Smart Grids to improve Power Scenario of Transmission & Distribution Sectors in India

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ABSTRACT: Energy losses in India's transmission and distribution sector exceed 30%, which is one of the highest in the world. The real challenge in the power sector in India lies in managing the upgrading of the transmission, distribution and metering sector efficiently. To meet ever increase in demand supply gap, high level of losses, untapped enormous renewable energy potential and lack of automation for power Transmission & Distribution there is need for implementing Smart Grid technologies. This paper studies issues & Challenges in Indian Transmission & Distribution Network, Blackouts – Major Reasons & methods to overcome it.

This paper aims to discuss the smart grid devices, technology utilize & its allied software. Smart Grid on different aspects such as, Advanced Metering Infrastructure (AMI), Outage Management System (OMS), Peak Load Management System (PLMS), Renewable Energy (RE) Integration etc. Smart grid Technology is used to achieve advanced asset management (AAM), which can enhance asset utilization, efficiency and improve system reliability. Electrical equipment maintenance is one of the most important tasks in asset management. Various methods of on-line condition monitoring of electrical equipments with the development of computers, sensors and other advanced monitoring technologies, conditions of overhead lines can be consistently monitored and condition-based maintenance (CBM) can be implemented. Paper presents use of smart Grid technologies for various maintenance techniques which improves performance of power system..This paper also shows implementation of Smart Grid pilot projects in India.

KEYWORDS: *Advanced asset management (AAM), Advanced Metering Infrastructure (AMI), Blackouts, condition-based maintenance (CBM), equipment maintenance, Independent Power Producers (IPPs), Micro-power producer (MPPs), on-line condition monitoring, Outage Management System (OMS), Peak Load Management System (PLMS), Renewable Energy (RE), Smart Grid Technology, system reliability, technical evaluation.,*

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I. INTRODUCTION

Smart grid technology will bring solutions to all of the problems Indian power system is facing like high AT&C Losses, poor distribution network, wide demand supply gap of energy, poor asset management etc This can be achieved with distribution system improvement through smart grid technologies [1- 2]. It is found that by transmitting power up to high KVs the power handling capacity increases with more power to be transmitted over large distance. Efficient utilization of available infrastructure & reduction of losses in a transmission System can improve the performance of existing lines. The economic advantage is also linked with reduction in losses. Renovation, Modernization and up gradation of existing projects is one of the cost effective alternatives to increase the power transmission capabilities. [1,7].

Smart Grid enables real time monitoring and control of power system as well as helps in power quality management, outage management, smart home energy system etc. Smart Grid will act as a backbone infrastructure to enable new business models like smart city, electric vehicles, smart communities apart from more resilient and efficient energy system and tariff structures. In this way Smart Grid technology shall bring efficiency and sustainability in meeting the growing electricity demand with reliability and best of the quality [3, 8]. Loading on transmission lines may have to be restricted keeping in view the voltage stability, angular stability, loop flows, load flow pattern and grids [4]. As per Govt. of India policies, National Missions is Restructured Accelerated Power Development and Reforms Programme (R-APDRP), AT&C loss reduction, Adoption of information technology in the areas of energy accounting, consumer care and strengthening of Distribution network of State Power Utilities [5]. The transmission lines are operated in accordance with Regulations/standards of Central Electricity Authority (CEA) / Central Electricity Regulatory Commission (CERC) / State Electricity Regulatory Commissions (SERC) [6]. It is expected that the deployment of PMUs in the Indian grid will continue at an accelerated pace to realize a smarter national grid [10].Smart grid and its allied technologies may be utilized to improve the power scenario in the country by a) Consumption Monitoring and Detection of Tampering b) AT & C Loss Reduction and Efficiency Improvements c) Access to Energy for the Masses d) Renewable Energy Integration into the Grid e) Peak Load Management thorough Demand Forecasting f) System Improvements and g) Outage Management and Customer Service [15]. Indian power system network faces various challenges such as hybrid transmission system for maintaining critical parameters, increase in MW flow per meter of Right of Way, controlling high Short Circuit Levels, Nondiscriminatory Open Access, Integration of upcoming wind and solar generations, integration of upcoming Independent Power Producers (IPPs) and Micro-power producer (MPPs), integration of dispersed generation etc. To meet these challenges for maintaining the grid security, reliability and stability under various operating scenarios monitoring by establishment of supervisory control & data acquisition system [17]. Smart Grid pilots for different stakeholders (including Utilities, Consumers, Government and Regulators) in India [18].Thus Paper studies the smart grid equipment & its technologies.

II. INDIAN POWER SCENERIO

Present Power Scenario in India having all India Installed Capacity (in MW) of Power station is 2,88,664.97 MW [6]. The vision statement of the Ministry of Power as per the RFD document follows: "Reliable, adequate and quality power for all at reasonable prices" [3]. Power System Operation Corporation Limited (POSOCO), is managing the National and Regional grid from National Load Despatch Centre (NLDC) and its five Regional Load Despatch Centres (RLDC) through state-of-the-art unified load dispatch & communication facilities [4]. Integration of Renewable Energy Resources with conventional sources is a top priority worldwide and special attention is being given in our country to harness the Green Energy. CERC has provided a framework for trading in Green Certificates (Renewable Energy Certificates or RECs) and National Load Despatch Centre (NDLC) of POSOCO has been designated as the Central agency for this purpose [2]. India's transmission and distribution losses are among the highest in the world, averaging 30% of total electricity production, with some states as high as 50%. When nontechnical losses such as energy theft are included in the total, average losses are as high as 40%. The financial loss has been estimated at 1.5% of the national GDP, and is growing steadily [19]. All the State-of-the-Art Load Despatch Centres in the country having SCADA / EMS have been established by POWERGRID 1,28,200 ckt kms of transmission lines at 800/765kV, 400kV, 220kV & 132kV EHVAC & +500kV HVDC levels and **206 sub-stations.** Also the transformation capacity of about **2,49,578 MVA** as on 29th February 2016 [8]. Implementation of RAPDRP (Restructured Accelerated Power Development & Reform Program) program for power distribution utilities across the country for preparation of baseline data for each project covering Consumer Indexing, GIS Mapping, Metering of all DT (Distribution Transformer) and substation Feeders, and also automated data logging for all DTs, Feeders and SCADA(Supervisory Control and data Acquisition) /DMS (Distribution Management System) for energy auditing /accounting and IT based consumer service centre [19].

