# A Review on Smart Grid Technlogy.

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***Abstract*—**Traditional power system was divided in to three segments as Generation, Transmission and Distribution, now a day's new generation resources(Distributed Generation, DG) are increasing such as Photovoltaic systems, Wind energy systems, Ocean energy, Direct energy conversion systems etc., by which traditional boundaries between Generation, Transmission and Distribution are disappearing, Distribution can supply local loads and reduce the dependence conventional generation by which carbon foot print was reduced. Traditionally power flow was monitored in one way from generation to consumer which is limited to transmission system only, there is a need to monitor power flow at end consumer also to satisfy customer by supplying quality power round the clock. The generation department has no visibility of distribution generation, in order to manage a grid with distributed generation resources connected at all low voltages in the grid, utilities need a new organizational structures, new skills and operating rules.

The smart grid is the electric grid with advanced automation, control, IT and IoT systems that enables real time monitoring, control of power flows from sources of generation to sources of consumption. Smart grid provide consumer with real time information on their energy usage, support pricing that reflects changes in supply and demand, enable smart appliances and devices to help consumer exercise choices in term of usage of energy. In smart grid technology who owns small distributed generation becomes prosumer (producer + consumer)

*Keywords—Distribution generation, Smart grid, carbon foot print, prosumer*

## I. INTRODUCTION

Smart grid is a sophisticated, digitally enhanced power system where the use of modern communications and control technologies allows much greater robustness, efficiency and flexibility than today's power systems [1]. Smart grid allows utilities to supply electricity for consumers using two way digital technology which enables more efficient management of consumers and utilization of grid effectively and detect faults in a self healing process.

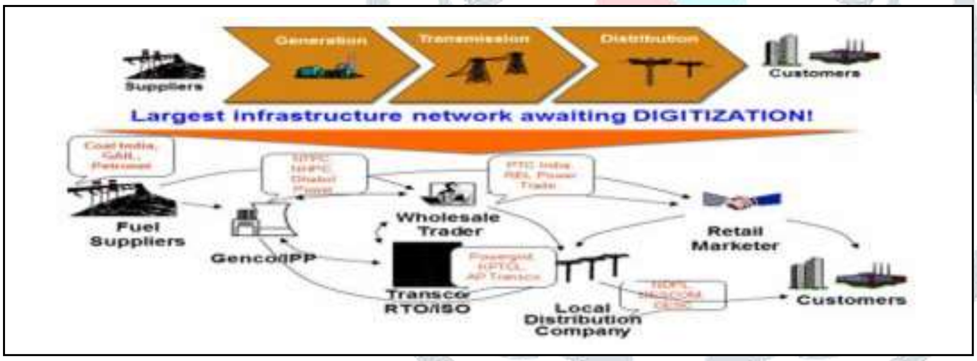


Figure 1: Structure of Traditional Grid

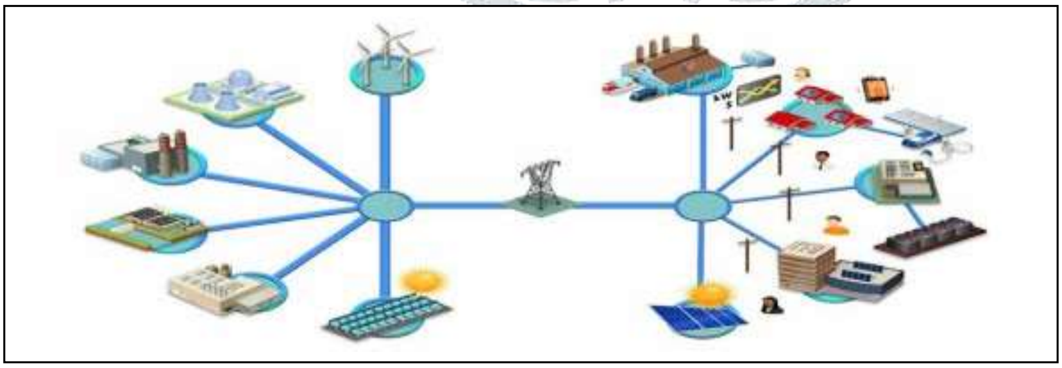

Figure 2: Picture of the emerging Integrated Grid

With the increasing share of generation resources being added at the distribution end, the traditional boundaries between generation, transmission and distribution are fast disappearing. With consumers becoming prosumer the grid that is built for one way flow of electricity is now facing bidirectional flow of electrons. With decreasing cost of energy storage solutions, there is already a debate on whether to invest in Transmission or in storage – the choice between "Generation + Transmission + Distribution" and "Distributed Generation + Storage + Distribution" is becoming real. This is even more relevant in regions where T&D losses are very high as with distributed generation there are fewer network Losses.

