

**GUIDELINES
ON
INTRODUCTION OF
AUTOMATION
IN
DISTRIBUTION SECTOR**



**Central Electricity Authority
2018**

1. INTRODUCTION

The growth of a Country depends upon the certain basic pillar of infrastructure and one of such basic infrastructure is availability of quality and reliable power in the country. The country needs 24x7 uninterrupted power supply to all the consumers along with transparency in the operation of sector and consumer participation. Since the enactment of the Electricity Act 2003, Indian power distribution utilities have come a long way but still distribution is the weakest link in the entire value chain of the Electricity sector. Thus, there is a need of introduction of IT and automation in operation of distribution utilities.

Considering the current situation of distribution utilities, there are following keys challenges with distribution utilities in the country :

- Poor Metering Billing and Collection efficiency resulting high AT&C losses.
- Weak distribution network which is not adequate and healthy.
- Obsolete infrastructure at sub transmission and distribution level which is not compatible to the automation and Intelligent Electronic Devices (IEDs).
- Poor forecasting and inadequate power procurement planning resulting in expensive bilateral transactions and power exchanges
- Capacity and capability constraints of the present workforce including technology embracing barrier.
- Poor financial performance due to lack of accountability and high power theft.

It is very crucial to overcome the present challenges and move towards a smarter utilities showcasing the best performance in terms of reliability and accountability. New businesses are entering the power distribution industry, shifting a historically monopolistic sector into a highly competitive age.

The following would be the key features of the UTILITY of FUTURE :

- Low AT&C losses leading to a rich financial condition of Distribution Utilities
- Customers' expectations would be high in terms of supply, reliability and quality of power supplied to them.
- Automation of the distribution system including Smart Grid to study the consumer data like consumption pattern, billing details, energy conservation, and outages information etc.
- Increase in Distribution Energy Resources (DER) with high availability and low cost like use of roof top renewable resources which would make the existing consumers as the generator feeding at distribution level. They would not only consume but would also inject power to grid through rooftop and community solar as and when available, thus there would be a paradigm shift from Unidirectional flow of power to Bidirectional power flow.
- Penetration of Electric Vehicles (EVs) slowly replacing the conventional petrol/ diesel/ gasoline vehicles. Thus, establishment of Electric charging stations and design of distribution system would have its impact on electrical distribution system.

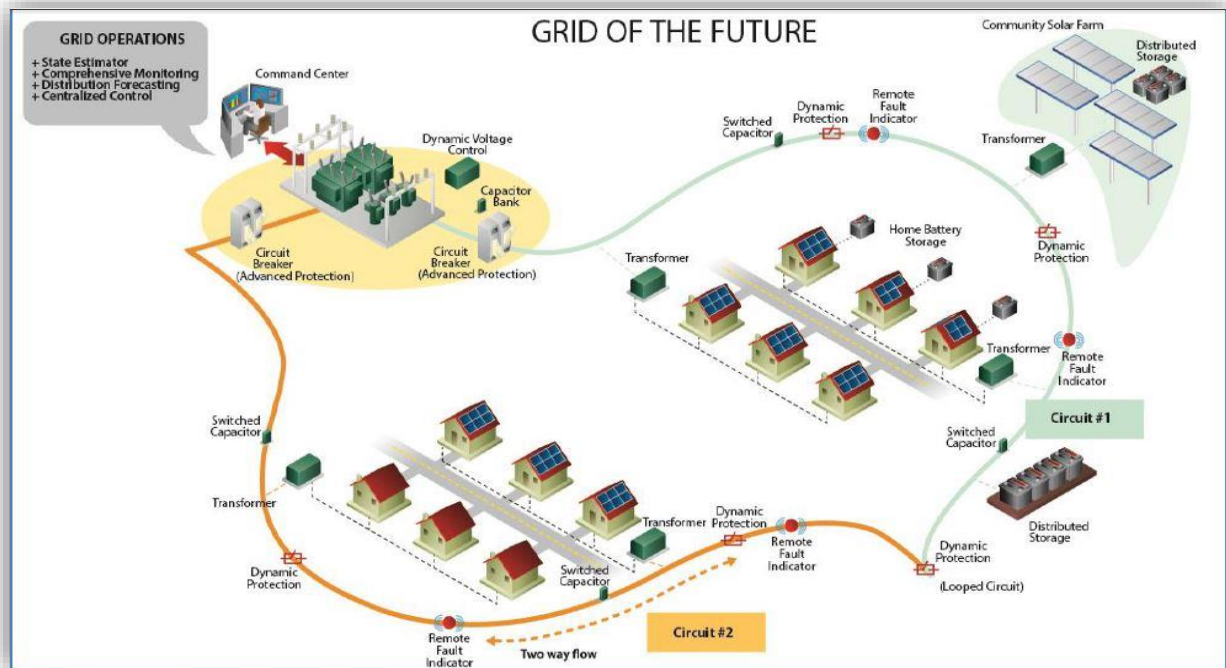
2. ENABLERS FOR THE USE OF AUTOMATION IN DISTRIBUTION SECTOR :

To achieve **affordability, reliability, quality** and **environmentally acceptable** power supply in the country, there are certain enablers which a smart utility must have:

- Very well planned and maintained network infrastructure
- Automated process flow supported by automated monitoring and control of network technology

- Automated process flow supported by state of art information Technology based Metering, Billing & Collection (MBC) , Customer Relation Management (CRM) and Enterprise Resource Planning (ERP) System.
- Automated process flow for field crew management for all practical purposes
- Advanced metering infrastructure and meter data management(MDM) system to bring about transparency, customer engagement and efficiency in utility operation.
- Advanced business analytics to bring out actionable reports.
- Robust communication system
- Updated GIS with automated data maintenance process.
- Technology oriented capability of workforce.
- Compliance for Cyber security etc.

A smart combination of Information technology (IT) and Operational Technology (OT) can allow us to optimize across the technologies on both the supply and demand side to achieve the affordable, reliable & clean power as per satisfaction of the consumers.



3. INFORMATION TECHNOLOGY (IT) AND OPERATIONAL TECHNOLOGY (OT) INTEGRATION

Information Technology plays a major role in the success of effective decision making at the utility level. Data and application integration, business intelligence, hardware capabilities to run complex algorithms and display mapping features, workflow coordination and reporting are some of the elements that IT facilitates to the business groups for efficient operations. The information system concept promises to increase operational efficiency, reduce cost and be more environment friendly. Real Integration of IT & OT not only helps to fulfill that promise, but enhances the opportunities to add more value and effectiveness to the energy value chain. Integration of IT & OT brings together real time systems such as SCADA, EMS and DMS with corporate applications such as ERP, Billing, CRM etc.