11. T& D and AT&C Losses (%)

	2010-11	2011-12	2012-13	2013-14
T&D Losses	23.97	23.65	23.04	21.46(P)
AT&C Losses	26.35	26.63	25.38	22.70(P)

Note: As per PFC for utilities selling directly to consumers P: Provisional

Table No.1.T & D and AT & C Losses [19].

III. Issues & Challenges in Distribution Network

1. Poorly planned distribution networks
2. Overloading of system components
3. Lack of reactive power support and regulation services
4. Low metering efficiency and bill collection
5. Power theft

IV. Issues & Challenges in Transmission Network.[1]

1. **Right Of Way**

The most notable and challenging issue of the transmission sector is the need of the hour to develop high intensity transmission corridor (MW per meter ROW) in an environmental friendly manner including protection of flora and fauna.

2. **Regulation of Power**

Another important aspect is the need towards regulation of power flow due to wide variation in demand on day as well as seasonal basis and change in the drawl pattern/shares of the utilities from time to time.

3. **Flexibility in Line Loading**

To handle more power as well as to optimize the use of transmission corridor, it is important to load the different lines in Controlled Series Capacitors (TCSC) and similar other means is an effective method.

4. **Improvement of Operational Efficiency**

Power system is required to be operated at the rated capacity with security, reliability and high availability. This can only be achieved through reliability based on-line condition monitoring, repair and maintenance in advance and making forced outage as zero.

5. **High Density Transmission Corridors**

In view of the above, key technological requirements for development of future power system are upgrading/up-rating of existing transmission system, technology suitable for bulk power transfer over long distances like high capacity EHV/UHV AC system, HVDC system, compact tower/substation, mitigating devices to address high short circuit level, intelligent grid etc. POWERGRID.

V. Methods to minimise issues & challenges [7]

In order to optimize right-of-way high density transmission corridors (MW per metre ROW) either by increasing voltage level, current order or both i.e. increase in voltage and current are need to be developed.

1. **Increase in transmission voltage:** Power density of transmission corridors (MW per meter ROW) is being enhanced by increasing the voltage level. Increasing the AC voltage level at 1200kV level has been planned. Research work for 1000kV HVDC system has also been commenced.

2. **Up gradation of transmission line:** Upgradation of 220kV D/C Kishenpur- Kishtwar line in J&K to 400 kV S/c, which was first time in India.

3. **Up gradation of HVDC Terminal: Up gradation of Talcher (ER) –** Kolar (SR) 500kV HVDC terminal from 2000MW to 2500MW has been achieved seamlessly without changing of any equipment. That has been achieved with enhanced cooling of transformer and smoothing reactor with meagre cost.

4. **High capacity 400kV multi-circuit/bundle conductor lines:** POWERGRID has designed & developed multi circuit towers (4 Circuits on one tower with twin conductors) in-house and the same are implemented in many transmission systems, which are passing through forest and RoW congested areas e.g. Kudankulam and RAPP-C transmission system.

5. **High Surge Impedance Loading (HSIL) Line:** In order to increase the load ability of lines development of HSIL technology is gaining momentum.

6. **Compact towers:** Compact towers like delta configuration, narrow based tower etc. reduce the space occupied by the tower base are being used.

7. **Increase in current: High Temperature Low Sag (HTLS) conductor line:** High temperature endurance conductor to increase the current rating for selected transmission corridors and urban/metro areas.

8. **Reduction in land for substation:** With scarce land availability there is a growing need for reduction of land use for setting up of transmission systems, particularly in Metros, hilly and other urban areas. Gas Insulated Substations (GIS), requires less space (about 70% reduction) i.e. 8-10 acres as compared to conventional substation which generally requires 30-40 acres area.

VI. Blackouts – Major Reasons in India [11].

On 30th July 2012 at midnight at 02:33 hrs. in the Northern region and On 31stJuly at 13:00 hrs. in North, East & North East Regions resulting in collapse of 48000 MW of power have distinct similarities in the development of cascading events leading finally to grid collapse [17]. The prevention of such blackouts requires elaborate plans for protection and emergency control which may be achieved only by strengthening the existing protection and control infrastructure. The real time information will be used to identify and calculate security margins and indices. It will facilitate early detection and monitoring of system security, prediction of emergency states and initiating restorative actions to avoid instability [10].

1. Depleted transmission network - Power swing - inadequate transmission lines - congested network.
2. Over drawls attributable to frequency control through commercial signals - Low frequency - Generation loss, inadequate defence mechanism.
3. Non-compliance of directions of LDCs and Regulatory Commissions.
4. Low Voltage - Inadequate Reactive Power.
5. Protection System Issues.
6. Lack of Visualization of power system.
7. Inability to control flow on 400 kV Bina-Gwalior-Agra line.