## II.DRIVERS FOR SMART GRID

Key drivers for smart grids for different stakeholders are:

### A. UTILITIES:

• Reduction in Aggregate Technical and Commercial (AT&C) losses
• Peak load management – multiple options from direct load control to price incentives to customers
• Reduction in power purchase cost
• Better asset management
• Increased grid visibility
• Self-healing grid- faster restoration of electricity after fault or disturbances
• Renewable energy integration

### B. CUSTOMERS:

• 24x 7 Powers for All
• Improved reliability of supply to all customers – no power cuts, no more DG sets and inverters for back up
• Improved quality of supply – no more voltage stabilizers
• User friendly and transparent interface with utilities
• Increased choice for customers – including green power
•. "Prosumer" enablement – can produce own electricity and consume or sell
• Options to save money by shifting loads from peak hours to off-peak periods

### C. GOVERNMENTS AND REGULATORS:

• Satisfied customers
• Financially sound utilities
• Tariff neutral system upgrade and modernization

## III.SMARTGRID COMPONENTS FOR TRANSMISSION

The EHV transmission networks above 110kv are smart enough with automation and communication systems for system operations. EHV systems are using SCADA (Supervisory control And Data Aquisisation) and EMS (Energy Management System) to monitor and control real time power flow by using communication networks between generating stations, control centers and EHV substations

**SCADA** require dedicated and reliable communication systems between various field devices (RTU) and the Master Station. Traditionally electric utilities used Power Line Carrier (PLC) communications in the past. The analog PLC could support limited bandwidth. PLC based SCADA are still in operation in many places.
Other communication options for SCADA are:
• Fiber Optic Cables (optic fiber ground wire or OPGW can be used as earth wire on EHV lines)
• Microwave Communication
• Satellite Communication
• PSTN or public telecom network can also be leveraged by leasing dedicated communication links from telecom operators (MPLS networks)

**Energy Management System (EMS**) is a set of computer-aided tools used by electric grid operators to monitor, control, and optimize the performance of the generation and/or transmission systems.

**Functions of EMS**

• Real time network analysis and contingency analysis
• Study functions like power flow, power factor, security enhancement etc
• Real time generation functions – allows the operator to monitor, analyze and control real time generation and automatic generation control (AGC)
• Economic dispatch - helps the dispatcher to determine economic base points for a selected set of units
• Reserve monitoring for calculating spinning reserve, operating reserve and regulating reserve
• Production costing – calculates the current cost of generating power of online units
• Load forecasting

• Transaction scheduling

**Advanced functionalities:**

• Enhanced grid reliability
• Increased grid capacity
• Advanced contingency awareness

**WIDE AREA MONITORING SYSTEM (WAMS)**

With the deployment of phasor measurement units (PMU), fast and accurate measurements from grid equipment are possible. Real-time wide area monitoring applications have strict latency requirements in the range of 100 milli-seconds to 5 seconds. A fast communication infrastructure is needed for handling the huge amounts of data from PMUs. Smart grid applications are designed to exploit these high through put real-time measurements. While SCADA data is collected in 1-5 seconds, PMU data is captured in milliseconds. SCDA data has no time stamps but PMU data is accurately time stamped. While SCADA is like an X-Ray, PMU Data is like an MRI

## IV.SMART GRID COMPONENTS FOR DISTRIBUTION

The distribution level is of two types, namely primary distribution 33kv/11kv and secondary distribution at 415/230v, in traditional distribution system there is less control and monitor of power flows, by which it is impossible to detect the power outages, faults, theft. To supply reliable power for customers at distribution level the following are the important automation and control features at distribution level.

A.SCADA AND DISTRIBUTION MANAGEMENT
SYSTEM (DMS)

In EHV transmission systems Remote Terminal Units (RTUs) are installed at substations, in case of distribution systems apart from SCADA, Field Remote Terminals (FRTUs) are installed at power transformers and distribution transformes.DMS is a computer software application that controls terminal equipment remotely.

