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"A STUDY ON TECHNOLOGY IMPLEMENTATION AND BENEFITS IN POWER DISTRIBUTION SECTOR (WEST BENGAL)"

BY

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A DISSERTATION REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

MBA (POWER MANAGEMENT)

OF

CENTER FOR CONTINUING EDUCATION

UNIVERSITY OF PETROLIUM & ENERGY STUDIES, DEHRADUN

Acknowledgement

This is to acknowledge with thanks the help, guidance and support that I have received during the Dissertation.

I have no words to express a deep sense of gratitude to the management of Bajaj Electricals Limited for giving me an opportunity to pursue my Dissertation and in Particular Mr.Nabin Ghosal (Project Manager) for his able guidance and support.

I must also thank to Mr. S. Porel, Divisional Engineer -Project & Mr.A.Malakar, Asst.Engg. Of West Bengal State Electricity Transmission Company Ltd. for their valuable support.

Further, I am grateful to all the respondents of the questionnaire, including staff of State Electricity Boards to answer the questionnaire and having interviews, by taking out time from their busy schedule.

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Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA/BBA/B.Sc.

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LIST OF ABBRIVIATIONS

1. ICT- Information and Communication Technology
2. Discoms – Power Distribution Companies
3. AMR- Automated Meter Reading
4. AT&C – Aggregate Technical and Commercial Losses
5. CRM-Customer Relationship Management
6. ERP- Enterprise Resource Planning
7. IT – Information Technology
8. OMS – Outage Management System
9. PLC- Programmable Logic Controller
10. SEM- Structural Equation Modeling
11. STM- Strategic Technology Management
12. SCADA- Supervisory Control and Data Acquisition
13. TAM- Technology Acceptance Model
14. EHV-Extra High Voltage
15. SAS- Substation Automation System
16. RTU- Remote Terminal Unit.
17. PRP- Parallel Redundant Port

Abstract

Power Systems mainly consists of transmission and distribution system in which power distribution system consist the final link to consumers from where the power is generated. Power saved is considered as power generated. The same concept can be applied if AT&C losses of our country could be reduced. Thereby financial health of Discoms could be improved. This will result in saving to Government. Power industry in performance improvement by building a strong and efficient power distribution system. Inefficiency in electricity distribution system results in high AT&C (Aggregate Technical & Commercial Losses) losses, poor quality of power and reduced reliability of power supply to consumers, leading to consumer dissatisfaction. It also affects the financial health of these utilities .So to reduced all this now a day's developed country are using information and communication system (ICT) but deployment of ICT is effectively less till now as compared to other developed nation, the state in India which are already implement this type of technologies they can easily reduced AT&C losses and thereby can improve financial health of that state.

The power of Technology has already been leveraged by electric utilities organizations in the developed countries, whereas deployment of ICT in India is significantly less, as compared to developed countries in the world. The states in India, which harnessed the power of these technologies, have succeeded in lowering their AT&C losses to a great extent, thereby improving the financial health of organizations. The research work has assessed the level of ICT deployment in Discom at West Bengal and evolves Technology Implementation Index, which captures relevant aspects on the use of various information, communication & automation technologies in Power Distribution companies.

The research further tries to find the aspects affecting acceptance and involvement of ICT, in particular, Substation Automation Technology in Discom. The survey has been carried out among the staff of Power Distribution Companies (WBSEDCL) and also in Transmission Companies (WBSETCL) using a questionnaire to gather information on the level of usage of ICT and factors influencing the use of technology in Discoms.

The major part of the research of assessment of SCADA (Substation Automation System) more specifically SAS (Substation Automation System) among State Owned & Quasi Government Power Distribution Companies in West Bengal helped in the development of new research framework.

This research has assessed of websites of Discoms in Kharagpur division in West Bengal involving key determinant factors for website quality. The research further tries to find the aspects affecting acceptance and dissemination of ICT, in particular, SCADA in Discoms in KHARAGPUR DIVISION and explore the association amid user acceptance aspects and user purpose to implement the ICT technology. The survey has been carried out among the staff of Power Distribution & Transmission Companies using a questionnaire to gather information on the level of usage of ICT and factors influencing the use of technology in Discoms.

The major part of the research of Implementation of SAS technology through SCADA among State Owned. Power Distribution Companies in KHARAGPUR DIVISION helped in the development of new research Framework which was used in this research to assess the state government companies in Power Discom.

The study wraps up by presenting conclusions, encapsulating the research outcome and outlining directions for future scope of research on the topic.

Chapter 1

Introduction

Chapter 1: Introduction

1.1 Overview

Electricity demand has grown over the past few years and will continue to grow in the Future. The increase in electricity demand is mainly due to industrialization and the shift from a conventional to a smart-grid paradigm. The number of micro grids, renewable energy sources, Plug-in electric vehicles and energy storage systems have also risen in recent years. As a result, future electricity grids have to be revamped and adapt to increasing load levels. Power Systems mainly consists of transmission and distribution system in which power distribution system consist the final link to consumers from where the power is generated. Power saved is considered as power generated. The same concept can be applied if AT&C losses of our country could be reduced. Thereby financial health of Discoms could be improved. This will result in saving to Government. In India State wise AT&C losses as depicted in the below chart.

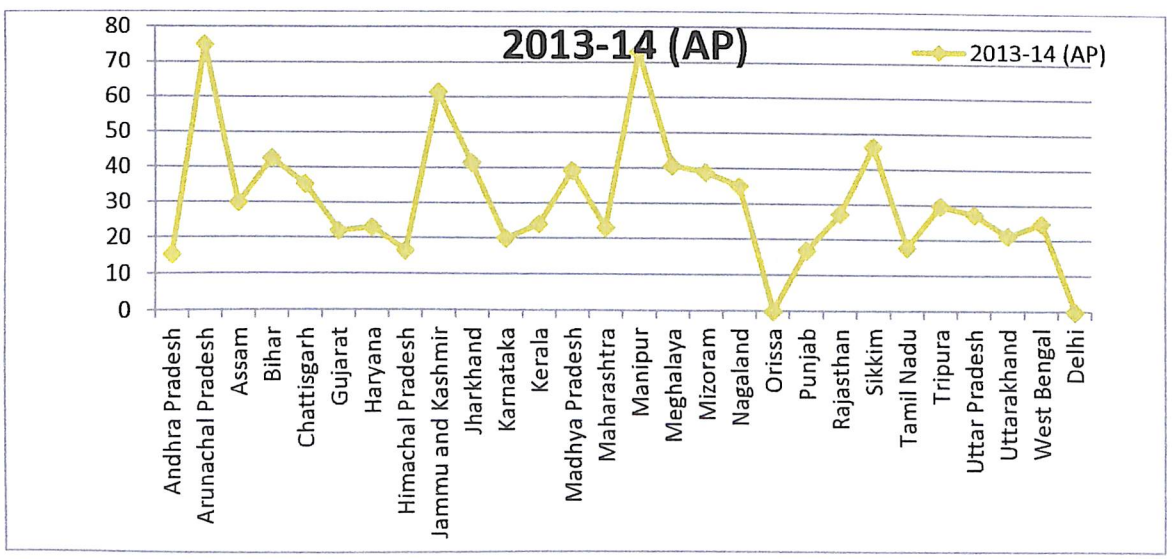


Fig:-1 State wise AT & C loss data

Source:-https://www.Data.Gov.in

Table 1: T&D losses as per CEA & PFC reports

Year	T&D (%) (CEA)	AT&C (%) (PFC)
2004 – 05	31.25	34.33
2005 – 06	30.42	33.02
2006 – 07	28.65	30.62
2007 – 08	27.20	29.45
2008 – 09	25.47	27.37
2009 – 10	25.39	26.78
2010 – 11	23.97	26.04
2011 – 12	23.65	26.63
2012 – 13	23.04	25.48
2013 – 14	22.84	22.58
2014 – 15	22.77	24.62

The AT&C losses of India are compared with countries of the Indian subcontinent, South East Asian Countries and Developed Countries as per World Bank Publication and Indicators report.

NAME OF THE COUNTRY	2009	2010	2011	2012	2013	2014
Australia	6	6	7	6	5	5
Austria	5	5	5	5	5	5
Bangladesh	11	11	10	12	13	11
Bulgaria	11	10	9	9	9	9
Bahrain	9	7	6	6	5	4
Chile	11	8	7	5	7	7
China	6	6	6	6	6	5
Congo, Rep.	70	59	52	45	45	45
Colombia	15	15	12	12	10	11
Denmark	7	7	6	7	6	6
Dominican Republic	12	12	12	12	11	12
Europe & Central Asia	8	8	8	8	8	8
Ecuador	18	17	16	14	13	13
BGypt, Arab Rep.	10	10	8	11	11	11
France	7	6	6	7	7	6
Greece	9	9	8	8	8	5
Hong Kong SAR, China	13	13	14	15	14	12
India	**21**	**20**	**19**	**19**	**18**	**19**
Indonesia	10	9	9	9	10	9
Iran, Islamic Rep.	16	14	15	14	14	13
Iraq	49	36	39	43	40	51
Iceland	3	4	3	3	2	3
Israel	3	3	3	3	4	3
Jordan	14	13	15	11	10	11
Japan	5	4	4	4	4	4
Kazakhstan	8	8	7	8	11	7
Mexico	16	16	16	16	17	16
Nepal	19	20	21	22	19	31
Netherland	4	4	5	4	4	4
New zealand	13	7	7	7	7	7
Norway	8	7	8	7	7	8
Pakistan	25	24	22	19	21	20

In above **Table -2** comparisons of AT&C Losses between in different countries and India. In different dataset Power distribution losses in European nations are 3-4%, whereas in India it is up to 50% in certain rBGions. The same has been shown in the Power Loss Map below (Fig 2).

Figure 2 Power Loss Map for 2012

Initial literature review for all technologies which are being used by Discoms in the world was done and exhaustive study of these technologies was undertaken. In fact, out of many power distribution companies in India, Discoms in Kharagpur Division. Thereafter, the research taken up initially tries to make an assessment of the different type of technologies being used in power distribution system.

Of the various ICT technologies being used in power distribution system, web technology has been taken up as assessment study for the research and SCADA has been taken for technology Implementation in the power distribution system.

1.1.1 Technology Implementation in Power Sector In India

The level of Technology Adoption in Indian scenario as compared with other countries can best be described in Figure 3 below, which draws comparison among the following

- Indian State Electricity Boards (SEBs)
- Asian Countries.
- Developed Countries like the United States of America (USA), United Kingdom (UK).

As shown, following Technology Elements were taken into consideration for comparison of Technology deployment among the utilities:

- Internet
- System Integration
- Networking
- Automation
- Metering Technology

The details of each of the parameter is discussed in more details in later chapters

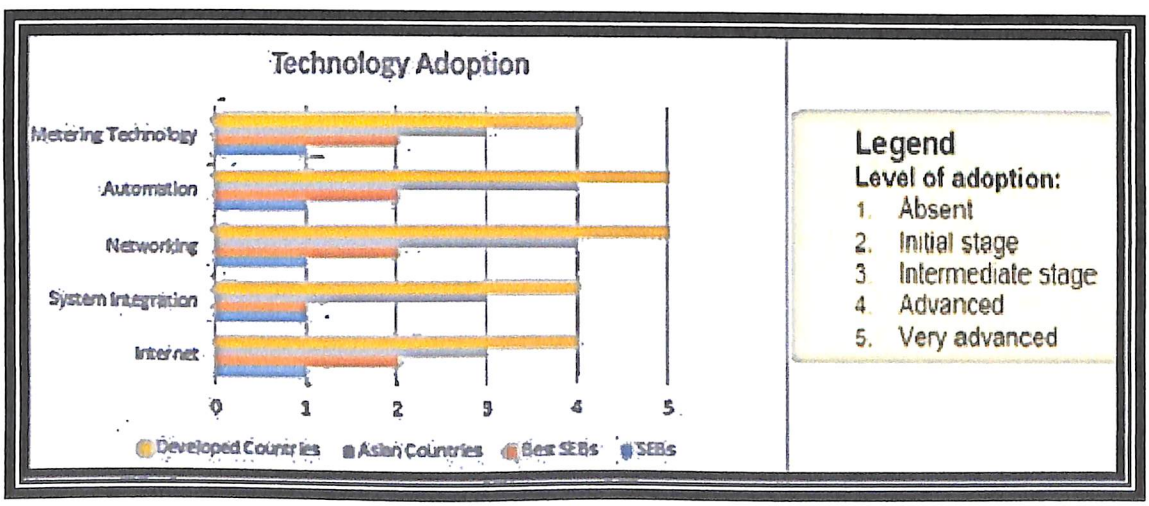


Figure 3 -Comparison of Technology Adoption in different countries
Source: Ministry of Power Report (Govt of India), 2010

The graph clearly States that India is behind in terms of implementation of Information and Communication technologies as compared other companies around the world. Indian companies should learn from global counterparts in terms of implementation of these technologies as they have way long experience in using these technologies.

A significant amount of work has been done related to ICT adoption in various industries but not much focus was placed power utilities in India. However, little has been said about the effectiveness of the strategy.

The endeavour is to find an appropriate answer to these questions with empirical evidence.

1.1.2 Introduction to Implementation of Technology and Its benefits

The Technology Implementation is life cycle approach with eight phases, which starts with technology creation, then monitoring and then moves to Technology assessment, transfer, acceptance , utilization, maturity and decline Out of the eight phases of life cycle , the areas selected for this research are **technology assessment, technology acceptance and finally technology utilization on practical field of power sector**.

Technology Assessment: The research area of technology assessment focuses on different technologies which are in being used in power utility and which are in different stages of implementation. Different technologies are associated with different business and the operational process.

Technology Acceptance: Since a number of technologies are used being in power Distribution system, to analyze acceptance of all technologies would be a difficult task, so only one of technology i.e.; SCADA/SAS is being taken for study.

Technology Utilization: This phase of the life cycle has been selected to analyze the utilization of technologies and how this has helped the organization, for example, web-based application has helped in Kharagpur division easing billing efficiency, solving consumer grievances and giving a tool to the consumer so that they can directly interact with power Discom.

1.2 Background of the Study

1.2. 1 Introduction

One of the objectives of the research has been the development study the modern and innovative technologies which are being used in power sector in the comprehensive and integrated way. Each technology plays a pivotal role in determining Discoms performance and efficiency. The chapter shows that technologies involved in the main three stages of technology being used in Power distribution sector i.e.; Automation, Communication and Information Technology. On the basis of technologies review, the importance of each technology is being studied. SCADA technology which one of the innovative technologies being used has been selected to study implementation of technologies in upcoming chapters.

1.2. 2 Present Application Status of Technology in the Indian Power Sector

Electricity demand has grown over the past few years and will continue to grow in the Future. The increase in electricity demand is mainly due to industrialization and the shift from A conventional to a smart-grid paradigm. The number of micro grids, renewable energy sources, Plug-in electric vehicles and energy storage systems have also risen in recent years. As a result, future electricity grids have to be revamped and adapt to increasing load levels. Thus, new complications associated with future electrical power systems and technologies must be considered. Most of the power distribution companies in India is suffering from manual and old orthodox process, poor customer satisfaction, and high revenue leakage. Many Discoms Have developed and deployed many IT applications, but most of them are in form of islands and holistic integration approach of technology management and implementation. On the other hand many Discoms implemented various modern and innovative technologies but still, they are at a very nascent stage in acceptance of technologies.

1.2. 3 Benefits of Technology Implementation in Power Distribution

Broadly there are two aspects of technology in power distribution sector which are as follows:

1. Information Technology
2. Operational Technology

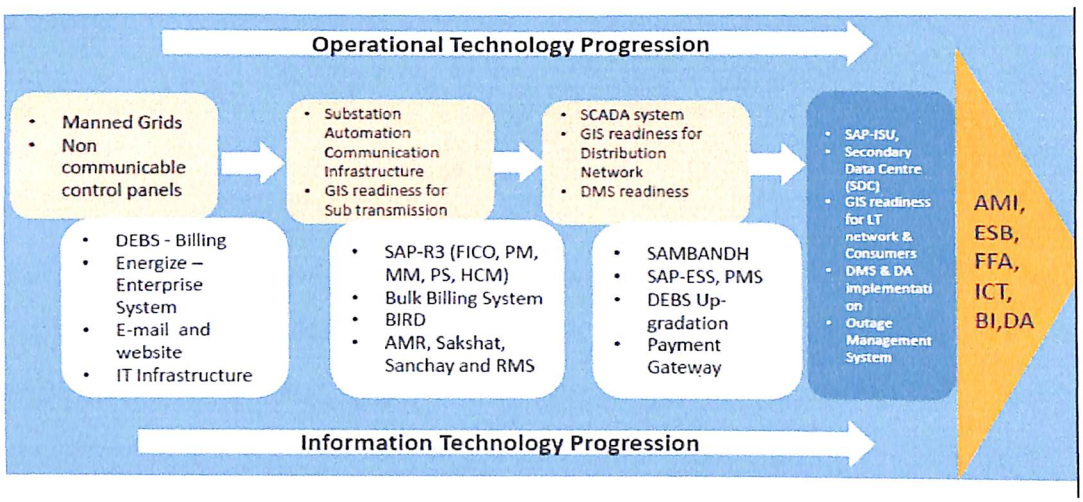


Fig:-4 IT - OT Convergence

In the current scenario, in most of the Discoms in India, there has been limited interaction among these technology mentioned in the fig above. Web technologies (IT) can be used to great extent as direct means to communicate with the customers. There is a serious need for all Discoms to focus on adoption of IT which can be a game changer in the transformation of their power utility business.

Automation and control Technologies assist the Discoms in the acquisition of data and supervision and monitoring of the power system. Many Discoms has started using many of these technologies but the implementation has been in isolated form and not as integral two-way integration with other technologies in Discom.

These automation technologies generate a large amount of the data which can be further used as analytics which in turn can help Discoms in solving many of their problems and better decision making. Communications technologies act as the path for the flow of data collected by automation and control systems, to Information Technology (IT) for the collection of various data and creation of an analytical method to resolve the problem. So, all technology is co-related and the benefits in power industry are numerous which are depicted in below fig-06-

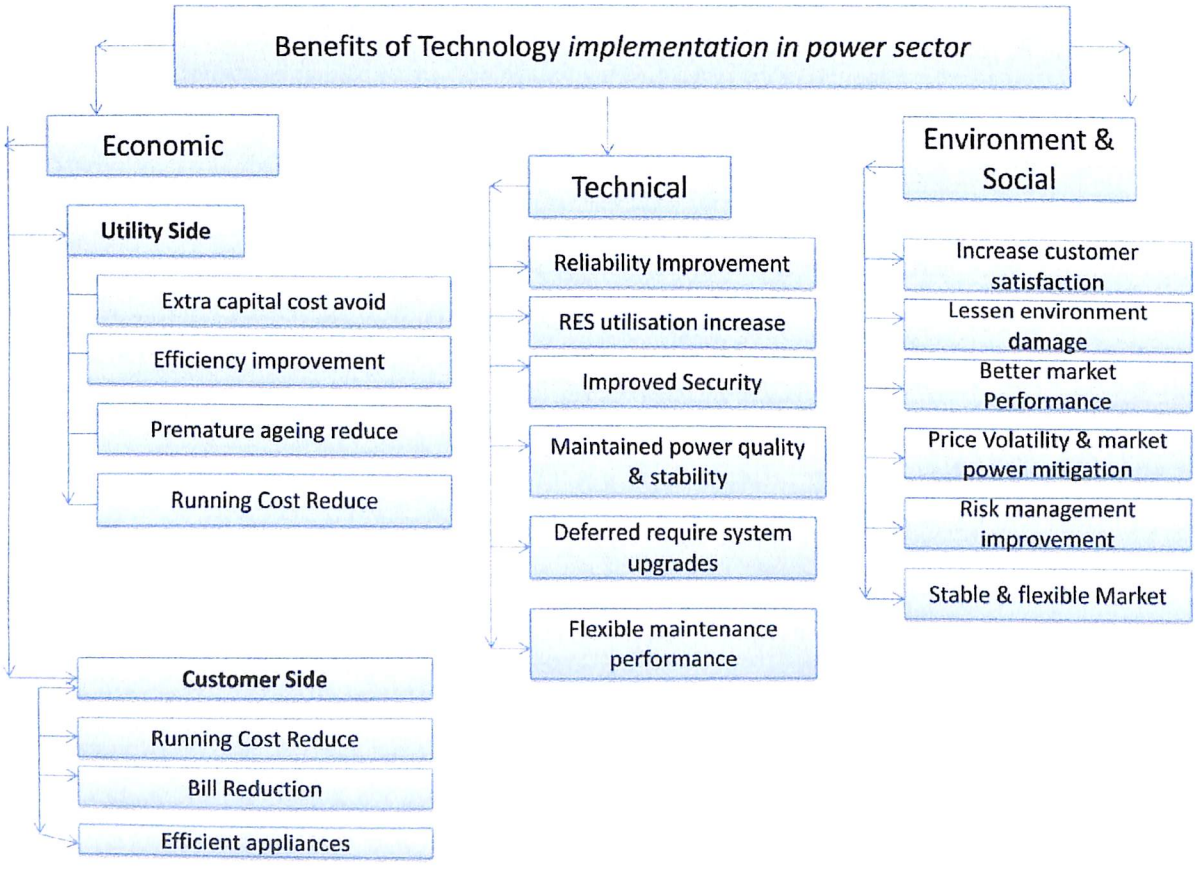


Fig: - 05 flow chart of Technology implementation benefits.
Source: - Designed By Researcher

1.2.4 Information Technology

Most of the developed countries have made use of advance IT technologies to Kharagpur division ease their efficiency, production and commercial gains. IT, when made part of the commercial process, reduces human errors and also check on corruption.