VII. Techniques to overcome Blackouts [11]

1. Primary response from generators.
2. Improvement in operational efficiency - Optimum utilization of available assets.
3. Operation of defense mechanism.
4. Regulation in Power Flow - Autonomy to Load Despatch Centres.
5. Intra-State transmission Planning and its implementation.
6. Dynamic security assessment and proper state estimation.
7. FACTS devices: With electricity market opening up further, more and more need has been felt to utilize the existing assets to the fullest extent as well as regulate the power. This could be possible through use of power electronics in electricity network.
8. Condition Based Monitoring:
   POWERGRID has adopted many state of the art condition monitoring & diagnostic techniques such as DGA, FRA, PDC, RVM etc. for transformers, DCRM for CBs, Third Harmonic Resistive current measurement for Surge Arrestors etc. to improve Reliability, Availability & Life Extension.
9. On-line monitoring systems :- for transformers have been implemented to detect faults at incipient stage and provide alarms in advance in case of fault in the transformers.
10. Preventive Maintenance: Preventive State-of-the-art maintenance techniques for various equipment applied in our system includes on line monitoring of various components of transformers and reactors, Circuit Breakers, Instrument transformers, Lightening arrester etc
11. Establishing national grid in the country:-which is one of the largest synchronously operating electrical grids in the world with all its five electrical regions interconnected synchronously.
12. Smart Transmission Grid Implementation
    In Smart transmission, POWERGRID has been implementing Synchrophasor Technology in its Wide Area Measurement System (WAMS), Project through installation of PMUs (Phasor Measurement Units) at different locations in all regions across the country, which facilitates better visualization and situational awareness [2].

VIII. Smart Grid is expected to provide benefits to Utilities & Consumers in the following areas

1. Benefits to Utilities: - [7]

A. Improved Efficiency:- Reduction in transmission and distribution lines losses, Improved load forecasting. Reduction in frequency of transformer fires and oil spills through the use of advanced equipment failure / prevention technologies

B. Improved Economics:- Reduced operational cost, capital cost transmission congestion costs and maintenance (O&M) costs. Increased revenues as theft of service are reduced. Improved cash flow from more efficient management of billing and revenue management processes.

C. Improved Reliability:-Increase asset utilization, improved employee productivity through the use of smart grid information that improves O&M processes, extended life of system assets through improved asset "health" management. Increased employee safety.

D. Improved Environment:- Increased capability to integrate intermittent renewable resources. Opportunity to improve environmental leadership image in the area of improving air quality and reducing its carbon footprint.

Benefits to Consumer: - .

A. . Improved Efficiency:- Higher customer satisfaction, increased asset data and intelligence enabling advanced control and improved operator understanding . Increased capability, opportunity, and motivation to be more efficient on the consumption end of the value chain.

B. Improved Reliability:- Improved level of service with fewer inconveniences, Reduced out-of-pocket costs resulting from loss of power. Opportunity to interact with the electricity markets through home area network and smart meter connectivity.

C Improved Economics:- Downward pressure on energy prices and total customer bills. Opportunity to reduce transportation costs by using electric vehicles in lieu of conventional vehicles. Opportunity to sell consumer produced electricity back to the grid.

D. Improved Environment:-Increased opportunity to purchase energy from clean resources, further creating a demand for the shift from a carbon-based to a "green economy".

IX. Smart Transmission Grid Equipment Implementation in India

1. Phasor Measurement Unit & Wide Area Technology in Power System Operation

1.1 WAMS (Wide Area Measurement System)

WAMS technology requires installation of hundreds of PMUs in each region and reliable communication network with very high band width and with least latency. Phasor data concentrators (PDC) are to be installed at National, Regional and major State Load Despatch Centre (in states having 400 kV transmissions system) [7]. Availability of PMU at strategically located 400 kV/ 765kV sub-stations / power stations and a robust fiber optic communication network will facilitate situational awareness (especially dynamic state of the grid in terms of angular stability and voltage stability), control and regulation of power flow to maintain grid parameters. Remedial action scheme (RAS), system integrated protection scheme (SIPS) and identifying corrective actions to be taken in the event of severe contingency to prevent grid disturbances. The process for installation of PMUs has already been started. Eight (8) PMUs (at Moga, Kanpur, Dadri and Vindhyachal in first phase and Agra, Bassi, Hisar and Kishenpur in second phase) have already been commissioned in the Northern Region and proposal for installation of PMUs in other regions is also in the pipe line [2]. The synchronized measurement from phasor measurement units known as Synchrophasors and the network of PMUs is known as WAMS (Wide Area Measurements System).

1.2 Advantages of PMU &WAMS technology

- Optimize Network Capabilities
- Accelerate the operators decision
- Avoid possible cascading effect
- Provide detailed Knowledge of system Behavior
- Improved assessment of the state of the system

ISSN: 2321-8169
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– System can be operated closer to its limits (Increased transmission capabilities)

1.3 Implementation of Technology.

For Validation of the dynamic model of the system following technology are used. Phasor Measurement Units (PMUs) is a promising tool to monitor modern electric power systems as well as to identify and respond in deteriorating or abnormal grid conditions more quickly[9].

1. 4. Role of PMUs In Indian Smart Grid

A. Reducing the Threat and Scope of Blackouts.
B. State Measurement.
C. Increasing the Transmission Line Capacity.
D. Calibration of Instrument Transformers.
E. Integration of Renewable Resources.

1.5 WAMS system Analysis

a)Post event analysis,
b) On-line system monitoring and enhancement to state estimation,
c) Wide area control,
d) Wide area protection.

