GIS BASED ASSET MANAGEMENT OF TRANSMISSION & DISTRIBUTION SYSTEM

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree
of

MASTER OF TECHNOLOGY
in
ALTERNATE HYDRO ENERGY SYSTEMS

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which has been presented in the dissertation entitled **"GIS BASED ASSET MANAGEMENT OF TRANSMISSION & DISTRIBUTION SYSTEM"** in partial fulfillment of the requirements for the award of the degree of **Master of Technology in Alternate Hydro Energy Systems**, submitted in Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, is an authentic record of my own work carried out during the period from July 2006 to June 2007 under the supervision of Dr. J D Sharma, Professor Electrical Engineering Department and Sh. Arun Kumar, Head and Chief Scientific Officer, Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee.

The matter embodied in the dissertation has not been submitted by me for the award of any other degree or diploma.

Date: 29/6/07

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Place: Roorkee

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief.

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ABSTRACT

Deregulation and an increasing competition in electricity markets urge energy suppliers to optimize the utilization of their equipment, focusing on technical and cost-effective aspects. This has created the need for new strategies commonly referred to as asset management.

The asset management program is an organized repository of the inventoried data and a tool to value the asset based on their existing condition. In this dissertation an interactive Geographic Information System (GIS) based asset management system is developed for IIT Roorkee Transmission & Distribution system. Using GIS along with traditional database technology enabled simplified access to the data through the use of spatial selection and queries. The dissertation task included creation of inventories of assets, asset evaluation and integration with GIS.

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CHAPTER –1

INTRODUCTION

1.1 GENERAL

The core business of electrical utilities is to manage their assets so as to provide the electricity consumers with the sufficient quantity of good quality at the least cost. In other word, asset management is the everyday business of electrical utilities.

The business of electric power delivery has changed. Utilities need to remain lean and profitable while pushing equipment to its limits. Utilities now recognize that the power system and Instrumentation & Control (I&C) system assets, such as cables, transformers breakers, and control systems require more visibility. These assets need to be instrumented, monitored, maintained, and eventually replaced. They need to be managed both physically and fiscally. Construction and instrumentation projects for new and existing assets need to provide a measurable return on investment (ROI). Historically, there has been no data to prove projected benefits. In the future, projects will be evaluated on the true value they provide. Each successful project must improve the bottom line with a positive ROI.

Nearly every wires business process involves some spatial element, whether that is a new retailer, customer, pole, wire, underground switch or communication device. Under industry restructuring, there will be an increasing need to leverage information to reduce costs and to provide better customer service. Regulated utilities, transmission providers and unregulated retailers are looking at GIS to meet their changing business needs.

1.2 DESCRIPTION OF AREA UNDER STUDY

The main supply for the entire distribution network of IIT ROORKEE is from the 33 kV substation situated in Govindpuri, whose incoming power is from a 220/132/33/kV substation located at Ramnagar in Roorkee. Ramnagar substation is at a distance of 4 km from IIT campus. The primary distribution that involves supply from distribution substations to distribution transformers is in the form of three ring main circuits or loop type circuits .These three ring main circuits form three local grids .In all there are 10 distribution substations forming three ring main circuits.

Each ring main circuit connects different distribution substations. Each ring main circuit begins and ends at the same substation. All the substations in a particular ring are connected through underground cables of different capacities and cross sectional areas. All the underground cables involved are of 3core, 11 KV type and are XLPE (cross linked polyethylene) insulated and material of conductor in the cables is Aluminum.

Some of the substations are compact secondary substations (CSS). CSS secondary substations occupy very less space i.e. the space required for the transformers as well as related equipment such as circuit breakers, relays etc is very less when compared to normal outdoor substation.

The secondary distribution starting from the primary feeders leaving each distribution transformer and supplying power to customers is through overhead lines. Each feeder line emerging from distribution transformers situated in the distribution substations is connected to the nearby pole through underground cables and from these poles power travels through overhead lines and finally the service line that provides supply to the customers is through underground cables of different lengths and cross sections depending on the load requirements of the customers.

LINE DIAGRAMS:

The figures of the three ring main circuits formed by different distribution substations are given below:

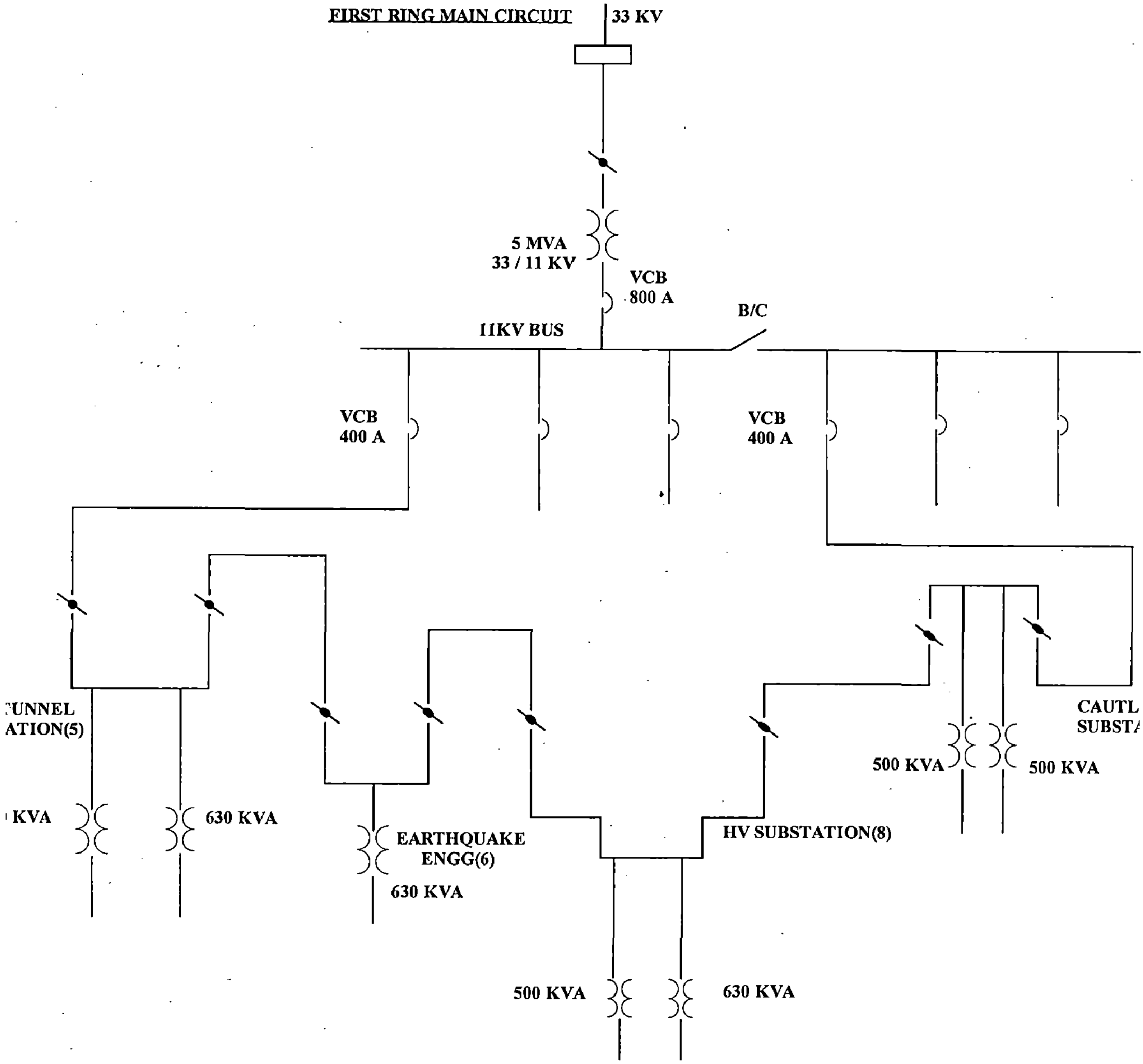


Fig 1.1: First Ring Main Circuit

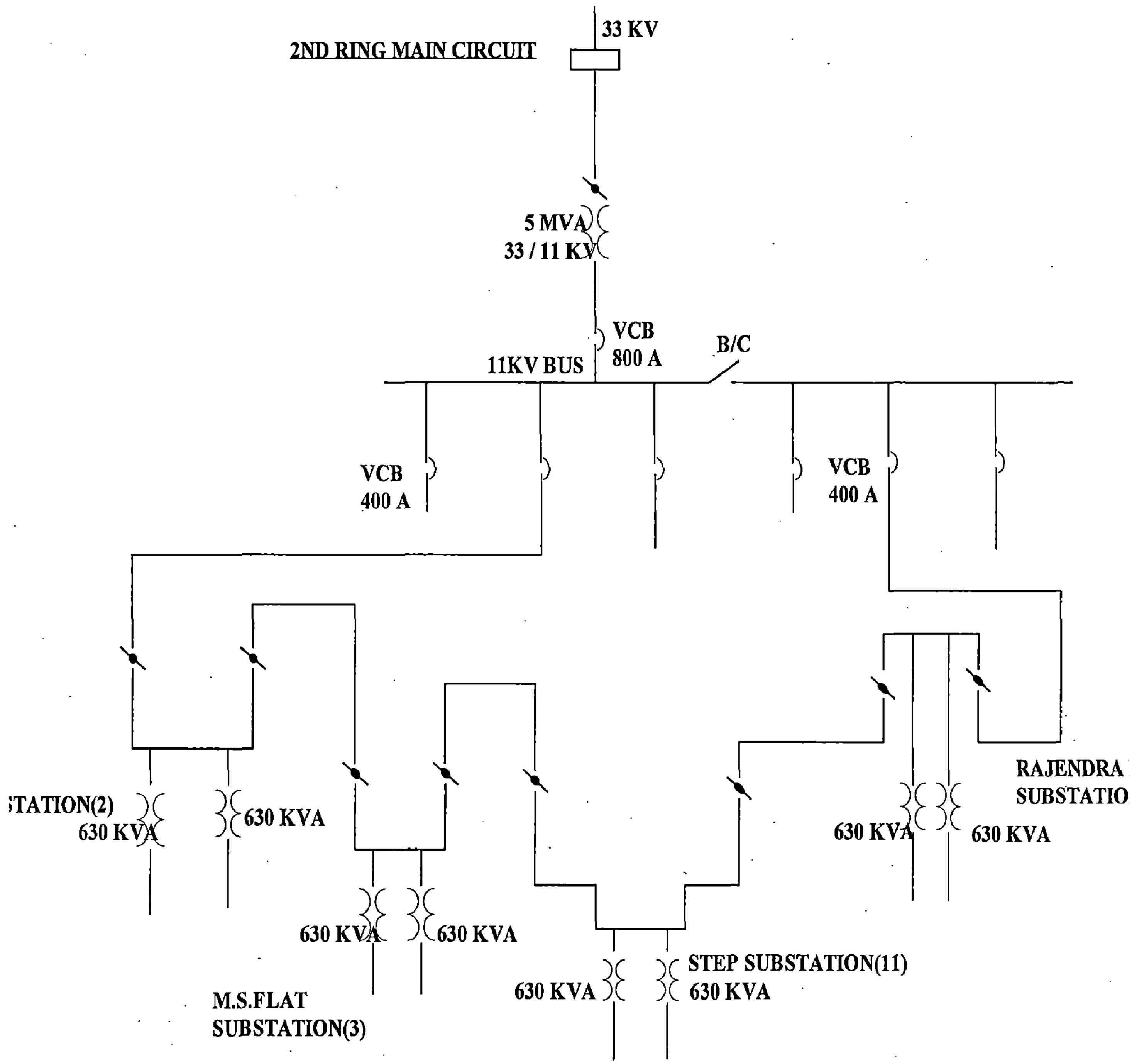


Fig 1.2: Second Ring Main Circuit

3RD RING MAIN CIRCUIT

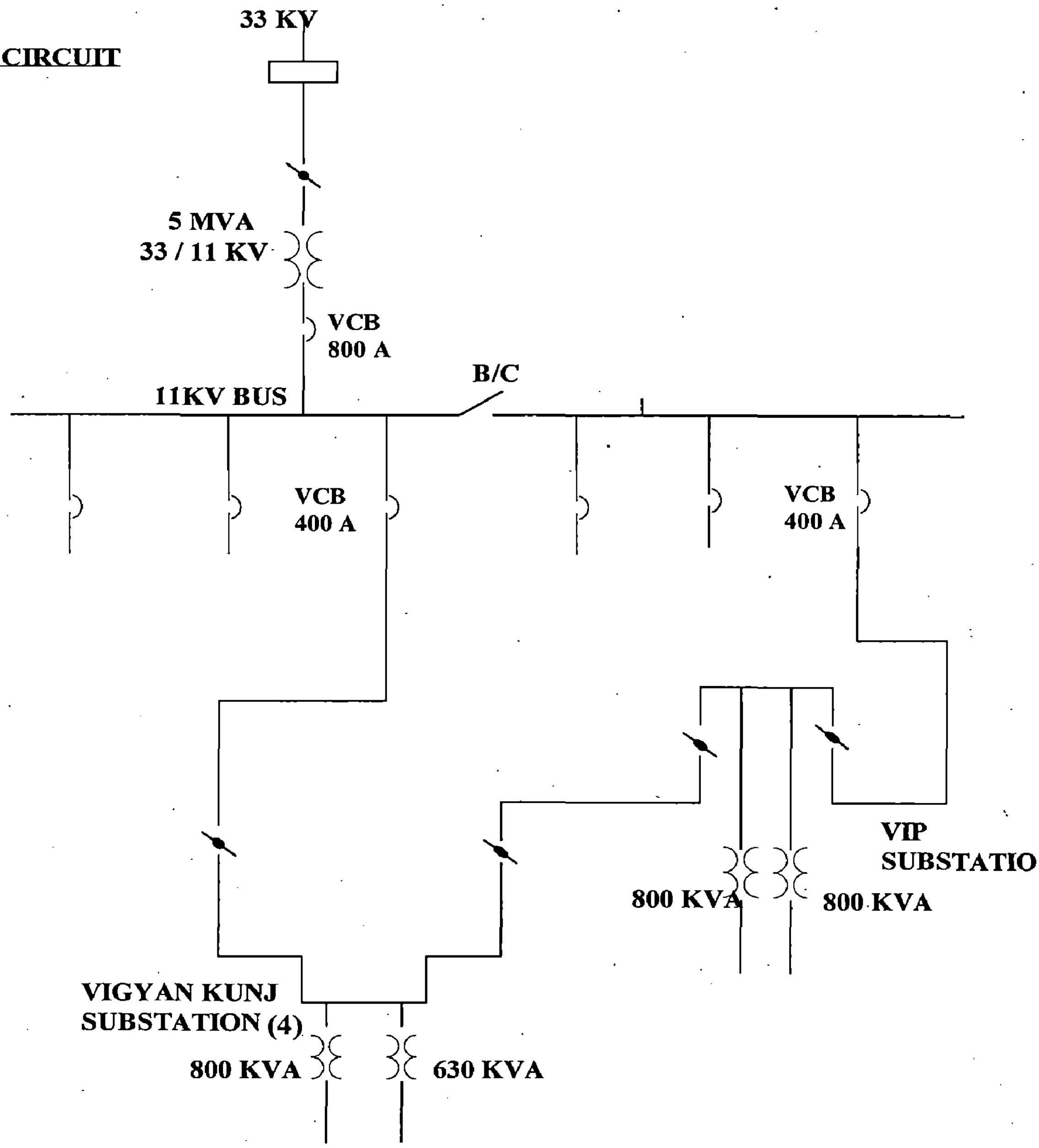


Fig 1.3: Third Ring Main Circuit

1.3 NEED OF THE STUDY

With the increasing size of the electrical utilities both in quantity of assets and the geographic reach, traditional method of maintaining the asset records is no more applicable. Maintaining records in GIS helps in fast and easy retrieval of information. This information can then be used for making any sort of analysis and taking decisions.