B. DISTRIBUTION AUTOMATION

Distribution Automation (DA) refers to various automated control techniques that optimize the performance of power distribution networks by allowing individual devices to sense the operating conditions of the grid around them and make adjustments to improve the overall power flow and optimize performance. In present scenario, grid operators in centralized control centers identify and analyze their power system manually and intervene by either remotely activating devices or dispatching a service technician. DA can be a critical component in outage prevention. The sensors and communications associated with DA can provide early detection of the devices that might not be working properly, thus allowing the utility to replace those devices before an outright failure occurs. DA is considered the core part of a smart grid, interacting with almost all other smart grid applications and making the grid more efficient and reliable.
DA helps enable renewable energy (RE) by dynamically adjusting distribution controls to accommodate variability, power ramping and bi-directional power flows. At the heart of the Distribution Automation is SCADA/DMS. Other key components of DA are Remote Monitoring Unit (RMU), Sectionalizer, Reclouser, Fault Locator and Capacitor Banks.

**C.SUBSTATION AUTOMATION**

Substation Automation (SA) system enables an electric utility to remotely monitor, control and coordinate the distribution components installed in the substation. SA has been focused on automation functions such as monitoring, controlling, and collecting data inside the substations. SA overcomes the challenges of long service interruptions due to several reasons such as equipment failures, lightning strikes, accidents and natural catastrophes, power disturbances and outages in substations. Main component of SA is digital (or numeric) relays and associated communication systems which can be operated remotely.

**D.ADVANCED METERING INFRASTRUCTURE (AMI)**

Advanced Metering Infrastructure (AMI) or Smart Metering comprises of Smart Meters, Data Concentrator Units (DCUs)/gateways/routers/access points, Head End System (HES), Meter Data Management System (MDMS) communicating over bi-directional Wide Area Network (WAN), Neighborhood Area Network (NAN)/Field Area Network (FAN) and Home Area Network (HAN). Multiple smart meters can connect to
a DCU/gateway/router/access point which in turn send aggregated data to the HES. The smart meter can also directly communicate with the HES using appropriate WAN technologies (for example GPRS sim cards in the smart meters can directly send data to the HES on servers in the control room). The Meter Data Management System (MDMS) collects data from the HES and processes it before sharing with billing system and other IT applications. Appliances such TV, fridge, air conditioners, washing machines, water heaters etc can be part of the Home Area Network (HAN). At the heart of AMI, is the Smart Meter. The key features that make a meter 'smart' are the addition of a communication module capable of two-way Machine to Machine (M2M) communications and a remote connect/disconnect switch. A smart meter is an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing. Smart meters enable two-way communication between the meter and the computers in the utility control centre. Smart Meters usually have real-time or near real-time sensors, power outage notification, and power quality monitoring features.

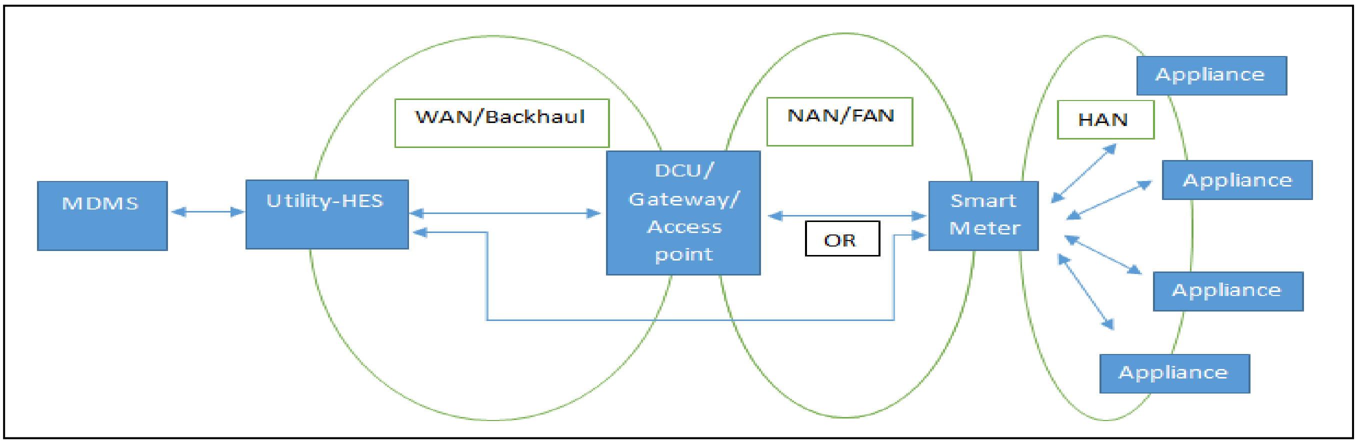


Figure 3: Typical Architecture of AMI

In-Home display (IHD) is a device kept in the customer's premises that could display meter data and get confirmation from the consumer regarding his/her participation in a demand response program. Hence consumers will become informed and conscious. However, with the rise of the smart phone applications or 'apps', customers would not require IHDs at their homes. A smart phone can work as an IHD and hence the utility or customers need not invest in IHDs.