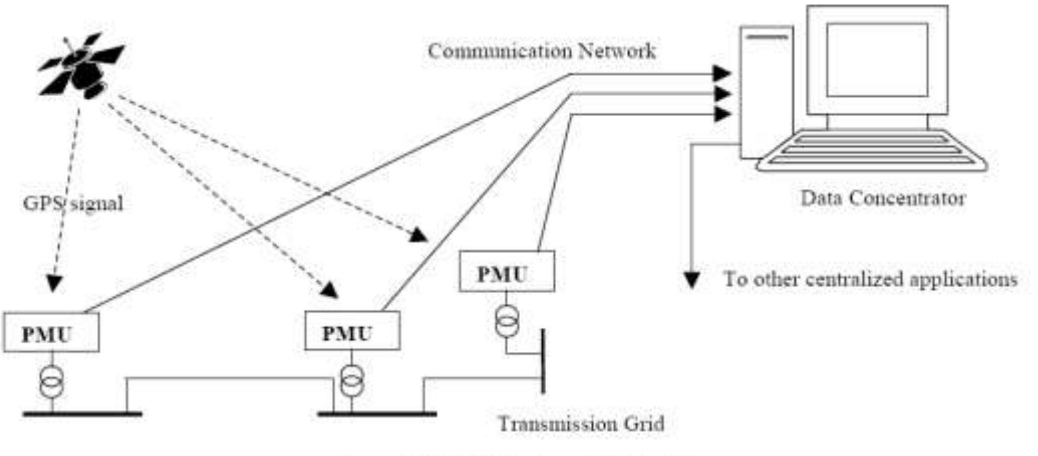

Figure 1: WAMS System Architecture

Fig.1. WAMS Systems Architecture ArchetectureArchetecture

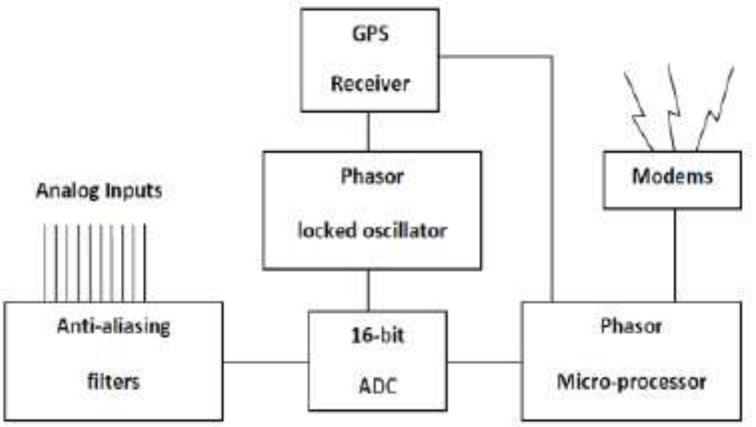

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Fig.2. Components of a Phasor Measurement Unit

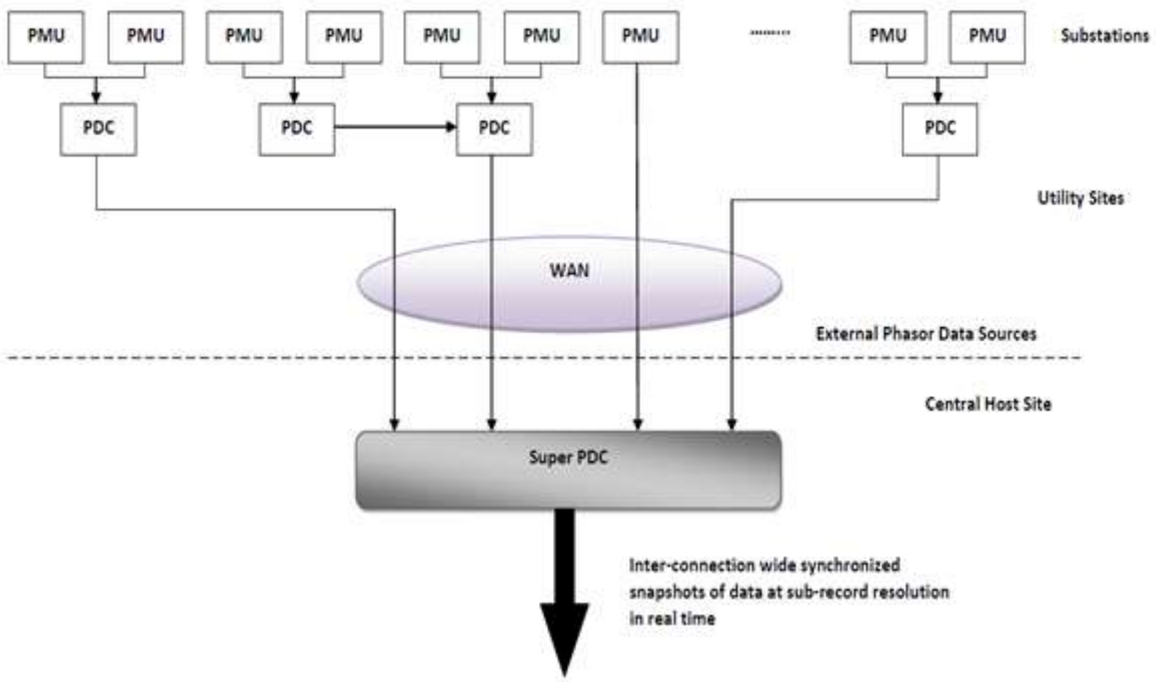

Fig.3. PMU Based Wide Area Measurement System

State estimation(SE) function utilize telemetered measurements of generator bus voltages, power injection at system buses, real and reactive line flows, circuit breaker statuses, and transformer tap settings etc. to generate an optimal estimate of the system state. As per the standard for communication data for PMU [6], an IEEE C37.118 messaging consisting of one 3 phase voltage Phasor, two 3 phase Current Phasors, frequency, Rate of change of Frequency and eight digital signals need a bandwidth of around 48.8 kbps at sampling rate of 50 samples per second. The Fiber Optic network is to be made available at all those substations and power plants where PMUs are to be installed [17].