Above all, the information system requires a more holistic view of how a utility operates at both the business and field levels, which translates to greater cooperation between IT and OT teams. IT as a part in the rollout of customer management and billing applications, has enhanced its standing within the business. Realizing many of the benefits of smart meter deployments such as more flexible pricing, improved customer understanding, participation and the deployment of new services requires a significant investment in IT.

IT has a leading role in the development of customer management systems and it is also playing a growing role in delivering operational efficiency in areas such as outage management, asset management, and workforce management systems, where there are clear benefits from a broader integration of enterprise and operational data. Even in core operation systems like DMS and Energy Management Systems (EMS), there is a trend toward greater integration across systems as IT has capabilities related to system security and large-scale data management and analysis.

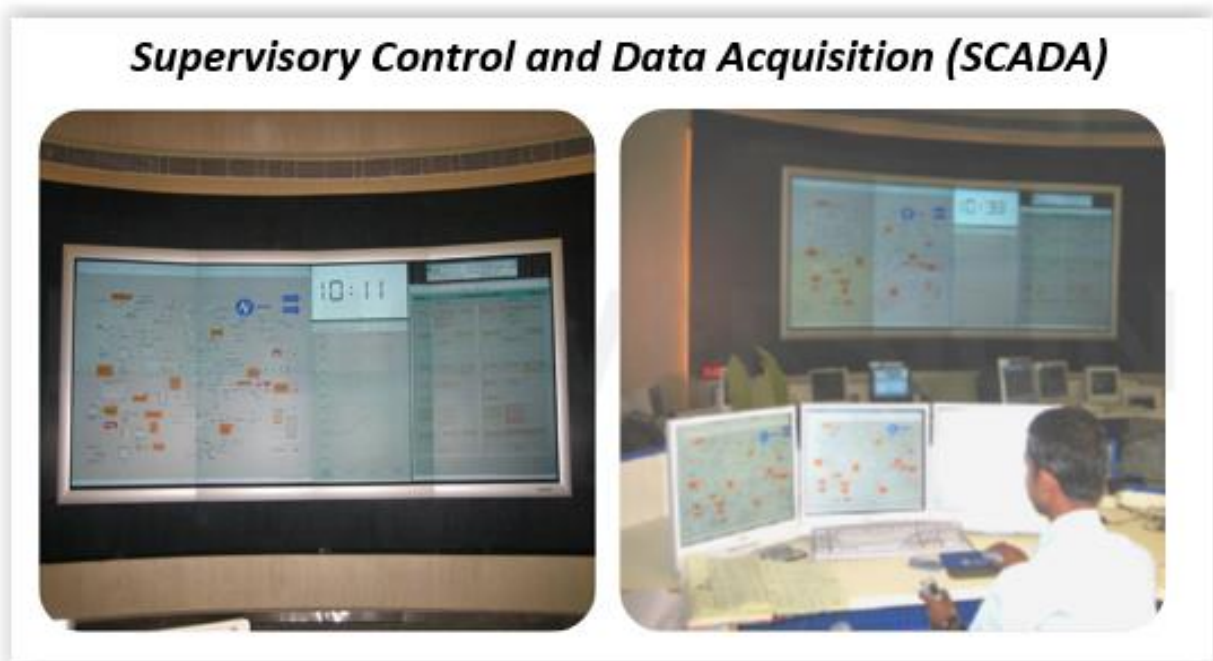
These developments are driving organizational and cultural changes as IT and OT teams learn to work together to meet common goals. IT and OT are not simply different departments but they also reflect different skills and different priorities. The need to define and deploy new IT systems to support the operational system is driving greater collaboration between IT and OT and is also providing a set of common objectives that can bring diverse teams together. *This integrated IT and OT approach basically paves the way for moving forward towards the "SMARTER GRID".*

The details of some of the Operations Technology applications are as under -

(a) SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

Distribution utilities generally operate three layers of network i.e. Sub transmission (66 KV and 33 KV), Primary Distribution (11 KV) and Secondary Distribution (0.415 KV). Any interruption at sub transmission level accounts for outage to thousands of customers. Thus it is necessary to monitor and control each and every network element in the sub transmission network remotely.

SCADA where name itself stands for Supervisory Control and Data Acquisition, is the software application program for acquiring the data on real time basis from each connected network equipment, be it normal condition or abnormal condition due to any fault, and provides this data to the control center for facilitating in decision making on switching operation of network remotely for faster action.



Benefits of SCADA:

- Information readily available within seconds to support operator actions and faster restoration of supply
- Elimination of the risk of equipment damage
- Enhanced safety in working environment
- Improved reliability indices like SAIDI, SAIFI, CAIDI, etc.
- Prepares the system for unmanned grid stations.
- More consistent process for operating the power system at least for sub transmission system and above.
- Better handling of the reactive power support equipment

(b) SUBSTATION AUTOMATION SYSTEM (SAS)

Electric utilities are required to tap into the wealth of information contained in the network equipment installed in field, and making this information available to persons throughout the organization for improved analysis and decision-making. Substation automation systems provide a mechanism that will enable utilities to establish effective data acquisitions, control and condition based maintenance programs.

This system would be the best approach to have a technological up-to-date protection system and get in a more cost-effective way inputs required by the SCADA. Substation Automation shall implement an open platform that may allow to purchase different Intelligent Electronic Devices (IEDs) from different vendors. This way, replacement all old dilapidated equipment as well as protection and control devices from grids substation with state of the art switchgear and make them SCADA compatible can happen. Also, provides an integrated monitoring, control and protection system having a number of advantages over the conventional equipment. This reduces installation costs, improve reliability of equipment required for feeding data to the SCADA system.

Further, to reduce maintenance costs without compromising equipment reliability, it is crucial for utilities for replacing conventional periodic inspection and maintenance practices with “condition-based” maintenance practices. Condition based practices enable the utility to increase routine inspection intervals (i.e., perform fewer inspections) and perform major teardown inspections only when the equipment exhibits symptoms of incipient failures.



Benefits of Substation Automation:

- Technologically advanced solutions at the substation level provide the best form of gathering data for local and remote support of functions.
- Open protocols and standards provide the possibility to implement a vendor independent solution.
- Amount of data available for monitoring and control including the power quality related data is at least about 10 times more in substations designed with SAS as compared with conventional substations.
- Provision for reconfigurations that require the change of settings remotely.
- Provides the implementation of remote maintenance of the relays in terms of change of settings.
- IEDs have built in diagnostics that announce equipment failures thus avoiding malfunctions.