A few prominent IT applications to the power sector are described below:-

a. Integrated Smart metering, billing and collection systems:

One of the key aims to integrate billing, payment, and collection is check on corruption and frauds and to Kharagpur division ease collection efficiency. In order to reduce commercial losses, Kharagpur division ease billing and collection efficiency has to be one of most import objective of the power Disco. Kharagpur division easing billing and collection efficiency is one of the important aspects of IT applications which power distribution companies' focuses on in order to reduce AT&C losses. Discom should have multiple convenient payment options for customers.

So that they can pay bills easily without much difficulty. In order to achieve this in recent years, all Discom have put lots of thrust on Kharagpur division easing customer care centres and strengthening the website through which customers can pay bills.

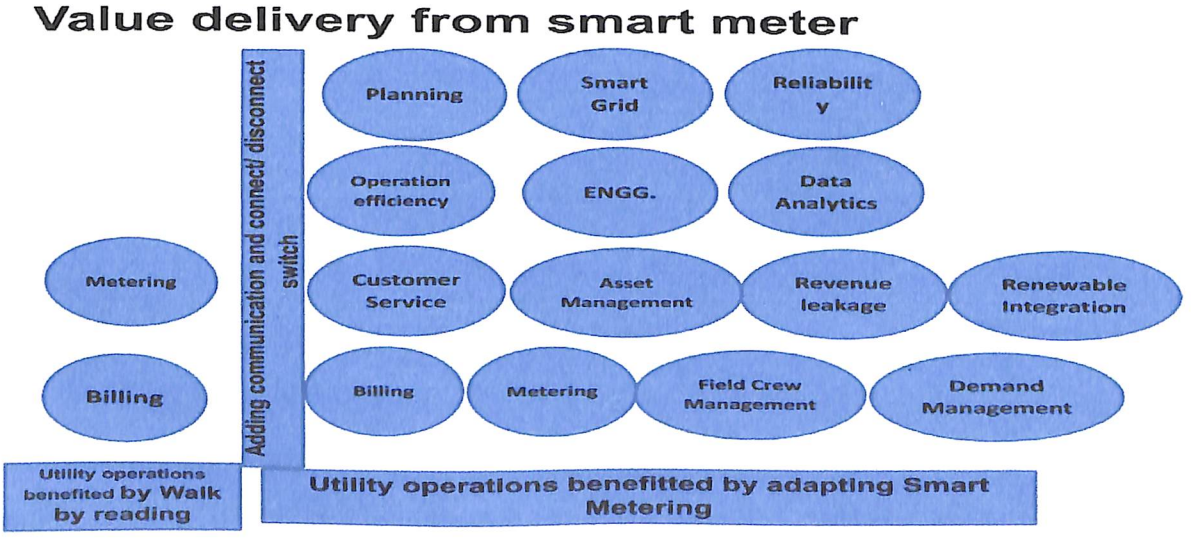


Fig: 06 Value Delivery System from Smart Meter
Source: Presentation by **B. S. Babel** - President, IEEMA, on **Smart Metering**

The Discom website is the single platform for any type of information related to bills and payments like E-Bills, Bill History, energy consumption pattern etc.

The various payment options information available for customers through website are as follows-

b. **Bill Payment Kiosk:** These are basically customer care offices spread throughout the geography of the Discom in order to provide the assistance to customers in person for various bill related issues and also payment counter where they can pay their bills directly.

c. **Instant Payment Options**: The Discom website provides a gamut of instant bill payment options. The figure below explains the options available where customers can pay their bills instantly online.

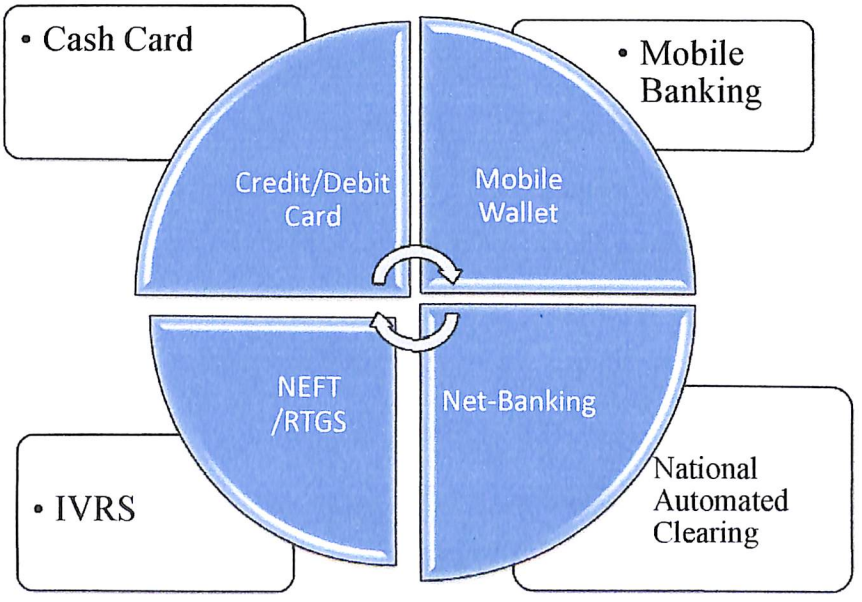


Figure 07 Bill Payment options on Discom Website
Source: Designed by Researcher

d. **Bank Branches:** The Discoms have tie-ups with various banks to provide the convenience to the customers to pay bills.

e. **Apps &Wallets:** With the advent of Mobile Application, the consumer today options of payments through various Apps like PAYTM, Google Pay, and Phone Pay etc. through them can also avail many cash back offers. Thus Discom website provides one gateway for all consumer bill related queries and payment options and also help to solve their complaints and grievances.

f. **Energy accounting system**

Energy accounting system constitutes an important of IT application in Discom. There are mainly three types of Energy Audit report prepared in the Discom.

g. **Grid EHV (Extra High Voltage) Level Losses**: It basically refers to input energy received by the Discom at transmission level and output energy distributed at downstream in the Discom.

h. **11 KV Feeder Losses**: Identification of HT feeders with different level of losses, these losses are computed by calculating the difference in energy at HT level and summing up of the energy of all DTs associated with HT feeder.

i. **Distribution Transformer (DT) Losses**: The DT losses are mainly computed by comparing the total amount billed to the consumer by the Discom and total energy that has been delivered to the Discom by taking DT meter reading. In order to map all correct consumers to DTs consumer indexing exercise plays a critical role. Correct Consumer Indexing help in delivering better energy Audit. Most of the Discoms there is a problem of a lot of discrepancies in consumer indexing.

The figure below depicts distribution network and metering done at a different level downstream right from transmission level up to the consumer.

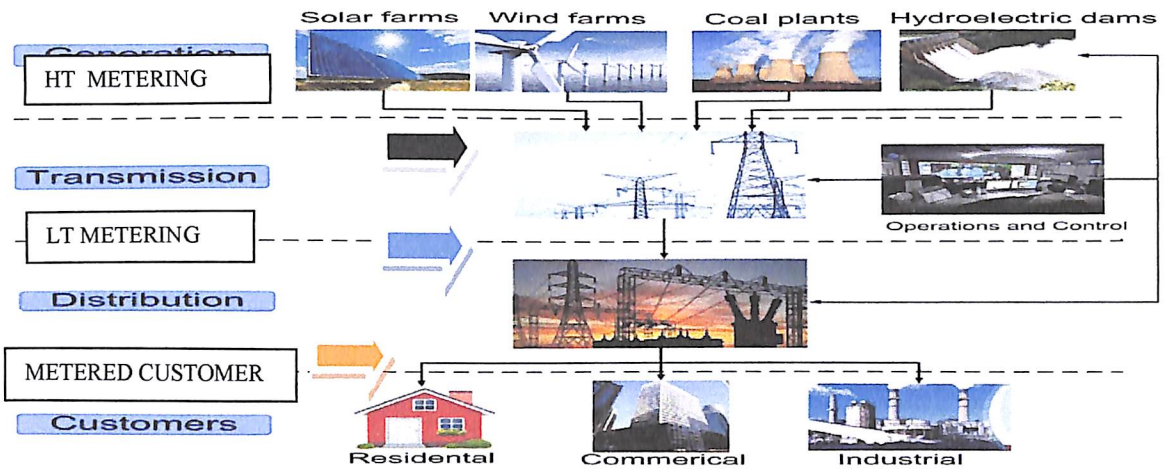


Figure-08 Metering System in Power Discoms
Source: Designed by Designer

j. **Complaint handling –**

Power distribution business in India is still not treated as a service industry for providing uninterrupted power supply to consumers. In the current scenario, consumers find difficult to lodge complaints and get information like when power will be restored etc. Discoms should have IVRS system, dedicated call centers and other mediums like a mobile app from where consumers can communicate with Discoms

.

k. **Enterprise resource planning (ERP)**

Kanth, R. (2012) elaborates need for ERP is to enable the flow of information among all the stakeholder within as well as outside the organization. Major Global companies which provide ERP solutions include SAP, Oracle, and Microsoft.

l. **SAP Utilities**

Kanth R (2012) explains SAP came up with its product Project IS-U/CCS in Aug 2002. The SAP (IS-U) acts as a central repository for all types of consumers like residential, commercial and industrial billing data. The IS-U contains all types of information like billing, invoice, reminders and new connection consumers.

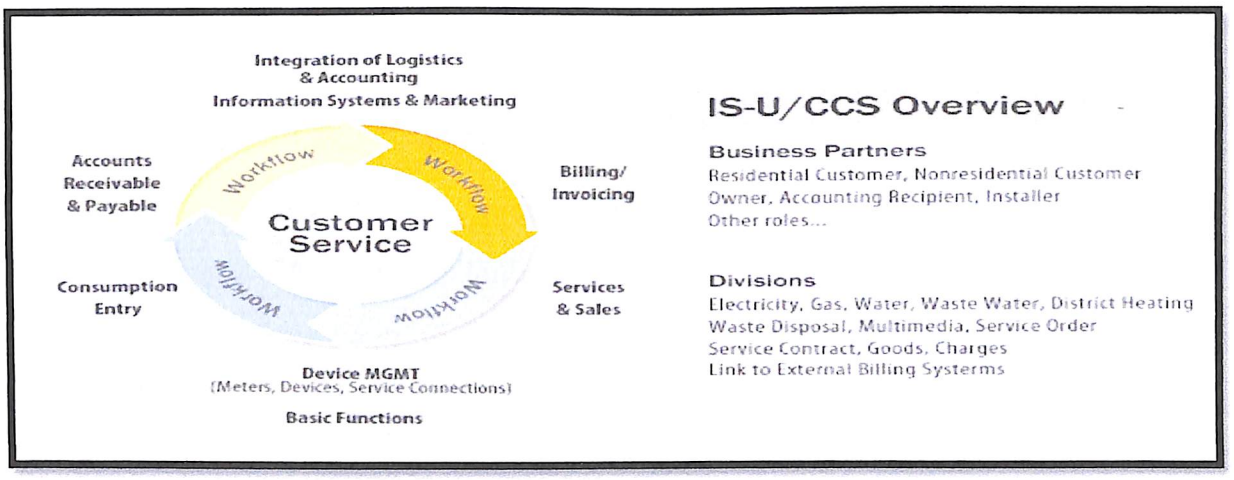


Figure 09 IS-U/CCS as a component in the ERP Solution
Source: https://www.bayforce.com

SAP for Utilities consists of two types of products:

- CRM – Customer Relationship Management: This has been framed in order to ensure complete promotion, customer acquirement, sales and customer services. It is tightly unified with the IS-U: CRM which act as a front end interface (contracts, customer services, market campaigns and whereas IS-U acts as-is a backend for billing, payment processing, work management purposes.
- BW – Business Warehouse: It is used for analytical reports. The package contains business content with lots of predefined info Cubs and reports.

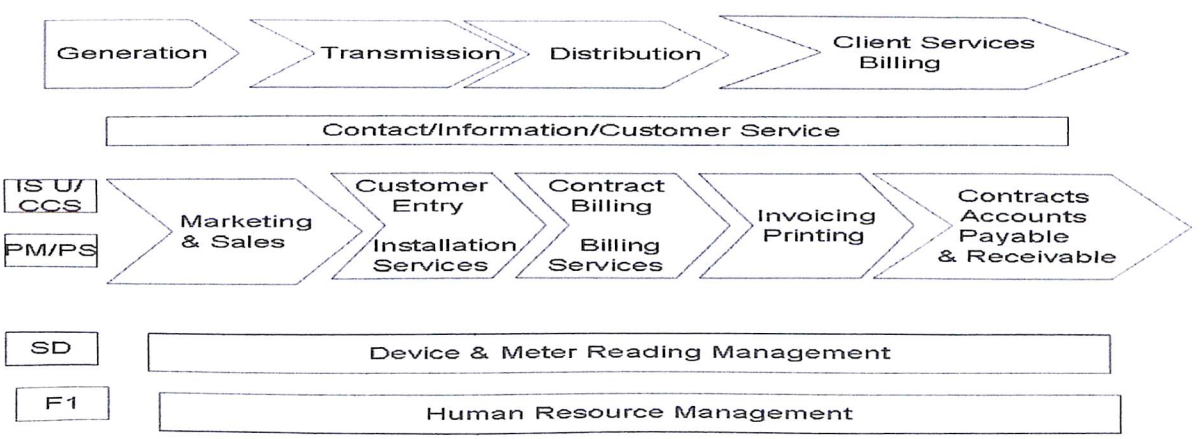


Figure 10 Functional Scope of SAP-ISU
Source: Kanth.R (2012), Information Technology Implementation in Indian Power Distribution

ERP Modelling of Distribution Business:

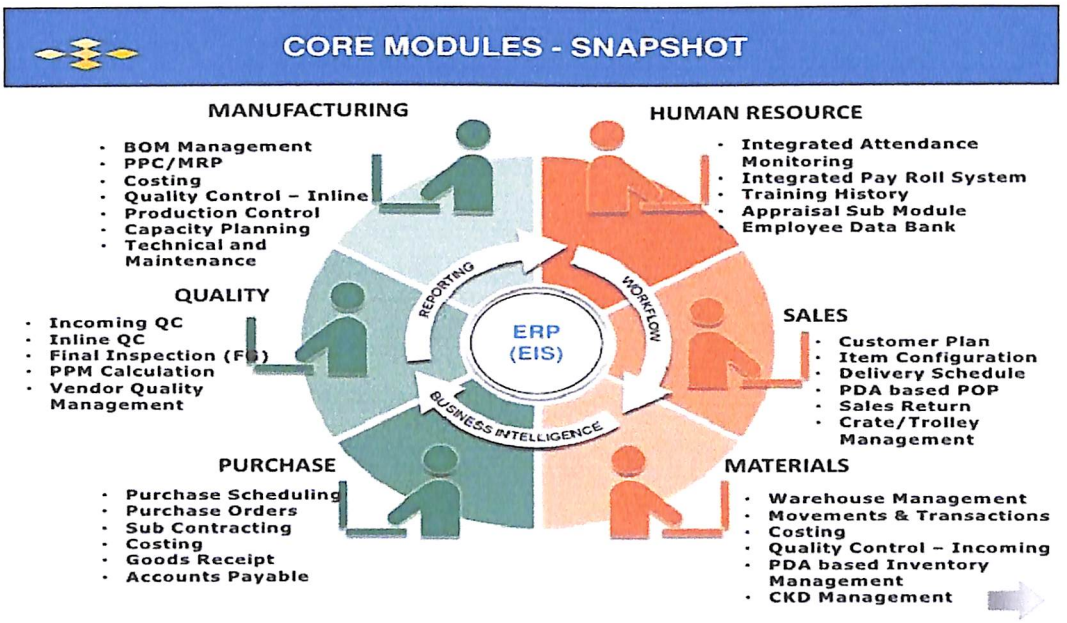
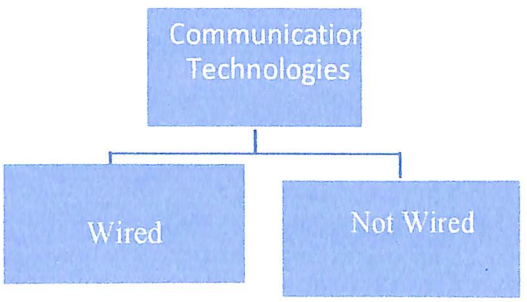


Figure 11 Functional Scope of ERP management System.

1.2.5 Communication

Communication technologies are largely classified into two types: Wireless and Wired.



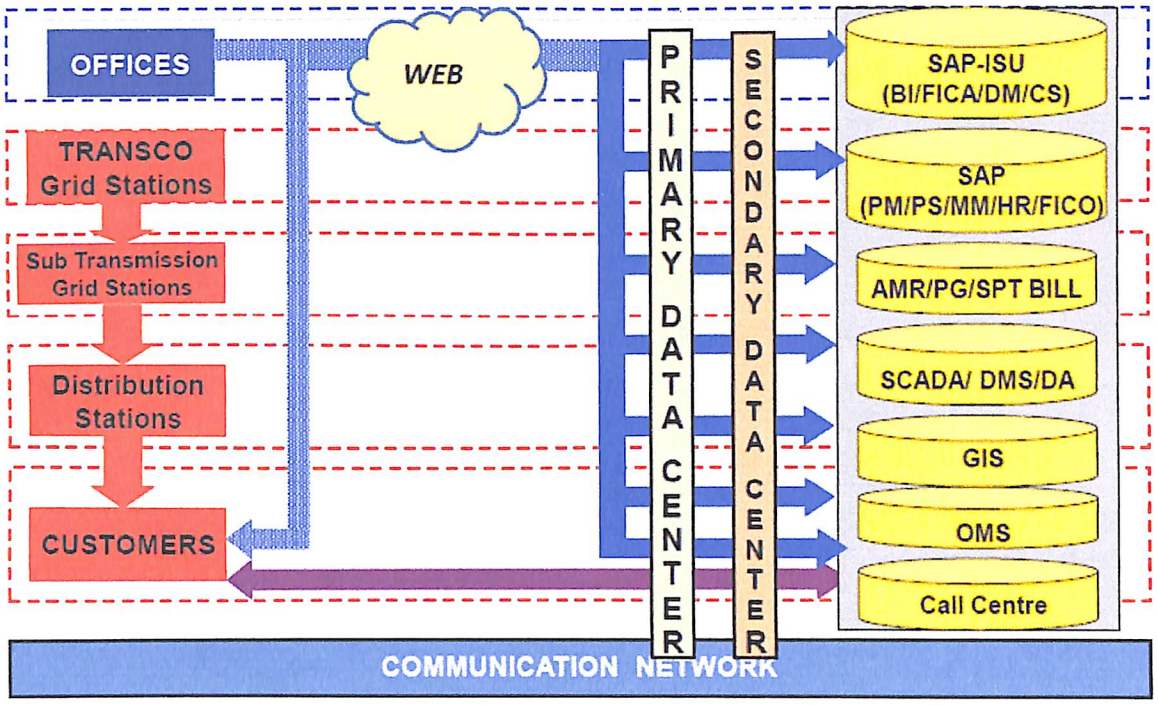


Figure 12 Communication System for data management.
Source: www.wbsedcl.co.in

The Wired communication requires a physical medium like cable to communicate data while wireless communication wants microwaves or radio-waves. In the current context, wireless technologies commonly used are ZigBee and RF Mesh as Smart Grid whereas wired communication technology as Power Line Carrier Communication (PLCC) and now discom's are using Optical Ground wire communication Technology for communication between two Sub-station and between load despatched centre and one specified zonal Sub-station. This type of optical wire fulfil two major different requirement of Discom's are being followed-

1. Provide proper earthing protection of Transmission line from direct stroke lightning effect.
2. Fulfil requirement of communication as its work as wired type of communication media. European countries use PLC to a greater extent, RF mesh is more widely used in the USA.

Wireless Technology	Data Rate	Approximate Coverage	Potential Power System Applications
Wireless LAN	1-54Mbps	100m	Distribution protection and automation
WiMAX	70 Mbps	48km	Wireless Automatic Meter Reading
Cellular	60-240 Kbps	10-50 km	SCADA and monitoring of power system network
ZigBee	20-250 Kbps	10-100m	Direct load control of home applications
Mobile-Fi	20 Mbps	Vehicular Std	Communication for PEVs and remote monitoring
Digital Microwave	155 Mbps	60 km	Transfer trip (point-to-point)
Bluetooth	721 Kbps	1-100m	Local online monitoring applications

Table 3 Different types of Communication System commonly used in Power Distribution system.

Source: .www.semanticscholar.org, wireless technology for power system

1.2.6 Automation & Control Technology

a. SCADA (Supervisory control and data acquisition)

SCADA is one ground-breaking automation technology that has been used to control, monitor and generate various types of required for the utility. This technology are extensively positioned in various industries to provide remote supervisory and control. It comprises of automated methods to support in the supervision and control of the power grid.

In power sector, SCADA has been implemented to monitor the quality, distribution, and losses, in the power structure. The implementation of SCADA is towards the ability to manage assets inventory more efficiently.

SCADA system mainly comprises of following components:

Human Machine Interface (HMI): It is an interface which displays the data and also acts as a controller of the system

1. Supervisory (computer) system: It manages and assembles the data and sends instructions to the electrical units.

2. Remote Terminal Units (RTUs): It acts as a sensor and collects signals for processing. It decodes sensor signals to digital data and maps digital data to the system.

