Using Geographic Information Systems to Develop a Robust Electricity Utility Network

Junaid Qadir, Faizan Jalal

University of Kashmir, Hazratbal, Srinagar – 190006, Jammu and Kashmir, India

Publication Date: 26 October 2017

DOI: https://doi.org/10.23953/cloud.ijarsg.320

Copyright © 2017. Junaid Qadir, Faizan Jalal. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract Electricity distribution reform is widely viewed today as fundamental to improving domestic and commercial performance and financial viability in different countries all over the world. Several steps have been taken in this regard to improve the performance by undertaking several measures such as reduction of technical and commercial losses, improvement in load management, strengthening of metering, billing and collection avenues, enhancement of attention towards the quality of electric supply and customer care. The role of Geographic information system (GIS) in electric utility has gained much attention worldwide. Using GIS an electric distribution utility uses a network of physical facilities to provide electric power and energy to customers connected to those facilities throughout a geographical area. Each component of the distribution system (i.e., asset) has a physical location and associated data. So does each customer. In order to design, maintain, operate and manage the electric distribution network it is necessary to utilize the geospatial data. A geographic information system (GIS) is a convenient and powerful way to collect, organizes, maintain and manage this geospatial data and display it on a geographic map. The present study focuses on the use of Geographic information system to develop a robust electricity utility network that helps in distribution system planning, analysis and asset management.

Keywords Asset; Electric utility; Geographic information system; Geospatial data

1. Introduction

Utilities all over the world are facing immense pressure and unprecedented change and now the focus has been on to develop new strategies to overcome any deficiencies pertaining to power supply transmission, load management, and other commercial services. The need of hour is efficient management and optimum utilization of installed capacity to meet the supply demand. Advancement in hardware, software, and networking technology has created opportunities for the utility industry to build and benefit from more comprehensive and sophisticated Geographic information system (GIS). Better use of geospatial data is one of the key areas of focus for many electrical utility companies. A Geographic information system (GIS) is a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modelling and display of spatially referenced data for solving complex planning and management problems (Rhind, 1989). GIS is playing a vital role in the field of planning and analysis with respect to the geographically organized demographic information to improve decision making (Prasad, 2006, Maps and Census). A common approach is to generate maps using existing GIS data sets, then send out crews to collect and verify field data for utility features and this is only accurate way to ensure the integrity of the data (James L.
Sipes, 2004). With the radical change electrical utility industry is facing, the consumer choice has become the top most priority in every country. The goal of incorporation new tools & techniques is to satisfy the growing and changing system load demand during the planning period within operational constraints and with minimal costs. The planning process comprises several phases; one of the most important is the optimization of the electric distribution networks. The network optimization is considered a hard-combinatorial optimization problem due to number of limitations network voltage level, network structure, quantum and location of loads, routes and types of feeders and voltage drop (Mathankumar et al., 2015). In this process it is important to have on time accurate relevant data and information on the electric distribution systems and its assets, and possibly to have data from other utilities. Computerization and development of various Geographic information systems have opened new horizons for all decision making processes as well as manipulation and dissemination of information (Mathankumar et al., 2015). The present study focuses on the use of Geographic Information system (GIS) to facilitate easily updatable and accessible database to cater the needs of design, monitoring and maintaining reliable quality electric supply.

2. Methodology

Satellite data was acquired and Thematic layers such as buildings and road network were extracted and represented in form of polygons and lines, also service lines and customer connection point were digitized and integrated in GIS environment. A personal geodatabase was involved with dataset projected using coordinate system WGS84 zone 43N. The personal geodatabase contain features named as building, roads, consumer points and service lines. The area of Interest was delineated from the satellite image and subsequently used to subset other thematic layer. The coordinate points of the transformer and low tension poles acquired with the handheld GPS and customer records were linked together and captured into the geodatabase using add XY coordinate in Arc Map 10.1. Electricity distribution network Map and data was created which shows the spatial location of the transformer, Low Tension poles as well as relationship between all asset and customer connectivity to the transformer.

The methodology for the study has been divided into different categories:

1. **Consumer & Asset indexing:** Each customer is uniquely indexed based on the electrical system codification, from the source of supply to the end customer end. Enable feeder wise energy accounting (33 KV feeders & 11 KV) also Distribution transformer wise energy accounting. Creation of database for each asset and individual customer indicating the exact geographical location.

2. **GIS based Mapping for Electrical Network:** Mapping of complete electrical network up to low voltage system and customer supply points with latitude and longitude overlaid on satellite image. Incorporation of present details of localities, landmarks and existing network details upto consumer level.

3. **GIS Based Consumer Indexing:** Activities involved are preparation of Base Map, Fixing Topographical details, GPS survey, Single Line Diagrams, Mapping and documentation of Network, Mapping and indexing of consumers, Database of electric network, consumer Database development, Segregation of consumers, 11 KV feeder wise and Distribution Transformer wise.

4. **GIS based Mapping:** Network creation (SLD/equipments/geographic representations/SS design), System Analysis (cost benefit analysis/reconductoring/network configuration/load flow studies/ load balancing/ short circuit studies). System optimization, Reports, Trend analysis.
3. Results and Discussions

3.1. Indexing and Mapping of Consumers

The purpose is to identify and locate the consumer in geographic space (Figure 2), which is being fed from main lines. There are many instances when the connection on the ground exists but the records are not properly maintained. It may be the case of unauthorized connection. On the other hand, connection exists in the electric record, but it may not exist on the ground. With the help of GIS the main LT lines coming from the Distribution transformer (DT) and all services connections coming out from main LT can be can be checked & verified with reference to the consumers connected (Figure 3).