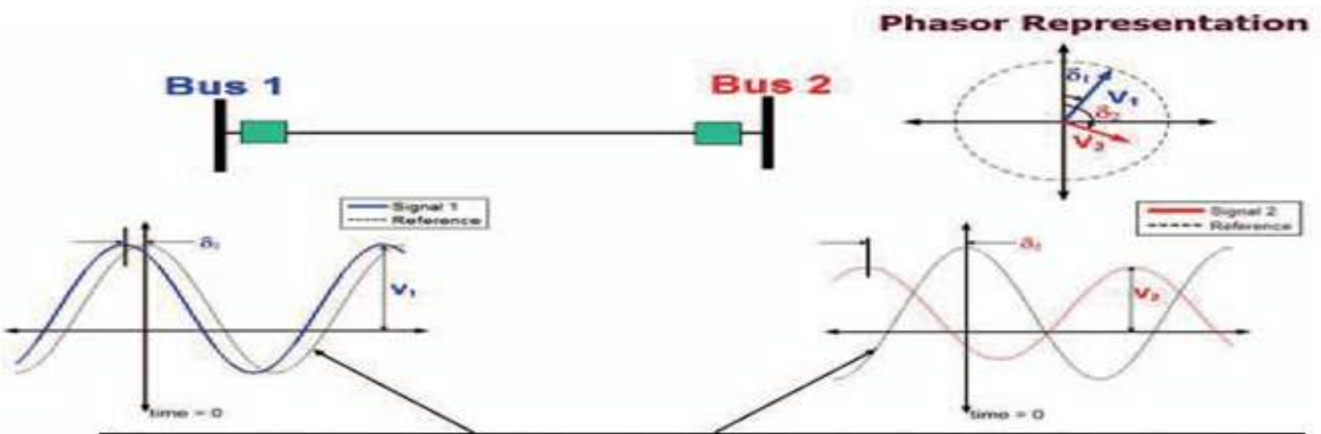

Fig.4.Common Reference Signal at remote locations due to GPS Synchronization

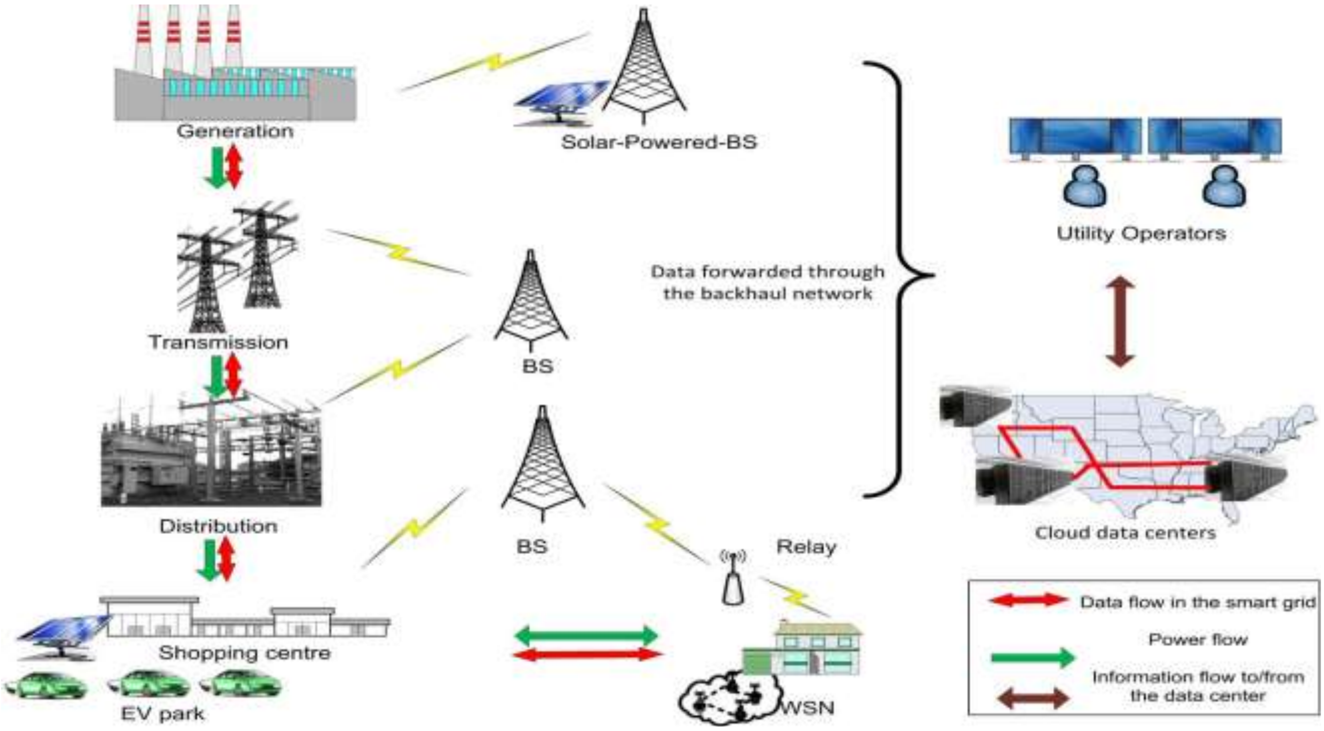

Fig.5. Smart grid, wireless wide area solutions and Internet data centers.