(c) DISTRIBUTION MANAGEMENT SYSTEM (DMS)

Distribution Management System (DMS) is a set of application designed to monitor and control MV distribution network reliably and efficiently. It acts as a decision support system to the network operator stationed in control Center with the monitoring and control of MV distribution system. It access real time data and provide all required information on a single console at the control center in an integrated manner

This helps to detect, report and correct outages which includes the estimation of fault Location and Service Restoration System. Application is also used for optimizing the network conditions including the Network Reconfiguration and the Volt-Var Control functions.



Snapshot of DMS control center

(d) DISTRIBUTION AUTOMATION (DA)

Distribution Automation (DA) is a smart Grid technology that is implemented in sync with the Distribution Management System (DMS). It is prudent to identify strategic automation points by doing the reliability analysis with a philosophy of 20% control can restore 80% of the network. This arrangement not only helps in

improving the network reliability significantly but also *reduce the Mean time to Restore (MTTR) value by 50%*. In terms of restoration, substations with DA capabilities not only immediately identify that the outage has happened but also pinpoints the switching devices which is experiencing the fault.

Benefits of DMS & DA:

- Improved monitoring and control of Distribution Network.
- Better control of power quality and enhanced use of reactive power sources.
- Chances of manual error can be eliminated, as all grid stations are unmanned and centrally controlled.
- Improved customer service on load shedding feeders through load forecasting and scheduling applications.
- Faster fault isolation and restoration
- Improved reliability Indices at Distribution Network
- Provide for maximum use of the installed equipment in terms of best configuration and/or best settings of controls to reach specific objectives such as minimum losses.
- Provide the means to analyze the present and hypothetical operating conditions of the distribution network to respond what if type of questions.

(e) OUTAGE MANAGEMENT SYSTEM (OMS)

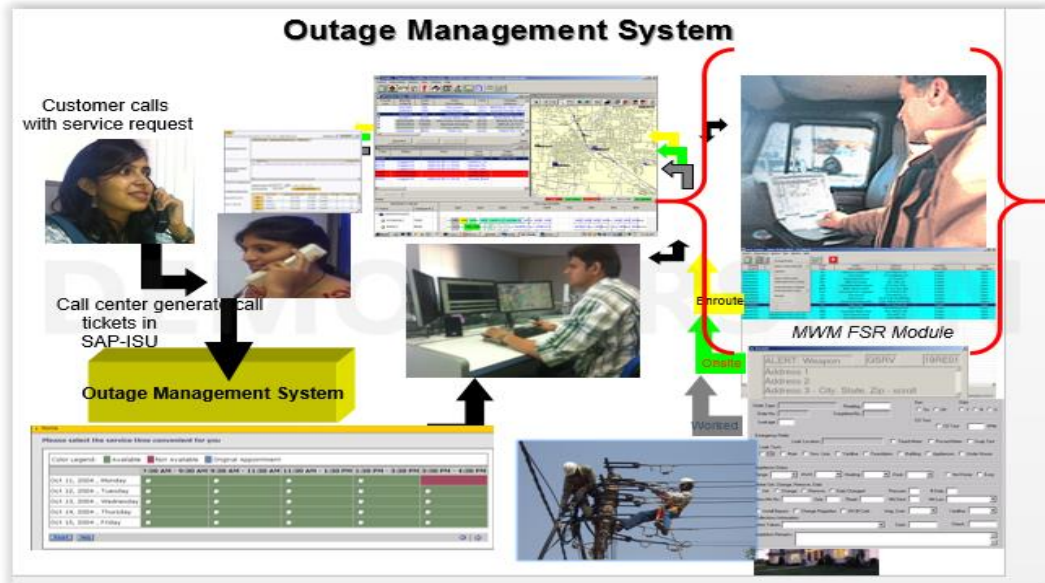
Outage Management System (OMS) provides the capability to efficiently identify and resolve outages and to generate and report valuable information. OMS typically works in conjunction with Geographic Information System (GIS) and Customer Information System (CIS) to give proactive response to the consumer regarding supply restoration status by predicting the location of faulty network component which has contributed to Outage to the consumer. On operational

front, it helps in prioritizing the restoration efforts and managing resources based upon the criteria such as locations of emergency facilities, size and duration of Outage. It also helps in analyzing repetitive nature of faults and help maintenance crew in prioritizing their maintenance schedule.

OMS applications predicts the outages encountered by customers. To predict the outages of customer, it is prerequisite to have complete network hierarchy from customer to the LT network followed by distributions transformers, 11 KV substations and 66/33 KV substations. The requirement of complete hierarchy can be obtained through GIS platform by maintaining and sustaining of up to date network, assets and consumer mapping into GIS. Based on the either numbers of calls from customers or outage information from SCADA/DMS trigger the system application to predict the numbers of affected consumers. The list of affected consumers is sent to CIS for providing proactive intimation to consumers experiencing outages and assigning of field crew for early restoration of outages.

Benefits of OMS:

- *Enables recording of End to End Outage data creating invaluable interruption data*
- *Improves Quality of service to Customers*
- *Reduction in Outage duration, Restoration time and Non-outage complaints*
- *Reduction in O&M costs and better regulatory relations with consumers*
- *Improves performance assurance standards*



(f) ADVANCED DISTRIBUTION MANAGEMENT SYSTEM (ADMS):

The latest trend in the distribution utilities is to implement the unified SCADA, DMS and OMS which is solution of the same box. An Advanced Distribution Management System (ADMS) is the software platform that supports the full suite of distribution management and optimization. An ADMS includes functions that automate outage restoration and optimize the performance of the distribution grid. ADMS functions being developed for electric utilities include fault location, isolation and restoration; volt/var optimization; conservation through voltage reduction; peak demand management; and support for micro grids and electric vehicles.

In fact, an ADMS transitions utilities from paperwork, manual processes, and siloed software systems to an integrated system with real-time and near-real-time data and automated processes.

The decision to implement an ADMS starts with a vision of where the utility would like to be in future that is based on the externalities specific to the utility.



Applications of ADMS looks for certain data which can be fed to this system through GIS which contains the asset, network and consumer modelling of utility. Based on this data, all applications can be run successfully provided the data in GIS is maintained and updated judiciously and always live in condition as available in field.

Applications of any system run effectively and efficiently in intergradation mode. To function effectively, it requires interfacing with GIS data, CIS, SAS as well as getting integration with forthcoming system like Field Force automation, Power portfolio module, Whether Forecasting, Smart grid technologies etc.