3.2. Mapping of Electric Network

The electric network and route is digitized and mapped on the base map at suitable scale using Arc Map (Figure 4), so that changes in the network can be timely made and updated on periodic basis. With the use of GIS software queries regarding the length of feeder, specifications of the network, number of consumers, HT/LT conductor, Transformer details can be easily obtained and even a proposal for new feeder design and feeder bifurcation can be suggested correlating and examining with the existing and proposed load of the feeder. It is important to note here GIS software helps in identifying the areas of high losses, and proven to be an important asset in electric utility mapping, segregating the energy input and consumption Distribution Transformer-wise and 11/33 KV feeder-wise. The losses are assessed by subtracting the total energy utilization of the consumers from the energy supplied to the respective Distribution Transformer and 11/33 KV Feeder.
Figure 2: Map showing Aerial view of distribution network

Figure 3: Map showing 11 KV LT Network of Jawahar Nagar, Substation Rajbagh, Srinagar Jammu & Kashmir, India
3.3. Energy Audit, Load flow and Network Analysis

In electric utility sector, GIS is being used for a number of applications like distribution network mapping, network analysis, load flow studies, asset management, energy audit and customer care. Spatial data analysis is helping the users to analyze patterns in spatial data for MIS and Business Intelligence, with the intent to improve network efficiency and customer services (Jayant Sinha, 2013). Energy audit has to be directly integrated with metering, billing and collection with minimal manual intervention. It has to capture electrical distribution network and energy parameters for feeder-wise and DT-wise loss analysis and identification of sections of revenue leakages. Therefore, 100% metering of consumers, substation feeders and distribution transformers is an essential requirement for total energy accounting. The foremost technical challenge is to affect a seamless integration of the entire business processes both the new systems and current legacy systems, unless the utility chooses to discard the latter altogether. The network analysis tool uses advance algorithms for calculating phase imbalances, identifying low-voltage or overloaded sections, calculating section-wise loss level sand taking decisions on system optimization through network reconfiguration. Geographic Information Systems (GIS) is being used in electric utilities for energy audit and network analysis, and emerging as a powerful tool for load planning and management with the focus to improve the quality of electricity supply and other related services. The electrical network overlaid on geographic area base map is handy for the utility in not only managing assets and their maintenance, but also for mapping the consumers for energy audit applications. By integrating GIS with electrical and network analysis application, various analytical studies are possible for load flow analysis, short circuit analysis, efficiency calculations and optimization.
Table 1: Comparison before and After GIS implementation

| Before GIS Implementation                                                                 | After GIS Implementation                                                                 |
|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| The HT line Regulation has not been calculated easily and not maintained within the norms. | The HT Regulation has been calculated easily and maintained within the norms.            |
| Difficult to identify the HT LT pole location, DT and not to control overload Distribution Transformer. Fuse of call to be attended slowly. | Easy to identify the HT LT pole location. Avoid overload Distribution Transformer and locate the new DT at load centre point. Fuse of call to be attended slowly. |
| The damaged pole and snapped conductor are difficult to identify there more chance to happen Fatal and Non-fatal accident. The fault trips are frequently happened. | The damaged pole and snapped conductor are easily identifying there less chance to happen Fatal and Non-fatal accident. The fault trips are happened rarely. |
| The maintenance and operation cost is high due to it requires high man power. This result having less efficiency. | Due to Computer technique it requires less man power and operational cost. This result having High efficiency. |

4. Conclusion

Geographic Information System helps users to integrate in simplest form and has tendency to manage the information and represent it in numerous interactive maps. The Web based Geographical Information System (GIS) is not limited to a certain Science or unique technology, but it has very extended branches of usage in a lot of the daily activities. GIS provides us to show all accumulated data which are stored in any format for long time as visible layers linked between location data and attributes. Our future perspective is to integrate this Electric Network Utility of GIS with SCADA to really simulate the real time flow of the energy across the networks, and which is aimed to be kept in server environment for any time any where identification and demarcation of any effect in the system / energy flow at any junctions across the networks. On integration with SCADA we could also provide diversified solutions in this electrical utility network sector.

References

James L. Snipes. 2004. Spatial Technologies: GIS for Utilities. Available From: http://www.cadatalyst.com/gis/spatial-technologies-gis-utilities-8616.

Jayant Sinha. 2013. Integrating issues and challenges of IT reforms in Power Distribution. Available From: https://jayantsinha.wordpress.com/tag/distribution-network-analysis/.

Mathankumar, S. and Loganathan, P. 2015. GIS Based Electrical System Planning and Network Analysis. World Engineering & Applied Sciences Journal, 6(4), pp.215-225.

Mathankumar, S. and Loganathan, P. 2015. Detection of Power Theft in HT Consumer Using SCADA Interfacing with GIS System. International Journal of Research in Engineering and Applied Sciences, 5(7).

Rhind, D. 1989. Why GIS? ARC News, Vol. 11, No. 3, Summer 1989, Redlands, CA: Environmental Systems Research Institute, Inc.

Prasad, M. 2006. Maps and Census. GIS Development: Asia Pacific. The Monthly Magazine on GIS, Vol. 10, No. 12, pp.7-48, December 2006.