3. Programmable Logic Controller (PLCs):

These are used as field devices. They are cost-effective, multipurpose, bendable, and configurable than special-purpose RTUs.

5. Communication setup: It acts as an interface connecting the supervisory system to the Remote Terminal Unit

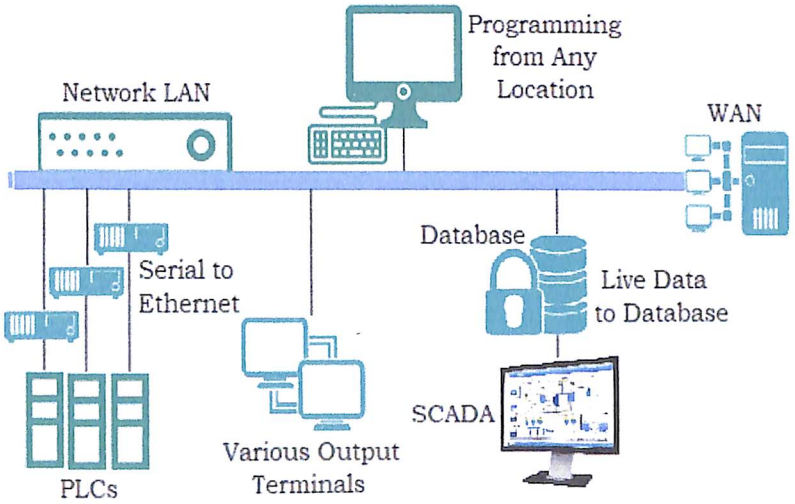


Figure 13 Basic SCADA System Architecture

b. Outage Management System

Outage Management System. ,basically, refers to computer aided systems which provide the information to the Operation and Maintenance Departments crew team about where there is no power supply or there have been some faults due to which power is being interrupted. The OMS system also assists team about the electrical assets which are associated with fault and overall give them a picture in knowing the extent of fault and how many consumers are being affected due to the fault in the circuit.

OMS is an intBGrated solution with major modules which are involved are SCADA, customer information system (CIS), customer centric applications like call center and interactive voice response (IVR) system.

Today OMS has been used as an intBGrated solution to calculate customer satisfaction Indexes like SAIFI and SAIDI based on various inputs data and analysis reports.

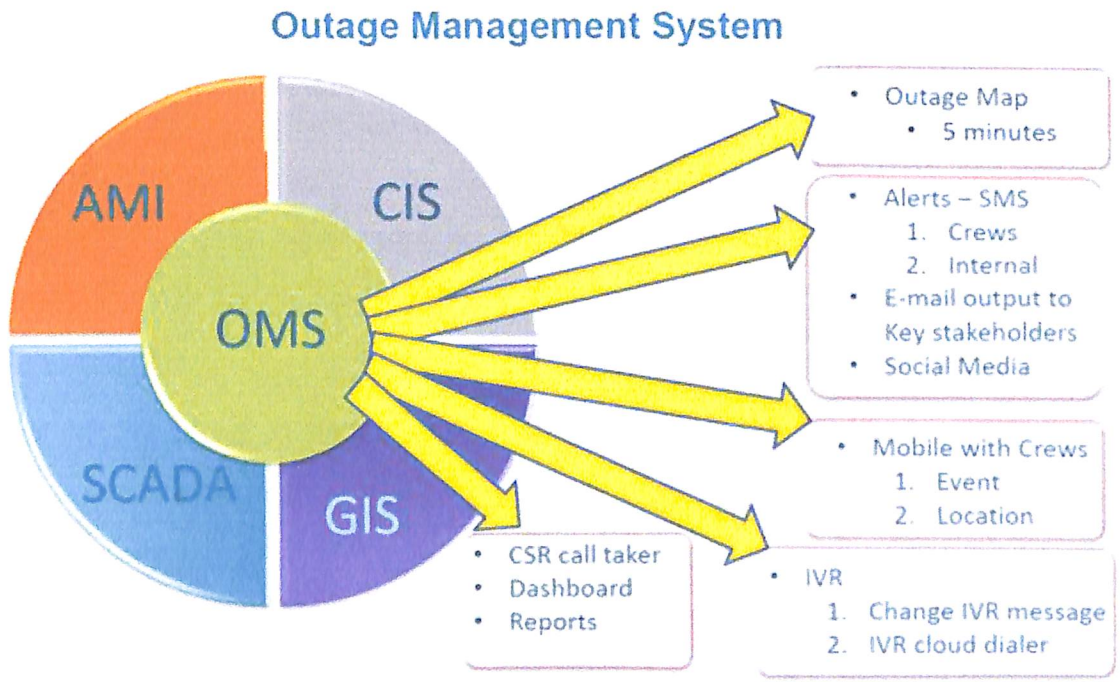


Figure 14 Outage Management System Working (An Example)

Source: WBSEDCL Reports and Presentations (2017)

c. Automated Meter Reading (AMR)

AMR technologies collects data from energy meters and transfer the same to the master station for various purpose like billing. It also helps in reducing human error, dependency on a human being for metered reading and overall it also helps in reducing the billing cycle thus Kharagpur division easing collection efficiency. One of the major benefits of AMR is one can connect/disconnect meter remotely based on the information like non-payment of bills etc.

There are basically two types of AMR architecture in AMR.

- GSM Based Communication: It forms links for communication amid meter and central station through GSM Model.
- Hybrid Communication: In hybrid communication there are two stages;
  a) Meters and Data Concentrator Unit (DCU)
  b) DCU and Host Central Station.

1. Electrical meter: The electronic meter processes and measures the electrical energy supplied to the consumer. It is also an interface which transmits data from remote terminal to collector.
2. Collector: It receives, processes and stores information received from electronic meters.
3. Concentrator: The collectors receives a signal from the concentrator for meter reading on a steady basis.
4. Central Hub: The central server responsible for managing the entire system.

d. Geographical Information System (GIS) & Network Analysis

In power sector, SCADA has been implemented to monitor the quality, distribution, and losses, in the power structure. The implementation of SCADA is towards the ability to manage assets inventory more efficiently, as it enables organization a map-based view of assets with the work information. Along with this SCADA also enables the user to present the graphical values of their work.

The new tool SCADA would let the field users do the expected in much better and faster way but have a capability for each and every action that have to be performed in the organization. Benefits of SCADA implementation on any utility organization are noticed in terms of "efficient updating of assets & facilities, more efficient retrieval of information, efficient engineering design and planning, elimination of redundant data entry, outage tracking and management" and many more to make the efficient and adequate supply.

Along with this SCADA also enables the user to present the graphical values of their work. The new tool SCADA would let the field users do the expected in much better and faster way but have a capability for each and every action that have to be performed in the organization. Efficient Update of assets &facilities, more efficient retrieval of information, efficient engineering design and planning, elimination of redundant data entry, outage tracking and management" and many more to make the efficient and adequate supply. SCADA sets the organization to an extent where it can with other tasks also keeps tracks on the consumers this can only be done by when each component (line, customer number, pole, and meter) is track-able and available in the digital database.

1.3 Research Objectives :

1.3.1 Introduction

The Thesis study aims to find out the Implementation of technology and its application in power distribution companies. The research tries to study different types of technologies being in used in Discoms but focuses on effective applications of the technologies. More specifically, the research aims to study effective application & Acceptance of SCADA technology more specifically SAS in power sector. The study identifies aspects that can help power distribution companies in India to overcome the technical, managerial, social and cultural barriers to effective ICT applications implementation.

Literature review shows the (ICT) have become an important part of many processes in Discoms. Therefore research requires an understanding of types of technologies which are implemented in Power distribution and processes.

1.3.2. Problem Statement

With advanced application of IT, and mobile technologies can shows us path of easy access of power discoms facility & consumers expects that utilities with accurate metering and billing free from any errors with facilities like online payment of bills and from mobile applications All of these can be possible only by adopting innovative and smarter technologies applications rather than manual approach and provide better services to the consumers in terms of handling complaints .Various applications build on IT and associated technologies also address in solving energy audit issues and identification of more problematic areas and which needs more focus and attention.

The research work tries to explore new technologies which are implemented in power discom and acceptance of technologies specifically SCADA used in power distribution industry.

The research tries to find out how factors play a crucial role in acceptance of the technologies by the consumers & power sector.The one of the main Intention of the research was to discover the how employees of government power distribution companies were utilizing SCADA technologies applications in their organization and various factors that were associated with level of utilization

- Calculation of level of acceptance of SCADA (SAS) technologies.
- Utilization of SCADA (SAS)technology by the staff

With the development of technology, a numerous number of studies has been carried out for acceptance of Information Technology (IT) system in the organization, still, there is a need for study of acceptance of SCADA in Indian Power distribution sector.

1.3.3 Objectives Details

Following Research Objectives were framed on the base of the breaches of research, noted in the Literature Survey. :

Research Objective 1

To Explore of different technologies which has been in use in power Discom & the benefits of use among the power distribution companies

Research Objective 2

To study about Implementation & acceptance SCADA Technology among different technologies which has been in use in power Discom which is one of the most recent and innovative technology has been taken up for the study .

Research Objective 3

To find how SCADA has been implemented in power distribution system through real time application in power substation.

1.4. Research Hypothesis

After understanding of power distribution sector extracted in the formulation of the following research hypothesis. Two sets of hypotheses have been formulated. One set is 'Hypothesis on the level of technology implementation used in power discom 'The second set is 'Hypothesis covering factor which affects adoption of SCADA acceptance in power distribution companies'.

1.4.1 Hypothesis on the level of technology implementation

Hypothesis based on technological implementation level

H0- The level of technology implementation is same in power distribution companies.

H1- There is a difference in level of technology implementation in power distribution Companies

1.4.2 Hypothesis covering factors which affect adoption of SCADA adoption

H1: Perceived Ease of Use (EU) has an encouraging impact on attitude (AT) of Discoms Staff.

H2: Perceived Ease of Use (EU) has an encouraging impact on Perceived Usefulness (PU) of Discoms workforce

H3: Perceived Usefulness (PU) has an encouraging impact towards Intention (INT) of Discoms workforce.

H4: Perceived Usefulness (PU) has a promising stimulus on Attitude (AT) of Discoms Staff.

H5: Discoms Staff attitude (AT) for SCADA has a favourable impact on intention (INT) to practice the system.

H6: Benefit (B) has an encouraging impact on the Perceived Usefulness (PU) of Discoms Staff.

H7: Discom Organization Culture & Management Support (OC) has a favourable influence on Intention (INT) of Discom staff.

H8: Discom engineering support & Govt Initiatives (ES) has an encouraging impact on Intention (AT) of Discom staff.

H9: Employees Age & Years of Experience (AE) has an encouraging effect on Intention (INT).

Research Hypothesis Model

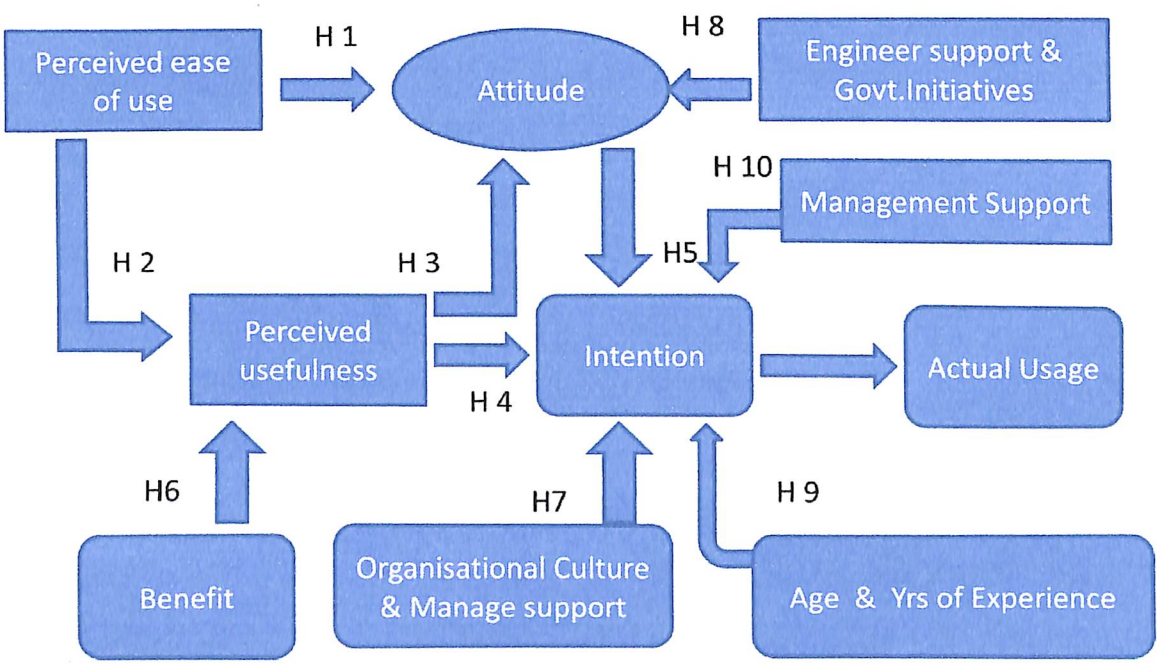


Fig: 15 Research hypotheses Model

1.5 Summary

The Chapter discusses current scenario of Indian power distribution sector and challenges faced in the current context. The chapter elaborates the AT&C loss level in India over the years and also compares the same with that of different countries. The level of technology adoption which is also one of a key area of research is also discussed and compared with that of different developed and Asian countries. Also in detail the objective taken for the research work. Each research objective which has been defined after analysis if research gaps and literature review is then defined ahead using hypothesis. Each research objective is then followed by the assumed hypothesis for the research. The Next chapter explained the research methodology adopted for the research

Chapter 2

Review of Literature

Chapter 2: Review of Literature

The literature on various aspects of the research topic was reviewed, as per the Literature Survey process, depicted in Fig-16

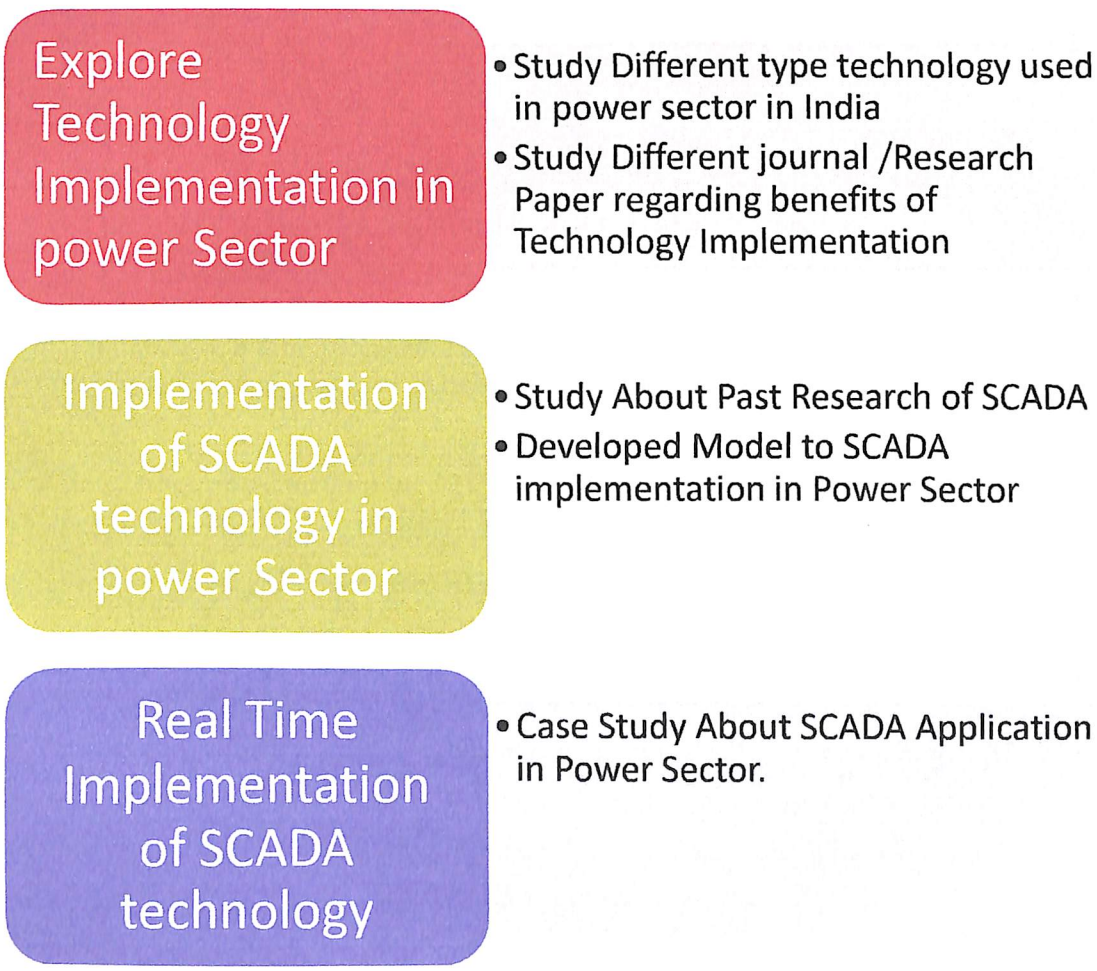


Figure 16 Research Objective Flow chart to focuses on Literature Survey adopted for this research

2.1 Overview of Literature Survey done

Vinuta V Koluragi (2014), discusses the SCADA implementation on power substations using IT and high-speed communications which help in protection, monitoring and information sharing in integrated power distribution system.

P.R. Shukla, DebashishBiswas, Tirthankar Nag, AmeeYajnik, Thomas Heller and David G. Victor, 2004-
"Impact of Power Sector Reforms on Technology, Efficiency and Emissions: Case Study of Andhra Pradesh, India.
"The Smart grid Vision for India's Power Sector", PA Government Services, Inc., March, 2010
M P Gupta (2007) demonstrates the use of Information Technology in different government organization and impact of top management, organization culture in use of IT

Meeta Dasgupta (2011) explains various technological innovations taken by Tata Power Delhi Distribution Ltd which has helped in revamping power distribution business.
Surajit Banerjee, Gautam Banerjee (2006) has explained the reduction in T&D Losses in CESC by IT based Surveillance focuses on various IT based initiatives which had led to a reduction of T&D losses in Kolkata.
R. P. Gupta and S. C. Srivastava (2007), has described homBGrown designed and developed power distribution automation system at IIT campus in Kanpur
P.V.Chopade B.E.Kushare Dr.D.G.Bharadwaj (2012) discusses the importance of IT in power distribution system and IT along with automation technology can play a key role in improving the quality of power distribution system.. This can be used by power utilities to reduce operational issues of networks.Aurobinda Basu,

Alok Tripathi-(2013) IT interventions in Power Distribution Reforms in India : Adoption of New Technologies and Integration challenges.

Zahoor Hussain1, Shahzad Memon1, Zulfiqar Ali Bhutto1, Raza Hussain Shah1, and Abdul Waheed Solangi (2016) of wireless communication networks on smart grid & electrical power distribution systems of electricity infrastructure. Robinson (2013) has effectively tried to give the brief idea regarding the impact of electricity on the economic status of people in Delhi.

2.2 Technology Application in Power Distribution Sector in India

Research Work Related to Technology Implementation in Power Distribution Sector In India					
Sl No.	**Literature Reviewed**	**Literature Type**	**Author**	**Brief Summery**	**Published Date**
1	**Smart Metering in electric power distribution system**	Karan Ganghi & Hari Om MansalInternational Conference on Control, Automation, Robotics and Embedded Systems (CARE) 2013	Karan Ganghi & Hari Om	This paper discusses the need of smart meters, their working, benefits and challenges in implementing them.It aims to improve the reliability, quality and security of supply. IntBGration of AMI into electricity grid needs implementation of a variety of techniques, controls depending on the required features	2013
2	**Outage management system for power distribution network**	Gourav Kumar & naran Pindoriya 2014 International Conference on Smart Electric Grid (ISBG)	Gourav Kumar & naran Pindoriya	This papers discussed about Unplanned outage detection is very important for improving the distribution system reliability and accessibility. Traditionally, customers' trouble calls are the primary source of outage notification.	2014
3	**Planning & Development of SCADA Based Power Distribution System**	Govind Rai Goyal & Mohit Kr.Jain 2017, Journal on smart grid Technology	Govind Rai Goyal & Mohit Kr.Jain	This papers discussed about Smart grid Technology and how it beneficial for endorsementof power distribution sector along with SCADA implementation in power sector.	2017
4	**A review on development of Smart Grid technology in India and its future perspectives**	Shiban Kanti Bala,Conference: Engineering and Systems (SCES), 2012	Shiban Kanti Bala	This paper presents various Smart grid initiatives and implications in the context of power market evolution in India. Various examples of existing structures of automation in India are employed to underscore some of the views presented in this paper.	2012

5	Power sector reality and a way to improve service quality with community involvement	K V James & RG Priyadarshini,3rd International Conference on Materials and Manufacturing Engineering 2018	K V James & RG Priyadarshini	This paper looks into a brief view on Indian power sector including recent advancements and a study on its customer services,The customer service quality was measured from the customer perspective.	2018
6	Tata Power Delhi Distribution Ltd,Beyond The Metrices	Monica Singhania,R.Venkatesh,Tata power Ltd beyond the metrices case studiescollection-2012	Monica Singhania, R.Venkatesh	this paper highlightes plan which developing growth and combat the climate	2012
7	Demand side management and load control — An Indian experience	Subrata Mukhopadhaya,Power and Energy Society General Meeting, 2010 IEEE	Subrata Mukhopadhaya	This research paper disscussed about Demand side Management in power distribution networks and how it beneficial than supplyside management of resources.	2010
8	INFORMATION TECHNOLOGY SOLUTION FOR POWER	P V Chopade,international Conference smart grid technology	P V Chopade,	present paper gives the IT solution which will enable the business operation at the transaction level and improve the overall quality in Decision Support System.	2013
9	Enabling Excellence in operation through Technological Innovation	Meeta Dasgupta ,Emerald emerging market case studies collection-2011	Meeta Dasgupta	this paper explain various Technological innovation which is adopted by Tata Power Ltd In delhi	2011

Table-4 :- Research Work Related to Technology Implementation in Power Distribution Sector In India

2.3 Literature Review Related to Implementation of SCADA technology in Power System

2.3.1 Earlier Studies Examining User Acceptance

Recognition the needs and acceptance of individuals is the beginning stage of any businesses and this understanding would be helpful to find the way of future development, thus academicians are interested to realize the factors that drive users' acceptance or rejection of technologies. A number of models and frameworks have been developed to explain user adoption of new technologies and these models introduce factors that can affect the user acceptance

This basically divided into two parts. The first part discusses on model and theories on technology acceptance, technology Implementation. The second part focuses on SCADA System, evolution of SCADA in electricity distribution companies, research related to SCADA and how this technology has been instrument for power distribution companies.