(g) GEOGRAPHICAL INFORMATION SYSTEM (GIS)

Many of us tend to associate GIS (Geographic Information System) and GPS (Global Positioning System) technology with research and its applications in agriculture, space, or climate change. But GIS/GPS is also a powerful tool in the hands of those who shape the destiny of India. It is already making major impact in some cities and towns of India in addressing specific challenges of service delivery.

It is the system which leverages the information of geography into your system/ mobile/ Tablet. GIS helps in addressing the challenges of utilities whose assets and network are spread across the geography for providing services to their

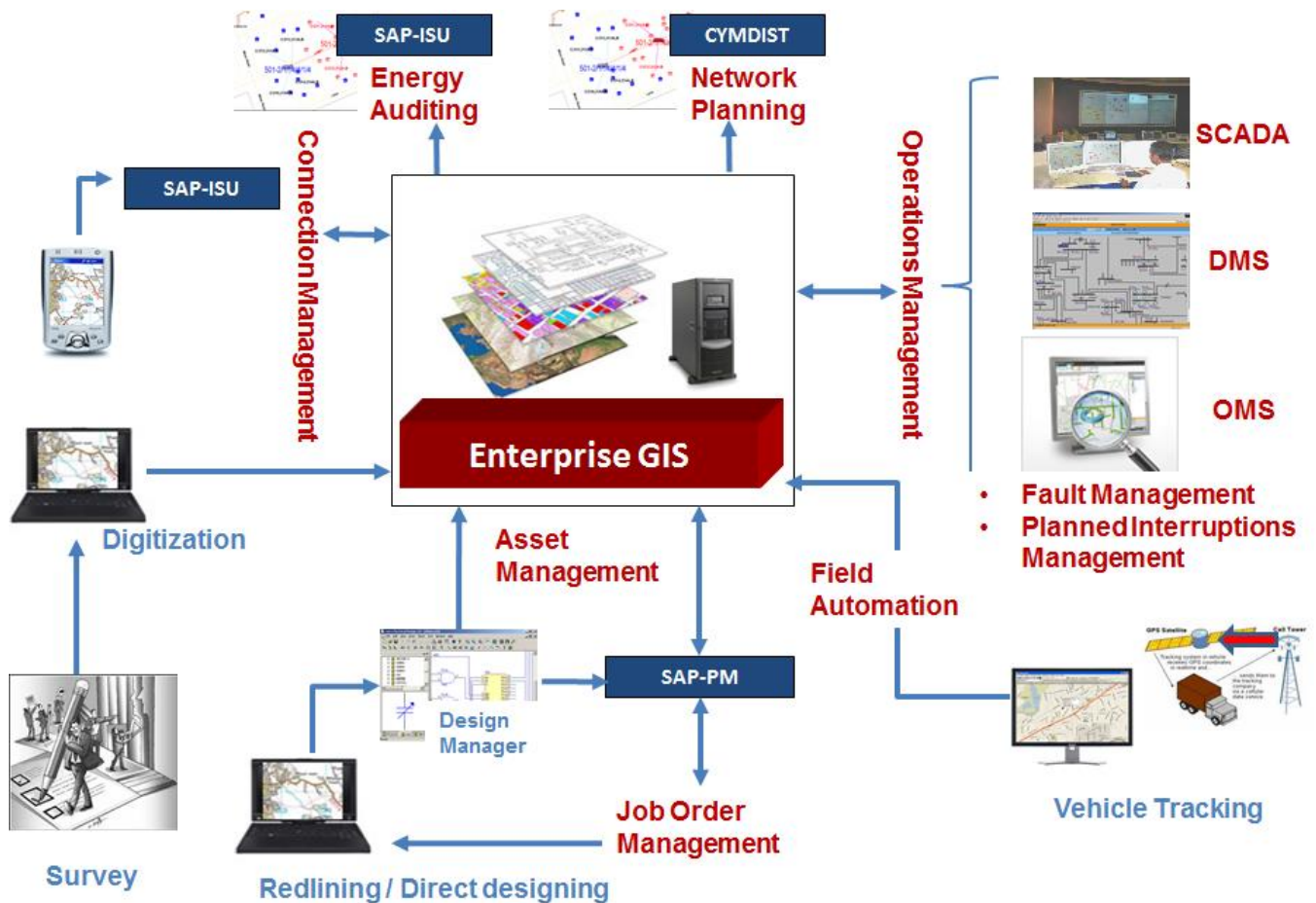
consumers. This is very helpful application for utilities like electric distribution utilities, Gas and water utilities, telecom utilities etc.

This is the optimal platform and foundation technology for utilities which contains the complete information as mentioned below:

- Geo coordinates controlled Asset record management.
- Network topology for operation service management.
- Consumer's location and indexing with network and asset for service delivery.
- Field Crew movement and tracking for ease of services to the customers.

Generally, GIS is presumed to be used as standalone system for data updation from various user groups and most of time, GIS loses its shine due to lack of timely data updation in GIS. With lack of latest data, the integration of GIS with other business systems gets impacted and the overall objective of GIS gets completely derailed.

Landscape of GIS which can help various other processes includes SCADA, Distribution Management System, Outage Management System, Network Planning, Energy Auditing, Field Force Automation, Asset Management, Customer Relationship Management and other associated processes.



