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Article

Geographic Information System (GIS) in Power System

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A B S T R A C T

Electricity is one of the most important and basic needs of today's community. Electricity is an aspect of the utility sector that is very essential to the smooth and meaningful development of the economy of our country. The projected growth of the Indian economy will be largely dependent on the presentation of the power sector and ability to fulfill the growing demand of power supply. In India, in the past decade the electricity consumption rate did not follow economic growth. Unless strong measures are taken the economy of India will face a serious setback.

Keywords: Generation, Economy, Electricity, Geological Survey

Introduction

While much effort is made towards generation of power, its subsequent transmission & distribution should not be overlooked. The all-India T & D losses, which were about 15% till 1966-67, increased gradually and are now at 29% One way to monitor and control these losses would be the maintenance of the voluminous data (both spatial & non-spatial) involved and also to have a decision support system that would have the power of deciding upon the various engineering problems. This paper aims at providing such a system.

Existing System

Electricity is produced in the power plants at a insignificant voltage of 11KV. This is stepped up to the transmission level voltage which is about 230KV or 400KV in order to diminish the transmission losses. This is then transmitted to the state level grids through Extra High Tension (EHT) Lines. It is then stepped down to 110KV and is sent to the substation via high-tension lines (HT). This is further converted to 33KV and 11KV and is supplied to the distribution transformers seen on the roads through HT. From these transformers it is supplied to the poles and pillars through Low Tension lines (LT) at 415V. The power reaches the customers from either the pole or the pillar as 415V or 230V.

All engineering information pertaining to the electrical distribution is today preserved only by analogue methods. In fact the data documentation in most of the utilities is very poor. Today, the data of distribution systems is maintained through hand drawn maps with facilities data printed in text form on them and available with the Assistant Engineer/ Lineman in charge of the feeder. These maps are rarely updated and there is a lack of linkage amid spatial and non-spatial data. Any decision-making regarding maintenance of transformers, new connections, fault logging etc are only made on a rough basis. The substation has very little or no information regarding performance status of transformers and the feeders. Need of the Study The current system lacks reliable and sufficient documentation of data, especially at the substation level? There is no link between spatial and non-spatial data.

To control the distribution losses, an accurate database on consumption including items such as technical losses is required. The regular maintenance and required replacement of transformers, poles, pillars etc are not done on a deterministic approach but only by a rough estimate.

New transmission lines that need to be added are today decided only manually based on the rough estimate of load from individual consumer connected to it. This calls for a more refined method of decision making.

For any new building coming up in an area, the transformer from which the power has to be drawn must be decided based on the current loading of the existing transformers and the expected load. This again needs a decision - support system.

In today's conventional method, if supply fails, the complaint management cell is loaded with calls from consumers. These calls are recorded manually, which takes considerable time to reach concerned substation staff. To restore the network, the fault crew is sent to the field to find out which transformer has failed, location of affected houses, cable faults and availability of alternate transformer back feeding arrangements for restoring its network. All these decisions are taken on the field on ad hoc basis and many times the substation is not aware of the changes made in the field. This necessitates the need for a quicker in-office solution for a planned, recorded action for restoration of power.

Today there is no real time data such as on-line reading of power, current, temperature, etc. available for distribution network beyond substation. This would facilitate tasks such as detection of power pilferage, detection of power failure even before call from a customer, identification of the need for transformer replacement, enhancement or service based on peak loads and performance trends.

It is necessary to model the spatial distribution of the electricity consumption in order to predict the future trend for the purpose of planning for management of electricity generation, to plan on efficient methods to control T&D losses and to minimize time for power restoration.

Why GIS

As per the definition given by the United States Geological Survey, GIS can be defined as "a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data (i.e., data identified according to their position) for complex planning and management problems."

On observing the necessities previously specified, the question may rise that any usual database organization system will do the job. But the electrical distribution system has a spatial dimension to it, which noises for the need of GIS. The Geographical Information System can grip both spatial as well as non-spatial data, which brands it more beneficial over the traditional database. Also GIS has the functionality of having information as layers, which assistances in a methodical and sophisticated way of managing voluminous data. The spatially referenced data delivers useful reference for setting up of new facilities, necessary information on land use pattern for planning optimum expansion of network and other network operations and conservation. The database can also handle non-spatial queries as done with any other normal DBMS.