Different types of Technology Acceptance Model Are-

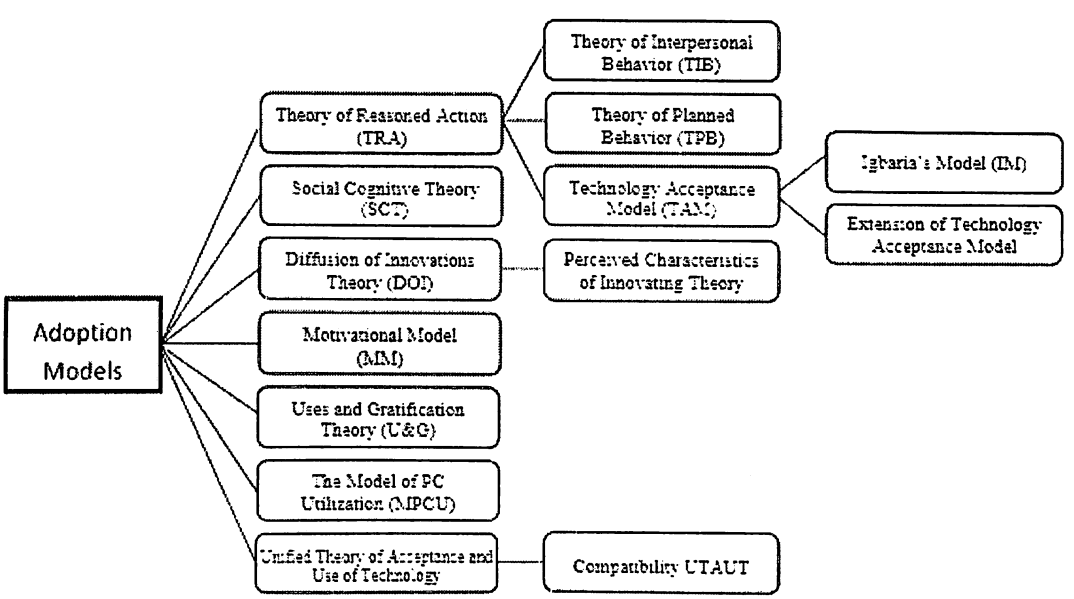


Fig17:- Various Technology acceptance Model
Source:- Hamed Taherdoost, A review of technology acceptance and adoption models and theories

2.3.2 The Theory of Reasoned Action

Although TRA model is firstly developed in 1975 by Fishbein and Azjen's for sociological and psychological researches, it is recently became foundation to investigate individuals' IT usage behaviour. In this model, any human behaviouris predicted and explained through three main cognitive components including attitudes (unfavourableness or favourableness of person's feeling for a behaviour), social norms (social influence), and intentions (individual's decision do or don't do a behaviour). This human behaviourshould be volitional, systematic and rational. Moreover, three boundaries factors, volitional control; intention stability over time; and measurement of intention in terms of target, time, context, action and specificity, are defined to test and evaluate the TRA. Furthermore, some methods such as generality, target, action, context, and time horizon are established to improve the robustness between corresponding intention and attitude. On the other hand, the main disadvantages of TRA arethe lack of addressing the role of habit, the cognitive deliberation, misunderstanding through a survey (attitudes, subjective norms, and intention of the respondents) and the moral factors. In addition, usage voluntariness is a crucial issue for validation of TRA.

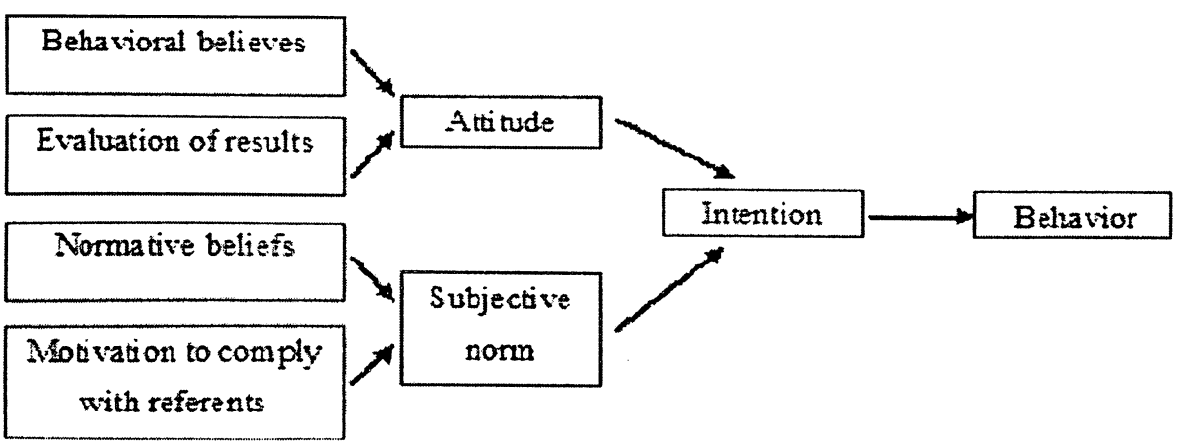


Fig 18:- Model of Theory of reasoned Action.
Source: - Fishbein & Ajzen, 1975

2.3.3 Theory of Interpersonal Behaviours (TIB)

This model is clarifying mainly the human's behaviour complexity which are effected by social and emotional factors. Therefore, this model not only contains all aspect of TRA and TPB but also, adding habits, facilitating conditions and affect in order to improve the prediction power. The concept of social factors which is similar to the subjective norms construct in TRA contain roles, norms and self-concept. In brief, in TIB, individual is neither fully deliberative nor fully automatic, further, neither fully autonomous nor entirely social.TRA differs from TIB, in the sense that TRA interests in accounting for the most variance with the fewest variables, whereas TIB interests in accounting for the most variance in total, because even a small amount of variance may be socially important, if the behaviour in question is critical. In this model, emotions, social factors (like subjective norms in TRA), and habits are identified as the main factors to form the intention. TIB has three levels to argue the behaviour. In the first level, personal beliefs, attitudes and social factors related to the behaviour is shaped by personal characteristics and previous experiences. The second level describes how affect, cognition and social determinants plus personal normative beliefs effect on intentions to a particular behaviour.In the third level, possibility of performing a specific behaviour is predicted by behaviour a intentions, situational conditions and past experience. The main disadvantage of TIB is complexity and lack of parsimony compared to TRA and TPB. Also, TIB isn't providing simple procedure for the operational definition of the variables among model.

2.3.4 Theory of Planned Behaviour (TPB)

In this model, perceived behavioural control (PBC) as a new variable is added to extend TRA model. Basically, PBC is determined by the availability of resources, opportunities and skills, as well as the perceived significance of those resources, opportunities and skills to achieve outcomes. Although both TPB and TRA assumed person's behavioural intention (BI) is affecting individual's behaviour, TPB is using the PBC for individual's actions which are not under volitional control. By adding PBC, not only realistic limitations are composed but also, a self-efficacy type factor is achieved.

Moreover, PBC has the direct influence on actual behaviours well as the indirect affect through the behavioural intentions. Therefore in TPB model, three main factors are affecting BI including perceived behavioural control, subjective norm, and behavioural attitude. However, there are two main problems with TPB model.

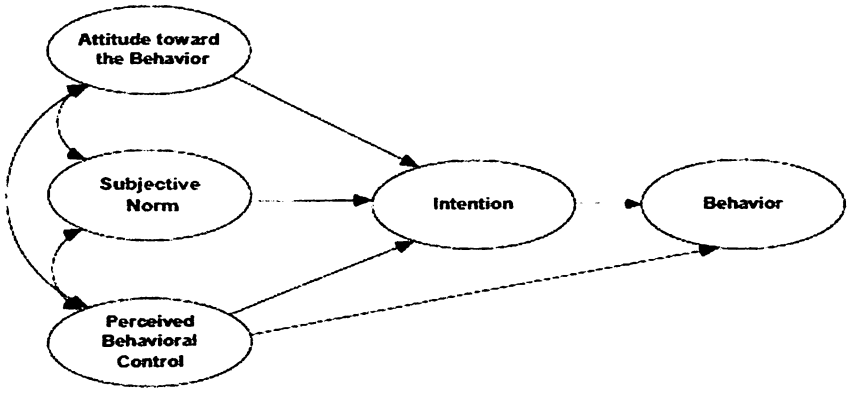


Fig 19:- Theory of Planned Behaviour (TPB)

First, the one's attitudes towards information technology will not be largely relevant if a computer system is not accessible. Second, the revised TPB may be viewed as the more suitable theoretical framework which is influenced the degree of individual's voluntariness that choose or not to choose the use of information technology in the workplace.

2.3.5 Technology Acceptance Model (TAM)

This model is derivate from TRA model. Due to uncertain theoretical and psychometric status in TRA model, TAM model is eliminated user's subject norms and interestingly. TAM explains the motivation of users by three factors; perceived usefulness, perceived ease of use, and attitude toward use. Therefore, not only BI would be contained in TAM but also, two chief beliefs like perceived usefulness and ease of use have considerable impact on attitude of the user.

These can be determined as an unfavourableness and favourableness toward the system. Sometimes, other factors known as external variables (user training, system characteristics, user participation in design and the implementation process nature) are considered in TAM model. TAM is probably one of the most widely cited models in the field of technology acceptance. During the past decades, it received substantial

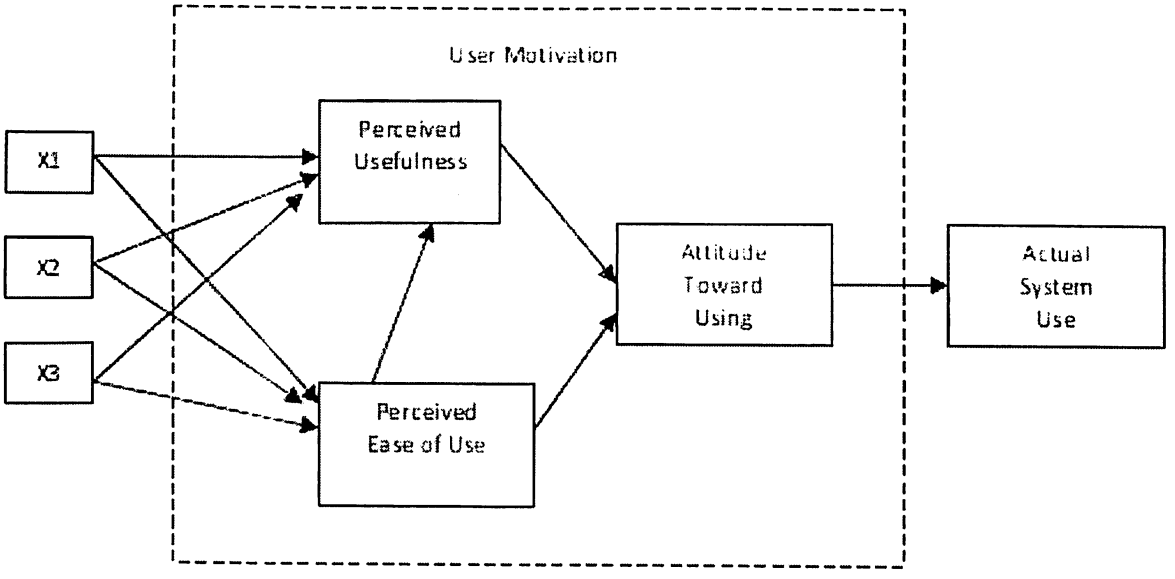


Fig 20:- Original Technology Acceptance Model (Davis, 1986)

2.3.6 Diffusion of Innovations Theory (DOI)

DOI model examines a diversity of innovations by introducing four factors (which are the time, channels' communication, innovation or social system) which influence the spread of a new idea. DOI not only has been used at both organizational and individual levels but also, offers a theoretical foundation to discuss adoption at a global level. DOI model integrates three major components: adopter characteristics, characteristics of an innovation, and innovation decision process. In innovation decision step, five steps namely confirmation, knowledge, implementation, decision, and persuasion have took place through a series of communication channels among the members of a similar social system over a period of time.

In characteristics of an innovation step, five main constructs; relative advantage, compatibility, complexity, trainability, and observability have been proposed as effective factors on any innovation acceptance. In adopter characteristics step, five categories; early adopters, innovators, laggards, late majority, and early majority are defined. In conclusion, DOI more focus on the system characteristics, organizational attributes and environmental aspects, it has less power in explanatory and less practical for prediction of outcomes compared to other adoption models.

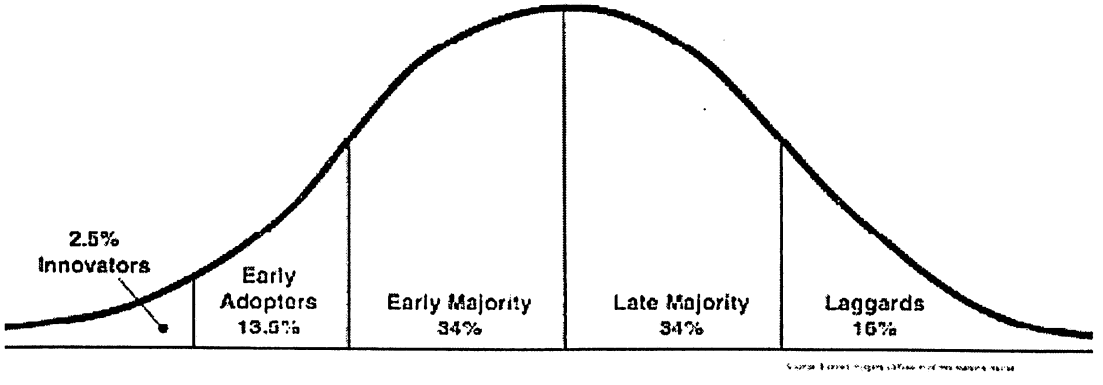


Fig 21:- Diffusion of Innovations Theory (DOI) (Rogers, 1995)

2.3.7 Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh, Morris compared the similarities and differences among the eight models which previously used in the context of information system, all of which had their origins in sociology, psychology and communications. These models are Technology Acceptance Model, Theory of Reasoned Action, combined TAM and TPB, Theory of Planned Behaviour, Model of PC Utilization, Diffusion of Innovation, Motivational Model and Social Cognitive Theory

UTAUT identified four antecedents of the acceptance of information systems. They were developed by tailoring the fourteen initial constructs from eight acceptance theories. The significant constructs are effort expectancy, performance expectancy, social influence and facilitating conditions. Furthermore, four significant moderating variables were identified; gender, experience, age and voluntariness of use.

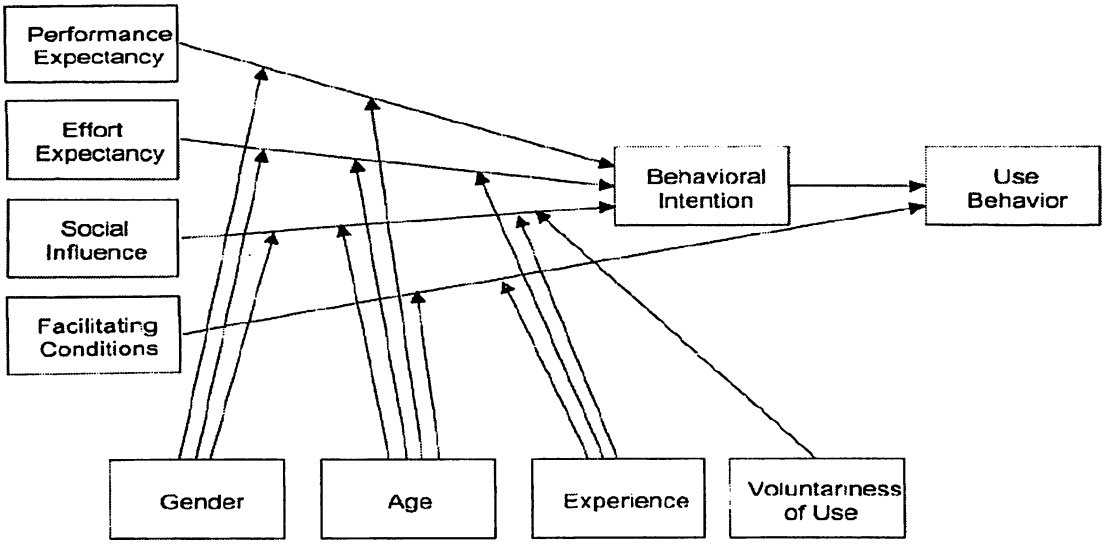


Fig 22:- Unified Theory of Acceptance and Use of Technology (UTAUT)- Venkatesh et al.

2.4 Research work on Technology Acceptance Model in different Sectors

Various researches have been carried out in India as well as abroad on Technology Acceptance Model (TAM) applied to various sectors like education space, agriculture etc. The thorough review of the research done earlier still find the gap of research to be carried out in India in power distribution sector.

There is lists of some of the research paper conducted on technology acceptance Model in various sectors.

Research Papers on Technology Acceptance Model in different Sectors

SL No	Literature Reviewed	Literature Type	Author	SCADAt & Essence	Research Gap	Year
1	Facilitators and inhibitors for the strategic use of information technology	Information & Management 27 (1994) 71-87	William R. King, Thompson S.H. Teo	The research made a comparison of companies which has used IT and which have no used IT for stratBGic purposes. Thus it reveals how technologies help companies in taking various strategic decisions.	Factors affecting acceptance of SCADA technology in the workforce in power distribution sector is a matter of research as not work has been carried out in this area. SCADA technology is still in nascent stage in India and benefits of technology stills needs to be understood by the Discom Staff.	1994
2	Factors affecting farmers' adoption of technologies in farming system: A case study in OMon District, Can Tho province, Mekong Delta.	Moonrise 10: 94-100 (2002)	Truong Thi Ngoc Chi1 and Ryuichi Yamada2	The study examines various factors which are responsible for the adoption of technologies for young farmers.	Factors affecting acceptance of SCADA technology in the workforce in power distribution sector is a matter of research as not work has been carried out in this area.	2002
3	Beyond Adoption: Development and Application of a Use-Diffusion Model	Journal of Marketing Vol. 68 (January 2004), 59–72	Chuan-Fong Shih &Alladi Venkatesh	The research reveals adoption do home technology use.	The concept note of the paper can be used in the research and be applied to adoption and application of technology in Discom	2004

4	A two Dimensional Framework for RFID Adoption and Diffusion: StratBGic Implications for Developing Countries	Journal of Technology Management & Innovation, Vol 6 Issue 2, 2011	Nyoman Adhiarna et al	The paper explains the study of RFID adoption and emphases on the phases of adoption, level of investigation and concerns of developing countries.	Application of Technology Acceptance Model and various cultural factors in various research but not in with reference to Indian Power Distribution Sector	2011
5	Customers' Adoption Factors and Willingness to Pay for Home Energy Information Management System in Taiwan	2012 International Conference on Smart Grid Systems (ICSGS 2012) IPCSIT vol.45 (2012) © (2012) IACSIT Press, Singapore	Jyh-Yih Hsu and Hai-Lun Yen +	The paper examines residential customer inclinations and readiness to pay.	Application of Technology Acceptance Model and various cultural factors in various research but not in with reference to Indian Power Distribution Sector. Also, need to develop a Technology Index which will set as a benchmark for measurement of implementation of Technology in Discom.	2012
6	Diffusion of innovation at the bottom of the_ pyramid: the impact of a payment system on_ the adoption of electricity in rural Uganda	Master of Science Thesis, KTH Industrial Engineering, and Management	Jonas Eder Christopher Mutsaerts	This thesis elaborates way by which a payment system has an impact on the diffusion of renewable electricity in rural Uganda.	Application of Technology Acceptance Model and various cultural factors in various research but not in with reference to Indian Power Distribution Sector	2013
7	Private Healthcare in Malaysia: Investigation on Technology Profiles and Technology Acceptance Factors	Information Systems International Conference (ISICO), 2 – 4 December 2013	Aliza Sarlan, Rohiza Ahmad, Wan Fatimah Wan Ahmad, P.D.D. Dominic	This study investigates IT profiles of Malaysian small, medium and enterprise (SME) private healthcare as well as personal perception towards Health Information System (HIS) usage in their organization.	Application of Technology Acceptance Model and various cultural factors in various research but not in with reference to Indian Power Distribution Sector.	2013
8	Diffusion and adoption of e-extension technology (computers and the internet) among extension agents in extension work in	African Journal of Agricultural Education Vol. 1 (5), pp. 094-099, November 2013.	Mansour Ahmed Mohamed Hefny	The study examines the impact of e-extension technology on business events and agriculture decision making.	Application of Technology Acceptance Model and various cultural factors in various research but not in with reference to Indian Power Distribution Sector.	2013

9	Geographic Information Systems (SCADA) And Instructional Technology Diffusion : K-12 Student & Educator Conceptualization S	North Carolina State University	Shannon Hill White	The paper evaluates Conceptualizations of SCADA and Instructional Technology (IT) in schools.	Diffusion of SCADA technology and to develop a model for research.	2005
10	Detailed Review of Rogers Innovations Theory & Educational Technology - Related Studies Based on Rogers Theory	The Turkish Online Journal of Educational Technology – TOJET April 2006 ISSN: 1303-6521 volume 5 Issue 2 Article 3	Ismail Sahin	The Paper discusses popular adoption models and its applications which have been found out in various disciplines like political science, public health, communications and education.	The process of research used in different can be useful in current areas of research,	2006
11	Effective Quality and Cognitive Absorption: Extending Technology Acceptance Research	Proceedings of the Hawaii International Conference on System Sciences, January 2006	Ping Zhang, Na Li, and Heshan Sun	The research paper tries to develop a model that exhibits the causal relationship among PAQ, cognitive beliefs, and IT use. The result indicate that PAQ has direct impacts on cognitive beliefs.	Application of Technology Models in Research on SCADA technology in Power Sector	2006

Table-05:-Lists of Research Papers on Technology Acceptance Model in different Sectors

2.5 Research work on Acceptance of SCADA technology in different Sector.

SCADA have been widely used these days in various sectors like power, environment, retail, mining etc. Implementation SCADA technologies by the user has also an area of research by the researchers since long. This section tries to find out the research which has been carrying out in Acceptance of SCADA technologies in various domains.

