GIS Based Power Distribution System: A Case study for the Junagadh City

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Abstract—In this paper power distribution data (poles, transformers and transmission lines) have been mapped using GPS and high resolution remote sensing images. These details have been put in GIS using ArcGIS 9.1 software. Various things like road network and land use are also superimposed on the power distribution system GIS layer. Various types of analysis like finding a pole or circuit of specific transformer can be done using GIS tools.

I. INTRODUCTION

The distribution system is a part of power systems which is dedicated to delivering electrical energy to the end user. Present reform focus of India is distribution sector as this sector immediately affects the consumers. Economic importance of distribution system is very high and the amount of investment involved dictates careful planning, design, construction and operation which assure growing demand for electricity in terms of growing rates and high load densities.

Present distribution system in India is the weakest link when compared to generation or transmission. High technical losses in the system are primarily due to inadequate investments over the years for system improvement works, which has resulted in unplanned extensions of the distribution lines, overloading of the system elements like transformers and conductors, and lack of adequate reactive power support. The commercial losses are mainly due to low metering efficiency, power theft and pilferages.

II. IMPORTANCE OF DISTRIBUTION SYSTEM

Distribution is the most critical segment of the electricity business chain. The real challenge of reforms in the power sector lies in efficient management of the distribution sector. The Act 2003 provides for a robust regulatory framework for distribution licensees to safeguard consumer interests. It also creates a competitive framework for the distribution business, offering options to consumers, through the concepts of open access and multiple licensees in the same area of supply. For achieving efficiency gains proper restructuring of distribution utilities is essential.

Economic importance of distribution system is very high and the amount of investment involved dictates careful planning, design, construction and operation which assure growing demand for electricity in terms of growing rates and high load densities. Scarcity of available land in urban areas and ecological considerations can put the problem of optimal distribution planning beyond the resolving power of unaided human mind. Load magnitude and geographic location of distribution system should be determined such that distribution substation must be placed and sized in such a way as to serve the load at maximum cost effectiveness by minimizing feeder loss and construction costs. Distribution system contains much wider varieties of voltage levels, components, loads and interconnections than the generation and transmission systems.

III. PROBLEMS ASSOCIATED WITH DISTRIBUTION SYSTEM

A. Increased equipment loading

Short-term financial pressures have led most utilities toward increased levels of "asset utilization." Although high equipment loading is well understood from the perspective of thermal aging and conductor sag, it is less understood in other ways. With everything else equal, high loading increases failure probability. Detailed failure rate models do not exist, but the probability of second-order failures increases with the square of failure rate, the probability of third-order failures increases with the cube of failure rate, and so forth. Reliability aside, thermal aging of organic insulation increases exponentially with temperature. This does not only substantially impact the useful life of moderately loaded equipment, but becomes a financial concern when systematic increases in equipment loading begin to materially reduce useful life.

B. Ageing Infrastructure

Before the 1970s, electricity usage grew at an annual rate of approximately 7%. Without considering failures, this implied that 14% of equipment would have been older than 30 years and 0.5% would have been exceeding 50 years. For the last 30 years, growth has been lower at approximately 2.5%, resulting in minimal procurement need for new equipment. This implies currently 49% of existing equipment is older than 30 years and 8% older than 50 years. Aging infrastructure is a major problem due to growth rate alone, is exacerbated by higher equipment loadings and less aggressive replacement programs, and has been recognized by the Department of Energy and one of the major issues facing electric utilities.

C. Increased demand for power quality and Reliability

While utilities are under increasing pressure to reduce cost and deal with aging infrastructures, many customers are demanding higher levels of power quality and reliability. Long interruptions halt production, short interruptions cause computer systems to crash, and waveform distortions, such as sags, can cause motor contacts to drop out and electronic controls to malfunction. To complicate matters, many customers are not willing to pay for increased quality; many see perfect reliability as an entitlement, and as an opportunity to ride free on others willing to pay for premium service. Different customers have different needs, and existing distribution systems are not able to differentiate

reliability accordingly. Reliability is too high for most, too low for some, and just right for few.

IV. POWER SECTOR REFORMS INITIATED BY GOI

Reform of power distribution is today widely viewed as fundamental to improving commercial performance and financial viability of the power sector in India. In recent years, a number of states have worked to improve the commercial performance of their state utilities, unbundling state entities, creating more independent regulatory systems, and putting in place measures to control losses and theft. However, progress has been difficult, and slower than many originally hoped. Some of the reforms measures are discussed below:

A. Accelerated Power Development & Reform Programme (APDRP)

APDRP was launched in 2001, for strengthening of Sub – Transmission and Distribution network and reduction in AT&C losses. The main objectives of the programme are:

1) Reduce Aggregate Technical & Commercial (AT&C) losses
2) Bring about commercial viability in the power sector
3) Reduce outages & interruptions
4) Increase consumer satisfaction

Schemes undertaken under APDRP are for renovation and modernisation of sub-stations, transmission lines & distribution transformers, augmentation of feeders & transformers, feeder and consumer meters, high voltage distribution system (HVDS), consumer indexing, SCADA, computerized billing etc.