1.6. Typical Synchrophasor/WAMS installation

Synchrophasor measurements are provided by PMU (Phasor measurement units) which enable us to understand the dynamic behavior of the Power System. Synchrophasor is modern technology for indication of stress on transmission, and can be used to trigger corrective actions to maintain reliability [9]. Monitoring the power flow is essential since excessive flow towards one direction may un stabilize the power grid while time synchronization provides a complete view of the grid at a specific time for interconnections covering multiple time zones[16]. The phase angle of a synchrophasor is governed by the waveform, the system frequency, and the instant of measurement. Thus, with a universal precise time reference, power system phase angles can be accurately measured throughout a power system. The global positioning system (GPS) technology provides an economic option for the same. An important advantage of the GPS technology is that its receiver can automatically detect accurate synchronization [10].

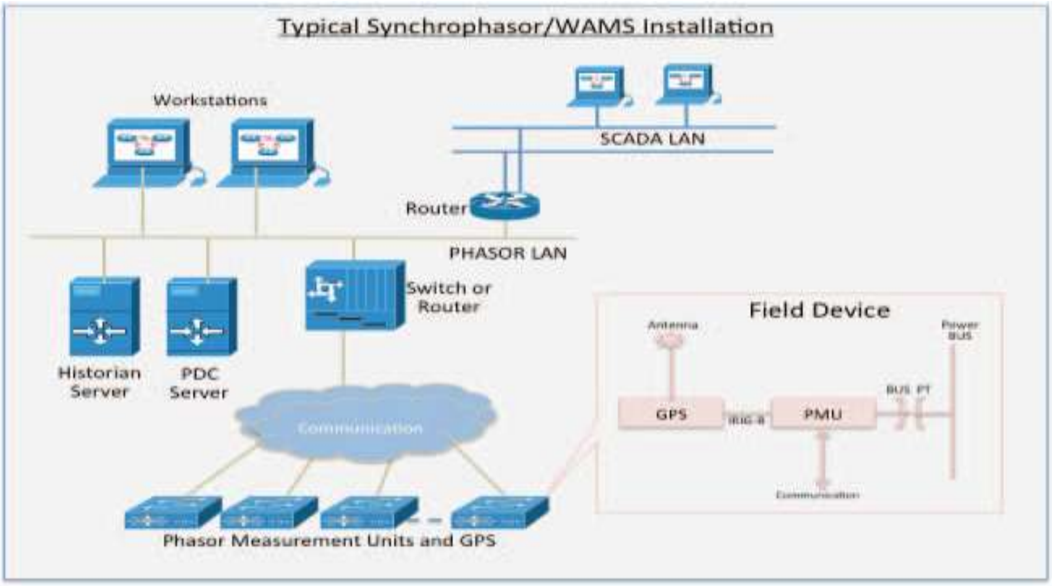

Fig.6. Typical Synchrophasor/WAMS installation

The angular difference is known as load angle. Synchrophasors can be used for self healings . Presently usage of Synchrophasors data in real time is limited for post event analysis & situational awareness etc and its use in Protection & Control is still under development. To bring down outage duration and ensure reliable supply to consumers, Outage Management System (OMS) having Distribution Transformer Monitoring Unit (DTMU) and Fault Passage Indicators (FPI) have also been installed integrated with Smart Grid Control Center. DTMU monitors various parameters of distribution transformers (DT) like oil level, oil temperature, load current, voltage, harmonics, palm temperature etc. on real time [19]. For integration of distributed generation in the form of roof top solar & integration into grid, net metering has been implemented in the premises of two different types of consumers' i.e. residential consumer and academic Institute in the Puducherry Project area.

Puducherry Smart Grid Pilot Project has not only been found to be very useful in understanding the evolving Smart Grid technology but also act as a proof of concept in India. Experts from distribution utilities across the country, regulators and policy makers, etc. are regularly witnessing various smart grid attributes like, AMI, OMS, PLM, net metering, smart street lighting, demand response etc.

1.6.1 Post Event Analysis

- Recording of PMU used to make a post analysis of the system after a major incident.
- This analysis gives a wide area view of the system behavior thus helps in under standing
  - the sequence of events that led to the grid incidents
  - the inter area oscillations, Analyzing the performance of the oscillation damping equipments
    Used by Italy ,NCG, Russia, Korea, France

1.6.2 On Line System Monitoring and Enhancement to State Estimation

- PMU technology improves real time system monitoring, helps in better assessment of the state of the system
- System monitoring covers

A. Monitoring of basic data such as voltage, power flow and frequency for each of the nodes.

B. Monitoring of voltage angle differences between the ends of major lines likely to be heavily loaded (to ensure that they can be easily re closed when a fault occurs).

C. Voltage stability monitoring, i.e. supplying the dispatcher with an estimate of the margins available to the system before a voltage collapse; in such situations PMU measurements can be extremely useful for assessing the dynamic behavior of loads.

D. Transient stability monitoring, i.e. monitoring of possible loss of synchronism between certain system areas.

E. inter-area oscillation monitoring, i.e. detecting the occurrence of any inter-area frequency oscillations, calculating the different modes and their damping.

1.6.3Wide area control

- Can control automatically Power system equipments like PSS, FACTS, SVC, and HVDC controllers.
- Controls can be made based on the wide view of the power system instead of local phenomena.
- Such operation will Increase reliability ,increase transfer capability, require a fast and reliable and secure communication signal should be transmitted in 20 to 50 milliseconds.

1.6.4Wide area protection

- PMU technology can be used for initiating System Protection Schemes.
- Wide area measurements give better understanding of the situation.
- Require a fast and reliable and secure communication signal should be transmitted in 20 to 50 mili seconds

1.7. Wide Area Communications Systems

1. It comprises of the Neighbourhood Area Network (NAN) and the Wide Area Network (WAN). NAN is a localized or regional network of several smart meters in an area aggregating data at a concentrator.
2. The concentrators end data collected from the smart meters to the Meter Data Management Systems (MDMS).
3. Components are AMI Smart Meters, Home Area Networks (HANs) , Wide Area Communications Systems , Meter Data Management Systems (MDMS) & Operational Gateway.