Research Work Related to SCADA Technology Implementation in Different Sector					
Sl No.	**Literature Reviewed**	**Literature Type**	**Author**	**Brief Summery**	**Published Date**
1	Security and Risk Assessment of SCADA	Pavan R. Gosavi,Prof.Mrs.R. S. Khule-International Research Journal of Engineering and Technology-2016	Pavan R. Gosavi,Prof. Mrs.R.S. Khule-	This paper discusses the cyber security risk analysis is to quantitatively determine the probability of an attack, the impact of the attack, and the reduction in risk associated with a particular countermeasure. Two recent methods, one based on compromise graphs and one on augmented vulnerability trees, have specifically targeted SCADA security.	2006
2	A Review on Industrial Energy Monitoring System Using PLC and SCADA	Gourav Kumar & naran Pindoriya 2016 International Conference on Smart Electric Grid (ISBG)	Gourav Kumar & naran Pindoriya	This papers discussed The ultimate aim is to reduce energy costs through improved energy efficiency and energy management control. Another benefits generally include increased resource efficiency, improved production budgeting and reduction in greenhouse gas (GHG) emissions	2016
3	Planning & Development of SCADA Based Power Distribution System	Govind Rai Goyal & Mohit Kr.Jain 2017, Journal on smart grid Technology	Govind Rai Goyal & Mohit Kr.Jain	This papers discussed about Smart grid Technology and how it beneficial for endorsementof power distribution sector along with SCADA implementation in power sector.	2017
4	A review on development of Smart Grid technology using SCADA in India and its future perspectives	Shiban Kanti Bala,Conference: Engineering and Systems (SCES), 2012	Shiban Kanti Bala	This paper presents various Smart grid initiatives and implications in the context of power market evolution in India. Various examples of existing structures of automation in India are employed to underscore some of the views presented in this paper.	2012

5	Implementation of SCADA in industries using wireless technologies	Shasank G.Hedge,Santosh R.Desai- 2015 International Conference on Industrial Instrumentation and Control (ICIC)	Shasank G.Hedge,Santosh R.Desai	This paper looks into a brief Large scale industries with better financial health can easily make use of SCADA (Supervisory Control and Data Acquisition) devices available in the market. SCADA helps to overlook the process from every angle.	2015
	Application of SCADA system in Steel Industries	Deepak Kumar Agrawal- International Journal of Scientific and Research Publications-2015	Deepak Kumar Agrawal	this paper highlightes The major application of SCADA system in steel plants is to supervision, online control of field instruments and equipments which are spread throughout the plant area and these instruments and equipments.	2015
6	Tailoring SCADA Systems for Standby Power Applications	Leslie David', Hlushko Andrew', Abughazaleh Samer. And Frank Garza (1994)-IEEE Computer Applications in Power	Leslie David', Hlushko Andrew', Abughazaleh Samer. And Frank Garza	This research paper disscussed about SCADA implementation in computer application in power	1994
7	Experimental study on the transmission of measurements by tolerance in SCADA systems	J.I. Escudero ; J. Luque ; A. Carrasco -IEEE transactions on power delivery	J.I. Escudero ; J. Luque ; A. Carrasco -	In this paper, it has been experimentally proved that send-by-tolerance method significantly reduces the transmission channel load.	2013
8	Batch Process Control System using SCADA	Ashish Tiwary, Shivani Narayan, Divya Mohana, Ranvijay kumar Singh- IEEE,Research Artical	Ashish Tiwary, Shivani Narayan, Divya Mohana, Ranvijay kumar Singh	this paper explain This paper presents automated solution called AOPS to synthesize master recipe and generate the corresponding control recipe. Master and control recipe are defined on the basis of recipe formal definition language (called RFDL),	2015

9	REAL-TIME MONITORING, CONTROL & PROTECTION OF TRANSFORMER USING PLC AND SCADA	Akansha Dubey,Dr. Jyoti ShrivastavaInternational Research Journal of Engineering and Technology-2017	Akansha Dubey,Dr. Jyoti ShrivastavaInter	In this paper presented a design of a system based on PLSCADA that is used to monitor and control the voltage, current and temperature of a distribution transformer in both sides.	2017
10	Design of Safety Instrumented System for Gas Turbine Power Plant using PLC and SCADA	S. Ahamed, K. Lokesh, B. Mohan, P. Swaminathan, V. Velmurugan Journal of Chemical and Pharmaceutical Sciences	S. Ahamed, K. Lokesh, B. Mohan, P. Swaminathan, V. Velmurugan	This paper has focused on gas turbine power plant consists of a various safety instruments in the system. To avoid accidents in gas turbine	2017

Table 06:- Research Work Related to SCADA Technology Implementation in Different Sector

The table shows the research papers as well doctoral and Master thesis research done on acceptance of SCADA Technologies worldwide. In India, the user acceptance of SCADA technologies has been a matter of great concern, especially in power sector. There is few factors which is described in below Figure which are involved in power distribution technology Implementation.

2.6 Division wise Power System Technology implementation :

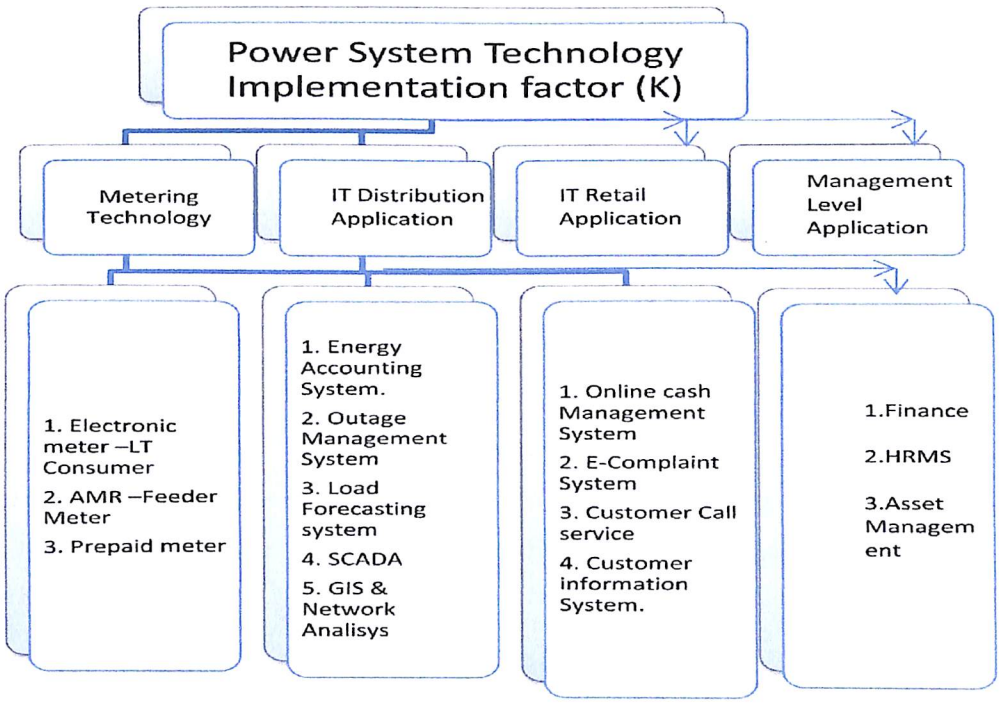


Figure 23 Factors Involvement for Power Distribution Technology.

These four factor of the of Power Distribution Technology which are being implemented to achieving automation and Kharagpur division easing efficiency for better customer satisfaction. The first Factor captures the degree to the level of implementation of different types of metering technologies which are an essential part of any Power distribution company. The current scenario is the major changes in transformation metering from mechanical meters to current prepaid. The Metering technologies discussed in the research are divided into four components:

- Installation of Electronic Meters -LT Consumers.
- AMR for HT Consumers.
- AMR for Feeder Meters
- CMRI Metering reading for HT/LT Consumers.
- Prepaid Metering

The second Factor of Power Distribution Technology degree to which a power utility has implemented IT (Information Technology) to address its various needs and developing Power Distribution applications. IT Distribution Apps are divided into following major components:

- Energy Accounting System.
- SCADA
- Load Forecasting Applications.
- Outage Management System.
- Meter Data Management System.
- SCADA & Network Analysis.
- Smart Grid Pilot Project

The third Factor of IT Retail Application captures the level, customers are able to get in touch with power Distribution Company for their various issues.and ways developed by power utility to reach its consumers and how IT applications can help in solving its various issues.

The IT Retail Applications factor is divided into the following components:

- Customer Information System.
- Centralized Call Center.
- Online Web-based Grievance redressal system.
- Online Bill Payment.
- Prepaid Metering.
- E- Complaint.
- Online Cash Collection.
- Spot Billing.

The Management Level Applications factor divided into the following components:

- Assets Management
- Finance
- Human Resource Development Dept.
- Performance Management System

2.7 Summary

The chapter then focuses on research work is done, so far, in areas of technology management in power distribution sector in India. Website assessment of power distribution companies which has been taken for research, the researcher tries to find out different kinds of research done in this areas not only in power sector but in general. Research work was done earlier and literature review related to technology acceptance model and Acceptance of technology is also summarized in detail. Research work done on acceptance of SCADA is discussed in detail. The chapter concludes with the strength of the research. The next chapters elaborate research methodology and techniques taken for research.

Chapter 3

Research Methodology

Chapter 3: Research Methodology

3.1 Introduction

Research problems can be solved by using Conceptual Framework and in a systematic way is actually the meaning of Research Methodology. In this research, the major concepts are research variables or the factor which used to define the technology factor and which affects the acceptance of SCADA in Power sector.

To solve a research problem or developing some new factor or benchmarks for comparison is challenging task. This task was systematically approached by identification of new research variables, develop the model which actually suited this research, formulation of research hypothesis and designing of the research methodology to meet the objective.

3.2 Sampling and Data Collection

A non-probabilistic method of sampling was followed in this work. In the survey, every item has an equal chance of getting selected, and however, in non-probabilistic sampling, it is assumed that sample within the population has even characteristics. Therefore we can believe that sample is representative of the population such that the results will be accurate. The current method is combination of judgment and conventional sampling (Zikmund 2012)

Out of approx. 53 power distribution companies in India, One power distribution companies in West Bengal was selected for the research.

For technology implementation and acceptance in power Discoms research hypotheses and objectives, It was primarily due to their busy schedule and also due to the hesitation of the employees to respond on such topic. So, it was supplemented with qualitative analysis By personal interviews with Discoms staff at conference, also face to face meeting also at their offices.

The researcher also made use of other source like historical documents, observations report, presentation report, annual survey report, customer satisfaction report, annual power journal to get the insights of the level of technology implementation in power distribution companies in West Bengal.

Summary of primary and secondary data Collected as follows:

Sl No	Item Considered for Acceptance of new technology Factor	Details	Nos
1	Discoms Reports Shared with Power Regulator	No. of Discoms Report	12
3	MOP Reports	No. of Ministry of Power Reports Referred	09
4	Utility Website	Web sites of Power Distribution Companies	3
5	Press Release & Power Market News	No. of Press Released referred	15

Table 07 Summary of sources of data collection

The total population size here refers to some of the key officials of the Discoms who had complete knowledge of different technology implementation.

Interview with Power Utility Officials .

Sl No	Power Distribution Company	Total Population
1	West Bengal-Kharagpur division	10

Table 08- Summary of sources of contacts with Utility Officials

3.2.1 SCADA Technology Acceptance

It was a bit challenging that to collect data from Power Discom staff and officials as they are busy with a tight schedule of resolving of power supply, information gathering from power Discom companies has indeed been a difficult exercise. Around questionnaire were circulated to 50+ people specifically in the Kharagpur division were approached.

Few important executives were identified who would give the right information about the in-depth Acceptance of technology in power Discom So even the size of the Sample size might be less but due to the people with key information it may be considered that informed which has been gathered for the research would provide the best insights for the research.

Power Distribution Company	Total Employees(Approx.)	Sample Size
West Bengal Discoms-Kharagpur division	200	80

Table 09: Summary of Power Utilities Staff Sample Size

3.3 Research Design

Process ahead from research questions to conclusion is termed as Research Design

3.3.1 Classification of research design

Research Design may be generally classified as:

1. Exploratory Research Design
2. Descriptive and Diagnostic Research Design
3. Hypothesis-Testing Research Design.

1. Exploratory Research Design:

This type of research design is used is to frame a research problem for the development of a hypothesis. The aim of studies is the finding of ideas and comprehensions. It aims merely to discover the research questions and does not intend to offer ultimate and conclusive answers to prevailing problems. Typically, the following three approaches are considered in the perspective of a research design for such studies. They are

- A survey of the related literature.
- Experience survey.

2. Descriptive Research Design:

It is a study designed to depict the participants in a precise way. It can also be referred as about research describing people who take part in research.

There three ways in which descriptive research project can be done:

- Observational also referred as a way of observing and recording the participants.
- Case study: It can be referred as in-depth study of individuals or group of individuals
- Survey: It is defined as brief interview or discussions with an individual with Reference to the specific topic.

3. Hypothesis-Testing Research Design:

In this type of research design researcher test hypothesis between two or more variables. In this research study of the identified research variables requires the use of quantitative as well as qualitative methods. Thus Data were collected using a questionnaire based. The data collected were then used for further analysis.

3.3.2 Factor Affecting Research Design:

Factors affecting the assessment of Technology of SCADA for power distribution sector are the research constructs that are required to be studied. These constructs namely Perceived Ease of Use, Attitude, Efficiency gain, Perceived Usefulness, Discom Organization Culture and Intention all were selected on the basis of literature review done earlier. All the variables are studied extensively because these would be factors determining the Acceptance of SCADA technologies.

Literature review and understanding of the power distribution sector has helped in identification of the Main factor and there is Sub-factor against each identified factors which would be further divided into the measurable dimensions. Factor for which dimensions are identified and can be measured quantitatively are measured and analyzed through the quantitative assessment approach. For other, dimensions are identified, measured and analyzed through further analysis utilizing qualitative analysis approach.

MacroFactor and its related Micro Factor identified and Study Required for Each

Technology Implementation factor

1. **Main Factor**:- Metering

   Sub-Factor

   a. Installation of Electronic meter-LT customer
   b. Installation of AMR- HT customer
   c. Installation of AMR- Main Feeder
   d. Installation of AMR-DT's Feeder
   e. Installation of Prepaid meter.

2. **Main Factor**:- IT Distribution Apps

   Sub-Factor

   f. Energy accounting system
   g. SCADA
   h. Load forecasting application
   i. SCADA application
   j. Smart grid technology

3. **Main Factor**:- IT Retail Service

   Sub-Factor

   k. Customer Information System
   l. Online Bill Payment
   m. Mobile Wallet
   n. Counter Spot Billing
   o. E-Complaint

4. **Main Factor**:- Management level Support

   Sub-Factor

   p. SAP Module for HR & Finance

Technology Acceptance Factor

1. **Main Factor**:- Perceived Ease of use (Adopted from Davis-1989 & Moore and Benbasat-1991)

   Sub-Factor

   a. Using of SCADA is not require to be an Intellectual.
   b. Basic working principal is easy to understand.
   c. System is flexible to work with.
   d. Understanding the system logic is not a tough challenge.

2. **Main Factor**:- Perceived usefulness (Adopted from Davis-1989 & Moore and Benbasat-1991)

   Sub-Factor

   e. It's a very useful tool to control.
   f. Decision making more easier in this system
   g. Good Response time for the work
   h. Understanding the system problem and action taken against it more effective.

3. **Main Factor**:- Attitude (Adopted from Taylor&Todd-1995)

   Sub-Factor

   i. It's a very User-Friendly System.
   j. Working with this is enjoyable.
   k. Reduce response time without visiting field.
   l. Working with SCADA is energetic and full of exitement.

4. **Main Factor**:- Benefit Gain

   Sub-Factor

   m. It's a very useful to customer service.
   n. SCADA is a Single View Application for field employees to solve Problem.
   o. Reduce response time without visiting field; it's a time saving tool.
   p. Working with SCADA easy to understand the whole system process and effective to decision making..

5. **Main Factor**:- Intention(Adopted from Venkatesh & Davis-1996)
   Sub-Factor
   q. Often get try to do new idea implementation using SCADA.
   r. Technical support required often to use this SCADA.

Perceived Ease of Use:

It discusses to use of technology in which user find how easy is the system to use without requiring much of effort. The technology discussed here with referred as SCADA technology should be easy to use and should be easy to accept. The interface of the SCADA system should be Flexible to work upon and a person can start using these technologies after basic training.

Attitude

Attitude toward use is defined as "an individual's overall affective reaction to using system" (Venkatesh, et al., 2003, p. 455). Melone (1990) also defines user attitude in "a predisposition to respond favorably or unfavorably to a computer system, application, system staff member, or a process related to the use of that system of Application".

Benefits Gain

Benefits gain refers to how the SCADA technology has helped them in their current daily work. Also how the SCADA technologies have reduced their efforts while giving the same output and reduced field efforts. Since SCADA display the condition of field process to the field engineers while sitting on their PC in the office, it used to measure how this technology has helped them in their work.

Perceived Usefulness

This was defined by Fred Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance".

Discom Organization Culture

It refers to individual belief and reaction created by seeing their supervisors, and others around support or discourage the use of technology in the organization. The user's gender, age, and experience also have an important impact on the Discom Organization Culture.

Intention

The intention in this research study has been used as an independent variable and used to study the impacts of the endogenous variables used in the research.

Engineering Support & Govt Initiatives

It refers to various initiatives from engineering division where SCADA has been linked with the various operational process as well as the business process.
And also various Govt initiatives where SCADA has been implemented

3.4 Research Methods

Different research methods which have been used in this study are as follows:

3.4.1 Questionnaire Survey

Questionnaire Design

A questionnaire refers to Group of questions that are suitable for the research topic and its objectives and the responses to which will provide necessary data to test research hypothesis.

Part 1) uses a tool for addressing technology which is being used in different power distribution companies. The different technologies are classified into different categories and each category is then further sub-classified and Markers added to each main factor to measure the research content and answer the research questions.

Part-2) contains questions which are used to study and investigate the various factors responsible for acceptance of technology in government power distribution companies in West Bengal-Kharagpur division

3.4.2 Survey

The survey for the research comprises of a different section of people based on the hypothesis chosen to answer research questions. Broadly there are two different sections of people were identified for the research.

The first survey technology assessment and adoption in power distribution companies comprises of Discoms own staff, consultant and also staff working in Discoms in third party payroll at a different level in the Discoms.

The second survey for since the research was to focus on technology implementation within the organization, in order to get in-depth idea and insight staff was interviewed as well surveyed.

3.4.3 Pilot Survey

After data collection complete through questionnaire is available and tested through a pilot survey.. A pilot survey was undertaken to test the potential, suitability, and clarity of the questionnaire so that it can finalize the questions and go for further research.

The response rate was about 60-70 % but since the questions were related to power Discoms at many places. Then it decided to referred qualitative method of research i.e. Grounded Theory which was more of survey based on questionnaire to collect data from the power Discoms staff, for this several methods were used to meeting Discoms staff at their offices and made use of different methods of grounded theory like historical documents, observations reports to get the insights of the level of technology implementation in power distribution company in kharagpur division(West Bengal).

This method actually effectively works in the research process and was successful in the data collection. The feedback and pilot give the researcher an indication of whether the interview is measuring the right concept being measured and hence its validity and reliability. Thus few interview questions, as well as questionnaire, were improved.