B. Centers of Excellence

Under APDP, 60 distribution circles have been identified in different States for improvement / strengthening of the sub-transmission & distribution network in such a manner as to develop Centers of Excellence. This would enable States to replicate the strategy in other circles. The objective is to ensure that the investment in these distribution circles would result in quantifiable physical & financial benefits.

C. 11 KV Feeder as Profit Centre

The approach mentioned above will need to be implemented for each 11 KV feeder upward upto 33/11 kV sub-station and in the entire identified circles. This will ensure energy accounting and reduction of commercial and technical losses in the entire feeder. This way each feeder can be operationalized as an independent profit centre.

V. SUGGESTIONS AND NEW TECHNOLOGIES FOR DISTRIBUTION SYSTEM

Restructuring of the power industry, changing expectation of the customers of the digital age, and advancements in technology will gradually impact distribution systems. The technologies that would have the biggest impact are distribution automation, power electronics, distributed energy resources, and distribution management systems (DMS), and distribution control centers (DCCs) and usage of remote sensing, GIS and GPS techniques in distribution system. The following section discusses the GIS application in distribution sector.

VI. GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN DISTRIBUTION SYSTEM

GIS technology is being widely implemented in the energy sector, especially with the advancement in modern management systems and automation, and the introduction of the digital utility. GIS provides adequate platform for system representation and manipulation, since network models and data bases can be easily accessed and modified to perform system analysis.

A. Why GIS?

GIS is a valuable tool for performing information analysis, automated mapping and data integration. There are many components necessary to make a GIS function properly, including an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. The common denominator in GIS is geography, or spatial distribution and location (e.g., coordinates of an irrigation well, an address of a house). Geographic information also includes information about those features such as the capacity of the irrigation well and the value of the house. It is precisely this ability to link spatial location with descriptive or attributes data that makes a GIS so powerful.

Essentially, any set of data that has a spatial extent and is referenced with a geographic identifier- such as an address, parcel ID, or latitude/longitude- can be utilized in a GIS to answer questions and solve problems. A GIS typically addresses questions and problems related to location proximity, conditions, trends and patterns. Additionally, a GIS can be used to perform analytical operations to support decision-making processes, such as site suitability analyses for future landfills or soil erosion potential within a specific region. A GIS can also answer "what if...?" questions based on different scenarios and situations. A GIS can be used to automate existing operations (e.g., map production and maintenance), as well as provide enhanced capability to analyze geographic information for decision-making purposes.

B. Case study for the Application of GIS

We have taken Vaisali feeder in the area of Kotra in Junagadh as area of our case study. This feeder is not having proper information of poles, transformers and minimum path for the power flow. The distribution company has poor maintenance of installed facilities, lack of proper planned network and lack of monitoring to prevent losses and manual updating of consumer records. From the field work we have observed that most of the transformers are unnumbered and they are not sited in proper location, some of the poles are unnumbered, some poles are in the middle of the house, some poles are still concrete, and some poles are bent which causes so much inconvenience to the public. It is very difficult to identify some poles because they are placed at point which is in some other transformers area. We have applied GPS and GIS techniques to that area so that we can have proper data base of the poles and transformers by that we can easily identify the consumer location and his connectivity. It can also be applied for routing of conductors

or cables, selection of size and location of transformers. Following are the steps taken in the case study:

- Field work or GPS survey
- Conversion of coordinates by using ilwis software
- Downloading images from google earth pro
- Georeferencing the image
- Forming the database
- Creating points to rectified image in ArcMap
- Generating Queries

C. *Field work:*

This survey includes collecting the position of various utilities like poles, transformers etc. by using GPS sport track receiver. Here the position of the utilities is in the form of easting and northing coordinates.

D. *Conversion of Easting and Northing coordinates to lat lon coordinates*

Transferring of GPS coordinates to lat-lon coordinates can be done by using iilwis software. For that first of all we have to create a new coordinate system from the open window.

E. *Downloading Images From Google Earth Pro*

Google Earth Pro is a business oriented upgrade to google earth that has more features than the google earth and google earth plus. This display the satellite images of the most inhabited regions of earth, allow users to visually see the things.

F. *Georeferencing the Image*

Georeferencing is the process of aligning spatial data (layers that are shape files: polygons, points, etc.) to an image file such as an historical map, satellite image, or aerial photograph.

G. *Creating Points from Lat Lon data in ArcMap*

This procedure outlines the steps necessary to create points from a simple text file containing latitude and longitude coordinates. Often, this type of file results from research has done using a GPS in the field. This procedure can be used to plot the GPS locations on a base map. Follow the prompts given or use the help files for assistance.

The original data is provided as a DBF file with latitude and longitude coordinates in decimal degrees. Once you made a data base table with latitude and longitudes which is saved in .dbf file, the following steps are to be followed

This completes adding points to the arc map. If we want to add any attributes right click on the shape file which we created points and open attribute table. Go to options in that and click on add field, then give details of what kind of field you want to add. Adding attribute is completed.