4. Worldwide Interoperability for Microwave Access (WIMAX) and narrowband wireless communications are also among the utilized technologies that allow remote configuration, meter reading and appliance control .
5. The smart grid can be roughly divided into three domains in terms of communication coverage and functionality; Smart Grid Home Area Network (SG-HAN), Smart Grid Neighborhood Area Network (SG-NAN) and Smart Grid Wide Area Network (SG-WAN). SG-HAN is a single residential unit with smart appliances, an energy display, power consumption control tools, storage, solar panels, small-scale wind turbines, electric vehicles and a smart meter.[16].
6. In smart grid, during off-peak hours smart meter data can be collected in a delay-tolerant manner since demand management will be less of an issue.
7. SG-HANs can be implemented by visible light technology which is a fairly new, high data rate communication technology.
8. Data center energy efficiency is generally measured by Power Usage Efficiency (PUE) that is given by:

$$PUE = \frac{\text{IT Equipment energy + Facility Overhead Energy [16]}}{\text{IT Equipment energy}}$$

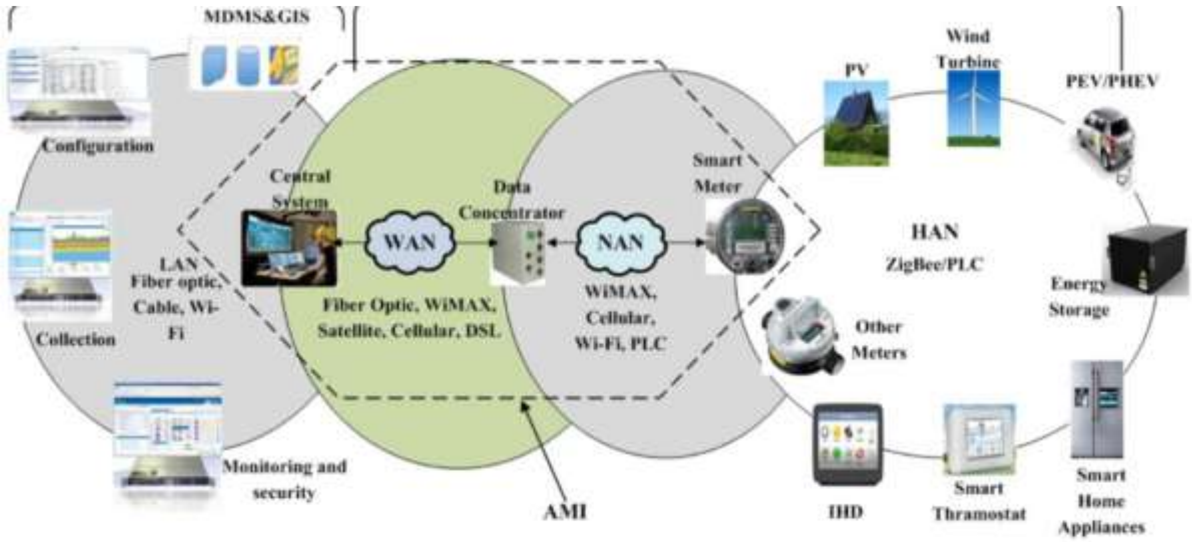

Fig.7. WAMS Communication Systems ArchetectureArchetecture

1.8. Home Area Network (HAN)

Home Area Network (HAN) is a kind of Local Area Network (LAN) that facilitates a two-way communication between smart home devices or appliances (such as heaters, refrigerators, air-conditioners etc.) and the Smart Meter or an in-home display for the benefit of both the consumer and utility. Usage of home area network (HAN) and home energy management system allows the residents to monitor consumption and efficiency across a range of appliances and devices, as such changing the way the consumer participates in the energy consumption [11]. The device communicates with other metering devices and home appliances connected to a HAN (Home Area Network). End-customer device: Appliances that communicate with the hub using a HAN.