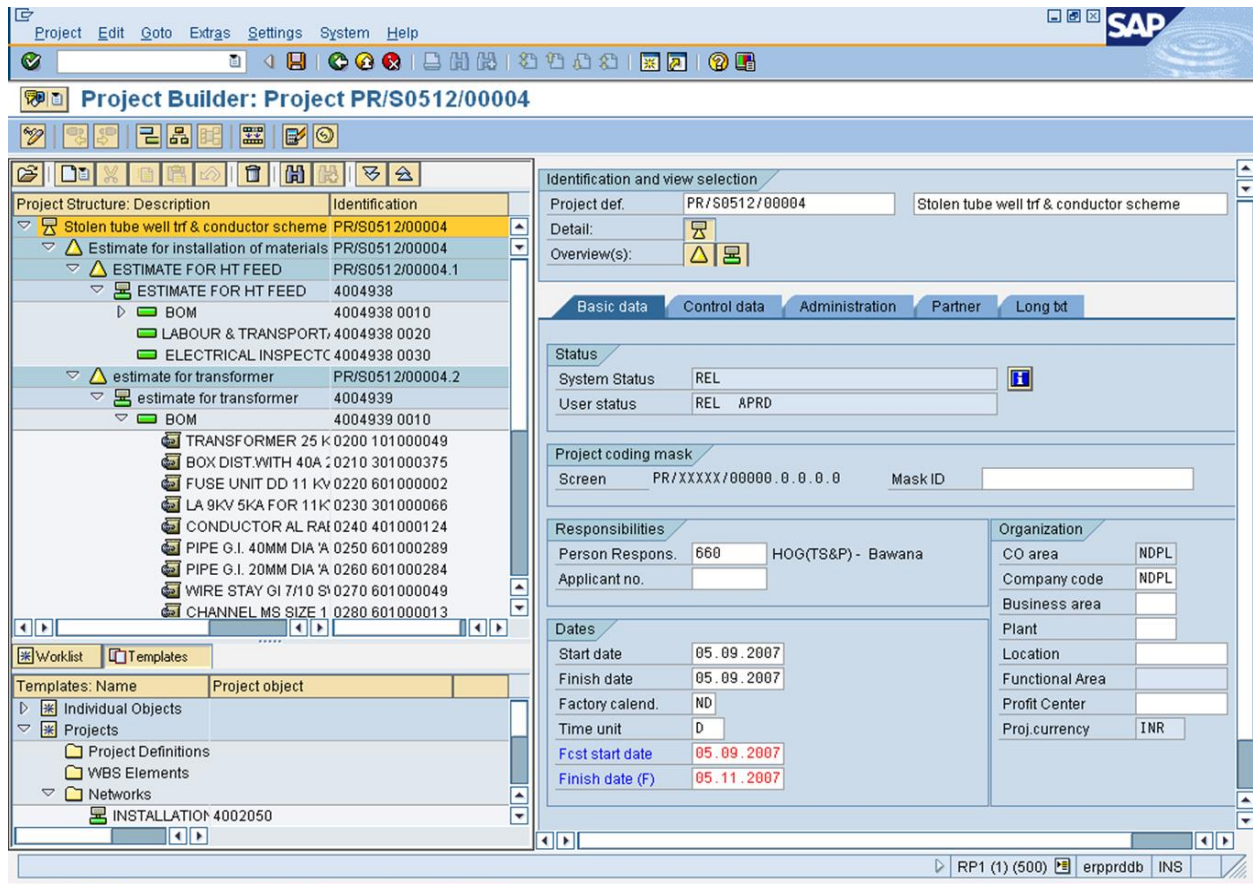
- **Operation management:** Network hierarchy along with consumer mapping from GIS can help the network operator using DMS and OMS for further taking decision on operation Management.
- **Asset Management:** All new assets can be mapped and managed in an integrated environment where information can be flow from GIS to SAP and vice versa to have a robust asset management.
- **Commercial management for new connection:** Consumer mapping is being utilized for verification of dues and technical feasibility before release of new connection. This would result in to reduction in releasing of new connection cycle time.

- **Energy Audit:** Consumer mapping with Pole No. is being utilized for further indexing with supply points and its linkage with source points for carrying out energy audit at various service level.
- **Network Planning:** Network and consumer mapping can be utilized for carrying out the planning of new network and optimization of investments.
- **Vehicle Tracking:** Tracking of vehicle devices on GIS result in enhancing the productivity and adoption of shortest route.

(h) **ERP... FOR UTILITY INTERNAL USE:** ERP like SAP (illustrative, though there are solutions available from various OEMs) includes the Maintenance Management across network layers of Utility. The key benefits which can be achieved by ERP solutions are as below:

- Improved Work Control.
- Improved Planning and Scheduling.
- Enhanced Preventive and Predictive Maintenance.
- Improved Parts and Materials Availability.
- Improved MRO Materials Management in Integration with GIS and with Design Manager Application.
- Improved Reliability Analysis.
- Increased Capability to Measure Performance and Service.
- Increased Level of Maintenance Information

Snapshot of the ERP solution of SAP is shown below:



(i) CUSTOMER RELATIONSHIP MANAGEMENT (CRM)

CRM is implemented for providing information in concise form to front staff for better consumer interaction and to back office for facilitating in day to day decision making. The information/option available in CRM can be broadly categorized into following major categories

- Search Options – In CRM, Multiple options are available for searching the consumer
- Fact Sheet – Information w.r.t Business Master Data Technical Master Data of a consumer is available

- Notification – In CRM, User can perform action like new connection, attribute change, billing, metering complaint, no supply and street lighting service requests w.r.t notification.
- Report – User can also view the different reports developed for different departments. These reports are used by user for analyzing consumer account in detail

Snapshot of the CRM User Interface is shown in the snapshot given below:

The screenshot displays the SAP CRM Interaction Center interface. At the top, the header includes the SAP logo, 'CRM Interaction Center', and navigation links for 'Help Center', 'System News', and 'Log Off'. Below the header, a status bar shows the customer name 'Mr. RAGHU RAJ SARAN . / 60005991843', the location 'DELHI,', and the status 'Consumer Not in serv'. A toolbar contains icons for various actions and buttons for 'Reset CTI', 'Clear Interaction', and 'End'. A 'Ready' indicator is also present.

The main content area is titled 'Identification' and features a left-hand navigation menu with options: 'CA Identification', 'Overview', 'General Enquiry', 'Connection Mgmt', 'Con Attribute Change', 'Reading', 'Billing', 'Financial Services', and 'Inspection & Testing'. The central panel displays the 'Contract Account 6000599184:' with a 'More Fields' link. The 'Address Details' section is expanded, showing 'Supply Address' and 'Billing Address' for 'House No 22 2ND FLOOR BLK-F DDA RES SCHEME NARAINA VIHAR CITY DELHI 110028 LANDMARK NEAR SANATAM DHARAM MANDIR'. The 'Contract Account' and 'Landline' fields are also visible.

Contract Account 6000599184:		Address Details	
Title	Mr.	Supply Address	House No 22 2ND FLOOR BLK-F DDA RES SCHEME NARAINA VIHAR CITY DELHI 110028 LANDMARK NEAR SANATAM DHARAM MANDIR
First Name / Last Name	RAGHU RAJ SARAN	Billing Address	HOUSE NO 22 FLOOR 2ND BLOCK - F LANDMARK NEAR SANATAM DHARAM MANDIR DDA RES SCHEME NARAINA VIHAR 110028 NEW DELHI
Middle Name			
Organisation Name			
Mobile Number	9899959011		
E-Mail Address			
Date of Birth			
Contract Account	60005991843		
Landline	9899959011		

Benefits of CRM

- Call Center Executive will use only one application for answering the consumer query or registering the consumer complaint due to which productivity of executive is improved. With implementation of CRM, the productivity of call center executive can be improved by about 25 %. The increase in productivity

ensures that utility can answer more call without increasing the number of seats in the commercial call center.