1.4 OBJECTIVES OF THE STUDY

- To study various aspects of asset management in electrical utilities
- To prepare a GIS based software model for asset management of distribution system of IIT Roorkee.

CHAPTER – 2

LITERATURE REVIEW

Most of the papers available are on various techniques applied for asset management in electrical utilities. Very few papers are available on GIS application in asset management. Papers available on asset management of various other asset oriented industries like road infrastructure, water supply, transportation vehicles etc are also referred. Review of some of the papers referred is given below.

Joachim Schneider et al. [1] describes the usage of the methods, particularly with regard to asset management and risk management within electrical grids. The essential information needed to set up an appropriate asset management system and differences between asset management systems in transmission and distribution systems are discussed. The bulk of costs in electrical grids can be found in costs for maintenance and capital depreciation. A comprehensive approach for an asset management in transmission systems thus focuses on the "life-cycle costs" of the individual equipment. The objective of the life management process is the optimal utilization of the remaining life time regarding a given reliability of service and a constant distribution of costs for reinvestment and maintenance ensuring a suitable return. In distribution systems the high number of components would require an enormous effort for the consideration of single individuals. Therefore statistical approaches have been used successfully in practical applications. Newest insights gained by a German research project on asset management systems in distribution grids give an outlook to future developments.

Mark Ostendorp [2] presents a cost-effective and innovative airborne inventory and inspection patrol system for distributed assets such as transmission lines, pipelines, and roadways. His results show that aerial high-resolution digital visual and spectral images tagged by Global Positioning Satellite (GPS) coordinates can be successfully used to cost-effectively identify the majority of conditional defects on electric power lines. He has shown that the condition and defect detection rate of the airborne inventory and inspection system is significantly higher than rates derived from traditional patrols and comparable to values achieved from driving patrols. Geographic Information Systems (GIS) based mapping tools can be used to quickly and efficiently interpret digital images collected from aerial platforms. Digital images provide an archival record of the condition of the distributed assets to estimate the long-term performance of the assets and to define cost-effective maintenance and replacement schedules.

David J. Dolezilek and Lee Margaret Ayers [3] together in their paper addresses overlooked asset management needs of determining and improving the health, reliability, ROI, and performance of apparatus and systems.

Biljana Stojkovska et al. [4] presents a combination of GIS and Distribution Load Estimation algorithm based on customer billing information to estimate the load. Because the great number of load points are scattered in the whole area supplied by distribution system, it is unrealistic to measure the load and to get the load profile of each load point (transformer MV/LV). This paper provides an assessment of how accurately combination of GIS and distribution Load Estimation algorithm is able to obtain needed dynamic load models for HV/MV substations.

Gene Kindrachuk [5] defines GIS and asset management with respect to electrical utility. The author specifies about data partitioning and analysis method in a GIS based asset management system.

Richard E. Brown and Bruce G. Humphrey [6] in their paper talk about goals and competencies of asset management. They also tell how risk management, budgeting maintenance etc., are done.

Aztec System, Inc [7] tells about the benefits of using GIS in asset management system.

T. Kostic [8] presents a unified picture of technical asset management related activities in utilities, with their relationships, shown on a map. The explicit relationships represent those aspects that particularly support the asset management process. This brings into focus the importance of supporting Information Technology (IT) and standards. In general, our map represents some of the many facets of asset management, and our hope is that it can contribute to the demystification of asset management, usually referred to as everything and nothing in particular. The paper also provides a number of references which helped to identify some pieces of the asset management puzzle.

CHAPTER – 3

ASSET MANAGEMENT IN ELECTRICAL UTILITIES

3.1 DEFINING ASSET MANAGEMENT

Asset management is a term derived from the financial industry, where it is applied to investment portfolios containing stocks, bonds, cash, options, and other financial instruments. Fundamental to financial asset management is the trade-off between risk and return. Investors identify acceptable risk, and asset management techniques are used to achieve this level of risk for the highest possible return

Some of the Swiss utilities defined asset management in the following way

"It is mastering the state of the equipment at any moment, i.e., knowing quantitatively in what shape your equipment is;"

"It is the identification of assets through the GIS (Geographic Information System);"

"It is the support for computing the ROI (return on investments) and the value of the assets;"

"It is about what equipment to buy, or whether to buy shares in a generating unit;"

"It all the legal issues related to asset ownership."

A broad definition of asset management is as given below:

"The process of guiding the acquisition, use and disposal of assets to make the most of their future economic benefit and manage the related risks and costs over their entire life"

Fundamental asset management tasks cover aspects from technical issues like network planning or the definition of operational fundamentals to more economical themes like planning of investments and budgeting, and end up in strategic planning issues.

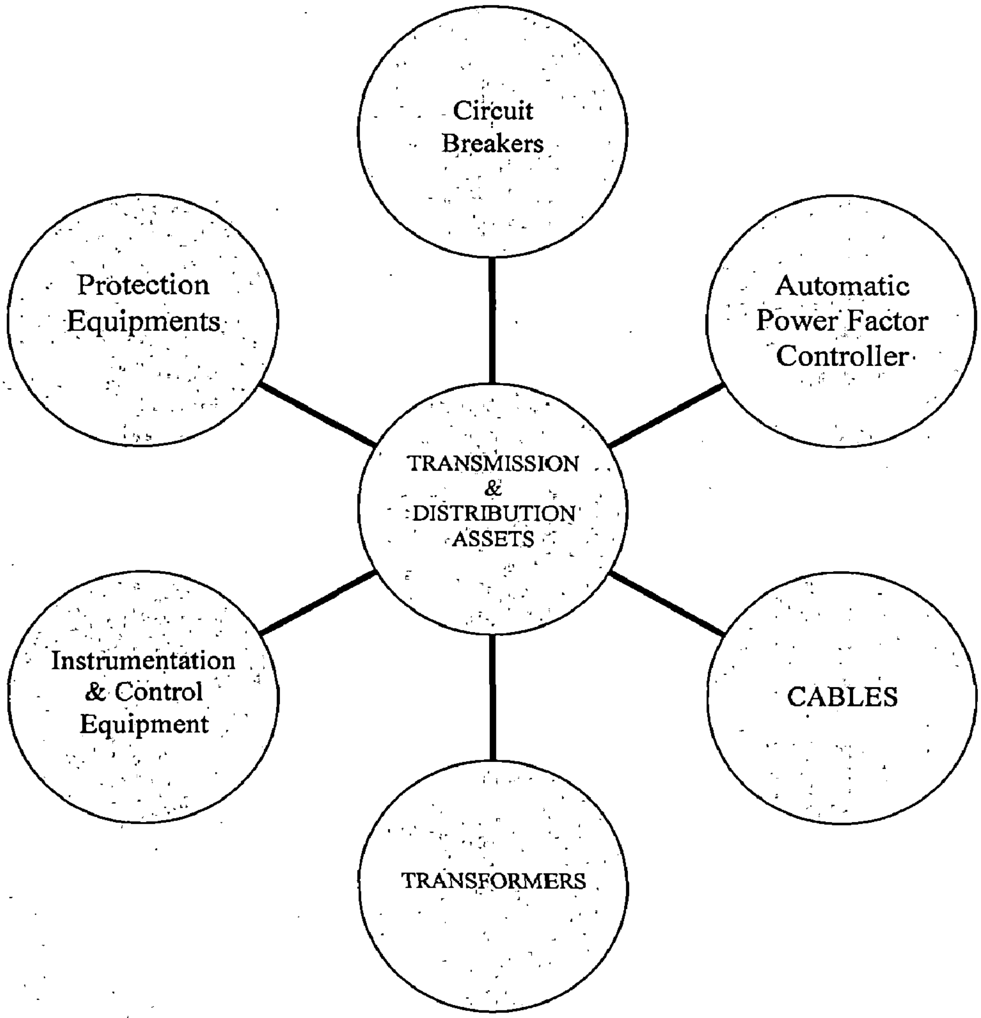


Fig 3.1 Basic Transmission & Distribution Assets

3.2 ASSET MANAGEMENT ACTIVITIES

Asset –oriented activities focus on an asset as a component (e.g., transformer "xyz"), or on the population of assets of similar type (e.g., all 500 MVA transformers).

Network-oriented (or system) activities deal with the outage scheduling (for maintenance), with respect to system constraints, such as maximum load and required network reliability.

Enterprise-oriented activities involve strategic decision taking about investments, overall reliability and policies set up. They are rather managerial activities, and rely on the results of the other two groups.

3.2.1 Operation & Maintenance

1. **Maintenance policy**

Maintenance policy is one of the operating policies, and in a given setting, it is selected to satisfy both technical requirements (reliability of supply) and financial constraints. A simple classification would be as follows:

- **Corrective and emergency** maintenance is applied after something had gone wrong, immediately or with the shortest delay possible after some condition monitoring(inspection or on-line) detects a danger of imminent failure (emergency), or after a failure itself occurred (corrective).

- **Preventive** (or scheduled, or planned) maintenance consists in carrying out pre-defined activities at fixed time intervals, selected on the basis of long-time experience and/or manufacturer recommendations, and sometimes through some type of optimization (usually, the least costly maintenance frequency).

- **Predictive** (or pro-active, or as-needed) maintenance can be called any approach that provides a quantitative connection from maintenance to reliability. It usually incorporates some type of analysis and assessment, and is performed when estimated necessary, based on periodic inspections, diagnostic tests, or other means of condition monitoring.

2. Assessment

Equipment assessment is one of the most important parts, carried out continuously by equipment specialists. It is ideally based on historical records of equipment operation and maintenance, and on the human expertise together with equipment manufacturer specifications. Historical data is the most critical issue in assessing the equipment, because it is often not available, or inconsistent, or too numerous and requiring a thorough validation for obtaining meaningful and reliable results. It is essential that historical data of equipment operation and maintenance be analyzed in order to determine equipment failure rate. The equipment exposed to higher stress will have shorter useful lifetime than the average for the type of equipment. Or, the equipment on which some maintenance has been performed will have its useful lifetime longer than the average. In conclusion, analysis of historical data produces failure and deterioration (ageing) statistics of the equipment.

3. Maintenance Scheduling

With the increase of predictive maintenance, maintenance annual cost increases linearly, while the cost of loss of service decreases (since more maintenance should result in less outage). The optimum amount of maintenance is when the two costs are equal.

This economic optimization is the first step in the processor long medium-term maintenance scheduling. Namely, maintenance time intervals per equipment are to be found that will give the optimal global cost. The way these intervals recalculated reflects the main difference between maintenance policies. Under a preventive policy, maintenance actions arc mostly planned by fixed intervals, usually based on manufacturer-provided fixed reliability indices. Obviously, if an important deterioration has been identified in the routine inspection, the equipment can be assigned high priority for maintenance, and the existing plans rescheduled.

The second step is to establish a prioritization scheme, which provides for ranking the possible actions in such a way that the highest benefit per cost unit is obtained, within the allocated budget.

4. Short-term Outage Scheduling

The short-term outage work scheduling must take into account both resources (on Maintenance side) and network reliability (on Operations side). Although there are not many methods reported in power systems literature for systematic optimization of short-term outage schedules (compared to long/medium-term), there are some.

5. Regular Maintenance Outage Work Management

There are different types of maintenance activities: those that are performed more or less frequently and those that door do not require the concerned equipment deenergisation (outage). Typical activities that require the outage are equipment tests, replacements while not failed, and different service levels, e.g., partial or full service, and refurbishment. They must be planned for and scheduled in accordance with operations, because they require outage. The concrete work must be co-coordinated with the network operator by means of an IT-based system or simply orally (phone/radio), if no system is in place.

6. Work Management in Case of Problems

Depending on the type and the place of a fault on the equipment, the function of a system may suffer. Any fault is supposed to be cleared by the protection, i.e., the faulty equipment should be isolated (i.e., a topological meaningful opening of breakers). If the equipment is a line or a cable, it may be difficult to find out where (on which line or cable section) the fault appeared, and consequently where to send the field crews. For this purpose (i.e., fault location), there are sometimes dedicated EMS/DMS or stand-alone software applications with sophisticated algorithms that can locate the fault. They also provide the fault analysis function, which generates valuable data for the equipment condition assessment

3.2.2 Strategic Decision Making

1. System Reliability Evaluation

System reliability studies are performed for two purposes. The first is for energy operations planning. It models the sum of generation against the sum of demand, and is used for evaluation of adequacy of generation capacity and power interchange. This kind of reliability studies are performed within the strategic operations planning. The second purpose is power operations planning. The model takes into account the location of generation and demand, and considers the whole network and all the load points in it.

2. Utility Economy

The utility must manage, in general, three inter-related activities a) prioritization of Maintenance/O&M resources, b) prioritization of capital spending, to meet new expansion needs and for replacement of equipment that is too old or costs too much to repair, and c) optimum utilization of its existing and any new equipment. These three activities should be a part of the overall utility managerial process during budget allocation.

The first two spend money, and it must be seen whether it is better to maintain the existing equipment, or to replace it with a new one. The last activity "spends" the assets' useful lifetime, which then leads to higher maintenance costs or non-deferrable capital spending for replacement. The overall optimization goal for the utility is to get the most value for all the above spending (i.e., using up its assets, its Maintenance/O&M budget and its capital budget), the value being defined by business objectives, most often reliability of supply.

CHAPTER – 4

GIS IN ASSET MANAGEMENT

4.1 WHAT IS GIS?

The term GIS is an acronym, which is commonly used in reference to Geographic Information Systems. A Geographic Information System is a system for management, analysis and display of geographic knowledge, which is represented using a series of information sets, processing and work flow models, data models, and metadata. Although many definitions for GIS exist, most users agree that a GIS is a network of computer software, hardware, spatial data, procedures, and personnel. This network is primarily used to collect, manipulate, analyze, and present information that is linked to a location on the earth's surface. However, the real power of a GIS lies in its ability to uncover spatial relationships and patterns within data that may not be revealed using other methods. Today, GIS technology plays an ever-increasing role in the decision making process for a variety of governmental agencies, commercial businesses, and educational institutions.

4.1.1 Definition of GIS

An arrangement of computer hardware, software, and geographic data that people interact with to integrate, analyze, and visualize the data; identify relationships, patterns, and trends; and find solutions to problems. The system is designed to capture, store and update, manipulate, analyze, and display the geographic information. A GIS is typically used to represent maps as data layers that can be studied and used to perform analyses.

4.2 COMPONENTS OF GIS

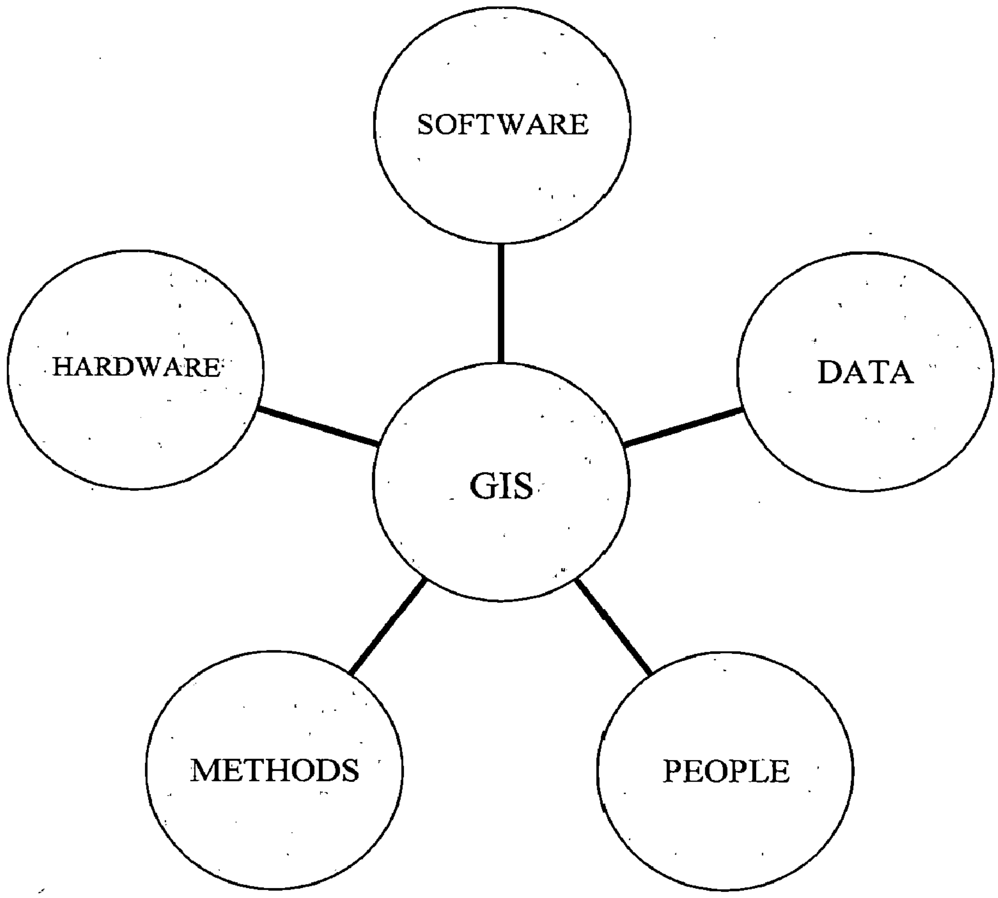


Fig 4.1 Components of GIS

4.2.1 Hardware

- Hardware is the computer on which a GIS operates.
- Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations

4.2.2 Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information.

