GEOGRAPHIC BASED MAPPING OF PRIMARY DISTRIBUTION NETWORK USING GPS AND GIS SYSTEM

Kinza Ali[1], Muhammad Kamran[2], Fahim Gohar Awan[3], Hira Tahir[4], Sardar Muhammad Usama[5]

[1] Center for Energy Research and Development, University of Engineering and Technology, Lahore, KSK Campus, Pakistan.

[2, 3] Department of Electrical Engineering, University of Engineering and Technology Lahore, KSK Campus, Pakistan.

[4]Department of Electrical Engineering, University of Engineering and Technology, Lahore, Pakistan.

[5] Department of Electrical Engineering, University of Engineering and Technology, Texila, Pakistan.

[1]kinza_29 @hotmail.com

ABSTRACT- *Management of power grids is a routine work for concern companies. Old method of data management of grids is based on hard files. It takes a lot of time in searching bundle of files whenever relevant information is needed. Secondly maps are made manually in form of sheets which also wastes significant time to make it according to standards. As a routine teams surveying the site makes maps in offices resulting in data not being temporally accurate. This study provides an innovative way to manage 11kV distribution networks using computers by some high technology method. The existing method is based on hand made drawings of network which are stored in office hard files and makes it very difficult to search when needed which affects the overall work efficiency. Using this novel technique all 11kV distribution networks can be mapped. We mapped 11kV feeder of Faisalabad Electric Supply Company (FESCO). Information related to equipment is stored in the form of database. Each component of network is made in a separate layer then a complete map is developed by integrating all these horizontal layers. Information stored in database can be used in future when required. This would help in shifting the load from one location to another location using computers. Further it would help for future planning of network. We have implemented a novel approach which provides an easy access to data, saves time thus provides a quick and efficient way to store and manage primary distribution networks.*

Keywords: GIS, GPS, Mapping, Primary Distribution

1. INTRODUCTION

Electricity basically is flow of electric current which transfers power from one point to another. The power which is being provided to consumers has different stages covering generation, transmission and distribution. Distribution networks mostly have low or medium voltage levels. The entire power system network should be smooth for better performance and result for better economics. Efficient working of power system is required for beneficial growth to obtain the desired objectives.

In recent scenario, Pakistan is facing problem of energy crisis. Electricity demand is increasing day by day. To meet demand existing power grids should be upgraded up to a large scale other than to make generation efficient. This is not possible without having an appropriate record of distribution networks. Correct information plays a vital role for their management and up gradation. An organization that wants to run an efficient day to day operation along with manage and develop its services must have knowledge of assets it has, what is their location, in what condition they are, how they are working and how much they are adding to the overall cost to provide the service [1].

Geographic Information System (GIS) and Global Positioning System (GPS) can help to cope up with these issues and can have record of each asset or component used in a typical distribution network. GIS is an organized way to store collection of data including hardware and software and helps to visualize data in digital form which are geographically referenced. Using this technique, High Tension (HT) network is mapped with all the required information associated with it. GIS helps to map utility structure, it can store assents as inventory, their respective location, working condition and effect of it on surrounding [2]. All the information is stored in databases and have different layer for their representation, e.g. the layer for pole stores all information regarding its type, pole number and pole location, similarly layer for conductor stores which conductors are being used in this network and what are their lengths, layer for transformer have information about its capacities, make etc. A complete map is then prepared after making suitable changes for better representation. For mapping, databases are required to store information. Databases can be of two types, one which has geographic data in terms of coordinates, other one which has no geographic base data, but any technical or non-technical data which corresponds to different asset in the network. To modify any parameter, databases need to be changed. After analyzing collected data, final geographic based map is prepared using ArcGIS. There is no need to send survey teams to the utility and then transfer it to the map [3]. This tool can also be used to display spatial data and equipment on a map taken by satellite image [4].

Digital elevation models or 3D models can also be prepared in GIS that can be used as base maps for overlaying equipment, mostly suitable for hilly areas [5]. GIS models were planned to organize production and consumption of power by plotting consumers and their needs in databases to avoid power theft by updating data on monthly bases [6]. GIS made it possible to implement network routing which gives an optimum length of network with the minimum possible cost [7]. GIS is helping to interlinking spatial data with system as well as assets in the system [8]. Spatial and geographic data have of great importance in solving energy problems for satisfaction of consumers or customers [3]. Different queries can also be applied for visualization according to requirement [9]. GIS technology in collaboration of RS technology can be used to figure out security zones within the area of $10km^2$ which helps to manage crisis [10].