- Unified call center to attend to all type of complaints (commercial or operational i.e. No Supply).

- In case of No Supply, Call Center user is able to identify the consumer and answer the consumer query in very less time due to which the average talk time (ATT) is reduced.

(j) SMART GRID TECHNOLOGIES

A smart grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources. Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid. To ensure a seamless transition from existing approach to Smart Grid scenario, focus of any distribution utility must be structured around four key priorities. These are:

- Empower Customers to better manage and control their electricity use.
- Improve Reliability.
- Maintain Privacy and Security.
- Support Renewable integration and economic development.

In order to address the above mentioned priorities, Smart Grid technologies needs to be implemented in conjunction with the existing application / technology. Smart grid generally refers to a class of technology that is being considered to bring paradigm shift in power distribution utility's performance.

The Smart Grid represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to economic and environmental health. The benefits associated with the Smart Grid include:

- More efficient transmission of electricity
- Quicker restoration of electricity after power disturbances
- Reduced operations and management costs for utilities, and ultimately lower power costs for consumers
- Reduced peak demand, which will also help lower electricity rates
- Increased integration of large-scale renewable energy systems
- Better integration of customer-owner power generation systems, including renewable energy systems
- Improved security

Some components of Smart Grid are:

➤ **Distributed Energy Resources (DER):**

Conventionally, Grid substation have been designed to transmit power from receiving station to end user for consumption. However, as the penetration of Distributed Energy Resources (DER) is going to increase, grid substations shall be used as carrier of bi-directional energy flows. The penetration of DER such as distributed generation, Electric storage, Electric Vehicles (EV) and demand response may significantly affect the operation of Distribution Grid substations. On the other hand, this DER development will help in reduction of CO₂ emission, reduction in loading on the network and increase in self – consumption.

DER serves as a flexibility service provider within the power distribution network i.e. facilitates a power adjustment sustained for a given duration in order to balance supply and demand at a given moment. DER creates opportunities for

customers to self-provide energy, manage load profiles, improve power quality and help meet clean energy goals.

Key motivating factors for the adoption of DER, for both customers and the grid, are often described with the following categories:

Economic Benefits. Avoided costs, increased efficiencies, and gained revenues. For customers owning DERs, benefits can be tied to incentive payments as well as avoided costs associated with electricity bills. For utilities, regulators, and ratepayers, benefits can be tied to more efficient utilization of the grid and deferred investments.

Deferred or Avoided Network Investments. Avoided expansion of generation, transmission, or distribution facilities. This benefit applies to the grid which can indirectly benefit all ratepayers. Apart from providing economic benefits, DERs can also help avoid lengthy siting processes or can provide options where technical challenges exist around traditional capacity expansion. In some cases, the utilization of DERs can provide a quick or novel means for addressing grid challenges

Resiliency and Power Quality. Uninterrupted service in the event of loss of grid service and the ability to ride through transient and short-term interruptions. This can be applied to both customers who seek to reduce outage times or power quality events, and the utilities that are coordinating outage recovery efforts and managing grid power quality.

Clean Energy. Social, regulatory, and economic reasons to invest in low or no-emission DERs. Many customers are motivated to purchase clean DERs to support clean energy goals. Likewise, many utilities are doing the same, often motivated by goals or explicit targets. The net effect on emissions, however, has to be

investigated per system because the displacement of centralized generation can have different effects on total emissions

➤ **Advanced Metering Infrastructure (AMI)**

Advanced metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. Customer systems include in-home displays, home area networks, energy management systems, and other customer-side-of-the-meter equipment that enable smart grid functions in residential, commercial, and industrial facilities.

Advanced Metering Infrastructure (AMI) refers to systems that measure, collect, and analyze energy usage, and communicate with metering devices such as electricity meters, either on request or on a schedule. These systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management software, and supplier business systems. Advanced metering infrastructure (AMI) differs from traditional automatic meter reading (AMR) in that it enables two-way communications with the smart meter.

It is architecture for automated, two-way communication between a smart utility meter with an IP address and a utility company. The goal of an AMI is to provide utility companies with real-time data about power consumption and allow customers to make informed choices about energy usage based on the price at the time of use.

Building Blocks of AMI

AMI is comprised of various hardware and software components, all of which play a role in measuring energy consumption and transmitting information about

energy, water and gas usage to utility companies and customers. The overarching technological components of AMI include:

- **Smart Meters**-Advanced meter devices having the capacity to collect information about energy, water, and gas usage at various intervals and transmitting the data through fixed communication networks to utility, as well as receiving information like pricing signals from utility and conveying it to consumer.
- **Communication Network**:Advanced communication networks which supports two-way communication enables information from smart meters to utility companies and vice-versa.
- **Meter Data Acquisition System**-Software applications on the Control Centre hardware and the DCUs (Data Concentrator Units) used to acquire data from meters via communication network and send it to the MDMS
- **Meter Data Management System (MDMS)**:Host system which receives, stores and analyzes the metering information.

Benefits:-

Benefits associated with AMI deployment can be broadly categorized as:

- System Operation Benefits
- Customer Service Benefits
- Financial Benefits

System Operation Benefits - primarily associated with reduction in meter reads and associated management and administrative support, increased meter reading accuracy, improved utility asset management, easier energy theft detection, and easier outage

Management.

Customer Service Benefits - primarily associated with early detection of meter failures, billing accuracy improvements, faster service restoration, flexible billing cycles, providing a variety of time-based rate options to customers, and creating customer energy profiles for targeting Energy Efficiency/Demand Response programs.

Financial Benefits - these accrue to the utility from reduced equipment and equipment maintenance costs, reduced support expenses, faster restoration and shorter outages, and improvements in inventory management.

➤ **Automated Demand Response**

Numerous contributions to overall improvement of the efficiency of energy infrastructure are anticipated from the deployment of smart grid technology, in particular including **demand-side management**, for example turning off air conditioners during short-term spikes in electricity price. To reduce demand during the high cost peak usage periods, communications and metering technologies inform smart devices in the home and business when energy demand is high and track how much electricity is used and when it is used. It also gives utility companies the ability to reduce consumption by communicating to devices directly in order to prevent system overload.