Beyond all the utmost supremacy of GIS is visualization. The whole electrical network can be visualized as it is laid on the ground. Impartial by looking at the map and clicking at a specific feature (say a transformer), all the info (both location and engineering information) is showed. This delivers a more supple sympathetic of the network and hence a faster method to the solution. EDIS Electricity Distribution Information System (EDIS) is a GIS that has precise location and engineering information of the electrical distribution network and equipment that are installed in the study area. EDIS also incorporates a decision support system that serves as an effective tool for analysis such as suitable location for placing new transformers, connection for a new building, trouble call analysis and fault management.

Workflow

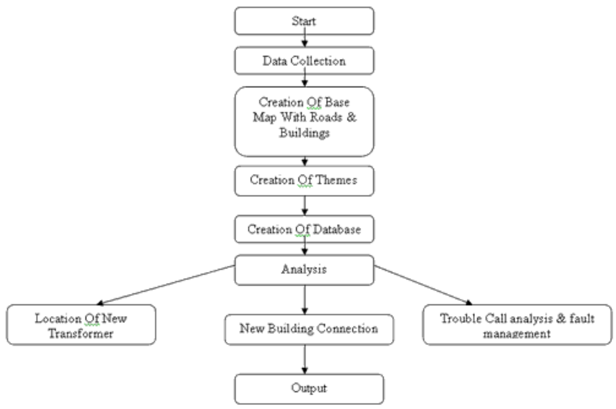

Figure 1

System Design

This section gives an insight on the design of the system.

Study Area

A part of Velachery with an area coverage of 2 Square km in Chennai city, Tamil Nadu is chosen as the study area. Details of the selected substation and feeder lines are Sub.

Station: Velachery 110/33/11KV SS

Selected Feeder: 11KV,Dhandeeswaran feeder off Velachery SS

Alternate Feeder: 11KV,Velachery feeder off Velachery SS 11KV,Tharamani feeder off Velachery SS

Feeder Feeding Area: Division No 153

- Dhandeeswaran Nagar
- Tansi Nagar
- VGP Seethapathy Nagar

LIC Colony

Data Collection

The first and foremost step in the design is the collection of the obligatory data for a stated study area. There are two types of data involved - spatial and non-spatial.

Spatial Data

Base Map

The velachery base map consisting of roads and buildings of the area was digitized form IKONOS data available at the Institute Of Remote Sensing.

Distribution Network Map

For the distribution network map, hard copy of the cable route line drawing was digitized.

Non-Spatial Data

The following data were collected from the Tamil Nadu Electricity Board (TNEB)

Consumer Detail: Account No, Address of the customer, the LT pole/pillar to which a customer is connected.

Electrical network Details: 11KV single line diagram of the selected Dhandeeswaran feeder with cable sizes, lengths, distribution transformer, parameters of the equipment, pillar, pole and low voltage networks. 11KV cable includes 11KV 3*300 sq mm XLPE cable, 11KV 3*120 sq mm XLPE cable, and ACSR conductor.

Layer Creation The following layers were created using GeoMedia Professional 5.1 and shape files were formed.

Road: The road network in the area digitized as lines

Bldg: The buildings in the area digitized as polygons

The High Tension (HT) Network:

- HTPOLE : HT poles in the area digitized as points
- HXCABLE: HT 11KV,XLPE cable of 3*120 sq mm, digitized as lines
- HTCABLE: HT 11KV, 3*300 sq mm XLPE cable digitized as lines
- HCCABLE: HT 11KV overhead conductor, digitized as lines
- DTRANS : Distribution transformers digitized as lines

Low Tension (LT) Network

- **Pill:** Pillars of the area digitized as points
- **LTPOLE :** LT poles digitized as points
- **LTOH :** LT overhead ACSR conductor digitized as points
- **LINK :** LT back feeding cable arrangement existing between the pillar and LT Pole, digitized as lines
- **L120C:** LT 3 ½ *120 sq mm cable digitized as lines
- **L240C:** LT 3 ½ *240 sq mm cable digitized as lines.

Development of Database The data stored in the database forms the information base. Once the layers are digitized, the non-spatial data are then added as attributes to the digitized features. This attribute table will be linked to the spatial themes containing topographical information. The database created therefore will include location and descriptive information for all the different components of the system. For line entities the database will also include the length.

Expansion of Code In Visual Basic Using Map Objects:

Subsequent to the creation of shape files and the database, the actual application is developed using Visual basic, Map Objects and NetEngine.