Key software components are:

- Tools for the input and manipulation of geographic information

- A database management system (DBMS)
- Tools that support geographic query, analysis, and visualization
- A graphical user interface (GUI) for easy access to tools

4.2.3 Data

There are two main types of data in a GIS database

1. **Cartographic**

Observation on spatially distributed features, activities, or events, which are definable as:

- **Point Features**

A 0-dimensional object is a point that specifies a geographic location on the surface of the planet e.g.

A Pole

A Tower

- **Line Features**

The simplest one-dimensional object is a straight line between two points or polyline when there are more than two points. Lines are having direction and magnitude (length) hence a vector data e.g.

Transmission / Distribution Line

- **Area Features**

It is two-dimensional object. An area is fully encompassed by a series of connected lines. Because lines have direction, the system can determine the area that falls within the lines comprising the polygon. Each polygon contains one type of data e.g.

A Power plant

Lake where plant's generating turbines operates.

- **Non-Cartographic**

Descriptive information in a database about the cartographic features located on a map:

Attributes

Attributes (tabular data) are descriptive data that is linked to map features (e.g. points, lines etc.). Possible attributes for a feature electric pole can be:

Height, diameter, type, condition, age etc.

4.2.4 People

- GIS technology is limited without the people who manage the system and develop plans for applying it to real-world problems

- GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work

4.2.5 Methods

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization

4.3 NEW CAPABILITIES REQUIRED FOR BETTER ASSET MANAGEMENT

4.3.1 Asset repository

The data necessary to determine an asset's life cycle history and ROAI is available from the existing asset systems but the systems are scattered throughout the organization, making manual computations impractical. The asset data needs to be organized by asset and aggregated into an Asset Repository.

The Asset Repository stores the following data for each asset:

- Basic asset data including engineering parameters, location, and distinguishing attributes such as manufacturer and serial number
- Current network configuration (if not available via the other systems)
- All life cycle events for each asset
- Complete cost history from procurement to abandonment including maintenance and configuration changes

- Compliance history (inspection, maintenance, or repair); the Repository may also be the system of record to demonstrate compliance
- Revenue billed and collected prorated to the assets
- Load profiles
- Measures of the financial value of the asset

The Asset Repository will include the analysis tools to present life cycle history (events and costs) and ROAI for potential plans, alternate configurations, and system betterment evaluation.

4.3.2 Unifying field and office

Unification of office and field capability is a method to reduce costs and make the office and the field more effective. Unifying office and field work and effectively deploying the work to the field offers the potential of dramatic business improvements in productivity through better asset utilization and work force unification. Unification requires organizational, cultural, and system changes. By moving more office capability to the field and aggressively removing barriers between the office and the field, utilities can make dramatic productivity improvements.

Since utilities are asset intensive companies most of their work is done where their assets are located – in the field. However, most of the improvements in processes, procedures, and systems have emphasized the office worker and not the field worker.

The field may be the "last frontier" for increased effectiveness and reduced costs. Industry studies have documented that a 30% to 50% improvement in field productivity can be achieved by:

- Implementing comprehensive system capability on mobile devices
- Redesigning business processes to unify field and office work
- Developing and monitoring key performance indicators
- Providing field access to current data

The first steps toward field productivity improvement – such as field map access and downloading work orders – have been available for years. These capabilities offer field workers ease of use benefits and reduce clerical work. However, even greater benefits are achieved when the utility fully integrates the field into its business processes, accepts field updates, and provides wide system access to the field worker.

Poorly defined business processes have hampered achieving projected system benefits in both office and field operations. The culture of many utilities separates the field and office staff as well as the construction and operations organizations. In fact, within some utilities, there is a tradition of disrespect for the needs of each party. This culture constrains the benefits that can be achieved.

To achieve the next level of utility effectiveness, the utility must shift its cultural focus from the office to the field where the work is performed. Executive support for these changes, including the necessary organizational changes, is required to help ensure their success.

4.4 CREATING A GIS BASED SYSTEM

4.4.1 Data Collection

To collect spatial asset data it requires extensive survey of all vital assets on field and also the important geographic features of the region where assets are located.

4.4.2 Attribute Collection & Digitization of collected data

After collection of geographic data attribute collection is done which requires extensive fieldwork. Map of the given geographic feature along with associated data is then digitized in appropriate GIS development software.

4.4.3 Map updating

The map should be continuously updated for any

- Addition/alteration of network
- Transformer / Substation equipment addition or alteration
- Addition/ alteration of grid
- Addition/demolition of civil structures
- Acquisition of new land

4.4.4 Integration of GIS with RDBMS and analysis tools

To get the real benefit of GIS it is required to be integrated with database like SQL, Oracle, and SAP etc. This helps in continuous attribute updating in RDBMS platform and then exporting the data into GIS. Through this integration the data is easily imported from GIS into an Electrical Engineering Analysis platform.

4.5 BENEFITS OF GIS

4.5.1 Conflict resolution

Often conflicts arise from inadequate information related to an agencies asset infrastructure. This results in a direct cost to the organization in the form of research time to investigate details about the asset in question. This information is often difficult to find, unorganized and inaccurate.

Collecting this information into a GIS eliminates repeated research and, when combined with a GIS-centric AMMS, the complete asset data is available together with the maintenance history about that asset. Staffs can quickly and easily determine important information to support decisions related to resolving customer inquiries, legal issues, maintenance concerns, ownership, and asset valuation.

Resulting benefits include decreased cost in time in repeated research, actual cost savings derived by sharing these data among multiple applications and across the enterprise.

4.5.2 Data accuracy

GIS and AMMS have created a means by which to store and maintain these data in an accurate and organized method. Moreover, using single-source asset database – the GIS geodatabase – accurate and timely information is available to not only support the maintenance lifecycle, but also other business processes within the organization. The GIS-centric approach enables fast, efficient and accurate decision support. This has been a principal driver among agencies investing in GIS and AMMS around the world.

4.5.3 Customer service

A GIS-centric approach offers users an easy-to-use, fast and efficient means to visually locate customer inquiries.

With a map-view interface, call takers can quickly determine if the caller is within the jurisdiction and if so, address matches the caller's location and/or incident location. As a result, the call taker can easily view the geographic model of the vicinity buildings, streets, signs and related infrastructure that may impact the caller's situation. As well, the call taker can quickly associate related calls.

These capabilities of a GIS-centric system account for measurably faster, more complete service to customers and enable more accurate dispatch of staff to investigate the incident.

4.5.4 Real-Time Mobile Access to Data

Providing information in real-time to field personnel offers measurable cost/benefits. It allows field staff fast and easy access to asset data at the source of the problem. When field personnel can find data to support fast, accurate decisions, cost/benefits can be innumerable.

Keeping field atlas books accurate and up-to-date continues to be a source for time delays and errors, costing public works and utilities unneeded expenditures. Having accurate, real-time data in the field is playing a significant role in mitigating this expense. Access to digital data in the field can also reduce cost by reducing the need to return to the service center because of incomplete information or for following instructions.

4.5.5 Efficient Dispatch

Dispatching maintenance staff to investigate customer issues and perform work has long been a source of resource mismanagement. A natural fit for a GIS-centric AMMS, supervisors can quickly and easily dispatch crews in a more organized and logical manner, mitigating overlapping schedules, misplaced and double booked crew assignments, and optimized routes. It also allows supervisors an efficient way to distribute equipment, materials and resources.

4.5.6 Workload Management

GIS is being used by many organizations as a workload management tool. One of the most common complaints among maintenance crews is an apparent unbalance of scheduled work assigned from crew to crew. By utilizing a GIS-centric AMMS, the geographic assignment of crews can be balanced among staff, crews, regions and other criteria. Among the variables used to balance work include the number of customers in a region, infrastructure quality and type, distance from service centers, number of vehicles, specialty equipment and skills and others. Optimizing the use of available resources is a clear and measurable cost/benefit.

CHAPTER –5

SOFTWARE MODEL FOR IIT ROORKEE DISTRIBUTION SYSTEM

There are 12 substations in IITR distribution system. Except Govindpuri (33/11 kV) every substation is 11/.433 kV station. Three substations are CSS type. There are total of 24 transformers, 155 circuit breakers, 34 isolators and several equipments installed in the network.

5.1 DATABASE CREATION

All asset management systems rely on an underlying database structure to analyze, maintain and update information. The database determines the amount of time needed to update the system, the interface and the abilities of the overall system. The quality of the original data, the way the data is handled, and the maintenance of the database determine the quality and applicability of the system in the decision making process.
The data for IITR distribution system is the primary data which is available at substations it is collected on field by visiting the individual substations. For the ease of storing the data it is recorded in MS Access first of all.

5.1.1 Description of various Database Tables

1. Substation

The substation data table keeps the record of all the substations in the distribution network of IITR.

Table 5.1 Substation Field Details

FIELD NAME	DATA TYPE	DESCRIPTION
SS_ID	Text	Primary key, unique id assigned to every substation
SS_NAME	Text	Name of the substation
INPUT_KV	Number	Input voltage rating
OUTPUT_KV	Number	Output voltage rating

CAPACITY(KVA)	Number	Rated kVA
NO of TRANSFORMERS	Number	Total number of transformers in a substation
NO_OF_INCOMING_FEEDERS	Number	Total number of incoming feeders
NO_OF_OUTGOING_FEEDERS	Number	Total number of outgoing feeders
LAT	Number	Latitude of substation
LONG	Number	Longitude of substation
TYPE	Text	Whether indoor or outdoor type substation

2. Cable

This table keeps the record of all the 11kV cables

Table 5.2 Cable Field Details

FIELD NAME	**DATA TYPE**	**DESCRIPTION**
FD_ASSETNO	Text	Primary key, unique code of every cable
SS_FROM	Text	Originating substation
SS_TO	Text	Substation at which cable ends
DISTANCE	Number	Distance between the substations
CABLE_SIZE	Number	Cross sectional area in square mm
VOLTAGE	Number	Voltage of power transmission
MAKE	Text	Manufacturer's name
COST	Number	Purchase cost in Rs/m
YR_MANUFACTURE	Number	Year of manufacture
AGE	Number	Age of the cable

3. Transformer

The technical details of transformers present in different substations are found in this table.

Table 5.3 Transformer Field Details

FIELD NAME	DATA TYPE	DESCRIPTION
TX_ASSETNO	Text	Primary key, Unique code given to every transformer to identify it.
SS_ID	Text	Code of substation at which Transformer is place
SS_NAME	Text	Name of substation at which Transformer is place
TX_RTG(kVA)	Number	Rated kVA
VOLRTI(kV)	Text	Primary to Secondary voltage ratio
CURRTI(A)	Text	Primary to Secondary current ratio
% IMP	Number	Percentage impedance
FREQ/PHASES	Text	Frequency and no of phases
MIN VOL(kV)	Number	Minimum voltage of transformer
MAX VOL(kV)	Number	Maximum voltage of transformer
YR_MANUFAC	Number	Year of Manufacture
AGE	Number	Age of Transformer
MAKE	Text	Manufacturer's Name
TYPE	Text	Whether outdoor or indoor type
COST	Number	Purchase cost in Rs
PR_VALUE	Number	Depreciated Value of Transformer
DRY/OIL	Text	Oil type or Dry type
COOLING	Text	Type of cooling
TAP RANGE (%)	Text	Percentage value at various tap settings
TAP SETTING	Text	Present tap setting
OTI	Number	Oil temperature
WTI	Number	Winding temperature
OC_PROTECTION	Text	Whether provided with over current protection

EF_PROTECTION	Text	Whether provided with earth fault protection
INSTLN_YR	Number	Year of Installation
Tx_id	Text	Id of transformer to link two tables in GIS

4. Circuit Breaker

Table 5.4 Circuit Breaker Field Details

FIELD NAME	DATA TYPE	DESCRIPTION
CB_ASSETNO	Text	Primary key, unique code to identify each circuit breaker
SS_ID	Text	Code of substation at which circuit breaker is installed
SS_NAME	Text	Name of substation at which circuit breaker is installed
SG_ASSETNO	Text	Asset No of switch gear in which the circuit breaker is installed
RTD_CURR(A)	Number	Rated current in amperes
RTD_VOL(kV)	Number	Rated voltage in kV
BRKG_CAP(kA)	Number	Breaking Current
COST	Number	Purchase cost in Rs
PR_VALUE	Number	Depreciated value of circuit breaker
TYPE	Text	Whether an air circuit breaker or vacuum circuit breaker or oil circuit breaker
MAKE	Text	Manufacturer's Name
YR_MANUFAC	Number	Year of Manufacture
AGE	Number	Age of equipment in years.
INSLD_AT	Text	Type of asset at which the circuit breaker is installed
INSLN_ASSNO	Text	Asset No of asset at which the circuit breaker is installed
Cb_id	Number	Id of circuit breaker to join two tables in arc view

The present value of equipment is calculated by applying the depreciation formula as given below.

Present Value = Purchase cost $(1\text{-}R/100)^{time}$

R=Rate of depreciation

Time=Present year-Year of manufacture i.e. age of the equipment

R = 7.84% for transformer

R = 7.84% for switchgear

R = 5.27 for cables

All these values of R are specified in the amended section 75 A of the Electricity (supply) Act,1948 (54 of 1948)

5. Isolator

Table 5.5 Isolator Field Details

FIELD NAME	DATA TYPE	DESCRIPTION
ISLTR_ASSETNO	Text	Primary key, Unique to identify each isolator
LOCATION	Text	Place at whish isolator is installed
OPERATION	Text	Whether manual or motor operation
OPERATED AT	Text	Whether on load or offload operation
INSTALLED_AT	Text	Type of asset at which isolator is installed
INSLN_ASSNO	Text	Asset No of the asset at which isolator is installed
Is_id	Text	Id of isolator to join tables in GIS

6. APFC

Table 5.6 APFC Field Details

FIELD NAME	DATA TYPE	DESCRIPTION
APFC_ASSETNO	Text	Primary key, Unique code to identify every APFC
SS_ID	Text	Code of substation at which the APFC is installed
TX_ASSETNO	Text	Asset No of transformer with which the APFC is associated
RTD VOLTAGE(V)	Number	Voltage rating of APFC
RTD Kvar	Number	Rated kVAR
COST OF CAPACITOR BANK	Number	Purchase cost of capacitors in Rs
MAKE	Text	Manufacturer's Name
YR_MANUFAC	Number	Year of manufacture
CB_ASSETNO	Text	Asset No of Circuit Breaker with which the APFC is associated
Apfc_id	Text	Id of APFC to join two tables in GIS

5.2 REPRESENTATION OF DATA IN ARCVIEW

The tables of collected data are spatially represented in ESRI's Arcview 3.2a. MS Access tables are imported into Arcview with the help of SQL connect facility. These imported tables are then converted into individual themes in different views.