Demand response support allows generators and loads to interact in an automated fashion in real time, coordinating demand to flatten spikes. Eliminating the fraction of demand that occurs in these spikes eliminates the cost of adding reserve generators, and allows users to cut their energy bills by telling low priority devices to use energy only when it is cheapest. In addition, ADR helps reduce greenhouse gas emissions and the need to run expensive peaking plants, which typically sit idle until customers require more electricity than the utility is able to provide using its primary, base-load generators

A typical DR implementation would consist of three main entities:

- An entity at the utility which stores the program information, generates and communicates the DR signal to consumer premises.
- An entity at the consumer premises capable of receiving the utility DR signal and controlling the load accordingly.
- An entity for measurement and verification.



➤ **Communication Infrastructure**

To support information collection, distribution and analysis, as well as automated control and optimization of the power system, we argue that the smart grid communication system will rely on two major subsystems: a communication infrastructure and a middleware platform.

Communication infrastructure. The communication infrastructure is responsible for providing the connectivity service among individual electric devices or entire grid sub-systems. In the context of smart grids, the key priorities

of this communication network are: (a) to ensure reliable and real-time data collection from an enormous number of widely dispersed data sources, and (b) to support the various communication services that are needed by power control applications to distribute commands and configuration instructions in the power system. This communication infrastructure is envisioned as a collection of interconnected networks that will be structured into a hierarchy of at least three main tiers or domains: (1) local area networks for the access grid segment and the end customers, (2) field area networks for the distribution segment, and (3) wide area networks for the utility backbone. A variety of technologies, network topologies and communication protocols are considered for each of these categories

Middleware platform. The middleware is a software layer running above the communication network, which provides communication and data management services for distributed applications, as well as standard interfaces between applications and smart grid devices. Different types of middleware solutions exist that differentiate from each other for the set of abstractions and programming interfaces they provide to applications, such as distributed objects, event notifications, distributed content management, synchronous/asynchronous communication functions, etc. Furthermore, middleware is increasingly used to create peer-to-peer (P2P) overlays, i.e., distributed systems in which devices self-organize into a network and cooperate with each other by contributing part of their (storage, computing, bandwidth) resources to offer useful services, such as data search, distributed storage, or computational intelligence. Given the ability of P2P technologies to scale with increasing numbers of devices and services, several studies have proposed to use P2P-based middleware technologies to deal with the complexity of managing and controlling smart grids

➤ **MDMS (Meter Data Management System)**

MDM system analyzes the data collected and sent by the Smart Meter to set electric power costs and to let consumers use energy efficiently. Collecting the metered data from consumers in real time makes it possible for electric power suppliers to understand how electricity is being used. Additionally, it improves the efficiency of recovery work after natural disasters or accidents happen to the power grid itself.

Consumers can use the data managed by MDMS to help them use electricity more efficiently.

An MDM system will typically import the data, then validate, cleanse and process it before making it available for billing and analysis. An MDM system performs long term data storage and management for the vast quantities of data delivered by smart metering systems. This data consists primarily of usage data and events that are imported from the head end servers that manage the data collection in Advanced metering infrastructure (AMI) or Automatic meter reading (AMR) systems.

It provides Meter-to-Cash system, workforce management system, asset management and other systems. Also an MDMS may provide reporting capabilities for load and demand forecasting, management reports, and customer service metrics. An MDMS provide application programming interfaces (APIs) between the MDMS and the multiple destinations that rely on meter data. Besides this common functionality, our advanced MDM may provide facility for remote connect/disconnect of meters, power status verification/ power restoration verification and On demand read of remote meters.

- Store all meter reads as the system of record.
- Validate the accuracy and performance of meter reads and outage event data.

- Assess possible diversion situations or issues requiring a field visit.
- Improve estimation and validation using multi-dimensional analytics.
- Synchronize data between MDMS, AMR/AMI databases and master systems.
- Improve utility back office operations and understand the potential of the AMI investment.

➤ ***Business Intelligence and Business Analytics***

Business intelligence (BI) is a technology-driven process for analyzing data and presenting actionable information to help corporate executives, business managers and other end users make more informed business decisions. BI encompasses a wide variety of tools, applications and methodologies that enable organizations to collect data from internal systems and external sources, prepare it for analysis, develop and run queries against the data, and create reports, dashboards and data visualizations to make the analytical results available to corporate decision makers as well as operational workers.

The potential benefits of business intelligence programs include accelerating and improving decision making; optimizing internal business processes; increasing operational efficiency; driving new revenues; and gaining competitive advantages over business rivals. BI systems can also help companies identify market trends and spot business problems that need to be addressed.

BI data can include historical information, as well as new data gathered from source systems as it is generated, enabling BI analysis to support both strategic and tactical decision-making processes. Initially, BI tools were primarily used by data analysts and other IT professionals who ran analyses and produced reports with query results for business users. Increasingly, however, business executives and workers are using BI software themselves, thanks partly to the development of self-service BI and data discovery tools.

Business intelligence combines a broad set of data analysis applications, including ad hoc analysis and querying, enterprise reporting, online analytical processing (OLAP), mobile BI, real-time BI, operational BI, cloud and software as a service BI, open source BI, collaborative BI and location intelligence. BI technology also includes data visualization software for designing charts and other info graphics, as well as tools for building BI dashboards and performance scorecards that display visualized data on business metrics and key performance indicators in an easy-to-grasp way

ERP Business Intelligence and Business Objects (BI/BO) is being proposed for analytical reports, monitoring reports and management dashboards. Data will be collected from all IT and OT systems in ERP BI/BO for analysis and reporting.

➤ **Enterprise Service Bus:**

System engineering is an approach to manage complexity. A system engineering approach is more appropriate during smart grid system design than a power systems automation or general information technology point of view and is well-matched for supporting application-to-application (A2A), substation automation and control room integration designs.

System engineering integration methods can be employed to plan complex systems and serve as smart grid project accelerators. These integration methods are based on using enterprise-class integration tools and information management technologies to support a highly decoupled design with scalability, maintenance, tuning and security mechanisms.

A key smart grid integration method is the accommodation of multiple ESB domains to communicate across the operation center, enterprise and substation. This approach brings with it all the native ESB advantages for A2A integrations and an in-depth security approach to supporting integrations with systems that

interact with the power system. The approach has its challenges; however, extending the use of a single corporate ESB will not address adequately all needs of a utility's smart grid environment.

Utilities typically design their substation automation schemes to support operations within the substation local-area network (LAN) and for remote monitoring and control via supervisory control and data acquisition (SCADA). IEDs play a critical part in the life cycle asset management of power system devices based on the functionality of newer IEDs. IEDs also can be used by software to provide useful analysis to warn the user of undesirable events and operating conditions. By integrating the appropriate information with the utility's SCADA system and smart grid data repository, the utility can gain the most value from deploying these new IEDs inside its substation.