Visual Basic is the Microsoft’s most popular Application development tool used to develop windows based applications. Developing an application is made simple in Visual Basic using readily built objects or development components. Map Objects is the product of ESRI. Map Objects is an ActiveX component containing tools for customization and developing a GIS application. Evaluation version of Map Objects 2.2 version has been used to develop this application.

NetEngine is an ESRI product that provides the capability for programmers to define, store, traverse, and analyze networks.

Map Objects mainly contains two controls. Map - Map control is the main control comprising almost all objects needed for GIS Functionalities Legend- control is to show the currently used layers status with check boxes.

The map layers i.e, the formerly created shape files are added to the VB form using the map control. Then the legend control is used for adding check box for each layer. The usual tools of GIS software namely Pan, Zoom-In, Zoom-Out, Zoom to full extent etc are created by writing appropriate code in BASIC language. Menus are created for in the form displaying the map. This would include one for location of new transformer and one for the establishment of new connection.

For the location of new transformer, the logic involved is that a point equidistant from the overloaded transformer and a nearby transformer is located also satisfying the criteria that the point is along the road. The equidistant point is located and displayed by writing the code using NetEngine.

Likewise for the establishment of connection to a new building, the expected load is taken and the most suitable transformer is located based on the nearest one from the new building and also the current loading of the transformer. The transformer is indicated on the map. The coding for the length of the wiring is also written based on the distance. Figure 1, shows the designed application with the layers in the legend. Figure 2, shows the information of selected low tension pole.

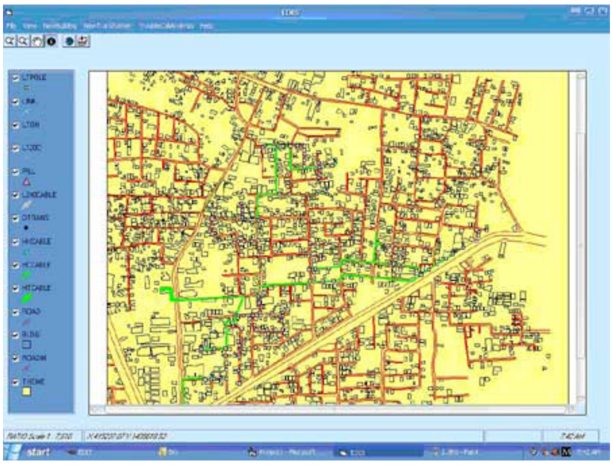

Figure 1.Different Layers of The System

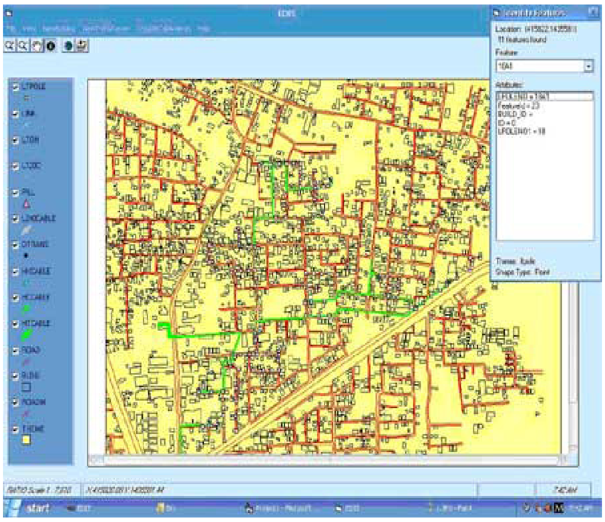

Figure 2.Information at Mouse Click

Functionality

The functionality of the system can be categorized as input from the user, search on the database, location on the map and proposed conclusion.

New Transformer Location

The menu for indicating new transformers is selected. The transformers whose current load is exceeding the maximum loading capacity are selected from the database. The current loading of the transformer is determined by summing up the electricity consumption of the individual consumer connected to that transformer.

The transformer nearby to the overloaded transformer is also located and a position on the road that is equidistant from both this transformer is chosen as the best location for the new transformer. This position is indicated on the map. Also the back feeding line for the new transformer is also indicated.