In this project the IIT Roorkee network is represented in one View.

This view consists of following themes

Substation----point data

Cable11kV---line data

Individual themes for outgoing 400V lines from every substation----line data
Background road map of IIT Roorkee---line data

All substation layouts are represented in distinct views. Each substation View has got following themes.

Outgoing feeder/Incoming feeder---line data
Transformer---point data
Circuit Breaker---point data
Isolator---point data
APFC---point data
Earth switch---point data
Current Transformer---point data
Relays—point data

Main view of IITR network is connected with all other views containing individual substation layouts with the Hot Link facility. Using avenue, different views of Arcview are linked together. Avenue script is also written to connect the Visual Basic application to edit the ".DBF" files and also to open the individual details of assets in excel sheet.

5.3 WORKING OF THE GIS PROJECT

When the project is started with the help of Arcview 3.2a the screen as shown below appears.

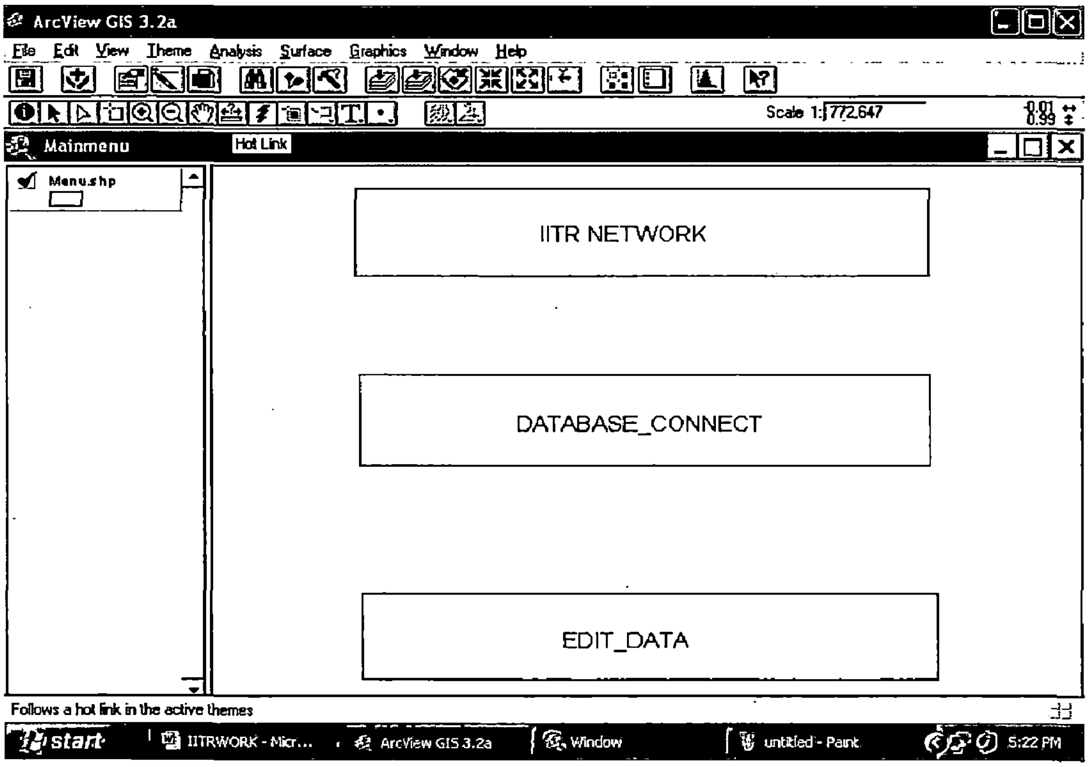
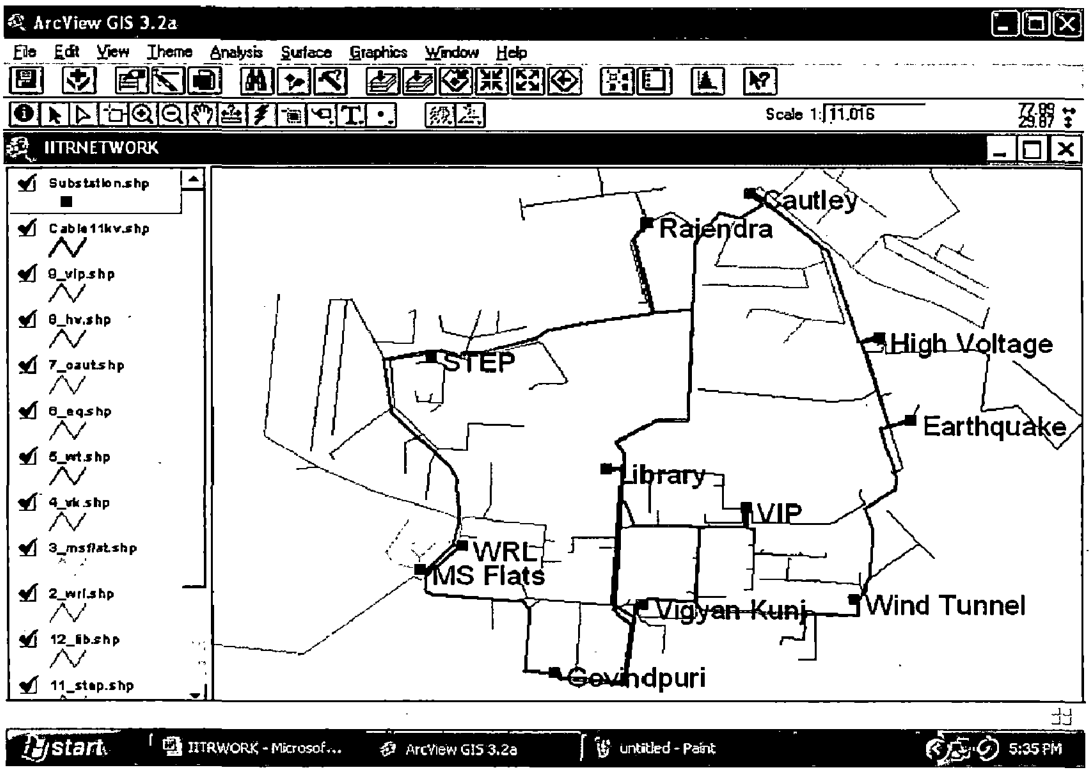


Fig 5.1 Main Menu of arc view project

Click on "IITR NETWORK" to view the next screen. The screen given below appears



This screen contains all the 11kV cables, 400V lines and substations.

The attribute table of substation is as given below

ArcView GIS 3.2a — Attributes of Substation.shp (0 of 12 selected)

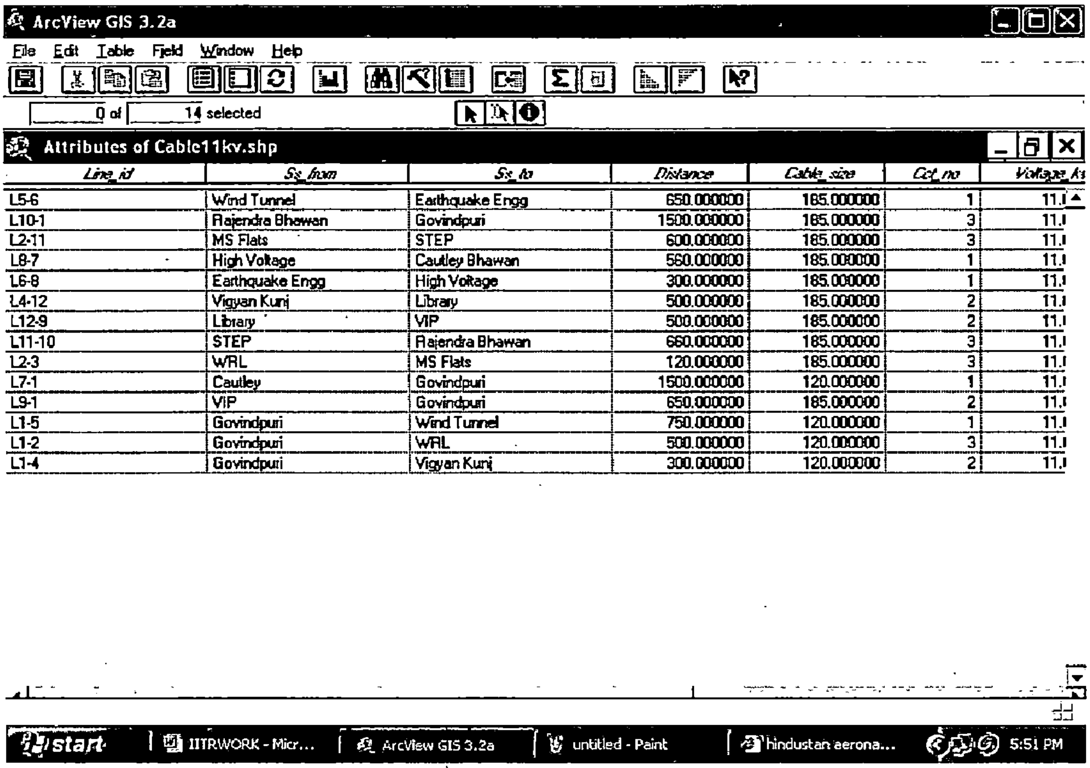
Ss_id	Ss_name	Input_kv	Output_kv	Capacity_k	No_of_tran	Kw_load
S01	Govindpuri	33.000000	11.000000	1000.000000	2.000000	9.900
S02	WRL	11.000000	0.433000	1360.000000	2.000000	0.600
S03	MS Flats	11.000000	0.433000	1260.000000	2.000000	0.400
S04	Vigyan Kunj	11.000000	0.433000	2230.000000	3.000000	0.900
S05	Wind Tunnel	11.000000	0.433000	1260.000000	2.000000	0.700
S06	Earthquake	11.000000	0.433000	630.000000	1.000000	0.320
S07	Cautley	11.000000	0.433000	1000.000000	2.000000	0.450
S08	High Voltage	11.000000	0.433000	1130.000000	2.000000	0.650
S09	VIP	11.000000	0.433000	1600.000000	2.000000	1.100
S10	Rajendra	11.000000	0.433000	1260.000000	2.000000	0.700
S11	STEP	11.000000	0.433000	1260.000000	2.000000	0.650
S12	Library	11.000000	0.433000	1600.000000	2.000000	0.300

ArcView GIS 3.2a — Attributes of Substation.shp (0 of 12 selected)

Kw_load	Kvar_load	No_of_inco	No_of_outg	Long	Lat	Type
9.900000	1.410700	1	6.000000	77.894000	29.861000	Outdoor
0.600000	0.085500	2	6.000000	77.892200	29.863600	Outdoor
0.400000	0.057000	2	9.000000	77.891400	29.863100	Indoor
0.900000	0.128250	2	11.000000	77.895700	29.862400	Outdoor
0.700000	0.099750	2	6.000000	77.899800	29.862500	Outdoor
0.320000	0.045600	2	1.000000	77.900900	29.866200	Indoor
0.450000	0.064125	2	6.000000	77.897800	29.870900	Outdoor
0.650000	0.092625	2	5.000000	77.900300	29.867900	Outdoor
1.100000	0.156750	2	7.000000	77.897700	29.864400	Outdoor
0.700000	0.099750	2	5.000000	77.895800	29.870300	Outdoor
0.650000	0.092625	2	6.000000	77.891600	29.867500	Outdoor
0.300000	0.042750	2	1.000000	77.895000	29.865200	Indoor

Fig 5.3 Attribute table of Substations

Attribute table of Cable 11kV is as given below



ArcView GIS 3.2a

File Edit Table Field Window Help

0 of 14 selected

Attributes of Cable11kv.shp

Line_id	Ss_from	Ss_to	Distance	Cable_size	Cct_no	Voltage_k
L5-6	Wind Tunnel	Earthquake Engg	650.000000	185.000000	1	11.1
L10-1	Rajendra Bhawan	Govindpuri	1500.000000	185.000000	3	11.1
L2-11	MS Flats	STEP	600.000000	185.000000	3	11.1
L8-7	High Voltage	Cautley Bhawan	560.000000	185.000000	1	11.1
L6-8	Earthquake Engg	High Voltage	300.000000	185.000000	1	11.1
L4-12	Vigyan Kunj	Library	500.000000	185.000000	2	11.1
L12-9	Library	VIP	500.000000	185.000000	2	11.1
L11-10	STEP	Rajendra Bhawan	660.000000	185.000000	3	11.1
L2-3	WRL	MS Flats	120.000000	185.000000	3	11.1
L7-1	Cautley	Govindpuri	1500.000000	120.000000	1	11.1
L9-1	VIP	Govindpuri	650.000000	185.000000	2	11.1
L1-5	Govindpuri	Wind Tunnel	750.000000	120.000000	1	11.1
L1-2	Govindpuri	WRL	500.000000	120.000000	3	11.1
L1-4	Govindpuri	Vigyan Kunj	300.000000	120.000000	2	11.1

Fig 5.4 Attribute table of Cable11kV

Any spatial query can be made for e.g. if we want to look for all substations having capacity less than 1260 kVA we have to perform the following things

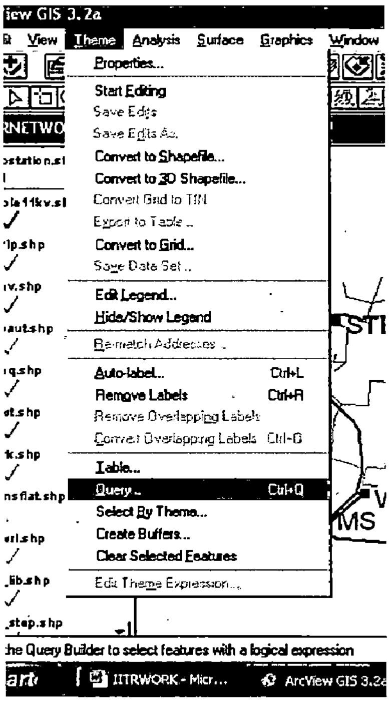


Fig 5.5 Method to select the Query application

Select Query from drop down of Theme or press Ctrl+Q

Small query window as shown below appears. When the query is made the selected area is shown in yellow color.

