuja
www.esri.com/electricgas

BIOGRAPHY:

Olaniy Saheed Salawudeen born on 28th March 1981 in Lagos, Nigeria. He studied at the Federal School of Surveying, Oyo Nigeria where he obtained higher national diploma (HND) in Surveying and Geoinformatics in 2005. He is currently undergoing his professional diploma in surveying and geoinformatics at the federal school of surveying, Oyo, Nigeria. He was the immediate past National president of the Nigerian Institution of Surveying Students and also a Student representative at the Nigerian Institution of Surveyors (NIS) council between 2005 and 2006. He was the Students Union President at the Federal School of Surveying, Oyo.

He has five years experience in the field of surveying, engineering and GIS.

Usman Rashidat studied at the Kaduna Polytechnics where she obtained higher national diploma (HND) in Civil Engineering. She has experience in facility mapping and had experience with water board in Kaduna state in Nigeria, Reid Crowther Co. Ltd on Property Identification Exercise in Lagos State (2001-2002). Currently, she is the CEO, Hafmani Nig. Ltd, a GIS & Mapping Consultants. Hafmani Nig. Ltd is the initiator of GIS in the Power Holding Company of Nigeria, Plc.

CONTACTS:

Olaniyi Saheed Salawudeen
Department of Surveying,
Federal School of Surveying, Oyo
Nigeria
P.M.B. 1024, Oyo
Tel: +234 8038078266
E-mail: sagasofts@yahoo.com, geospatialpro@yahoo.com

Usman Rashidat
Hafmani Nig. Ltd
55, Obafemi Awolowo way, Ikeja.
Lagos
Nigeria
Tel: +234 8037011267
E-mail: hafmani@yahoo.com