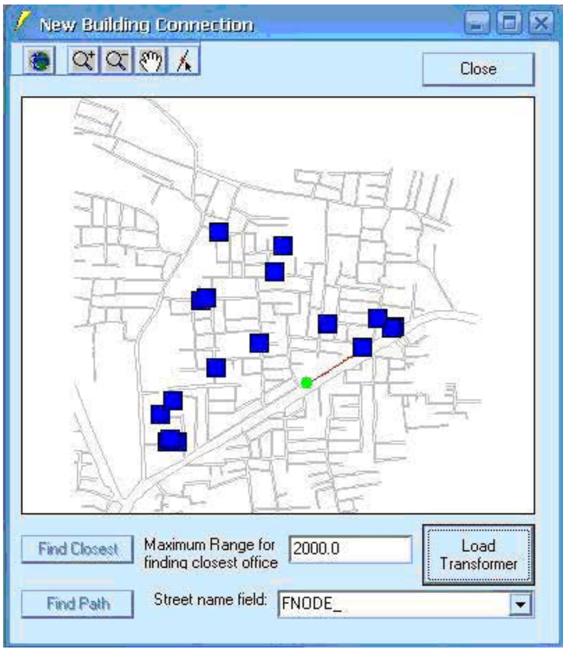

Figure 3.New Building Connection

New Building Connection

The menu for new connection is selected. The user gives the input about the new building location and the expected load. The new building is located on the map and the nearest transformer is also located based on the network analysis. The current loading of this transformer is determined and is checked with the expected load for overloading. If this transformer is not acceptable then the next nearest one is chosen and is tested for. The best transformer is then indicated on the map and also the length of wiring required is calculated using network analysis and is displayed. Figure 3.shows the VB form displays an analysis performed for new building connection.

Trouble Call Analysis & Fault Management

Trouble outages are created when customers call to report loss of power. The trouble call analysis helps in maintaining adequate services to all the customers. On receipt of the trouble call from the consumer, by entering the account no., the address and the electrical network feeding of the consumer is displayed on the screen. The trouble point of supply with the terminal point of supply with the cable network and electrical entities are displayed. Fault management is done when the transformer under fault is known. The distribution transformer under fault is selected and is linked to the database. From the database the affected area are found and displayed on the map. The alternate back feeding arrangement are also selected and displayed.

Future Add-Ons

The process discussed above deals only with static data. This data must be updated manually on a regular basis. A further enhancement on the system would be to integrate GIS with real-time data from systems such as Supervisory Control and Data Acquisition (SCADA) or Distributory Control Systems (DCS). These are systems, which collect data on a real time basis from remote electronic energy meters having built-in transmitters/data cables/Ethernet. This data can be used to update the database at the backend of the GIS regularly. This will have the following beneficiaries:

T&D losses can be accurately determined based on the meter readings from the substation transformers, feeder lines, and distribution transformers. This helps in assessing the performance of the equipments and hence in maintenance.

Distribution Transformers can also be fitted with meters so that loading of the transformers can be monitored on a real-time and the need for new transformers can be decided. This can be made visual by assigning a different color on the map for a transformer once it is overloaded hence giving a proper voltage drop analysis. This will help in the planning of maintenance.

The system also helps in modeling the area wise electricity consumption, which will be essential for future power budgeting.

Integration of this system with real-time metering will aid in day-to-day monitoring, operation & maintenance. This will improve the efficiency of the system resulting in customer satisfaction.

Drawbacks

The initial design of the system for a large area involves volumes of data that needs to be carefully entered.

The initial cost involved in setting-up the system of on-line metering and real-time data is high and is only on a trial basis as on date in India.

The designed system in the paper is windows based i.e., platform dependent.

Conclusion

Electricity is one of the most vital needs whose generation & distribution needs to be properly monitored and maintained. Digital system provides timely, accurate, and easier way of acquiring information, which are very vital in taken prompt and accurate decisions necessary in the economic development of any enterprise. More efforts must be made to bring in such refined and scientific warning. Any aberration can be easily detected.

Outages can be located faster even before the complaint from the consumer and maintenance crews can be immediately dispatched with critical information.

v Power thefts can also be identified and curbed. Installing meters on all incoming and outgoing feeders of transformers with real-time energy audits can do this.

Merits of The System

GIS has faster analysis capabilities, simple operation and versatility. It has speedy retrieval of data. Updating and sharing of data is also easy.

The spatially enabled information provides a unique dimension and interpretation of the problem at hand.

The system assists in choosing suitable alternatives within the limits of the design parameters, working out a precise diagram of existing network and mapping them onto maps of the area thus ensuring optimal allocation of resources for maintenance.

The system provides an electrical engineering analysis platform that helps in modeling the unbalanced load, perform load flow analysis, approaches. GIS would prove to be cutting edge technology in decision making for power safeguarding.

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