In section 2, methodology is described with the help of flow chart which is also explained in detail. Section 3 describes the

mapping process and its major steps in detail. It has a brief introduction to ArcGIS software also. Step by step figures are shown corresponding to the mapping process. In section 4, concept of databases is given with tables representing related databases to different equipment. Section 5 and section 6 covers conclusion and future work respectively. References are given in section 7.

2 METHODOLOGY

Process flow chart is given in Figure 1

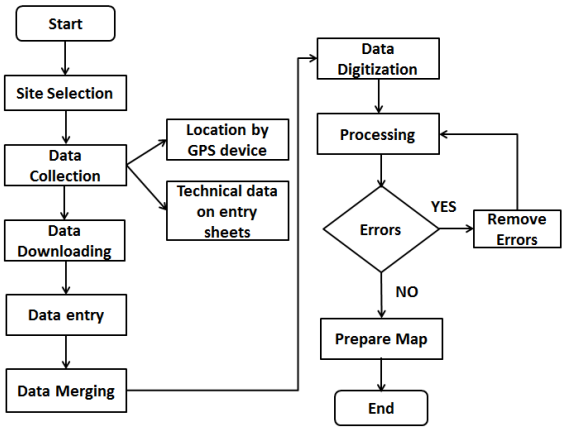

Figure 1: Process Flow Chart

The Process starts by specifying a location which is to be mapped by ArcGIS software using a GPS device. After selecting site survey is being conducted. The GPS device is connected to a satellite which collects required data in terms of longitude and latitude of desire equipment/element and technical data associated with it can be entered in prescribed forms or sheets. The data collected by GPS device is downloaded in computers. The GPS device can easily be connected to computers by a common data transfer cable. Data collected by GPS device is downloaded in a GPS supported software, e.g. map source software. It plots poles on basis of its coordinates (latitude, longitude and altitude, which is distance from sea level). Besides this, technical and non –technical data which was entered in sheets are entered manually in computer in MS Access. Both sets of data are being merged in ArcGIS to make a complete set of data (locations by device and data entered manually). After merging data it is digitized in forms of different symbols. Assigning symbols makes it easy to identity its poles, conductor or transformers. Now collected data is processed to analyze for errors. Possible errors can be several points are taken by standing at a point. Branches are not ended accurately that it makes a loop is network etc. If there are errors remove them and then run processing again. If still there are errors repeat the process and if there are no errors prepare a final complete map. For better understanding different conductors, poles and transformers can be digitized differently.

3 MAPPING

Mapping means to map selected area or site according to its actual location in field. This task is accomplished using GPS device. GPS device stores coordinates in term of latitude, longitude and altitude (distance from sea level). ArcGIS 10.1 software is used to map the coordinates collected by GPS device. It provides a wide range of editing tools with which can be worked. GIS and GPS are interlinked with each other. It offers a lot of features including Arc Tool box (i-e. a set of tools used to perform different functions), Arc Catalogue (manages shape files and databases), Arc Editor (enables to do editing) etc.

3.1- Mapping process:

Mapping Process is shown in Figure 2.

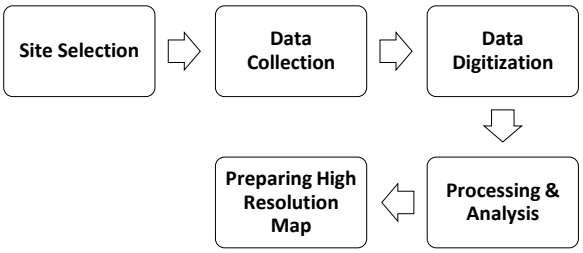

Figure 2: Mapping Process

3.1.1 Site Selection

The first step is to choose or select a site which is desired to be mapped. 11kV Ghazi Shah feeder of distribution company FESCO is selected for this purpose. This feeder is emanating from Jhang-1 grid station lies in Satellite subdivision. Its overall route including poles, conductors, grid station and transformers are being mapped.

3.1.2 Data Collection

After specifying the site to be mapped, it's time to collect data associated with it. Survey has to be conducted to gather all the information, including technical and non-technical by using GPS device. GPS device is necessary to determine the accurate and correct location of poles, transformers and their attributes. Information related to transformers and conductors has been collected with the help of FESCO officials. There is an option to have a good quality map from satellite, but to do survey is recommended to collect data. While conducting survey, each pole in the network can be assigned a unique code to ensure its consumers and also to show that it is a legal connection. Each connection can be checked in record to verify either it is legal or not. This can save the theft problems also. Attributes can be type of pole, conductor, and capacity of the transformer, its use, make etc.