Smart grid solution architecture should support the operation of the power system via substation automation/SCADA integrations and substation automation/enterprise integrations supporting asset management and troubleshooting of missed events. Substation automation operational information should go from the substation to the control room via SCADA, and the substation automation nonoperational information should go from the substation to the enterprise via a different communication infrastructure designed to support the nonoperational payloads and security requirements

Given the complexity in utilities' managing distribution smart grid systems, systems engineering approach and integration methods can ensure systems are scalable, secure and provide the ability to leverage information for future data mining activities. Utilities should support an in-depth security paradigm through multiple ESB domains and use the auditing and logging functionality of the ESB. Substation automation data concentrators/data gateways are key architectural

components for security and dual-access paths into the substation LAN. Centralized DMS/DSCADA applications must coordinate with and respect substation automation and DA autonomous schemes. The substation automation solution should report errors and remediation failures back to the DMS/DSCADA system. Acknowledge that the field work force is a key factor to maintaining a zero-latency power system model in your DMS

➤ **Home Automation**

As with other industries, use of robust two-way communications, advanced sensors, and distributed computing technology will improve the efficiency, reliability and safety of power delivery and use. It also opens up the potential for entirely new services or improvements on existing ones, such as fire monitoring and alarms that can shut off power, make phone calls to emergency services, etc.

Automation is, unsurprisingly, one of the two main characteristics of home automation. Automation refers to the ability to program and schedule events for the devices on the network. The programming may include time-related commands, such as having your lights turn on or off at specific times each day. It can also include non-scheduled events, such as turning on all the lights in your home when your security system alarm is triggered.

Energy savings is one of the most important aspect of home automation. One clear advantage of home automation is the unmatched potential for energy savings, and therefore cost savings. Your thermostat is already "smart" in the sense that it uses a temperature threshold to govern the cooling system. In most cases, thermostats can also be programmed with different target temperatures in order to keep energy usage at a minimum during the hours when you're least likely to benefit from the cooling.

At the most basic level, home automation extends that scheduled programmability to lighting, so that you can suit your energy usage to your usual daily schedule. With more flexible home automation systems, electrical outlets or even individual devices can also be automatically powered down during hours of the day when they're not needed.

Benefits of Home Automation: -

- Convenience for the consumers
- Home Security
- Remote Access Control & Connectivity
- Energy Efficiency

(k) SCIENTIFIC DISTRIBUTION SYSTEM PLANNING USING PLANNING S/W TOOLS

For any power distribution utility, planning of adequate distribution system to cater existing as well as future load growth requirement is of utmost importance. The driving factors for Discoms generally are Consumer growth, consumption growth, Price of Electricity, Financial Aid, Energy Efficient Measures, Plausible Decline in the number of High Value Consumers, Risk of Migration of consumers to open access etc. The Discoms need to work out Electrical Energy Requirement Projections, Electrical Demand Projections, Trajectory of T&D losses, Selection of Load Factor, Impact of DSM measures etc through use of software tools available for distribution planning.

The planning for distribution system includes the analysis of existing system and planning of optimal future requirement of sub transmission and Distribution lines & Distribution Substations keeping in view the futuristic approach . This would

also include the requirement of adequate Communication system and IT infrastructure like SCADA, DMS, OMS, AMI etc

Through this approach, a distribution company should be able to analyze the distribution network for following

- Optimization of loading of Transformers (power transformers and distribution transformers) and Feeders.
- Ensuring an adequate network for existing as well future need with N-1 redundancy in the network i.e. at Medium Voltage (MV) (11 KV) and High voltage (HV) (66 and 33 KV).
- Reduce technical loss by optimizing the network configuration.
- Ensure voltage regulation as in line with the Regulations.

The system is planned with the primary objective of meeting load growth and maintaining the desired redundancy level in the system to meet current supply requirements. System has been analyzed during contingency condition and loading of various network elements has been reviewed, cases where space and transmission up-stream network availability is there have to be considered in the plan. Area wise loss level is also assessed along with the ground reality for future T&D loss reduction trajectory.

Through the use of system software , the new development/addition/augmentation has to be studied against the overloaded network element based on the degree of overloading (Transformers/ Feeders/ grid stations/ Substations). The works required to upgrade IT tools/software to meet various business requirements, install compatible hardware and provide better connectivity between various offices, Grid Substations etc are also to be planned for introducing transparency in the system.

4. BENEFIT OF INTEGRATION OF IT AND OT FOR CUSTOMER CONVENIENCE.

Power Distribution utilities generally select and implement technological solutions on piecemeal basis and various systems operate in isolation to each other. Operating the systems in isolation, deprives the user of reaping the full benefits of investments. By having various systems integrated, the overall operational efficiency and resource optimization can be enhanced. For example, the following systems have a dedicated works as stated under-

- SCADA system is capable of informing about the status of the breaker controlling sub-transmission/distribution lines but cannot let the utility operator know who the affected customers are.
- GIS system has got the network and customer hierarchy but cannot update the consumers, in case they are out or even cannot know which of the device in field is out at any given point of time.
- Any Maintenance Module of any ERP is capable of maintenance planning and asset management but due to any equipment being out for any maintenance and which of the customers will be out, it cannot be ascertained.
- CRM system is capable of taking consumers complaint but cannot update the status until feedback is received from any other system.

In case, all the above IT enabled systems runs in isolation, it would give an overall picture of the system but if all of the above systems are designed to operate in integration with each other and implemented in integrated mode, then it will provide the operator an wholesome picture which not only increases the operational efficiency but also optimize the human resources required.

The integrated approach helps in

- Proactive response for the customer outages due to tripping of SCADA monitored devices with the help of integration with SCADA/DMS/GIS for getting status update of the out devices, integration with GIS for list of affected customers from GIS network hierarchy and with SAP CRM for updating the customer records for updating the customers.
- Prediction of location of faulty network component which has contributed to outage to the customer by utilizing the GIS network hierarchy and calls registered due to outage of any non SCADA monitored device which helps in curtailing downtime.
- Prioritizing restoration efforts and managing resources based upon pre defined criteria such as locations of emergency facilities, size of outages, and duration of outages etc.
- Providing information on extent of outages and number of customers under outage to the call centre so that the consumers can be kept updated.
- Updation of estimated time of restoration based on historical data for first cut and then on the basis of crew feedback.
- Advance intimation to customers about outages to the customers in case of planned maintenance outages.

Thus, with the use of integration of various IT and OT modules would facilitate the utilities to be smart and proactive and would increase the satisfaction level of the consumers.