3.5 Interviews

The different types of interview format are as follows:

- Structured interviews: It refers to a type of interview done in which types and number of questions is fixed.
- Unstructured interviews refer to the types of interviews which are shapeless and questions are not prepared beforehand and the interview goes on in an informal manner.

  Interview has a list of questions beforehand but can go beyond that also and ask additional questions.

3.6 Data Analysis

The Hypothesis for find out the level on technology implementation were tested through Parametric and Non-parametric statistical analysis. Hypothesis covering dimensions of a factor which affects acceptance of SCADA technology were tested partially through the Parametric and Non-parametric test but for this hypothesis determination 'Structural Equation Modelling (SEM) ' was used.

3.6.1 Parametric and Non-Parametric Statistical Analysis

The data analysis included testing the hypotheses and defining the technical assessment and adoption in power distribution companies. This is one of the significant components of data analysis and which lays the foundation for the formulation of the results of various hypotheses assumed. The analysis was conducted through the statistical analysis software i.e. Statistical Analysis in (SPSS), version 25.

3.6.2 Structural Equation Modelling (SEM) Analysis

SEM has widely used research tool test hypothesis about connections between observed and latent variables. In other words, we can say it is used to test directional and non-directional relationship among observed and latent variables.

The basic approach to performing a SEM analysis is as follows:

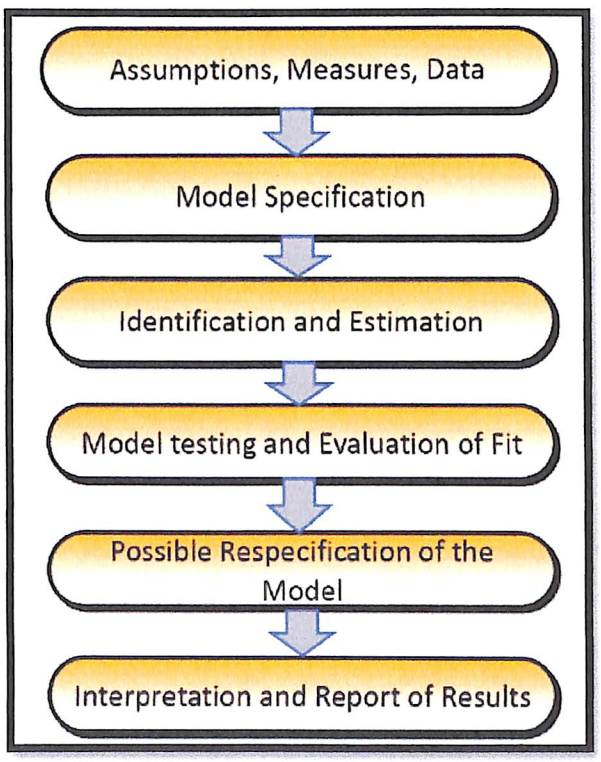


Figure 24 Process Flow of SEM Analysis

The research design framed from literature for technology acceptance in power distribution companies helped in identifying factors that delayed the SCADA current technology Implementation .The variables ie; exogenous and endogenous defined in the construct for the application of technology through SEM Mode

3.6.3 Data Analysis Methodology

Technology Implementation depend on different criteria.

Diffusion of Innovation (DOI) Theory by E.M. Rogers in 1962, is one of most acceptable social science concepts on technology management and hereby using SEM technique as There is high multi-co linearity among the variables i.e.; independent variables overlap and using regression we cannot differentiate the complete impact of one variable from another.So,its the best method to analyse the data.

The different set of adopters and their characteristics are as follows:

1. Innovators – These are the type of people who take lead in trying innovation, interested in new ideas and willing to take risks.
2. Early Adopters – These are types of people who are at leadership roles and always welcome accepting new ideas. There is no need to convince as they are aware of the future changes.
3. Early Majority – They are not a leader but adopt the changes and innovation.
4. Late Majority – They are not convinced of the change and adoption takes place only after a majority of the people have tried and adopted.
5. Laggards – They are conservative and traditional and not accept the changes.

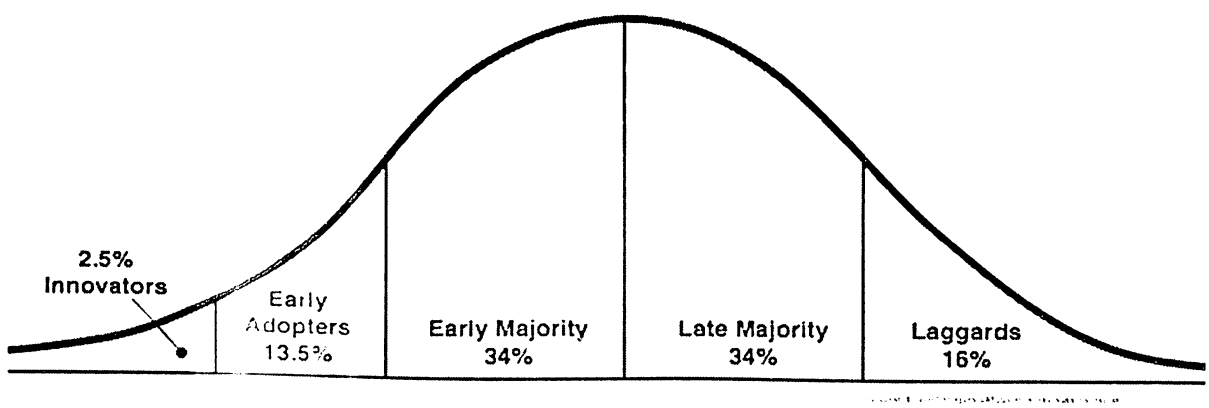


Figure 25 Rogers Diffusion Theory

Research Analysis has to develop an organizational level framework for Kharagpur division for effective acceptance of technology by:

- Classification Discoms staff according to diffusion theory.
- Understanding their specific requirement.

As per Rogers's diffusion theory, the promptness of technology adoption is evaluated by two features:

p= adoption speed

q=later growth speed.

A good ICT at first step have lesser p-value but once a optimum level of organization adopts it, the q value would be more since this technology has network effect

3.7 Summary

This part of research contain of the detailed description of the methodology for a research study. The research methods involved in the study like questionnaire survey, interviews and survey population is talking about. Once data collection process is completed, various parametric and non-parametric tests and. Validation of Software techniques used in the research is elaborated.

Chapter 4

Study of Acceptance of SAS Technology through SCADA among State Owned Power Companies in KHARAGPUR DIVISION

Chapter 4: Study of Acceptance of SAS among State Owned Power Companies in KHARAGPUR DIVISION under Midnapore Zone (West Bengal)

4.1 Introduction

In recent times, SAS is becoming a popular technology which is a part of SCADA Technology for power distribution companies. Government have given importance to Sub-station Automation System in power segment, there is need to investigate the effective utilization and behaviours of user acceptance of SAS technology by State-owned Government Power distribution companies.

With the development of technology, *a* number studies have been carried out for acceptance of Information Technology (IT) system in the organization, still, there is a need for study of acceptance of SAS in Indian Power sector.SAS technologies are still in narrow stage in terms of technology acceptance in the power companies. The research is an attempt to explore and evaluate the elements the use of SAS technologies among state-owned companies in Kharagpur Division under Midnapore Zone, West Bengal.

4.2 Methodology

The study was to determine the how employees of government power distribution companies were utilizing technologies in their organization and various factors that were related to the level of application.

- Determine level of accessibility to SAS technologies
- Determine current application and use of SAS technology by staff in the organization.

On account of Research Acceptance of Technology government owned Discom of Kharagpur Division under Midnapore Zone was selected.

Figure 26: Area showing Study area in Kharagpur Div.(Midnapore Zone)

4.3 Variables

4.3.1 Dependent Variables

Dependent Variable: Intention to Use & Attitude

In this research, the dependent variable is an intention to use the SAS technologies in Power distribution companies.

4.3.2 Independent Variable

Ease of Use

It refers to a level where modernization can be easily understood and operated. Further, also user discovers it better than existing substitutes. "Perceived ease of use" only of the user can handle and use it easily.

Perceived Usefulness

According to Davis (1989), perceived usefulness (PU) is effective if it aids the user in job performance and Kharagpur division eases its productivity.

Benefit Gain

Benefit Gain refers to point at from where user think his efficiency to perform has Kharagpur division eased due to use SAS technology, for power utility staff who is in the field.

4.4 Proposed Research Model for Acceptance of Technology:

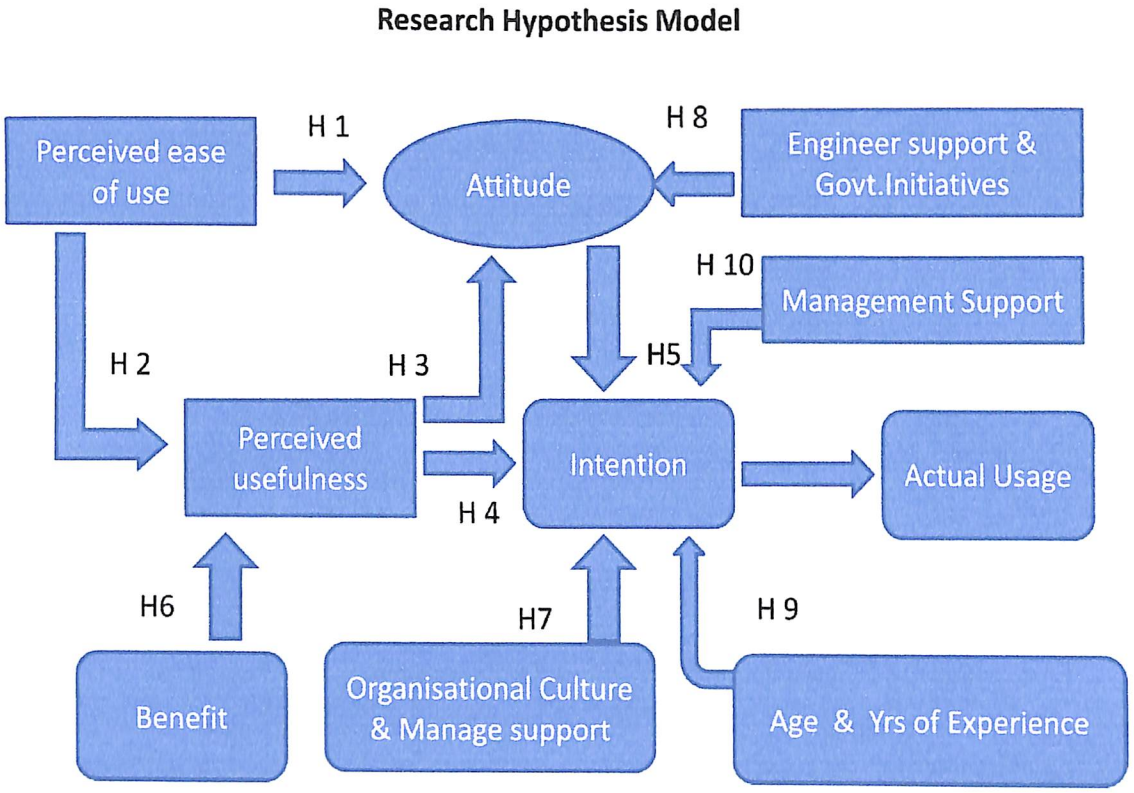


Figure 27 Research Framework developed by the Research Scholar

H1: Perceived Ease of Use (EU) has an encouraging impact on attitude (AT) of Discoms Staff.

H2: Perceived Ease of Use (EU) has an encouraging impact on Perceived Usefulness (PU) of Discoms workforce

H3: Perceived Usefulness (PU) has an encouraging impact towards Intention (INT) of Discoms workforce.

H4: Perceived Usefulness (PU) has a promising stimulus on Attitude (AT) of Discoms Staff.

H5: Discoms Staff attitude (AT) for SCADA has a favourable impact on intention (INT) to practice the system.

H6: Benefit (B) has an encouraging impact on the Perceived Usefulness (PU) of Discoms Staff.

H7: Organization Culture (OC) has a favourable influence on Intention (INT) of Discom staff.

H8: Discom engineering support & Govt Initiatives (ES) has an encouraging impact on Intention (AT) of Discom staff.

H9: Employees Age & Years of Experience (AE) has an encouraging effect on Intention (INT).

H10: Management encouragement (ME)) has a favourable influence on Intention (INT)

4.5 Survey & Data Collection

In this Study survey as well interview method was used to collect information mainly keeping in view key indicators mentioned. The survey through hard copy printout was used to collect information from the power Discoms. It was supplemented with interviews. The research variables like perceived usefulness and perceived ease of use were measured by survey method in 5-point Likert scaling design (0 = totally deny, 1 = deny, 2 = Neutral, 3 = acceptable, 5 = totally Acceptable).

Constructs: Perceived Usefulness: Variables to measure usefulness of SAS (PU)

Application: SAS provides better picture of Field requirement (PU1)

SAS Kharagpur division ease visualization of and extent of the Problem (PU2)

SAS is good feedback system to confirm reports (PU3)

SAS improves in decision making of staff (PU4)

SAS is Flexible in day to day work (PU5)

Constructs: Perceived Ease of Use

Application: Interaction with the SAS technologies is clear and understandable-(EU1)

Lot of Technical ability is not required for using SAS (EU2)

Intellectual Efforts are not required for utilization of SAS in work (EU3)

It is simple and easy to operate (EU4)

Constructs: Organization Culture (OC)

Application:

Other Depts. personnel and top management often asks for SAS-based reports (OC1)

Intellectual Efforts are not required for utilization of SAS in work (OC2)

Workforce think SAS as reliable decision support system (OC3)

Mid-level Managers Support the SAS initiatives to the system(OC4)

Constructs: Benefit gain

Application:

Using SAS has reduced field visit to large extent(BG1)

Using SAS system has saved time to a great extent(BG2)

SAS has provided a single platform for field staff & supervisors to Understand the problem (BG3)

SAS has helped in providing better services to customers(BG4)

SAS has reduced fault time and helped in faster fault restoration(BG5)

Constructs: Attitude -AT

Application:

like to working with such flexible system like SAS(AT1)

Using SAS system is exciting(AT2)

SAS system makes work more user-friendly than the others(AT3)

Working with the SAS system is enjoyable. (AT4)

SAS system can be used in decisions making(AT5)

Constructs: Intention -INT

Application:

Given that access to the SAS, intend to use it in my job(INT1)

Often try to explore different Idea using SAS & technical skills(INT3)

I often contact SAS staff for technical support(INT4)

In my spare time, I try doing new things using SAS (INT5)

Constructs: Engineering support & Govt. Initiatives-ES

Application:

SAS Based drawings proposal submission and Approval done in Discom(ES1)

Govt schemes and initiatives to encourage SAS technologies(ES2)

SAS as a part of Government Regulator Audits(ES3)

SAS Communication system has in-house design at discom. (ES4)

Constructs: Management Encouragement-ME

Application:

Top-level Managers percolates down the SAS initiatives to the system.(ME1)

Senior manager of department encourages bottom staff in using SAS. .(ME2)

Regular training to Depts. Bottom Line Users.(ME3)

Top management always encourage to work with SAS. .(ME4)

Management Often ask report Verification of SAS. .(ME5)

The data was collected through survey and interview method. The data collected from the survey, structural equation modelling (SEM) analysis was performed with help of SPSS software Version 25.0.

Confirmatory Factor Analysis (CFA) is a measurement model which provides validity test for constructs. A construct is an unobserved latent factor whose usefulness has been empirically supported by IBM SPSS AMOS

4.6 Studies on Real Time SAS Implementation on 132/33kV Power Sub-station at Kharagpur Division, West Bengal.

4.6.1 Introduction

In the previous chapter discuss about all innovative and useful technologies which are presently uses in the power distribution sector and also come to know Automation of power distribution system has increasingly been adopted by power utilities worldwide in recent years. As part of its efforts to provide a more reliable supply to the customer and to enhance operational efficiency, the automation of the power system can be achieved by SAS (Sub-station Automation system). It is a boon to the automation concept of dynamic technology. West Bengal State Electricity Transmission Corporation Limited has undertaken steps to automate existing substation and new substation by use of most advanced controlling and monitoring technology SAS which is one of the part of SCADA System , presently with the help of SCADA covers major generating stations and Independent Power Producers (IPP), receiving Sub- stations ranging from 33kV to 400kV, collects data from all feeders from 11 KV to 400 KV, upgrades information to Load Despatch Centre (LDC). Real time data acquisition from all interface points by SCADA, helps to perform energy billing, energy audit and Availability Based Tariff (ABT) functions, and Sub-system to perform Open Access operations. In this chapter try to understand how this SCADA is beneficial to actual field application and its statistics to work on power Distribution sector.

4.6.2 What Is SCADA and SAS?

SCADA is a collection of equipment that will provide an operator at a remote location with sufficient information to determine the status of particular equipment or a process and cause actions to take place regarding that equipment or process without being physically present. SCADA provides open architecture rather than a vendor controlled proprietary environment. It interfaces hardware and software, and it includes functionality such as trending, alarm handling, logging archiving, report generation, and facilitation of automation. Thus SCADA has been used has powerful tool for power system automation, that refers to automatic switching, regulating, controlling, logging, protection etc. of electric power flow without human intervention.

SAS or Substation Automation System is a system to enable an electrical utility to remotely monitor, control and co-ordinate the distribution components which are basically installed in the substation. So, SCADA one of the important parts of SCADA and mostly used in Automated or Unmanned substation which can remotely controlled.

4.6.3 SAS System Architecture of 132/33kv Power Substation

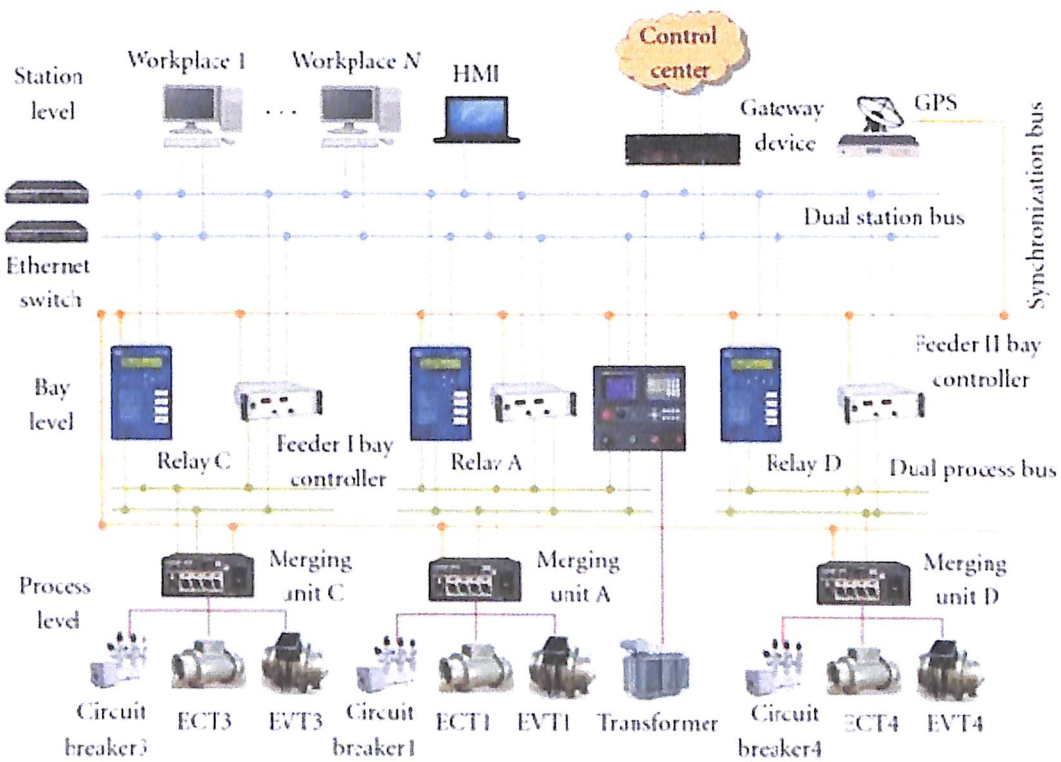


Fig 28: Basic System Components of Sub-station Automation System.

According to the figure 27 this automation technology provide three different level of control and remote operation are being followed-

1. Station Level
2. Bay Level
3. Process Level

a. **Station Level**

A redundant PC based HMI enables local station control through the software package Micro SCADA Pro, which contains an extensive range of SCADA functions. The station level contains the station-oriented functions, which cannot be realized at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centers. A dedicated master clock for the synchronization of the entire system shall be provided.

a. Bay Level

A bay comprises of circuit breaker and associated isolators, earth switches and instrument transformers. At bay level, the IEDs provide all bay level functions such as control (command outputs), monitoring (status indications, measured values) and protection. The IEDs are directly connected to the switchgear without any need for additional interposing or transducers. Each bay control IED is independent of the others and its functioning is not affected by any fault occurring in any of the other bay control units of the station.

b. Process Level

It consists of all the switchyard devices which are hardwired using copper cables and use fiber optic cables to connect the bay level IED's used for control and protection.

4.6.4 Implementation of Sub-station automation (SAS) system through SCADA:

According to features of ULDC Expansion project, WBSETCL covers all receiving substation ranging from 33 kV to 400 kV. 132/33kV GIS Substation at City was one of station to acquire data, monitor and to control remotely SCADA was implemented through GE Make SAS Technology at this station. This section briefly describes about SAS System, implementation, SAS equipment, connection, and operation at 132/33kV GIS substation.