## E.GEOGRAPHICAL INFORMATION SYSTEM (GIS)

By using GIS all the utility assets, critical loads, automated vehicle location, weather conditions in particular locality can be identified easily and necessary action can be taken to restore supply by minimizing response time by which economy loss can be avoided at distribution end. In the process smart meter plays a key role by sending power outage locations. Whenever a new asset is added or removed or a new customer is given connection or an existing customer is removed, that information must be captured in the GIS map so that it remains up to date.

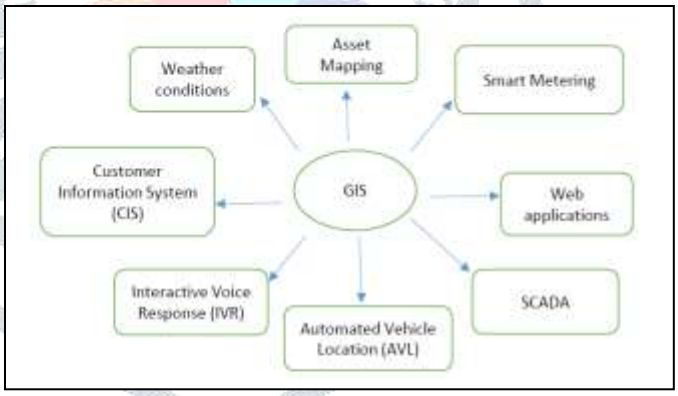


Figure 4: GIS Functionalities

## V.COMMUNICATION SYSTEMS FOR SMART GRID

In smart grid two machine to machine communication systems can be used to monitor and control power flow in the low voltage grid till the end consumer. M2M communication uses a device (sensor, meter etc.) to capture an 'event' (motion, video, meter reading, temperature etc.), which is relayed through a network (wireless, wired or hybrid) to an application (software program) that translates

the captured event into meaningful information. M2M is a subset of Internet of Things (IoT) in which every 'thing' such as electricity, gas and water meters, appliances such as television, refrigerator, air conditioner etc., street lights, security cameras, vehicles, dustbins, etc. are connected to a telecommunications network. Besides M2M, IoT includes Human-to-Machine communication (H2M) and Machine-to-Human communications (M2H) also.

## VI. ELECTRIC VEHICLES AND STORAGE SYSTEMS

Now a day's automobile in changing its phase to build the eco friendly vehicles, in the process electric vehicles are evolved and large improvement is needed to improve its performance. These electric vehicles play a key role in smart grid, generally these vehicles are to being charged at evening hours which causes sudden increment in the load, and this can be avoided by scheduled charging plans during non peak hours. Moreover the electric vehicles can be used as storage devices, the stored energy can be availed during peak hours or supplied back to grid and can be profited. The

Process reduces the burden on generating stations, transmission and distribution systems by which systems and devices can be protected by avoiding peak load operation, which also avoids huge investment on new generating stations.

Other storage systems such as flywheel, sensible and latent heat systems, SMES (Super conducting magneto energy storage systems can be utilized to avoid peak load operations on the grid. These storage systems are to be installed at different locations in distribution network and can be owned by public sector, private or individual customer which becomes a business practice.

## VII.STANDARDS FOR SMART GRID

If all the equipment required for design and implementation of electric is supplied single vendor there will be no problem of coordination during operation and communication between devices. If different vendors supply equipment there is requirement of standard operating conditions in each sector like peak values, communication requirements etc.,.these standards are designed by standards development organizations(SDOs). The important standards are

- IEEE1547 (Interconnection of DGs)
- IEEE1547.1(Test procedures for Interconnecting equipment)
- IEEE1547.2(Interconnection of Resources)
- IEEE1547.3(Guide for Monitoring, Information exchange and Control)
- IEEE C37.118.1(Measurement definitions and Requirements)
- IEEE C37.118.1 (Data Communications and Structures).

## VII.CONCLUSION

This paper reviews the importance and necessity of smart grid technology, implementation method, challenges and benefits. The paper discusses important components required at transmission and distribution stages, storage systems, importance of electric vehicle in grid. Also reviewed communication techniques for smart grid and standards that are used at different stages.

## VII.ACKNOWLEDGMENT

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