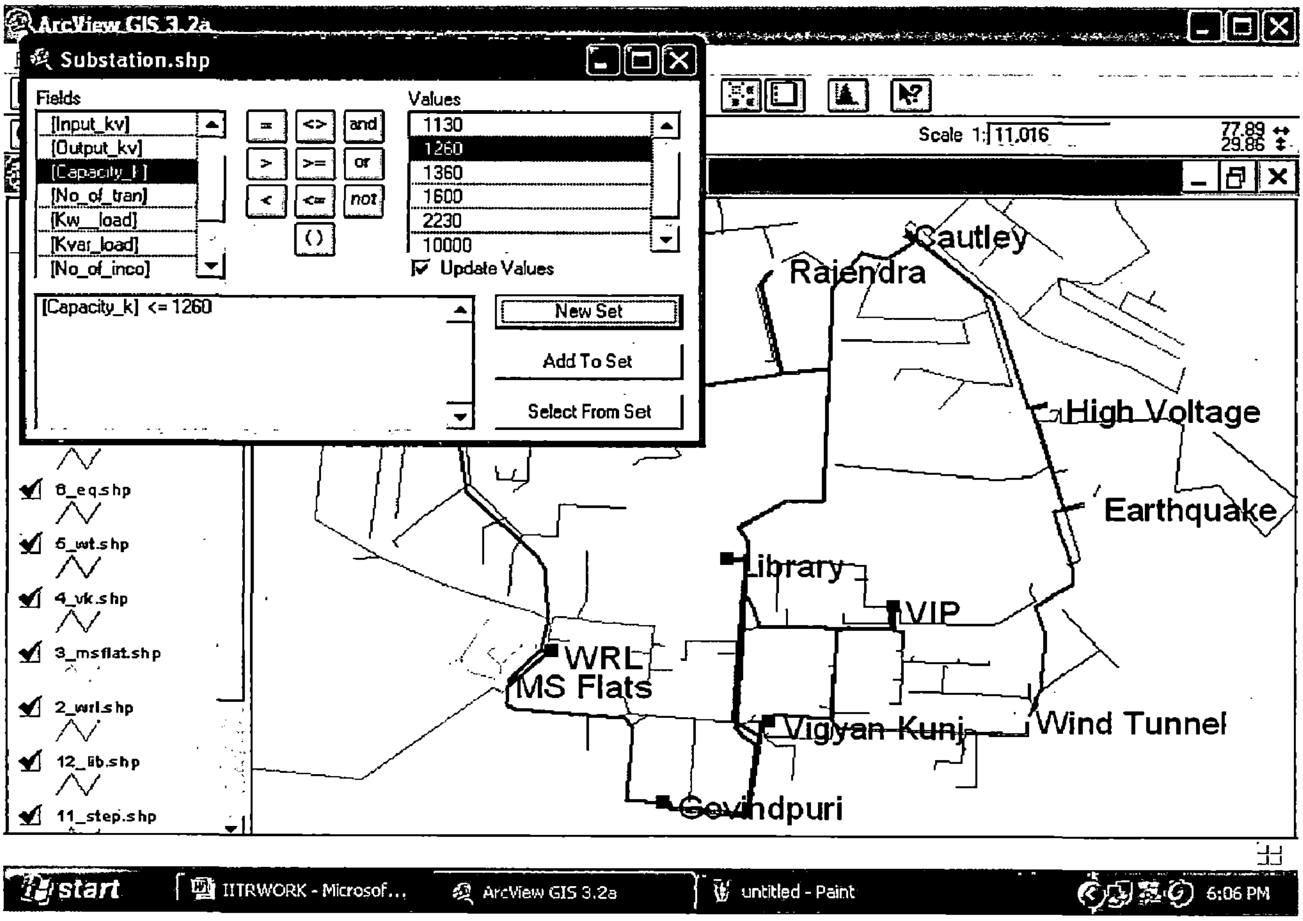


Fig 5.6 Making a Query in Substation view

As the Hot Link indicator is clicked on any of the substation the individual layout view of that substation appears. For e.g. if Hot Link indicator is clicked on Vigyan kunj.

The substation details of Vigyan kunj appear as shown below.

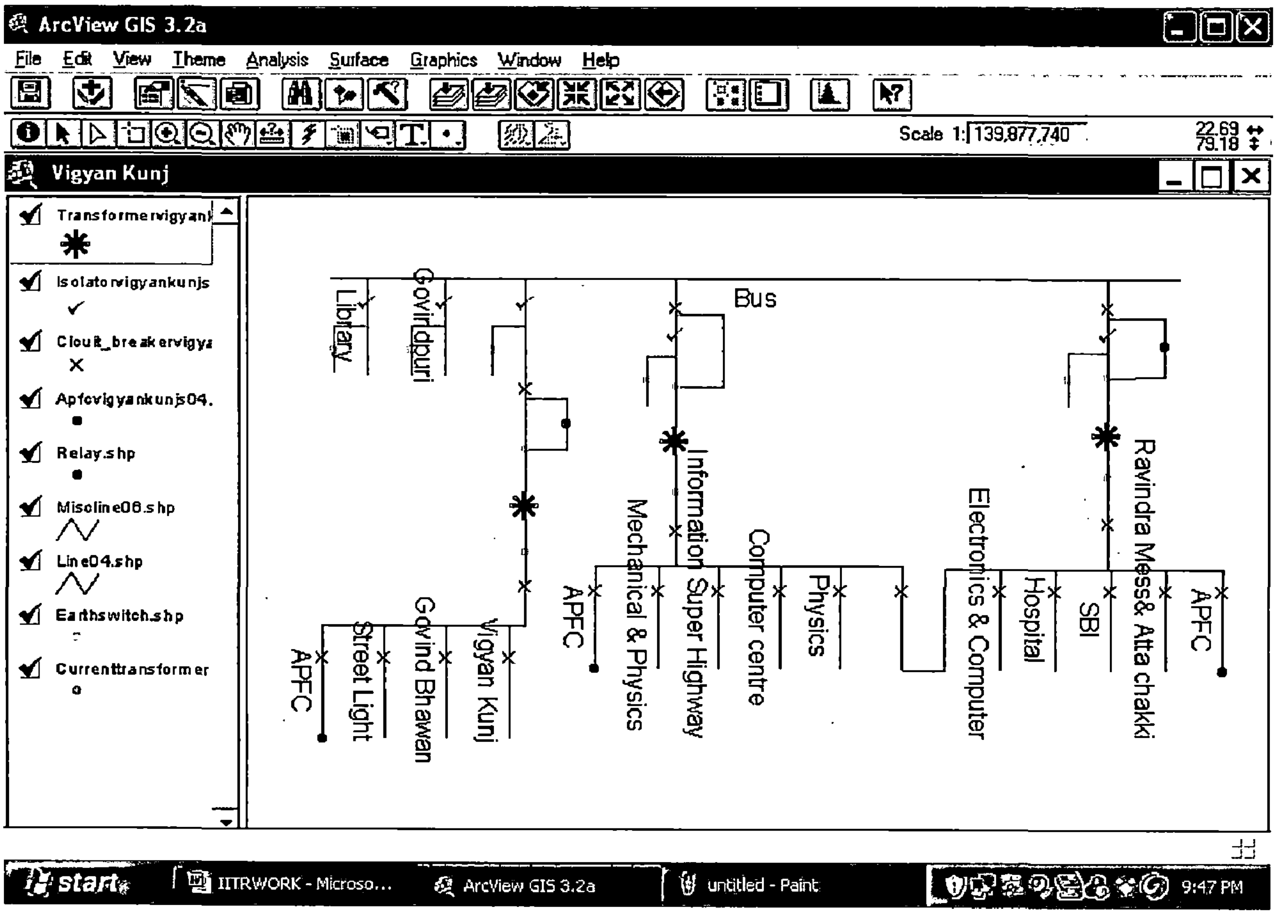


Fig 5.7 Layout of Vigyan kunj substation in a different view

Different kind of query can be made in this view

For e.g. if we want to the transformers whose year of manufacture is 2005 it can be done in the following manner.

The selected features are represented in yellow color.

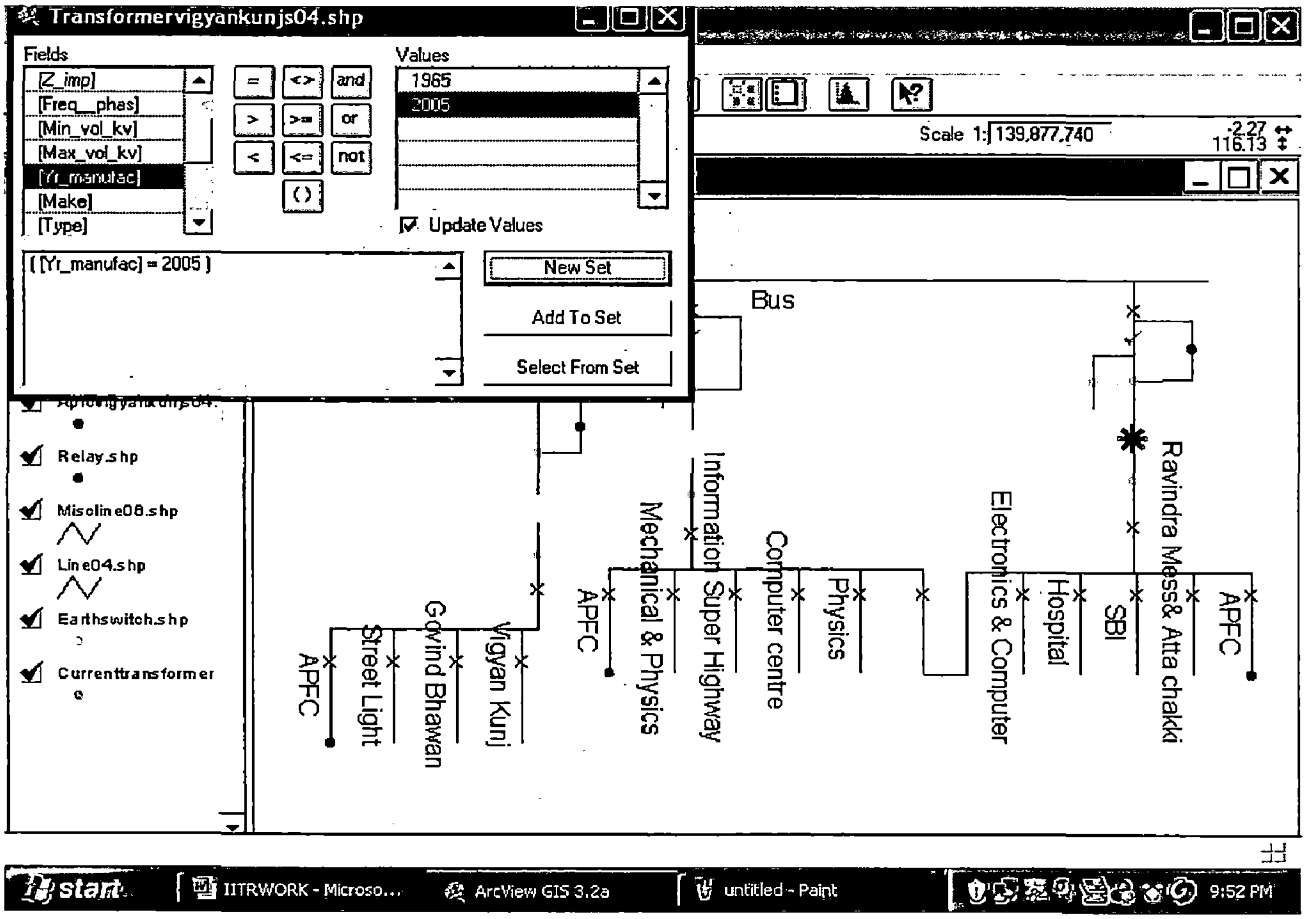


Fig. 5.8 Making a query about transformers in Vigyan Kunj View

When the "Edit Data" button is clicked on the main menu. A visual basic main form appears as shown

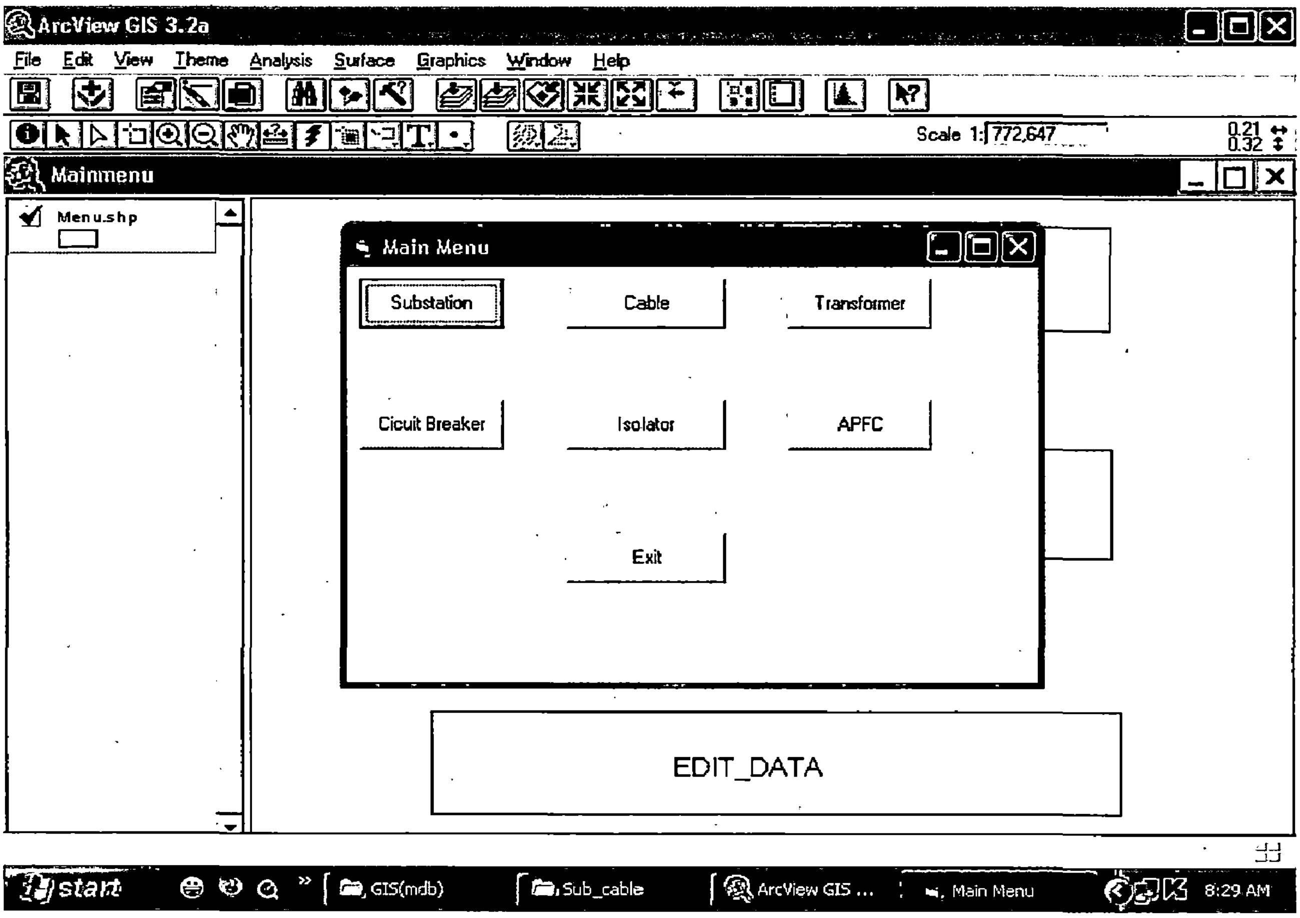
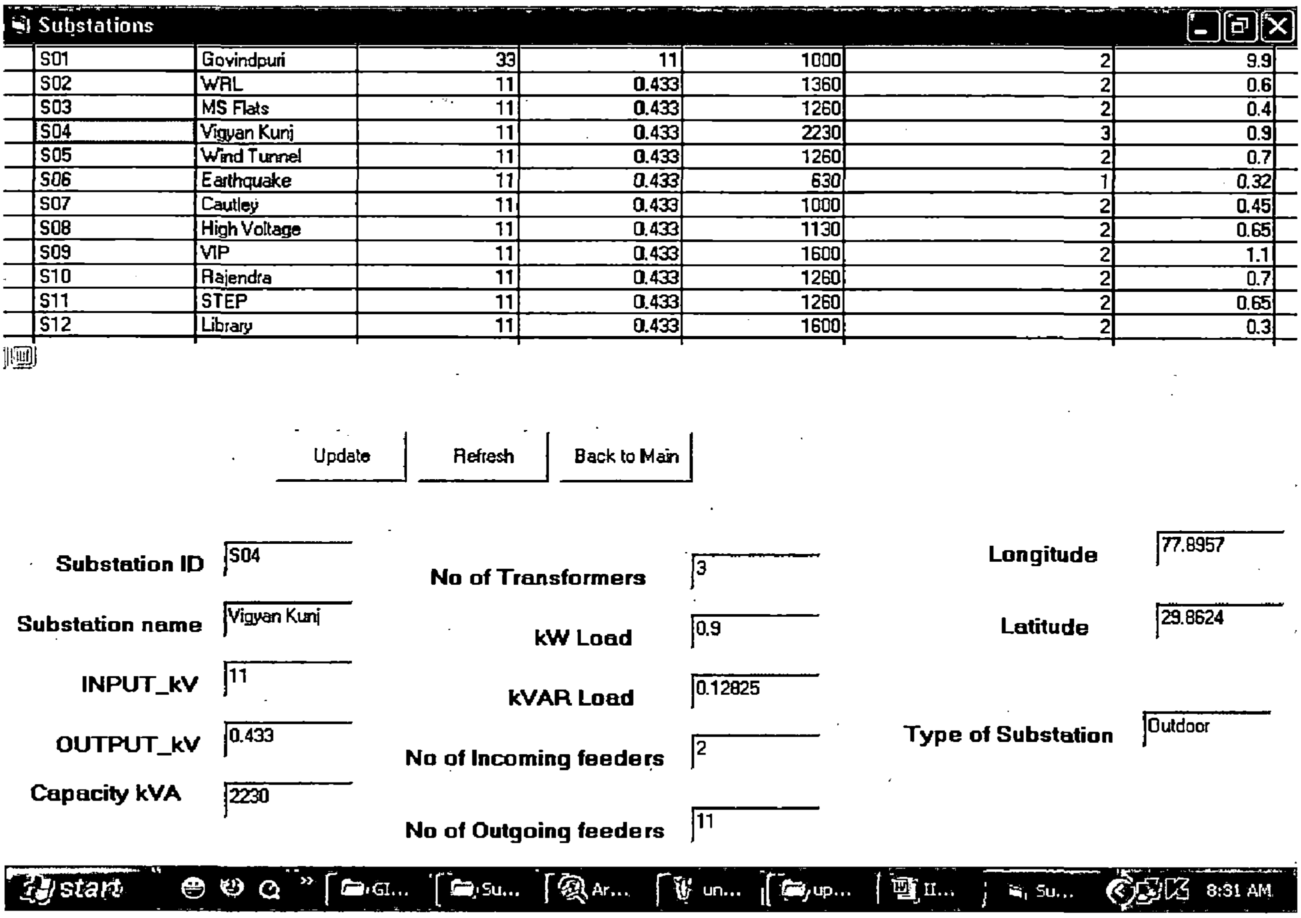


Fig 5.9 Main Menu of Visual Basic form to edit the dbf tables

In the above Visual Basic form options are given to edit .dbf files associated with substation, cable, transformer, circuit breaker, isolator and APFC.