According to abbreviation of SAS , Substation Automation System which is a part of SCADA function by this technology we can easily monitoring ,control And gather Data and perform all

these task can be done from remote position and when needed send those data to master station for decision making purpose. SAS perform main tasks at substation. Through Supervision - of the incoming line, Control and Relay Panels (C&R panel), Control - Switch gear and data acquisition - such as Voltage (phase), current (phase), active and reactive power, frequency etc.

4.6.5 Common System Components of SCADA & SAS

A **SCADA** system usually consists of the following subsystems:

- Remote Terminal Unit (RTU)
- Telemetry system
- Data Acquisition Server
- Human Machine Interface
- A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the SCADA system.
- Communication infrastructure connecting the supervisory system to the remote terminal units. Various processes and analytical instrumentation.

The **SAS** shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IED s) for control and monitoring.
- Station Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware from local control centre through IEC60870-5-101/104 protocol.

- Gateway for remote supervisory control from SLDC, the gateway should be able to communicate with SLDC on IEC 60870-5-101/104 protocol.

- Remote HMI.
- Peripheral equipment like printers, display units, key boards, Mouse etc.
- Control & monitoring of Sub-station ACDB/DCDB, Battery chargers system, Fire-fighting system, surveillance system, Standby Aux. Power supply (DG) system etc.

A. IED (Intelligent Electronics devices)

An Intelligent Electronic Device (IED) is a term used in the electric power industry to describe microprocessor-based controllers of power system equipment, such as circuit breakers, transformers and capacitor banks. IEDs receive data from sensors and power equipment, and can issue control commands, such as tripping circuit breakers if they sense voltage, current, or frequency anomalies, or raise/lower voltage levels in order to maintain the desired level. Common types of IEDs include protective relaying devices, On Load Tap Changer controllers, circuit breaker controllers, capacitor bank switches, recloser controllers, voltage regulators etc.

B. Substation HMI Operation

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object. Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

C. Ethernet network topology

SAS shall comply with IEC62439-3 clause 4 PRP (Parallel Redundant Protocol) principle, based on the duplication of the Ethernet network infrastructure. Preferably, main system component (bay controllers, protection devices, HMI and gateway PC's) shall embed redundant interface to be doubly attached on a PRP network.

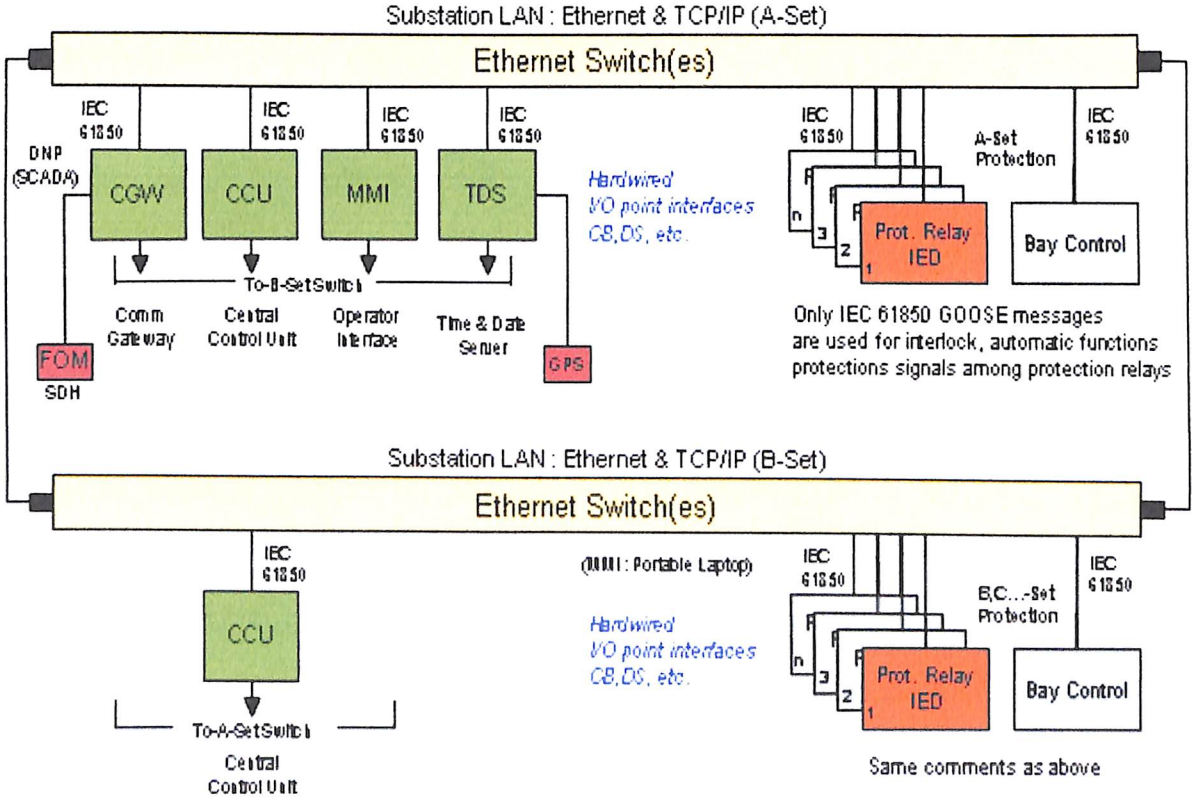


Fig-29 Ethernet Based Communication in SCADA

D. Gateway Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have four ports for Remote Control Centres.The communication interface to the SCADA shall allow scanning and control of defined points within the substation automation system independently for each control centre.

The substation automation system shall simultaneously respond to independent scans and commands from employer's control centers (RCC).

The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centers. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

E. Remote Control Centre Communication Interface

The communication channels between the Substation Automation System and the remote control centre consist, optical fiber, and GPS System as shown in figure-31

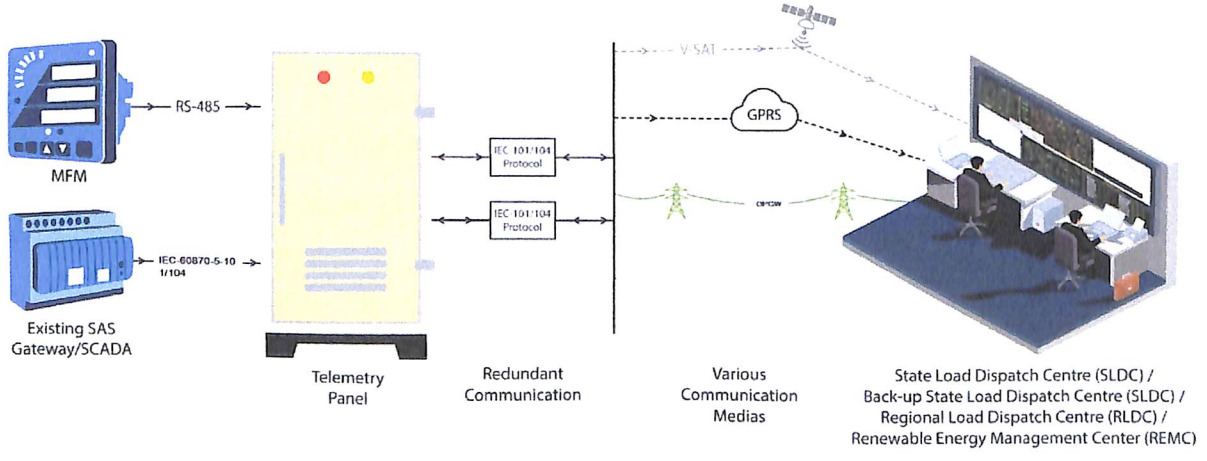


Fig-30 Communication Interface between Sub-Station & SLDC

F. Bay Control Unit(BCU)

The bay control unit to be provided for the bays preferably installed in the CB relay panel/feeder protection panel for respective 132 and 33 kv bays. The Control & relay panel also house the Ethernet switch (es) to be provided. The bay control unit for future bay (if required as per section project) installed.

The Bay level unit meets the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. One no. Bay level unit shall be provided for supervision and control of each 132KV and 33 kV bay of thee sub-station (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

G. I/P & O/P Modules

The I/O modules form a part of the bay level unit and provide coupling to the substation equipment. The I/O modules acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current from the secondary of instrument transformers. The digital inputs are acquired by exception with 1ms resolution. Contact bouncing in digital inputs is not being assumed as change of state.

Table 10 gives information about parameters, input and output, relation of these with SCADA at 132/33 kV substations

SAS	Supervision	Control	Data Acquisition
Input/ Output	Digital input	Digital output	Analog input
Observation	Status indication Control & relay panel	Switch Gears CT&PT	Measured value such as voltage current etc.

H. Auxiliary Power Supply

Power for the substation automation system derived from substation 220V DC system. There is an arrangement of 2 Nos. 5 KVA UPS system which are running in parallel mode and it consists of individual Battery Bank shall be provided for station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. For Gateway 220v DC Power supply with +ve Earth may be used if found necessary for the system power.

4.6.6 Basic System Operation

Real time data acquisition from BCU which are dedicated for each and every bays of 132 & 33KV .after collection of data it can be used for monitoring and controlling & decision making process and also send it to State Load Despatch Centre (SLDC) requires data with respect to available load to be attended. As such real time data is required from receiving stations and Interface points from where power is delivered to Distribution companies or Consumers. Real time data such as Feeder ON OFF indication, Circuit Breaker status, tap change of transformer, etc. to SLD. Operator at SLD can observe single line diagram of substation shown in figure .

Status monitoring and alarming: If operator at LDC operates any of circuit breaker remotely, to indicate this information for local operator at substation SAS Control Annunciation is provided,which alarms operator. At present only few substation at West Bengal is operated remotely.

Sequence of event recording also provides facility of recording events about fault occurred at substation. Information storage & Data retrieval for ABT functions: SAS collects analog data like MW, MVAr, kWh import/export, frequency, voltage from metering core of CT, PT through MFTs and digital indications like CB open, close, auto trip, Isolator open.

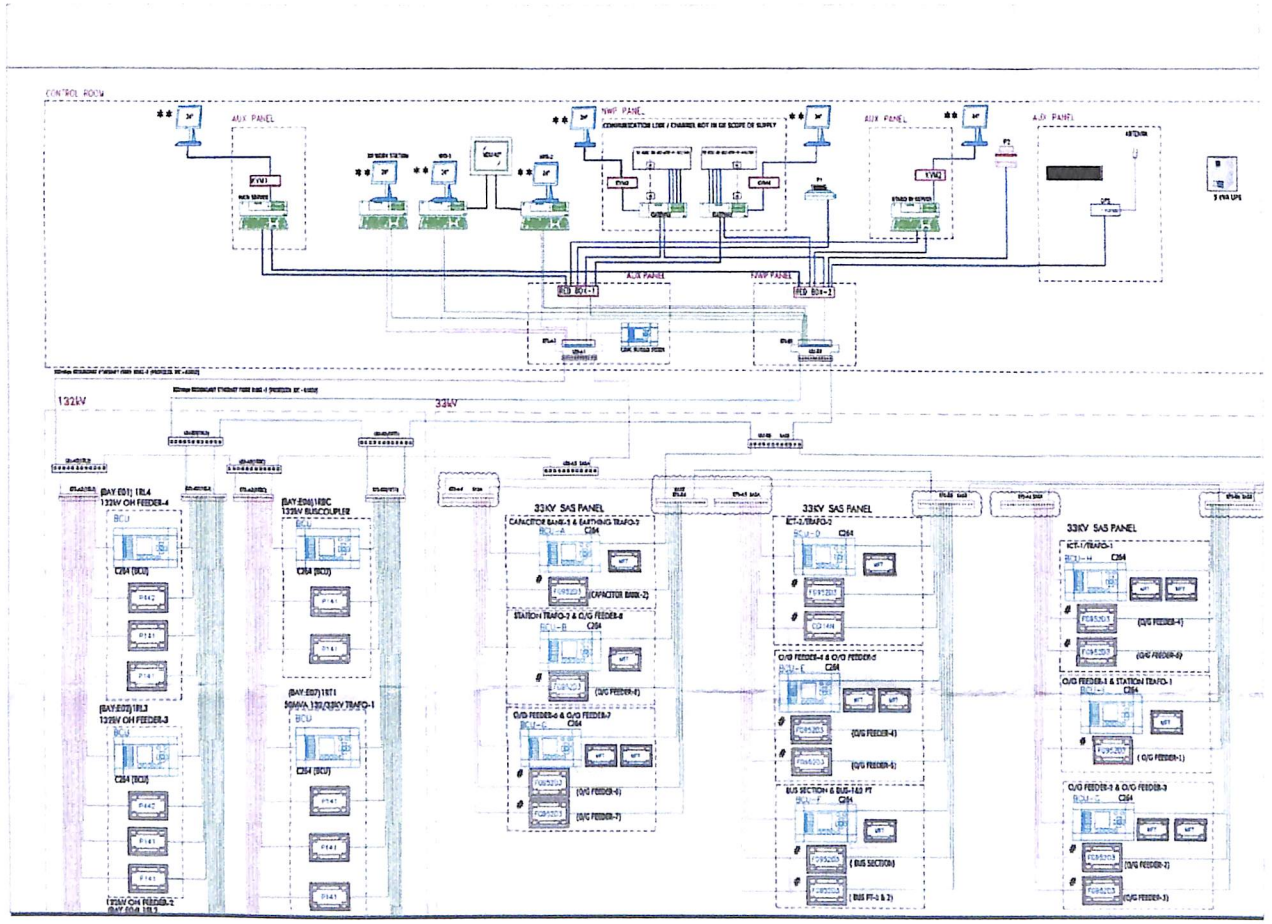


Fig-31 SAS Overall System Architecture of 132/33kv S/S

4.7 Summary

The chapter discusses on acceptance of SAS technologies among the government owned Discoms and later compares also the results based on the analyses. The chapter also elaborates the research process adopted to conduct the research and types of variables used in the research. The research framework designed based on literature and other sources are then converted to constructs and indicators also discuss real time SAS application on SCADA domain in a 132/33 kV sub-station along with operation procedure and also how one Power distribution substation operate remotely from SLDC. Next Chapter 5 discusses the interpretation of data and analysis done for various research objectives.

Chapter 5

Interpretation of Data and Analysis

Chapter 5: Interpretation of Data and Analysis

5.1 Data Collection & Analysis

The data is collected in two forms:

Primary Data Collection: The methods of primary data collection were in form of survey, focused and unstructured interview. The researcher made use of various forums, seminars and workshop for conducting interviews and data from the Discoms officials.

Secondary Data Collection: The secondary data collection mainly comprised of regulatory and audit reports, information from Discoms websites etc.

5.2 Findings &Analysis on Acceptance of SAS –SCADA among staff in Discom in Govt Sector in Kharagpur Division

5.2.1 Introduction

The findings of Implementation & Acceptance of SAS technologies have been grouped into two parts. The first part deals with results of acceptance of SAS Technologies in Government Companies in Kharagpur and second part of result analysis government-owned state electricity boards in kharagpur division .

This section is divided into two parts; first part describes the descriptive statistics of the Dependendent and Independent variables in the research. The second part deals with the structural equation model analysis done to validate the new framework designed by the researcher.

5.2.2 Analysis on Acceptance of SCADA –SAS among Workforce in Partnership Discom

The study was conducted for one government Discom of Kharagpur for technology Acceptance.

The study was conducted among the Staff of Discoms, 95 surveys were dispersed to staff, and out of which 80 responded to the questionnaire. These 80 responses were considered for the research study and analysis.

As per Surveyed Data for Kharagpur Discoms.

Details of respondent profiles of Discoms		
	Kharagpur	
Level of Management	No	% of total
Top Management	6	7.5%
Middle Management	28	35%
Junior Management	46	57.5%
Total	80	**100.0%**

Table:-11Distribution of Discom Officials who took part in research with respect to Management Cadre

Experience(In years)	Nos.	% Percentage
0-10	15	18.75%
10-20	43	53.75%
20-30	14	17.5%
30 and above	8	10%
Total	80	100.00%

Table-12 Distribution of Discom Officials who took part in research with respect to working Experience

Qualification	Nos.	% Percentage
Post-graduates	5	6.25%
Graduates	26	32.5%
Diploma	15	18.75%
ITI	34	42.5%
Total	80	100.00%

Table-13 Distribution of Discom Officials who took part in research with respect to Highest Qualification.

Summary of data collected from Kharagpur Division			
			Nos
Rank	Addl.Chief Engineer		3
	Chief Engineer		2
	Deputy Engineer		9
	Asst.Engineer		17
	Junior Engineer		5
	Supervisor		12
	Lineman		32
		Total	80
Yr. of Experience	0-10		15
	10-20		43
	20-30		14
	> 30		8
		Total	80
Education	Post Graduates		5
	Graduates		26
	Diploma		15
	ITI		34
		Total	80

Table-14 Summery of Data collected for research.

As depicted in table-11 The majority of the respondents, i.e. 46% were from junior management cadre. It is the junior management cadre who actually uses the technology for their work at field level and brings the use of SAS directly to the mainstream of work in power Discom. Only 8% of the upper middle management cadre participated but the interaction with them to Support and understand the social environment for the use of technology.44% of the middle management took part in the research which helped in making a bridge between Junior and top management and explore actual scenario of the use of SAS technology in Discom

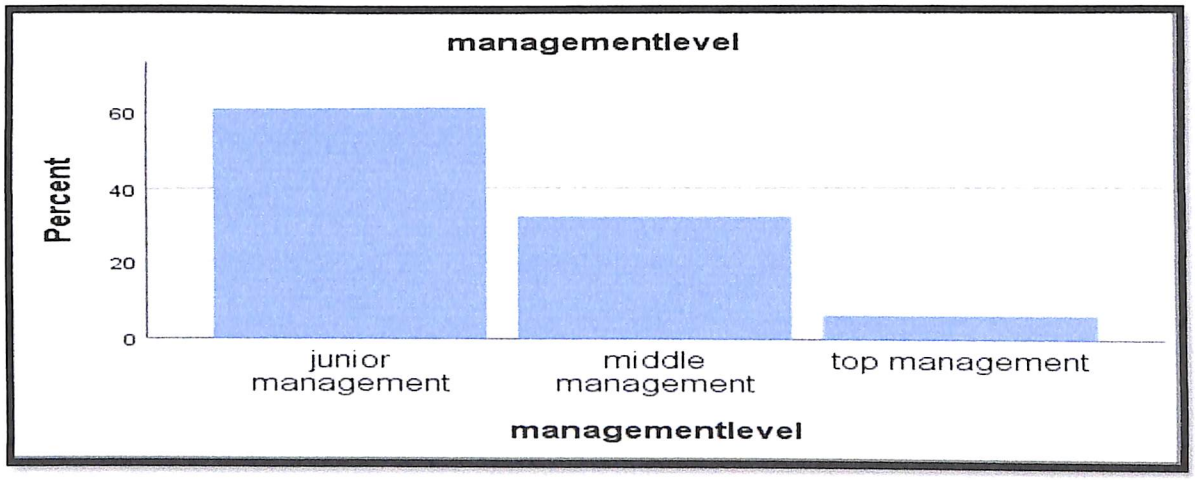


Fig-32 Distribution of Discom Officials who took part in research with respect to Management Cadre(SPSS-Ver.25)

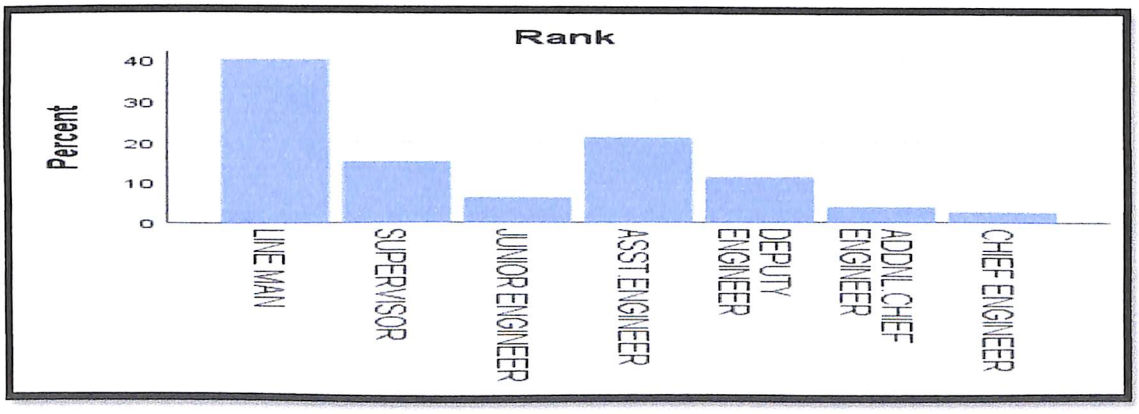


Fig-33 Distribution of Discom Officials who took part in research with respect to Position(SPSS-Ver.25)

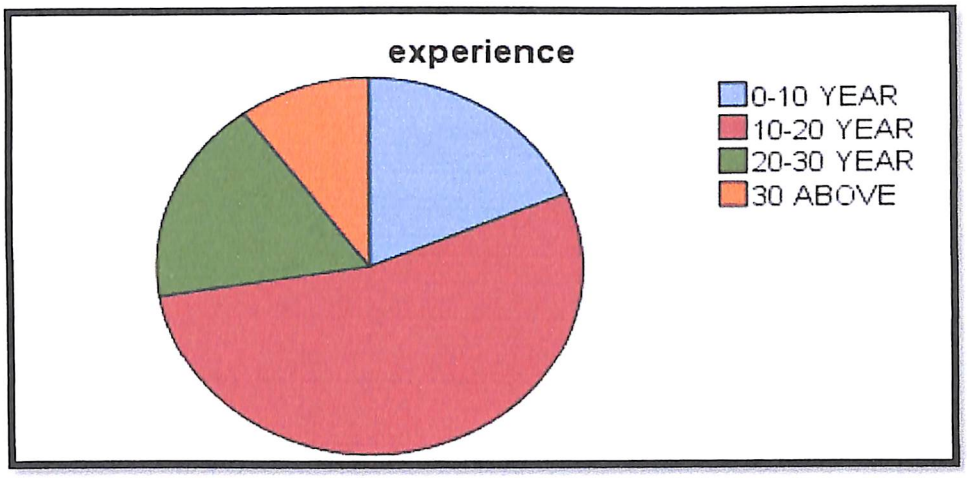


Fig-34 Distribution of Discom Officials who took part in research with respect to Yrs of Experience. (SPSS-Ver.25)

As depicted in Fig-32 32.5% of the staff who participated in the research were graduates with the majority of them having a technical qualification. Only 6% of the staff who were postgraduates were part of the research, while 18% of the staff were either diploma holder & 42.5% staff were ITI by qualification.