3.1.3 Data Digitization

Data digitization means to convert the collected data in form of paper data into digital form by assigning different symbols for their representation. In this research HT line or 11kV line given symbol of red line, poles are represented by red filled circles, transformers are shown by red filled triangles and in the same manner capacitors, isolators and grid station are given symbols for their representation and better identification. ArcGIS works in layers which makes easy to manage and retrieve information easily. For each element a separate layer is formed e.g. poles, conductor, transformer are in separate individual layers. A complete map is prepared in which all these layers are shown**.**

Poles in the network are shown in figure 3. Poles are digitized by using red filled circles. Each circle represents an individual pole. Secondly they seem to be connected to each other but they are not. As the poles are close to each other or

distance between them is small that's why they appear to be connected and overlapping each other.

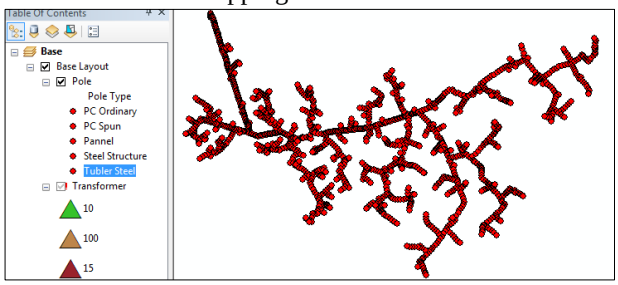

Figure 3: Pole layer

Transformers in 11kV Ghazi Shah Feeder are shown in figure 4. This layer only has transformers which are shown by red filled triangles. There is a feature of labeling by which any equipment can be labeled according to requirement. These transformers are labeled by their respective capacities. Labeling depend on the attributes given in corresponding databases e.g. transformers can also be labeled by their location, make, status etc. Some of the transformers are overlapping because distance between them is small.

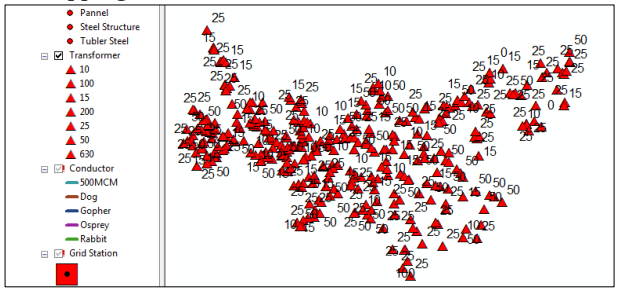

Figure 4: Transformer layer

Conductor layer is shown in figure 5. It shows the complete path of 11kV Ghazi Shah Feeder of FESCO. Red line is used for its digitization. It gives total length of feeder. Length of individual span, branch and complete network can be calculated by in built calculator of GIS.

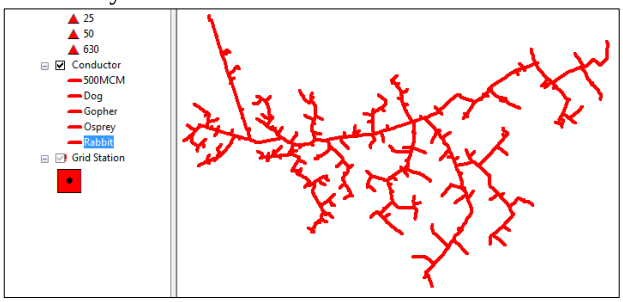

Figure 5: Conductor layer

3.1.4 Processing and Analysis

After digitizing, data is checked by processing function of software for errors. In case there are some errors they have to be removed for further analysis. Possible errors can be that dates of GPS device and date entered in ArcGIS are not same, several points are taken at a single point, there can be loops in system, etc. Final map cannot be prepared in case of any error.

3.1.5 Preparing high resolution map

After checking and analyzing, a final map is prepared. It can be made attractive and presentable by adding legends for lengths of spans, transformers etc. It can be exported into adobe reader and can be uploaded on Google earth as well.

Finalized map is shown in figure 6. It shows all layers (pole layer, transformer layer, conductor layer) which were described before. Red filled box shows grid station from which feeder is emanating. Symbols used for digitization is same but different quality is shown by different colors. There are different types of poles (PC spun, PC ordinary etc.) which are given different colors. Similarly transformers with different capacities are given different colors. In the same manner different conductors are assigned with different colors. This can be made standard so that by just looking map anyone identity which conductor, transformer it is.