If the mouse is clicked on command box named substation, the form as given below appears. Full table of substation appears inside a grid. As the mouse is clicked on any of the substation code the details of that substation appears inside the respective text boxes.



Substations

S01	Govindpuri	33	11	1000	2	9.9
S02	WRL	11	0.433	1360	2	0.6
S03	MS Flats	11	0.433	1260	2	0.4
S04	Vigyan Kunj	11	0.433	2230	3	0.9
S05	Wind Tunnel	11	0.433	1260	2	0.7
S06	Earthquake	11	0.433	630	1	0.32
S07	Cautley	11	0.433	1000	2	0.45
S08	High Voltage	11	0.433	1130	2	0.65
S09	VIP	11	0.433	1600	2	1.1
S10	Rajendra	11	0.433	1260	2	0.7
S11	STEP	11	0.433	1260	2	0.65
S12	Library	11	0.433	1600	2	0.3

Update | Refresh | Back to Main

Substation ID: S04
Substation name: Vigyan Kunj
INPUT_kV: 11
OUTPUT_kV: 0.433
Capacity kVA: 2230
No of Transformers: 3
kW Load: 0.9
kVAR Load: 0.12825
No of Incoming feeders: 2
No of Outgoing feeders: 11
Longitude: 77.8957
Latitude: 29.8624
Type of Substation: Outdoor

Fig 5.10 Substations dbf file represented on VB form for editing

Options are available in the above form to update the details of any substation.

Graphs related to circuit breakers and transformers of IIT Roorkee distribution system are given below. In total there are 155 circuit breakers and 24 transformers.

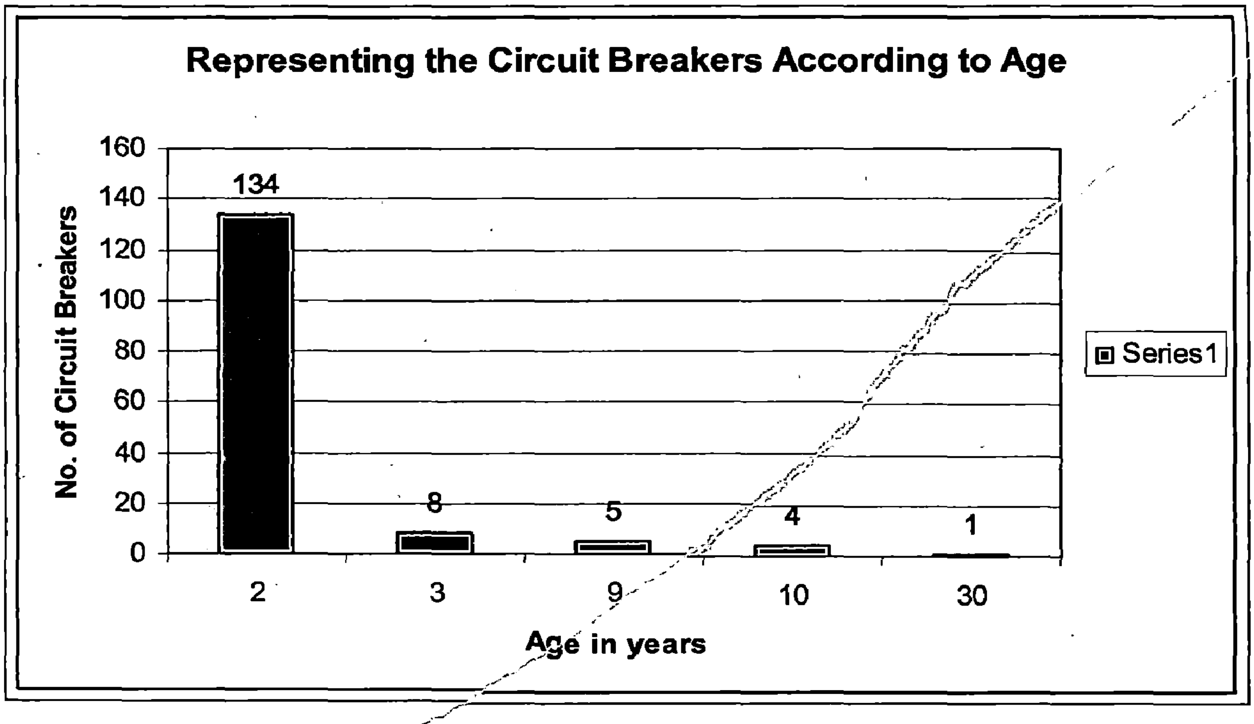


Fig 5.11 Graph of Number of Circuit Breakers Vs Age in years

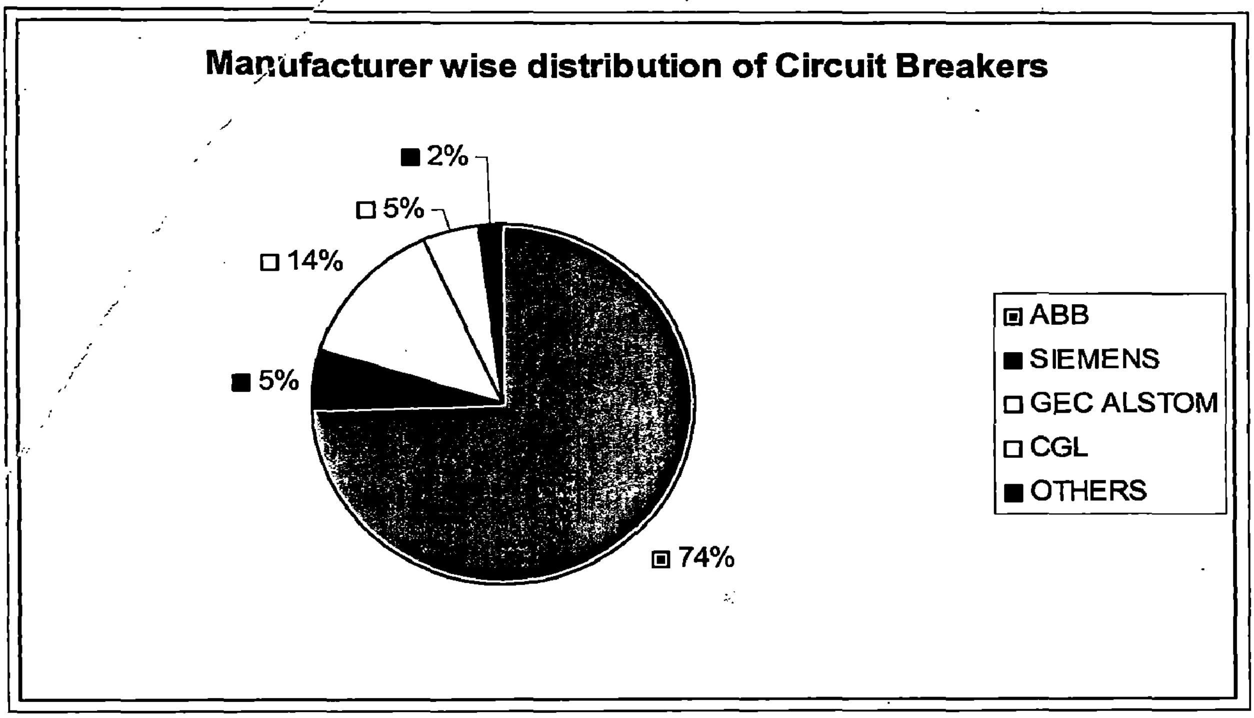


Fig 5.12 Pie chart distribution of circuit breakers according to manufacturers

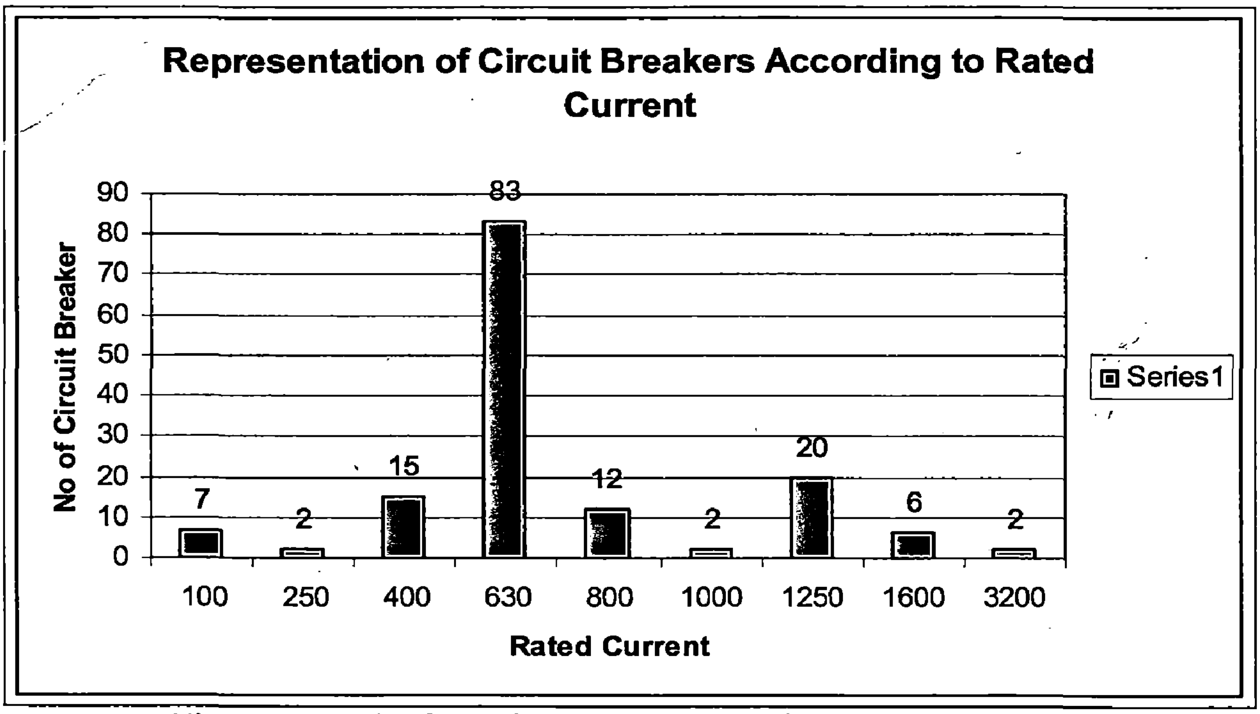


Fig 5.13 Graph of Number of Circuit Breakers Vs Rated Current

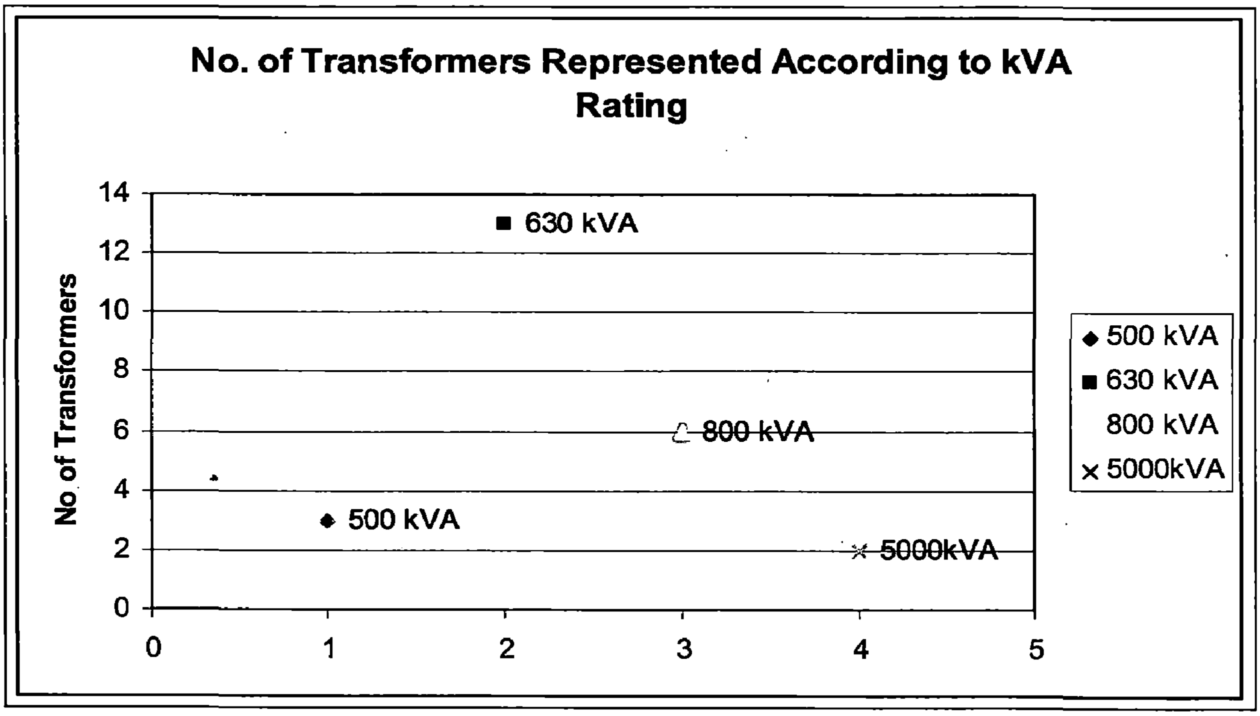


Fig 5.14 Graph depicting distribution of Transformers according to Ratings

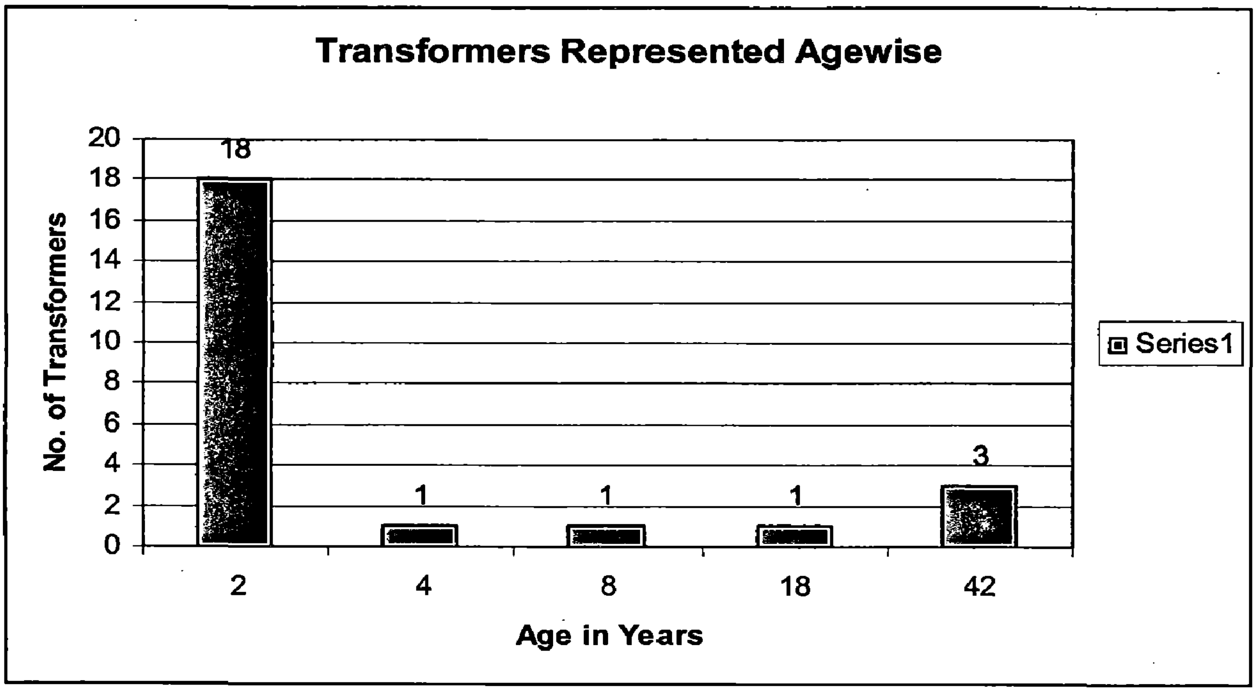


Fig 5.15 Graph of Number of Transformers Vs Age in years

CHAPTER – 6

CONCLUSIONS

6.1 CONCLUSIONS

Based on the work performed following conclusions are made:

1. Representing electrical assets on GIS helps in accurate and fast retrieval of information
2. By interfacing the database like MS Access, Excel etc with GIS software (e.g. Arc View) the retrieved information can be analyzed and graphs can be drawn to study the trends which helps in decision making
3. Based on the survey done it is found that
   - Most of the equipment in IIT Roorkee distribution system e.g. cables, isolator, APFC are new and in proper condition.
   - Three transformers and one OCB have crossed their expected life limits. These transformers and OCB may be replaced to prevent any failure in future.

6.2 FUTURE WORK

This work can be further applied to bigger network on large scale. The work can be oriented toward Reliability Centric Maintenance (RCM). In the present work Arc View is kept at the front end. In future works Visual Basic can be kept at the front end in which the Arc View application is called. This will help in better data analysis because visual basic is more compatible with different RDBMS.

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ANNEXURE

SUBSTATIONS

SS_ID	SS_NAME	INPUT_KV	OUTPUT_KV	CAPACITY(kVA)	NO of TRANSFORMERS
S01	Govindpuri	33	11	1000	2
S02	WRL	11	0.433	1360	2
S03	MS Flats	11	0.433	1260	2
S04	Vigyan Kunj	11	0.433	2230	3
S05	Wind Tunnel	11	0.433	1260	2
S06	Earthquake Engineering	11	0.433	630	1
S07	Cautley Bhawan	11	0.433	1000	2
S08	High Voltage	11	0.433	1130	2
S09	VIP	11	0.433	1600	2
S10	Rajendra Bhawan	11	0.433	1260	2
S11	STEP	11	0.433	1260	2
S12	Library	11	0.433	1600	2

SUBSTATIONS

KW_ LOAD	KVAR_LOAD	NO_OF_INCOMING_FEEDERS	NO_OF_OUTGOING_FEEDERS	LATITUDE
9.9	1.4107	1	6	77.894
0.6	0.0855	2	6	77.8922
0.4	0.057	2	9	77.8914
0.9	0.12825	2	11	77.8957
0.7	0.09975	2	6	77.8998
0.32	0.0456	2	1	77.9009
0.45	0.064125	2	6	77.8978
0.65	0.092625	2	5	77.9003
1.1	0.15675	2	7	77.8977
0.7	0.09975	2	5	77.8958
0.65	0.092625	2	6	77.8916
0.3	0.04275	2	1	77.895

SUBSTATIONS

LONGITUDE	TYPE
29.861	Outdoor
29.8636	Outdoor
29.8631	Indoor
29.8624	Outdoor
29.8625	Outdoor
29.8662	Indoor
29.8709	Outdoor
29.8679	Outdoor
29.8644	Outdoor
29.8703	Outdoor
29.8675	Outdoor
29.8652	Indoor

TRANSFORMERS

TX_ASSETNO	SS_ID	SS_Name	TX_RTG(kVA)	V0L RTI(kV)	CUR RTI(A)	% IMP
T102	S01	Govindpuri	5000	33/11	87.5/262.43	7.15
T101	S01	Govindpuri	5000	33/11	87.5/262.43	7.15
T201	S02	WRL	630	11/0.433	33.1/840	4.5
T202	S02	WRL	630	11/0.433	33.1/841	4.5
T301	S03	MS Flats	630	11/0.433	33.07/840.02	4.57
T302	S03	MS Flats	630	11/0.433	33.07/840.03	4.57
T402	S04	Vigyan Kunj	800	11/0.433	41.98/1066.69	4.59
T403	S04	Vigyan Kunj	630	11/0.433	33.1/840	4.5
T401	S04	Vigyan Kunj	800	11/0.433	41.98/1066.69	4.59
T501	S05	Wind Tunnel	630	11/0.433	33.1/840	4.5
T502	S05	Wind Tunnel	630	11/0.433	33.1/840	4.66
T601	S06	Earthquake	630	11/0.433	33.1/840	5.22
T701	S07	Cautley Bhawan	500	11/0.433	24.25/698	6.89
T702	S07	Cautley Bhawan	500	11/0.433	24.25/698	6.89
T802	S08	High Voltage	630	11/0.433	33.06/840	4.65
T801	S08	High Voltage	500	11/0.433	26.2/666	4.5
T901	S09	VIP	800	11/0.433	41.98/1066.69	4.65
T902	S09	VIP	800	11/0.433	41.98/1066.69	4.65
T1001	S10	Rajendra Bhawan	630	11/0.433	33.06/840	4.5
T1002	S10	Rajendra Bhawan	630	11/0.433	33.06/840	4.5
T1101	S11	STEP	630	11/0.433	33.06/840	4.66
T1102	S11	STEP	630	11/0.433	33.06/840	4.66
T1201	S12	Library	800	11/0.433	39.99/1066.7	5.22
T1202	S12	Library	800	11/0.433	39.99/1066.7	5.22

TRANSFORMERS

FREQ/ PHASES	MIN VOL(kV)	MAX VOL(kV)	YR_MANUFACTURE	AGE IN YRS
50/3	28.05	33	2005	2
50/3	28.05	33	2003	4
50/3	10	11	2005	2
50/3	10	11	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2
50/3	10	12	1965	42
50/3	10	11	2005	2
50/3	10	12	2005	2
50/3	10	11	2005	2
50/3	10	11	1999	8
50/3	10	12	1989	18
50/3	10	11	1965	42
50/3	10	11	1965	42
50/3	10	12	2005	2
50/3	10	11	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2
50/3	10	12	2005	2

TRANSFORMERS

MAKE	TYPE	COST(RS)	PRESENT_VALUE	DRY/OIL	COOLING
Accurate Transformers LTD,Ghaziabad	Outdoor	3000000	2546933.88	Oil	ONAN
Marson's Electrical Industries, Agra	Outdoor	3000000	2162290.73	Oil	ONAN
Transtron Electrical Pvt Ltd,Meerut	Outdoor	340000	288652.5064	Oil	ONAN
Transtron Electrical Pvt Ltd,Meerut	Outdoor	340000	288652.5064	Oil	ONAN
VOLTAMP Transformers Pvt Ltd, Baroda	Indoor	600000	509386.776	Dry	AN
VOLTAMP Transformers Pvt Ltd, Baroda	Indoor	600000	509386.776	Dry	AN
Govt Electric Factory,Bangalore	Outdoor		2500	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Outdoor	340000	288652.5064	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Outdoor	380000	322611.6248	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Outdoor	340000	288652.5064	Oil	ONAN
Transtron Electrical Pvt Ltd,Meerut	Outdoor	200000	103900.0267	Oil	ONAN
General Electrical Co. of India	Outdoor	70000	16038.57512	Oil	ONAN
Crompton & Parkinson	Outdoor		2500	Oil	ONAN
Crompton & Parkinson	Outdoor		2500	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Outdoor	340000	288652.5064	Oil	ONAN
Transtron Electrical Pvt Ltd,Meerut	Outdoor	290000	246203.6084	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Indoor	380000	322611.6248	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Indoor	380000	322611.6248	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Indoor	340000	288652.5064	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Indoor	340000	288652.5064	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Indoor	340000	288652.5064	Oil	ONAN
Kotsons Pvt Ltd ,Agra	Indoor	340000	288652.5064	Oil	ONAN
Kirloskar T/f Ltd.	Indoor	380000	322611.6248	Oil	ONAN
Kirloskar T/f Ltd.	Indoor	380000	322611.6248	Oil	ONAN

TRANSFORMERS

TAP RANGE(%)	TAP SETTING	OTI	WTI	OC_PROTECTION	EF_PROTECTION	INSTLN_YR
0,-2.5,-5,-7.5,-10,-12.5,-15	Normal	50	55	Yes	Yes	2005
0,-2.5,-5,-7.5,-10,-12.5,-15	Normal	50	55	Yes	Yes	2005
+2.5,0,-2.5,-5,-7.5	Normal	50	58	Yes	Yes	2006
	Normal	48	55	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	49	54	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	49	54	Yes	Yes	2006
+2.5,0,-2.5,-5,-7.5	Normal	45	50	Yes	Yes	1966
+5,+2.5,0,-2.5,-5	Normal	46	51	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	45	50	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	51	55	Yes	Yes	2006
+2.5,0,-2.5,-5,-7.5	Normal	51	56	Yes	Yes	1999
+5,+2.55,0,-2.45,-5	Normal	45	51	Yes	Yes	1989
+2.5,0,-2.5,-5,-7.5	Normal	46	52	Yes	Yes	1965
+2.5,0,-2.5,-5,-7.5	Normal	46	52	Yes	Yes	1965
+5,+2.5,0,-2.5,-5	Normal	55	60	Yes	Yes	2006
+2.5,0,-2.5,-5,-7.5	Normal	50	65	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	37	60	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	37	60	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	35	60	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	35	55	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	35	55	Yes	Yes	2006
+5,+2.5,0,-2.5,-5	Normal	36	56	Yes	Yes	2006
	Normal			Yes	Yes	2006
	Normal			Yes	Yes	2006

CIRCUIT BREAKER

CB_ASSETNO	SS_ID	SS_NAME	SG_ASSETNO	RTD_CURR(A)	RTD_VOL(kV)	BRKG_CAP(kA)	COST(Rs)
CB101	S01	Govindpuri		1250	36	40	366000
CB102	S01	Govindpuri		1250	36	40	366000
CB208	S02	WRL		800	0.415	50	
CB2010	S02	WRL		800	0.415	50	
CB204	S02	WRL		1250	0.415	65	
CB205	S02	WRL		1250	0.415	65	
CB209	S02	WRL		1250	0.415	65	
CB206	S02	WRL		630	0.415	36	
CB207	S02	WRL		630	0.415	36	
CB2011	S02	WRL		630	0.415	36	
CB2012	S02	WRL		630	0.415	36	
CB2013	S02	WRL		630	0.415	36	
CB2014	S02	WRL		630	0.415	36	
CB201	S02	WRL		630	11	21	508000
CB303	S03	MS Flats		1000	0.415	50	
CB304	S03	MS Flats		1000	0.415	50	
CB3010	S03	MS Flats		63	0.415	0	
CB307	S03	MS Flats		100	0.415	25	7000
CB308	S03	MS Flats		100	0.415	25	7000
CB309	S03	MS Flats		100	0.415	25	7000
CB3012	S03	MS Flats		100	0.415	25	7000
CB3013	S03	MS Flats		100	0.415	25	7000
CB3014	S03	MS Flats		100	0.415	25	7000

CIRCUIT BREAKER

CB3015	S03	MS Flats		100	0.415	25	7000
CB305	S03	MS Flats		250	0.415	25	15500
CB3018	S03	MS Flats		250	0.415	25	15500
CB306	S03	MS Flats		400	0.415	36	
CB3011	S03	MS Flats		400	0.415	36	
CB3016	S03	MS Flats					
CB3017	S03	MS Flats					
CB301	S03	MS Flats		630	11	21	508000
CB302	S03	MS Flats		630	11	21	508000
CB4012	S04	Vigyan Kunj		630	0.415	50	
CB4013	S04	Vigyan Kunj		630	0.415	50	
CB4017	S04	Vigyan Kunj		630	0.415	50	
CB4018	S04	Vigyan Kunj		630	0.415	50	
CB405	S04	Vigyan Kunj		1600	0.415	65	
CB406	S04	Vigyan Kunj		1600	0.415	65	
CB4016	S04	Vigyan Kunj		1600	0.415	65	
CB4011	S04	Vigyan Kunj		630	0.415	36	
CB4014	S04	Vigyan Kunj		630	0.415	36	
CB4015	S04	Vigyan Kunj		630	0.415	36	
CB4019	S04	Vigyan Kunj		630	0.415	36	
CB4020	S04	Vigyan Kunj		630	0.415	36	
CB4021	S04	Vigyan Kunj		630	0.415	36	
CB402	S04	Vigyan Kunj		630	11	21	508000
CB403	S04	Vigyan Kunj		630	11	21	508000

CIRCUIT BREAKER

CB506	S05	Wind Tunnel		800	0.415	50	
CB507	S05	Wind Tunnel		800	0.415	50	
CB5010	S05	Wind Tunnel		800	0.415	50	
CB5011	S05	Wind Tunnel		800	0.415	50	
CB5012	S05	Wind Tunnel		800	0.415	50	
CB503	S05	Wind Tunnel		1250	0.415	65	
CB504	S05	Wind Tunnel		1250	0.415	65	
CB509	S05	Wind Tunnel		1250	0.415	65	
CB505	S05	Wind Tunnel		630	0.415	36	
CB508	S05	Wind Tunnel		630	0.415	36	
CB5013	S05	Wind Tunnel		630	0.415	36	
CB501	S05	Wind Tunnel		630	11	21	508000
CB502	S05	Wind Tunnel		630	11	21	508000
CB707	S07	Cautley Bhawan		630	0.433	50	
CB706	S07	Cautley Bhawan		630	0.433	50	
CB7010	S07	Cautley Bhawan		630	0.433	50	
CB7011	S07	Cautley Bhawan		630	0.433	50	
CB7012	S07	Cautley Bhawan		630	0.433	50	
CB703	S07	Cautley Bhawan		1250	0.433	50	
CB704	S07	Cautley Bhawan		1250	0.433	50	
CB709	S07	Cautley Bhawan		1250	0.433	50	
CB705	S07	Cautley Bhawan		630	0.433	36	
CB708	S07	Cautley Bhawan		630	0.433	36	
CB7013	S07	Cautley Bhawan		630	0.433	36	