H. *6.8 Generating Queries Selecting Features by attributes*

In addition to identifying, selecting, and finding features, we can select features by attributes by writing a query that automatically selects features that meet specified criteria. The simplest type of query consists of an attribute, a value, and a relationship between the two. A more complex query combines these simple queries using operators like 'and' 'or'. These queries are constructed using Structured Query Language (SQL). ArcMap creates the query automatically in this format.

VII. RESULTS

Table 1 & 2 shows the Data collected for transformers and Pole details in a survey respectively. In the second step we collected images of Kotra by using google earth pro software, which was explained earlier. We collected 13 images and these images are rectified and georeferenced by using ArcGIS 9.1 software. Figure 1 gives the image after rectification and Georeferencing.

X'mer No.	Location	Cap.	Make	Sr. No.	MFG Year	Id-Code
1	Dtype NN	200	NGEF	4055		863080-8
2	Surya Nagar	100	ABB	9030	Sep-04	
3	Rushipath	100	VIJAY	9070	Mar-04	
4	MIG Kotra	200	VOLTECH	6		

Table.1: Data for Transformers and their details

X'mer No.	Circuit No.	Pole No.	Easting	Northing
6	1	1	745336	2570027
6	1	2	745349	2570038
6	1	3	745361	2570060
6	1	4	745293	2570053

Table.2: Data for Poles and their details

Fig 1: Image after Rectification and Georeferencing

Next we have to add points as poles and polygons as transformers. The procedure for adding poles and transformers is already discussed. Figure 2 gives the image with added poles and transformers. From the figure we can observe that if we click on any pole all the details of the poles are available and the clicked pole is highlighted.

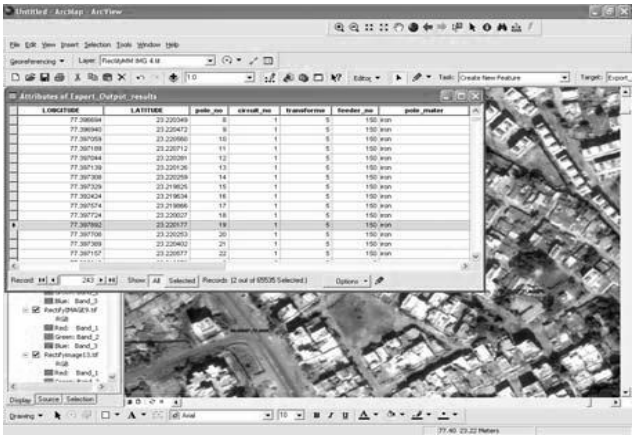

Fig. 2: Image with Added Poles

After this last step is query generation. Figure 3 gives the result for query generation. In this we gave a query to find the pole 19 of transformer 11. Then pole 19 got highlighted.

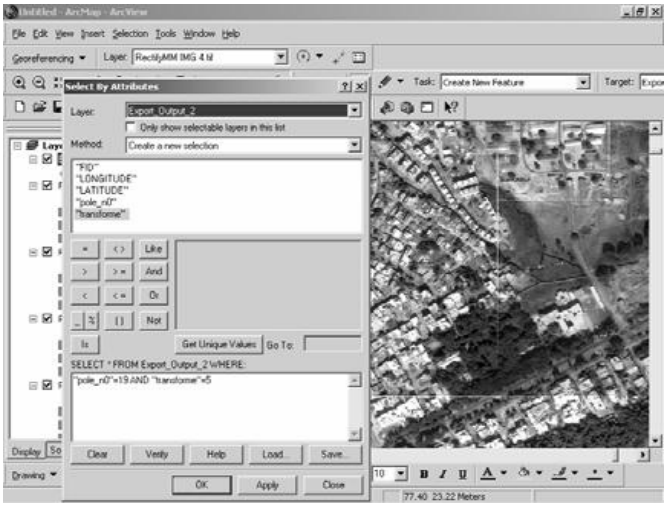

Fig. 3: Generating Queries

VIII. CONCLUSIONS

From this study undertaken, it can be concluded that the power Distribution Company and the department can be used in many ways to improve the planning, maintenance and management standards of the department. It can be used to achieve following things efficiently

- This study has proved that updated complete information is required for identification of the consumers.
- A Database management system integrated with Geographical Information System can help find solutions like identification of each and every consumer and their locations with their connectivity in the area.
- This GIS based system helps in not only identification of each and every plot location but also provides complete information about the consumer.
- This enables to go for carrying out analysis of each and every consumer bills payment and to find the average annual distributed power and utilized power.

The GIS based system thus helps to perform different types of analysis such as Load analysis, location analysis, network analysis, problem identification analysis etc. The GIS based system help the company to find the shortest route from the office to problem location. This is found very much helpful to the lineman of the department in carrying out their surveillance work by identifying and reaching their place very easily and even in less time even though they are not familiar with the place.

REFERENCES

[1] U.S. Dept. Energy's Power Outage Study Team, 2000," U.S. Dept. Energy.
[2] Brown R.E, 2002 "*Electric Power Distribution Reliability"*. Tutorial course, New York
[3] Whei-Min Lin, Ming-Tong Tsay and Su-Wei Wu, 1996 "*Application of Geographic Information Systems to Distribution Information Support", IEEE transactions onPower Systems"*, vol 11, No 1, 1996.
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