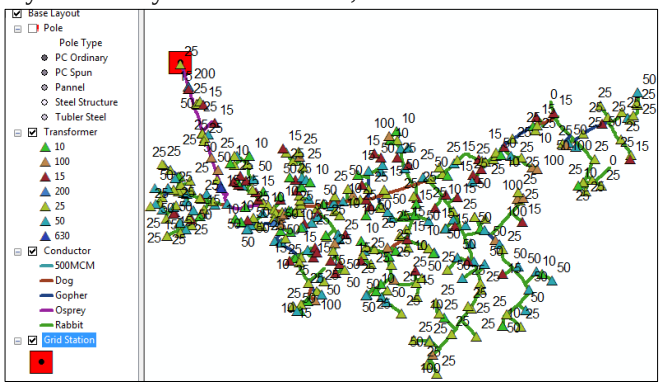

Figure 6: Complete map

4 PURPOSE OF DATABASES

Databases are helpful to store spatial data. They show attributes with which company is concerned and working. Each element or equipment has its own database to store its information. It makes very easy to retrieve any information. It helps to edit any data. Databases of conductor, poles and transformers are shown.

Table 1: Pole Attributes

Attribute	Description
Pole number	A unique numeric code
Class of pole	Primary pole, Secondary pole, Transformer pole, Capacitor pole, Tap pole, Feeder pole
Height of pole	36,40,45 etc.
Type of pole	Tubular steel, PC spun, PC ordinary etc.
Condition	Broken, damaged

Table 1 shows concerned features of poles. This information can be helpful in future. Poles can be labeled by any of these features according to requirement.

Table 2: Conductor Attributes

Attribute	Description
Type of conductor	Osprey, Dog, Rabbit etc.
Length of spans	Length between two poles, no need to measure, can be calculated by software calculator.

Table 2 shows features of conductors/cables which exist in system. Lengths will be calculated by ArcGIS. There is no need to calculate them manually.

Table 3: Transformer Attributes

Attribute	Description
Capacity of transformer	10KVA, 25KVA, 50 KVA etc.
Location	As per site
Make	PEL, Siemens etc.
No. of phase Connected	R-Y-B, R-Y etc.
Connection type	Domestic, General duty, Industrial
Status	Connected, Not connected

Features of transformer are shown in Table 3. They can be labeled by any of these attributes.

5 CONCLUSION

This technique proves to be a valuable tool for upgrading existing system. It's easy to manage and store information of all the networks in a single computer and saves searching time when any data corresponding to specific network is needed. There is no need to visit site again and again for any changes, extension and load shifting. Hence this technique provides an innovative way to manage distribution networks.

6 FUTURE WORK

This study strengthens the idea that this technique can be applied to LT/ secondary distribution, on combined HT/LT lines as well as transmission networks. It is not restricted to electrical side only; it can be used by other departments to manage their assets.

7 REFERENCES

[1] D. Pickering, J. Park and D. Bannister, Utility mapping and record keeping for infrastructure. Washington, D.C.: Published for the Urban Management Programme by the World Bank, 1993.

[2] J. Dangermond, 'Enterprise GIS: Powering the Utility of the Future', Australia, 2008.

[3] A. Sekhar, K.Rajan and A.Jain, 'Spatial Informatics and geographical information systems: Tools to Transform Electrical Power and Energy Systems', in Proceedings of IEEE Region 10 Conference, TENCON'08, India, 2008, pp. 1-5.

[4] J.I Igbokwe and E.Emengini, 'GIS in Management of Electricity Distribution Network: A Case Study of Onitsha-North L.G.A., Anambra State, Nigeria', Department of Surveying and Geoinformatics, Faculty of Environmental Sciences, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria, 2005.

[5] M.Rusko, R. Chovanec and D. Roskova, 'An Overview of Geographic Information System and Its Role and Applicability in Environmental Monitoring and Process Modeling', Faculty of Materials Science and Technology in Trnava Slovak, University of Technology in Bratislava, 2010.

[6] S.Nawaz-ul-Huda, F. Burke, M. Azam and S.Naz, 'GIS for power distribution network: A case study of Karachi, Pakistan', Malaysia Journal of Society and Space 8, 2012, Issue 1, pp. 74 – 82.

[7] N. Rezaee, M Nayeripour, A. Roosta and T.Niknam, 'Role of GIS in Distribution Power Systems', World Academy of Science, Engineering and Technology, 2009, pp. 902-906.

[8] O. Saheed Salawudeen and U. Rashidat, 'Electricity Distribution Engineering and GIS', Shape the Change XXIII FIG Congress Munich Germany, 2006, pp.1-14.

[9] W.Chao, W.Qiang, L.Yuanlong, W.Su, T. Lihui and L. Ludong, 'Applications of GIS to Power Distribution Dispatching',International Conference on Electricity Distribution, China, September 2010, pp.1-5.

[10] B. Hooshyarkhah, F. Separi, M. Samakoush and M. Shafi, 'Crisis Management and Electricity Power Distribution Network Security Zone Determination with Using GIS&RS Technology (Case Study of Neka)', International Geoinformatics Research and Development Journal, vol. 5, issue iv., pp. 1-8, 2014.