CIRCUIT BREAKER

CB701	S07	Cautley Bhawan		630	12	21	500000
CB702	S07	Cautley Bhawan		630	12	21	500000
CB806	S08	High Voltage		800	0.433	50	
CB807	S08	High Voltage		800	0.433	50	
CB803	S08	High Voltage		1250	0.433	50	
CB804	S08	High Voltage		1250	0.433	50	
CB808	S08	High Voltage		1250	0.433	50	
CB805	S08	High Voltage		630	0.433	36	
CB809	S08	High Voltage		630	0.433	36	
CB8010	S08	High Voltage		630	0.433	36	
CB8011	S08	High Voltage		630	0.433	36	
CB8012	S08	High Voltage		630	0.433	36	
CB802	S08	High Voltage		630	12	21	500000
CB906	S09	VIP	SGLT09	630	0.433	50	
CB907	S09	VIP	SGLT09	630	0.433	50	
CB9012	S09	VIP	SGLT10	630	0.433	50	
CB9013	S09	VIP	SGLT10	630	0.433	50	
CB903	S09	VIP	SGLT09	1600	0.433	65	
CB904	S09	VIP	SGLT10	1600	0.433	65	
CB9011	S09	VIP	SGLT10	1600	0.433	65	
CB905	S09	VIP	SGLT09	630	0.433	36	
CB908	S09	VIP	SGLT09	630	0.433	36	
CB909	S09	VIP	SGLT09	630	0.433	36	
CB9010	S09	VIP	SGLT09	630	0.433	36	

CIRCUIT BREAKER

CB9014	S09	VIP	SGLT10	630	0.433	36	
CB9015	S09	VIP	SGLT10	630	0.433	36	
CB9016	S09	VIP	SGLT10	630	0.433	36	
CB9017	S09	VIP	SGLT10	630	0.433	36	
CB9018	S09	VIP	SGLT10	630	0.433	36	
CB901	S09	VIP	SGHT09	630	12	21	500000
CB902	S09	VIP	SGHT09	630	12	21	500000
CB1008	S10	Rajendra		630	0.415	50	
CB10011	S10	Rajendra		630	0.415	50	
CB10012	S10	Rajendra		630	0.415	50	
CB1006	S10	Rajendra		800	0.415	50	
CB1007	S10	Rajendra		800	0.415	50	
CB1003	S10	Rajendra		1250	0.415	65	
CB1004	S10	Rajendra		1250	0.415	65	
CB10010	S10	Rajendra		1250	0.415	65	
CB1005	S10	Rajendra		400	0.415	36	
CB1009	S10	Rajendra		400	0.415	36	
CB10015	S10	Rajendra		400	0.415	36	
CB10013	S10	Rajendra		630	0.415	36	
CB10014	S10	Rajendra		630	0.415	36	
CB1001	S10	Rajendra		630	11	21	508000
CB1002	S10	Rajendra		630	11	21	508000
CB1106	S11	STEP		630	0.415	50	
CB1107	S11	STEP		630	0.415	50	

CIRCUIT BREAKER

CB11011	S11	STEP		630	0.415	50	
CB11012	S11	STEP		630	0.415	50	
CB1103	S11	STEP		1250	0.415	65	
CB1104	S11	STEP		1250	0.415	65	
CB11010	S11	STEP		1250	0.415	65	
CB1105	S11	STEP		400	0.415	36	
CB11017	S11	STEP		400	0.415	36	
CB1108	S11	STEP		630	0.415	36	
CB1109	S11	STEP		630	0.415	36	
CB11013	S11	STEP		630	0.415	36	
CB11014	S11	STEP		630	0.415	36	
CB11015	S11	STEP		630	0.415	36	
CB11016	S11	STEP		630	0.415	36	
CB1101	S11	STEP		630	11	21	508000
CB1102	S11	STEP		630	11	21	508000
CB105	S01	Govindpuri		630	12	20	508000
CB106	S01	Govindpuri		630	12	20	508000
CB107	S01	Govindpuri		630	12	20	508000
CB108	S01	Govindpuri		630	12	20	508000
CB109	S01	Govindpuri		630	12	20	508000
CB1010	S01	Govindpuri		630	12	20	508000
CB103	S01	Govindpuri		3200	11	50	508000
CB104	S01	Govindpuri		3200	11	50	508000
CB202	S02	WRL		400	12	32.75	

CIRCUIT BREAKER

CB203	S02	WRL		400	12	32.75	
CB401	S04	Vigyan Kunj		400	12	13.1	
CB404	S04	Vigyan Kunj		800	0.415	35	
CB801	S08	High Voltage		630	11	18	
CB407	S04	Vigyan Kunj		400	0.415	36	
CB408	S04	Vigyan Kunj		400	0.415	36	
CB409	S04	Vigyan Kunj		400	0.415	36	
CB4010	S04	Vigyan Kunj		400	0.415	36	
CB60	S06	Earth Quake		400	11	18	
CB8	S08	High Voltage		0	0	0	

CIRCUIT BREAKER

PRESENT_VALUE(Rs)	TYPE	MAKE	YR_MANUFACTURE	AGE IN YRS	INSLD_AT
310725.9334	SF6	CGL	2005	2	Transformer
310725.9334	SF6	CGL	2005	2	Transformer
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Bus Coupler
	MCCB	ABB	2005	2	APFC
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	APFC
431280.8037	VCB	ABB	2005	2	Feeder
	ACB	GEC	2005	2	Transformer
	ACB	GEC	2005	2	Transformer
	MCCB	GEC	2005	2	Feeder
5942.84572	MCCB	GEC	2005	2	Feeder
5942.84572	MCCB	GEC	2005	2	Feeder
5942.84572	MCCB	GEC	2005	2	Feeder
5942.84572	MCCB	GEC	2005	2	Feeder
5942.84572	MCCB	GEC	2005	2	Feeder
5942.84572	MCCB	GEC	2005	2	Feeder

CIRCUIT BREAKER

5942.84572	MCCB	GEC		2005	2	Feeder
13159.15838	MCCB	GEC		2005	2	APFC
13159.15838	MCCB	GEC		2005	2	APFC
	MCCB	GEC		2005	2	Feeder
	MCCB	GEC		2005	2	Bus Coupler
	Spare	GEC		2005	2	Feeder
	Spare	GEC		2005	2	Feeder
431280.8037	VCB	GEC		2005	2	Transformer
431280.8037	VCB	GEC		2005	2	Transformer
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Transformer
	ACB	ABB		2005	2	Transformer
	ACB	ABB		2005	2	Bus Coupler
	MCCB	ABB		2005	2	APFC
	MCCB	ABB		2005	2	Feeder
	MCCB	ABB		2005	2	Feeder
	MCCB	ABB		2005	2	Feeder
	MCCB	ABB		2005	2	Feeder
	MCCB	ABB		2005	2	APFC
431280.8037	VCB	ABB		2005	2	Transformer
431280.8037	VCB	ABB		2005	2	Transformer

CIRCUIT BREAKER

	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Bus Coupler
	MCCB	ABB	2005	2	APFC
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	APFC
431280.8037	VCB	ABB	2005	2	Transformer
431280.8037	VCB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Bus Coupler
	MCCB	ABB	2005	2	APFC
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	APFC

CIRCUIT BREAKER

424488.98	VCB	ABB	2005	2	Transformer
424488.98	VCB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Bus Coupler
	MCCB	ABB	2005	2	APFC
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	APFC
424488.98	VCB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Bus Coupler
	MCCB	ABB	2005	2	APFC
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder

CIRCUIT BREAKER

	MCCB	ABB		2005	2	Feeder
	MCCB	ABB		2005	2	Not in use
	MCCB	ABB		2005	2	Not in use
	MCCB	ABB		2005	2	Not in use
	MCCB	ABB		2005	2	APFC
424488.98	VCB	ABB		2005	2	Transforme
424488.98	VCB	ABB		2005	2	Transformer
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Transformer
	ACB	ABB		2005	2	Transformer
	ACB	ABB		2005	2	Bus coupler
	MCCB	ABB		2005	2	APFC
	MCCB	ABB		2005	2	Spare
	MCCB	ABB		2005	2	APFC
	MCCB	ABB		2005	2	Spare
	MCCB	ABB		2005	2	Spare
431280.8037	VCB	ABB		2005	2	Transformer
431280.8037	VCB	ABB		2005	2	Transformer
	ACB	ABB		2005	2	Feeder
	ACB	ABB		2005	2	Feeder

CIRCUIT BREAKER

	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Feeder
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Transformer
	ACB	ABB	2005	2	Bus Coupler
	MCCB	ABB	2005	2	APFC
	MCCB	ABB	2005	2	APFC
	MCCB	ABB	2005	2	Spare
	MCCB	ABB	2005	2	Spare
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Feeder
	MCCB	ABB	2005	2	Spare
	MCCB	ABB	2005	2	Spare
431280.8037	VCB	ABB	2005	2	Transformer
431280.8037	VCB	ABB	2005	2	Transformer
397382.1325	VCB	Siemens	2004	3	Feeder
397382.1325	VCB	Siemens	2004	3	Feeder
397382.1325	VCB	Siemens	2004	3	Feeder
397382.1325	VCB	Siemens	2004	3	Bus Coupler
397382.1325	VCB	Siemens	2004	3	Feeder
397382.1325	VCB	Siemens	2004	3	Feeder
397382.1325	VCB	Siemens	2004	3	Transformer
397382.1325	VCB	Siemens	2004	3	Transformer
	OCB	Alstom	1998	9	Transformer

CIRCUIT BREAKER

	OCB	Alstom	1998	9	Transformer
	OCB	GEC-Alsthom	1998	9	Transformer
	OCB	Mysore Electrical Industries Ltd	1998	9	Transformer
	OCB	CGL	1998	9	Transformer
	MCCB	CGL	1997	10	APFC
	MCCB	CGL	1997	10	Feeder
	MCCB	CGL	1997	10	Feeder
	MCCB	CGL	1997	10	Feeder
1500	OCB	Bieco	1977	30	Transformer
	Spare				

APFC

APFC_ASSETNO	SS_ID	SS_NAME	TX_ASSETNO	RTD VOLTAGE(V)	RTD kVAR
AP202	S02	WRL		440	50
AP201	S02	WRL	T202	440	100
AP301	S03	MS Flats	T301	440	150
AP302	S03	MS Flats	T302	440	150
AP401	S04	Vigyan Kunj	T401	440	200
AP402	S04	Vigyan Kunj	T402	440	200
AP403	S04	Vigyan Kunj	T403	440	35
AP501	S05	Wind Tunnel	T501	440	100
AP502	S05	Wind Tunnel	T502	440	100
AP701	S07	Cautley	T701	440	100
AP702	S07	Cautley	T702	440	100
AP801	S08	High Voltage	T802	440	100
AP802	S08	High Voltage	T801	440	50
AP901	S09	VIP	T901	440	100
AP902	S09	VIP	T902	440	100
AP1001	S10	Rajendra	T1001	440	100
AP1002	S10	Rajendra	T1002	440	100
AP1101	S11	STEP	T1101	440	100
AP1102	S11	STEP	T1102	440	100

APFC

COST OF CAPACITOR BANK(Rs)	PRESENT_VALUE	MAKE	YR_MANUFACTURE
26500	22497.91594	L&T	2005
56400	47882.35694	L&T	2005
84750	71950.88211	L&T	2005
84750	71950.88211	L&T	2005
110000	93387.5756	L&T	2005
110000	93387.5756	L&T	2005
13000	11036.71348	L&T	2005
56400	47882.35694	ABB	2005
56400	47882.35694	ABB	2005
56400	47882.35694	ABB	2005
56400	47882.35694	L&T	2005
56400	47882.35694	L&T	2005
26500	22497.91594	L&T	2005
56400	47882.35694	ABB	2005
56400	47882.35694	ABB	2005
56400	47882.35694	ABB	2005
56400	47882.35694	ABB	2005
56400	47882.35694	ABB	2005
56400	47882.35694	ABB	2005

CABLE11kV

FD_ASSETNO	SS_FROM	SS_TO	DISTANCE	CABLE_SIZE(sq mm)	VOLTAGE(kV)
FDHT1-2	Govindpuri	WRL	500	120	11
FDHT2-3	WRL	MS Flats	120	185	11
FDHT2-11	MS Flats	STEP	600	185	11
FDHT11-10	STEP	Rajendra Bhawan	660	185	11
FDHT10-1	Rajendra Bhawan	Govindpuri	1500	185	11
FDHT1-4	Govindpuri	Vigyan Kunj	300	120	11
FDHT4-12	Vigyan Kunj	Library	500	185	11
FDHT12-9	Library	VIP	500	185	11
FDHT9-1	VIP	Govindpuri	650	185	11
FDHT1-5	Govindpuri	Wind Tunnel	750	120	11
FDHT5-6	Wind Tunnel	Earthquake Engg	650	185	11
FDHT6-8	Earthquake Engg	High Voltage	300	185	11
FDHT8-7	High Voltage	Cautley Bhawan	560	185	11
FDHT7-1	Cautley	Govindpuri	1500	120	11

CABLE11kV

YR MANUFACTURE	MAKE	COST(Rs/m)
2005	Havells	800
2005	Havells	1275
2005	Havells	1275
2005	Havells	1275
2005	Havells	1275
2005	Havells	800
2005	Havells	1275
2005	Havells	1275
2005	Havells	1275
2005	Havells	800
2005	Havells	1275
2005	Havells	1275
2005	Havells	1275
2005	Havells	800

ISOLATOR

ISLTR_ASSETNO	LOCATION	SS_ID	OPERATION	OPERATED AT	INSTALLED_AT	INSLN_ASSNO
IS201	WRL	S02	Manual	On load	Feeder	FDHT1-2
IS202	WRL	S02	Manual	On load	Feeder	FDHT2-3
IS203	WRL	S02	Manual	Off load	Transformer	
IS401	Vigyan Kunj	S04	Manual	On load	Feeder	FDHT4-12
IS402	Vigyan Kunj	S04	Manual	On load	Feeder	FDHT1-4
IS403	Vigyan Kunj	S04	Manual	On load	Transformer	T403
IS404	Vigyan Kunj	S04	Manual	Off load	Transformer	T402
IS405	Vigyan Kunj	S04	Manual	Off load	Transformer	T401
IS501	Wind Tunnel	S05	Manual	On load	Feeder	FDHT5-6
IS502	Wind Tunnel	S05	Manual	On load	Feeder	FDHT1-4
IS503	Wind Tunnel	S05	Manual	Off load	Transformer	T501
IS504	Wind Tunnel	S05	Manual	Off load	Transformer	T502
IS601	Earthquake	S06	Manual	On load	Feeder	FDHT6-8
IS602	Earthquake	S06	Manual	On load	Feeder	FDHT5-6
IS603	Earthquake	S06	Manual	On load	Transformer	T601
IS701	Cautley	S07	Manual	On load	Feeder	FDHT8-7
IS702	Cautley	S07	Manual	On load	Feeder	FDHT7-1
IS703	Cautley	S07	Manual	On load	Not in use	
IS704	Cautley	S07	Manual	Off load	Transformer	T701
IS705	Cautley	S07	Manual	Off load	Transformer	T702
IS801	High Voltage	S08	Manual	On load	Feeder	FDHT8-7
IS802	High Voltage	S08	Manual	On load	Feeder	FDHT6-8
IS803	High Voltage	S08	Manual	On load	Transformer	T801
IS804	High Voltage	S08	Manual	Off load	Transformer	T802
IS901	VIP	S09	Manual	On load	Feeder	FDHT9-1
IS902	VIP	S09	Manual	On load	Feeder	FDHT12-9

ISOLATOR

IS903	VIP	S09	Manual	Off load	Transformer	T901
IS904	VIP	S09	Manual	Off load	Transformer	T902
IS1001	Rajendra	S10	Manual	On load	Feeder	FDHT10-1
IS1002	Rajendra	S10	Manual	On load	Feeder	FDHT11-10
IS1003	Rajendra	S10	Manual	Off load	Transformer	T1001
IS1004	Rajendra	S10	Manual	Off load	Transformer	T1002
IS1101	STEP	S11	Manual	On load	Feeder	FDHT2-11
IS1102	STEP	S11	Manual	On load	Feeder	FDHT11-10
IS1103	STEP	S11	Manual	Off load	Transformer	T1101
IS1104	STEP	S11	Manual	Off load	Transformer	T1102