As shown in Fg-33 18.75 % of the workforce of the Discoms who participated in the research were of work experience of the range 0-10 years .53.75% of the staff who were of work experience in the range 10-20 years. Only 10% of the Discoms staff who participated in the research were of work experience more than 30years. 17.5% of the Discom staff were off work experience 20-30 years

5.2.3 Descriptive Statistics:

The table illustrates the descriptive statistics of the data collected from the respondents. The analysis has been using IBM SPSS Statistics software (V25.0) and the descriptive statistics includes mainly sum, mean, standard deviations and Skewness factor.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
perceived usefulness1	80	0	4	3.01	1.073	-1.034	.269
perceived usefulness2	80	1	4	3.01	.974	-.868	.269
perceived usefulness3	80	1	4	2.78	1.158	-.498	.269
perceived usefulness4	80	1	4	2.73	1.190	-.462	.269
perceived usefulness5	80	1	4	2.55	1.179	-.242	.269
Ease of use1	80	0	4	2.63	1.151	-.442	.269
Ease of use2	80	0	4	2.58	1.188	-.322	.269
Ease of use3	80	1	4	2.59	1.209	-.254	.269
Ease of use4	80	0	4	2.86	1.177	-.729	.269
Ease of use5	80	0	4	2.83	1.134	-.715	.269
Organisational Culture1	80	1	4	2.81	1.181	-.524	.269
Organisational Culture2	80	1	4	2.74	1.166	-.449	.269
Organisational Culture3	80	0	4	2.56	1.200	-.354	.269
Organisational Culture4	80	0	4	2.56	1.221	-.256	.269
Benefit 1	80	0	4	2.51	1.283	-.231	.269
Benefit 2	80	0	4	2.54	1.169	-.386	.269
Benefit 3	80	1	4	2.89	1.263	-.634	.269
Benefit 4	80	0	4	2.70	1.118	-.658	.269
Benefit 5	80	1	4	2.80	1.130	-.620	.269
Attitude1	80	1	4	2.86	1.209	-.611	.269
Attitude2	80	1	4	3.09	1.138	-.967	.269
Attitude3	80	1	4	2.74	1.040	-.695	.269
Attitude4	80	1	4	2.55	1.113	-.383	.269
Attitude5	80	1	4	2.99	1.153	-.839	.269
Intention1	80	1	4	2.91	1.203	-.677	.269
Intention2	80	1	4	2.69	1.098	-.582	.269
Intention3	80	1	4	2.72	1.067	-.643	.269
Intention4	80	1	4	2.93	1.220	-.712	.269
Intention5	80	1	4	2.60	1.121	-.368	.269
Engineering Support1	80	1	4	2.70	1.072	-.570	.269
Engineering Support2	80	1	4	2.76	1.082	-.615	.269
Engineering Support3	80	0	4	2.80	1.226	-.662	.269
Engineering Support4	80	0	4	2.70	1.184	-.517	.269
Age & year of experience1	80	0	4	2.14	1.220	.160	.269
Mgmnt encourage1	160	0	4	2.77	1.188	-.521	.192
Mgmnt encourage2	80	1	4	2.71	1.116	-.469	.269
Mgmnt encourage3	80	1	4	2.86	1.099	-.659	.269
Mgmnt encourage4	80	1	4	2.76	1.150	-.491	.269
Mgmnt encourage5	80	0	4	2.77	1.113	-.667	.269
Valid N (listwise)	80						

5.2.4 Hypothesis Testing

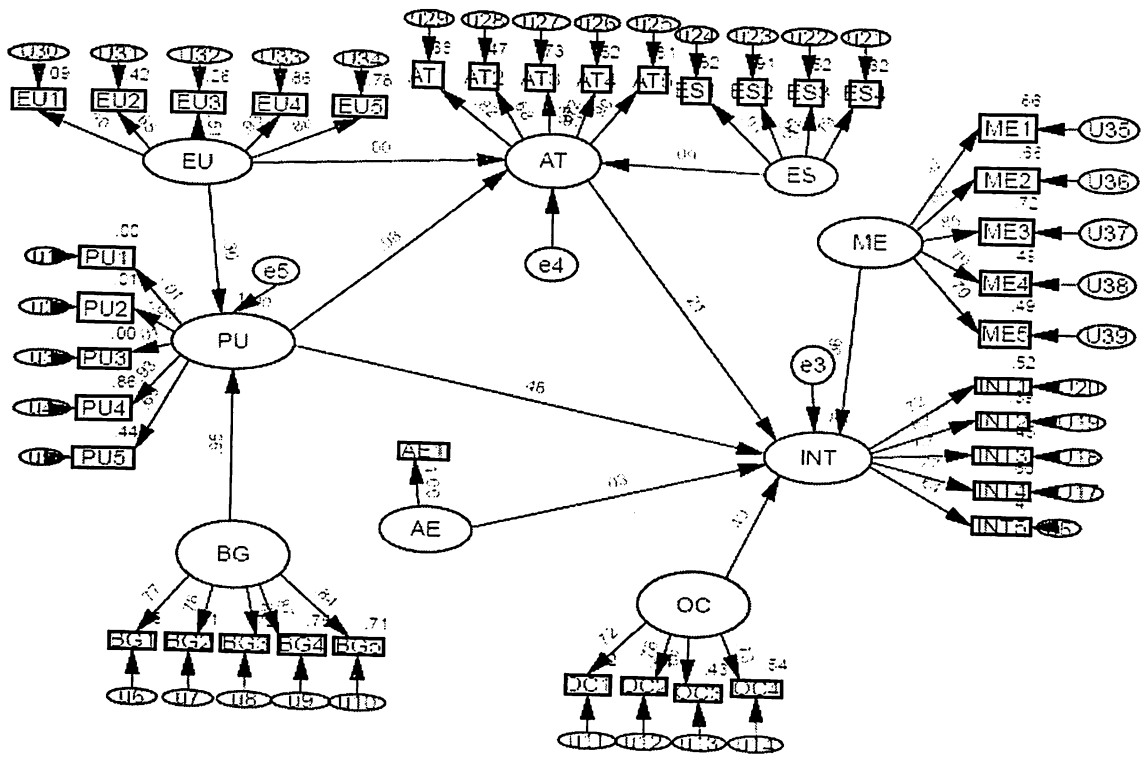


Figure 35 Model for SEM Analysis by IBM SPSS AMOS (V25.0)

Hypothesis Testing Results

H1: Perceived Ease of Use (EU) has an encouraging impact on attitude (AT) of Discoms Staff.

The SEM analysis exhibits not so favorable effect of attitude of Discoms Staff for SCADA technologies because according to finding (β=.00)which means that there 0% change in rise of attitude.

H2: Perceived Ease of Use (EU) has an encouraging impact on Perceived Usefulness (PU) of Discoms workforce.

The analysis that the second hypothesis was supported. The finding (β = .30) exhibits a good encouraging impact among perceived ease of use and perceived usefulness of Discoms Staff for the acceptance of SAS technology. Thus we can say there's is 30 % surge in usefulness for one element on ease in ease of use for Discoms staff.

H3: Perceived Usefulness (PU) has a favorable influence on Attitude (AT) of Discoms Staff in acceptance of SAS system.

The usefulness of the SAS technology creates a favorable impact on the attitude of the power Discoms staff,as β=.98 the analysis results proves the same.

H4: Perceived Usefulness (PU) has an encouraging impact towards Intention (INT) of Discoms workforce.

The finding (β = .48,) showed that hypothesis was supported and shows a good strong association among perceived ease of use and perceived usefulness of Discoms Staff for use of SAS . This favourable association exhibits 48% surge in intentions with every element rise in Usefulness of Discoms staff.

H5: Discoms Staff attitude (AT) for SAS has a favourable impact on intention (INT) to practice the system

This hypothesis was not supported. The finding (β = .21) specifies positive effect which means that 21% increase in (AT) attitude with the rise of one element ease in perceived ease.

H6: Efficiency Gain (BG) has an encouraging impact on the Perceived Usefulness (PU) of Discoms Staff.

The analysis outputs clearly show that benefit gain has an positive impact on the usefulness of the system. This can very well understand the fact that one element increase in BG results in 95% change perceived usefulness.

H7: Discom Organization Culture (DC) has a favorable influence on Intention (INT) of Discom staff

The results showed that social norms have significant influence on the intentions for use of SAS technologies for their work. This favorable effect shows that for 49% surge in intention for the rise in Organization Culture

H8: Engineering Support & Govt Initiatives (ES) has a favorable influence on Intention (INT) of Discom staff.

The hypothesis was supported as engineering support and government initiatives have a good relationship with Intention of the Discom staff to make use of SAS technology. This clearly indicates that government is very much concerned with the use of SAS technology in Discoms In fact, the government has initiated various scheme based on SASto enable it in various process and also help them in reduced field visits of the staff.

H9: Employees Age & Years of Experience (AE) has an encouraging effect on Intention (INT).

The hypothesis has negligible effect on the basis of SEM Model. The results show that there is an insignificant relationship between the age and experience of the employees and Intention to perform the work using geospatial technologies in the Discom.

H10: Top Management Encouragement has a favorable influence on Intention (INT) of Discom staff

The hypothesis was supported as Top Management Encouragement has a good relationship with Intention of the Discom staff to make use of SAS technology. Also senior management of the Discom also support and encourages on the infusion of the technology in the various process of the Discoms.

A brief summary of the regression analysis performed through SPSS is mentioned below. The tables and figures below explain the hypothesis results.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.603[a]	.364	.355	.966	.364	44.545	1	78	.000

a. Predictors: (Constant), Organisational Culture1

b. Dependent Variable: Intention1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	41.580	1	41.580	44.545	.000[b]
	Residual	72.807	78	.933		
	Total	114.387	79			

a. Dependent Variable: Intention1

b. Predictors: (Constant), Organisational Culture1

Table:-15 Regression analysis between Organisational culture (OC) to support for use of SAS & Intention of staff (INT) to use same. (SPSS-Ver.25)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	1.185	.280		4.224	.000	.626	1.743
	Organisational Culture1	.614	.092	.603	6.674	.000	.431	.798

a. Dependent Variable: Intention1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	1.185	.280		4.224	.000	.626	1.743
	Organisational Culture1	.614	.092	.603	6.674	.000	.431	.798

a. Dependent Variable: Intention1

Results are significant. There is an significant relation between the analysis between Organisational culture (OC) to support for use of SAS & Intention of staff (INT) to use same. (SPSS-Ver.25)

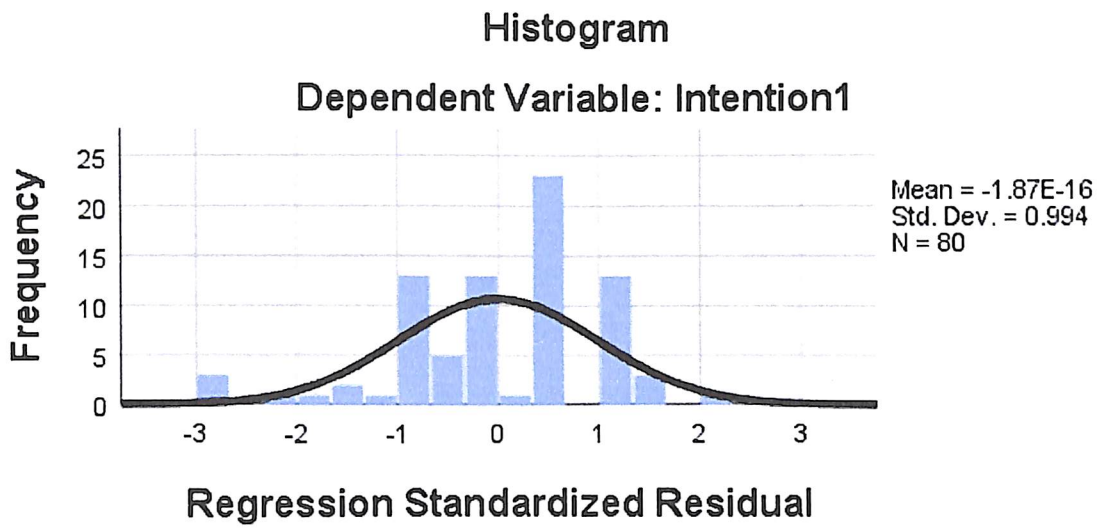


Fig-36 histogram plot for dependent variable (SPSS-Ver.25)

5.2.5 Summary

In this chapter we have discussed about data collection and survey and analysis of the data was performed using the research methods and techniques considered. This chapter analyses on acceptance of SAS among the State government-owned power companies was performed and the conclusion was drawn. The next chapter discusses in detail the conclusion and results of the analysis performed.

Chapter 6

Conclusion & Future Scope

Chapter 6: Conclusion and Future Scope

6.1 Introduction

The research broadly divided into three part based on the objectives for research. The broad and narrow point literature survey is done before the finalization of the research objectives by identifying the gaps. After research objectives are finalized, literature related to specific objective has been done. The research factor are mark out for the research construct and data collection. A literature review related to the specific objective is done separately for all objectives. Then questionnaire is structured for Survey based on research variables. The data analysis has been done using both qualitative methods. The results are analyzed and summarised through Statistics software SPSS and to make a better understanding for hypothesis testing using AMOS Software (V25.0)

6.2 Conclusion: Analysis on Acceptance of SAS among Discom Workforce

For Kharagpur Zone Staff ease of use is more important than usefulness of the application . The study reveals that although SAS technology may not be very easy to use, the employees knows their usefulness and importance in improving their work which can be revealed by the fact that ease of use has a favorable influence on perceived usefulness as per H2. Always a new Technology is not very easy to use to staffs to accept it fully for the first time but when they know about the usefulness of the technology and how that technology can help in their day to day work and make their work easier then they more concerned to accept it and it same for SCADA also . Discom internal teams demonstrate the user group usefulness of the SAS and how their present process can be improved using SAS or SCADA

According to Hypothesis analysis H3 & H4 a positive attitude towards using useful applications of SAS technologies deployment in Kharagpur.

Some of the applications are not flexible to use for field staff the Discoms staff and due to that sometimes influences negative attitude to staff.

The study reveals that current SAS user interface may not be very easy to use , but the employees knows their usefulness and importance in improving their work which can be revealed by the fact that ease of use has positive influence on perceived usefulness.

As per Research hypothesis-H7 & H8 implies that top management along with Organisational culture also encourage using SAS in power sector and Also Govt. Itself support by taking few beneficial initiative to make more popular the technology among the power distribution sector.

6.3 Research Summery

In this research has used various techniques to complete the research and arrive at conclusions and based on that the following research summery has been made:

- Literature survey overview, such study and survey on technologies used in Indian Power Distribution sector have not been conducted till date. Thus, this research the way for academics and executives to understand the concerns in technology acceptance in this sector

- As different technologies are used in power sector, among this here in this research focused on Sub-station Automation system which is one of the most popular and as well as beneficial automation technology used in power Substation.

- The research study establishes the relevance of qualitative methods of research which has been used by the researcher in the research and this can form the base of similar types of research of other locations too.
- The research was conducted for government power Discoms in KHARAGPUR Zone, Considering that technology acceptance by employees for enhancing operational efficiencies of all industries, the same methodology can be adopted with modifications, if needed, for taking up studies in other sectors too.

- Along with research study, to prove actual beneficial part of using SCADA technology in power Substation, conducted a real time study of implementation of SCADA in 132/33 kv Power Sub-station on same location and that showed actual working procedure and its component details.

6.4 Scope for Future Work

This research can be conducted in other part of State or other than this state where most of these technologies are implemented. Studies also applied for other that state Govt owned power project.

This research can be further amended detailed research carry out research on acceptance of some specific technologies like GIS technology, Outage management etc. The research framework, which has been used in the research, can be used for research in other countries with similar socio-economic conditions as to Indian conditions, which may include South Asian and African countries.

6.5 Summary

The Chapter summarizes the complete research process adopted for the study. The chapter then explain the major findings leading to discussions on the research summery. Areas for further research are suggested to close the gaps and to keep enriching the research.

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APENDIX A:

Questionnaire for Acceptance of Substation Automation System among Staff.

Name:

Dept.:

Designation:

ACCEPTANCE OF SAS TECHNOLOGY AMONG THE WORKFORCE OF POWER DISTRIBUTION SECTOR

Please put a ✔ mark on the most preferable option for you-'0'- Totally Deny , '1'- Deny , '2'- Neutral , '3'-Acceptable, '4'- Totally Acceptable.

SL NO.	CONSTRUCTS	INDICATOR	LIKERT SCALE				
			Totally Deny	Deny	Neutral	Accept	Totally Accept
1	PU	**Perceived usefulness**					
1.1	PU1	SAS provides better picture of Field requirement	0	1	2	3	4
1.2	PU2	SAS Kharagpur division ease visualization of and extent of the Problem	0	1	2	3	4
1.3	PU3	SAS is good feedback system to confirm reports	0	1	2	3	4
1.4	PU4	SAS improves in decision making of staff	0	1	2	3	4
1.5	PU5	SAS is Flexible in day to day work	0	1	2	3	4
2	EU	**Perceived Ease of Use**	0	1	2	3	4
2.1	EU1	Interaction with the SAS technologies is clear and understandable	0	1	2	3	4
2.2	EU2	Lot of Technical ability is not required for using SAS	0	1	2	3	4
2.3	EU3	Intellectual Efforts are not required for utilization of SAS in work	0	1	2	3	4
2.4	EU4	It is simple and easy to operate	0	1	2	3	4
3	OC1	**Organisational Culture**	0	1	2	3	4

3.1	OC2	Other Depts. personnel and top management often asks for SAS-based reports	0	1	2	3	4
3.2	OC3	Intellectual Efforts are not required for utilization of SAS in work	0	1	2	3	4
3.3	OC4	Workforce think SAS as reliable decision support system	0	1	2	3	4
3.4	OC5	Mid-level Managers Support the SAS initiatives to the system	0	1	2	3	4
4	BG	**Benefit Gain**	0	1	2	3	4
4.1	BG1	Using SAS has reduced field visit to large extent	0	1	2	3	4
4.2	BG2	Using SAS system has saved time to a great extent	0	1	2	3	4
4.3	BG3	SAS has provided a single platform for field staff & supervisors to Understand the problem	0	1	2	3	4
4.4	BG4	SAS has helped in providing better services to customers	0	1	2	3	4
4.5	BG5	SAS has reduced fault time and helped in faster fault restoration	0	1	2	3	4
5	AT	**Attitude**	0	1	2	3	4
5.1	AT1	like to working with such flexible system like SAS	0	1	2	3	4
5.2	AT2	Using SAS system is exciting	0	1	2	3	4
5.3	AT3	SAS system makes work more user-friendly than the others	0	1	2	3	4
5.4	AT4	Working with the SAS system is enjoyable	0	1	2	3	4
5.5	AT5	SAS system can be used in decisions making	0	1	2	3	4
6	INT	**Intention**	0	1	2	3	4
6.1	INT1	Given that access to the SAS, intend to use it in my job	0	1	2	3	4
6.2	INT2	Often try to explore different Idea using SAS & technical skills	0	1	2	3	4
6.3	INT3	I often contact SAS staff for technical support	0	1	2	3	4
6.4	INT4	In my spare time, I try doing new things using SAS	0	1	2	3	4
7	ES	**Engineering Support & Govt.Initiatives**	0	1	2	3	4

7.1	ES1	SAS Based drawings proposal submission and Approval done in Discom	0	1	2	3	4
7.2	ES2	Govt schemes and initiatives to encourage SAS technologies	0	1	2	3	4
7.3	ES3	SAS as a part of Government Regulator Audits	0	1	2	3	4
7.4	ES4	SAS Communication system has in-house design at discom	0	1	2	3	4
8	ME	**Management Encouragement**	0	1	2	3	4
8.1	ME1	Top-level Managers percolates down the SAS initiatives to the system	0	1	2	3	4
8.2	ME2	Senior manager of department encourages bottom staff in using SAS	0	1	2	3	4
8.3	ME3	Regular training to Depts. Bottom Line Users	0	1	2	3	4
8.4	ME4	Top management always encourage to work with SAS	0	1	2	3	4
8.5	ME5	Management Often ask report Verification of SAS	0	1	2	3	4