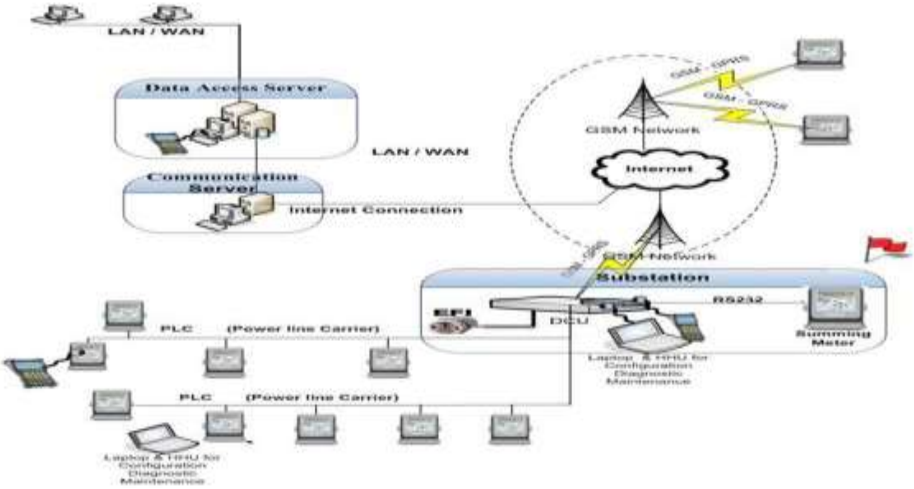

Fig.8. HAN Communication Network

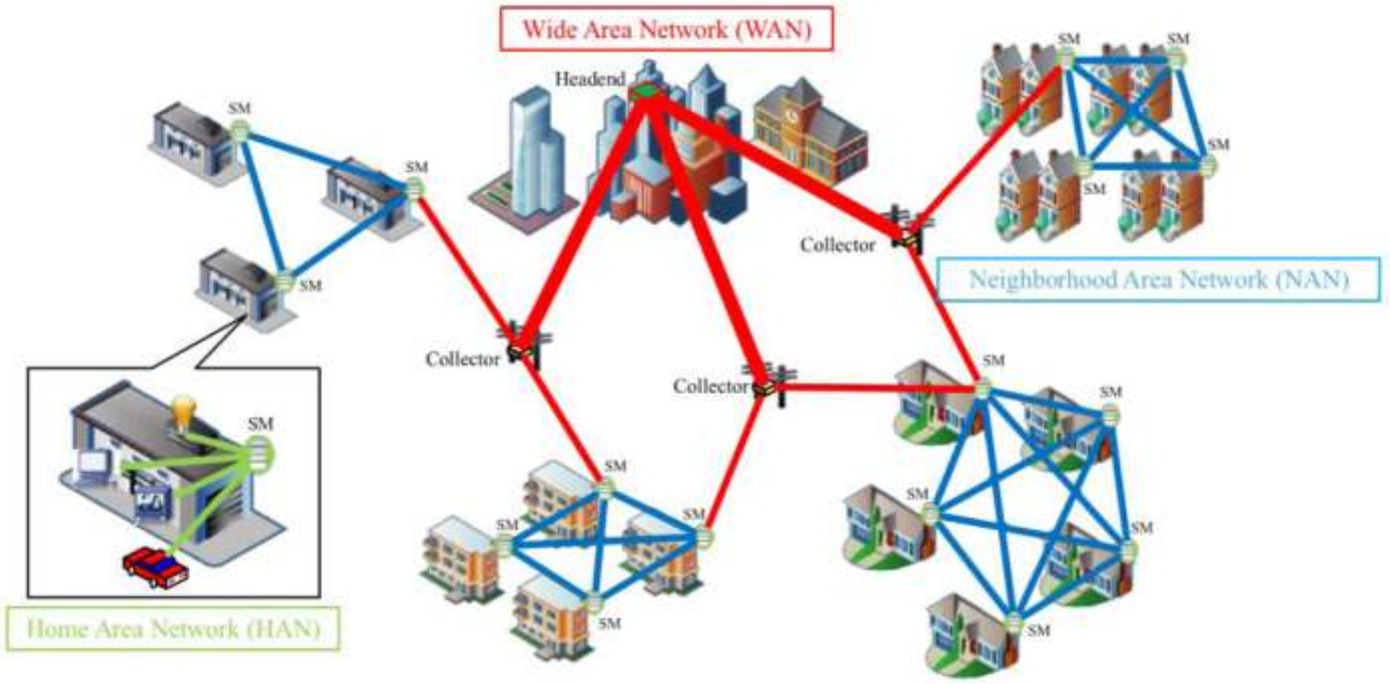

Fig.9.WAN Communication Network

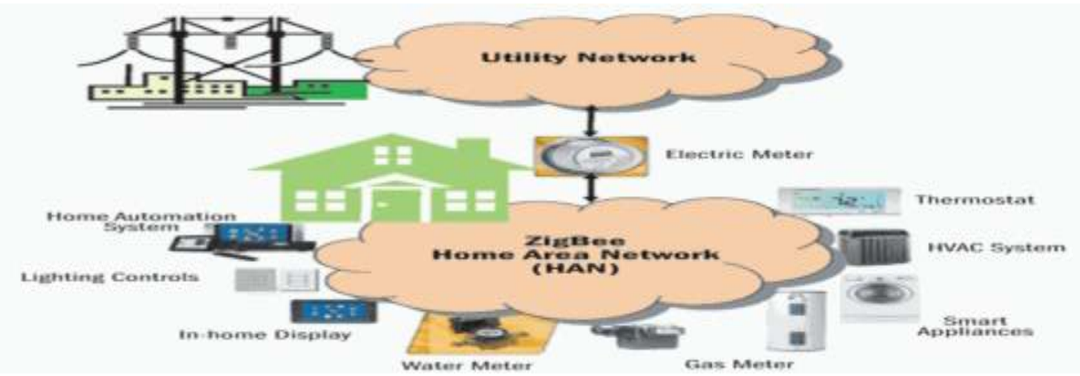

Fig.10. HAN, LAN Communication Network

1.9.Advanced Metering Infrastructure

AMI (Automated Metering Infrastructure) refers to system that measure, analyze and read energy consumption. Different time-variant tariff schemes such as Time-of-use pricing (ToU), Real time pricing (RTP) & Critical peak pricing (CPP) have put requirements on smart meters. AMI communication network necessary to run advanced metering applications can be used to transport data for all kinds of other emerging Smart Grid applications[9].The smart meter responds in keeping track of the energy consumed from the electricity network as well as for the energy injected back into the grid. Smart Meters Store and communicate the requested data as per programmed interval. They can detect, resolve abnormal & tamper events and store the same with alert to control centre. They are remotely configurable remotely including and support remote load management. Smart Metering provides actual and accurate overview of energy consumption for Energy Auditing. Any large differences in the input and consumed energy shall generate alert. One can identify meters with zero / lower than threshold consumption over a customizable time period and to generate reports and investigation requests and take other utility defined actions'

1.9.1. AutomaticMeterReading

The system utilizes several different types of commendations media such as, PLC, RS458, LAN/ WAN, GSM/GPR for AMI

Fig.11. Advance Metering Infrastructure

1.10. Smart Power Management System [14]

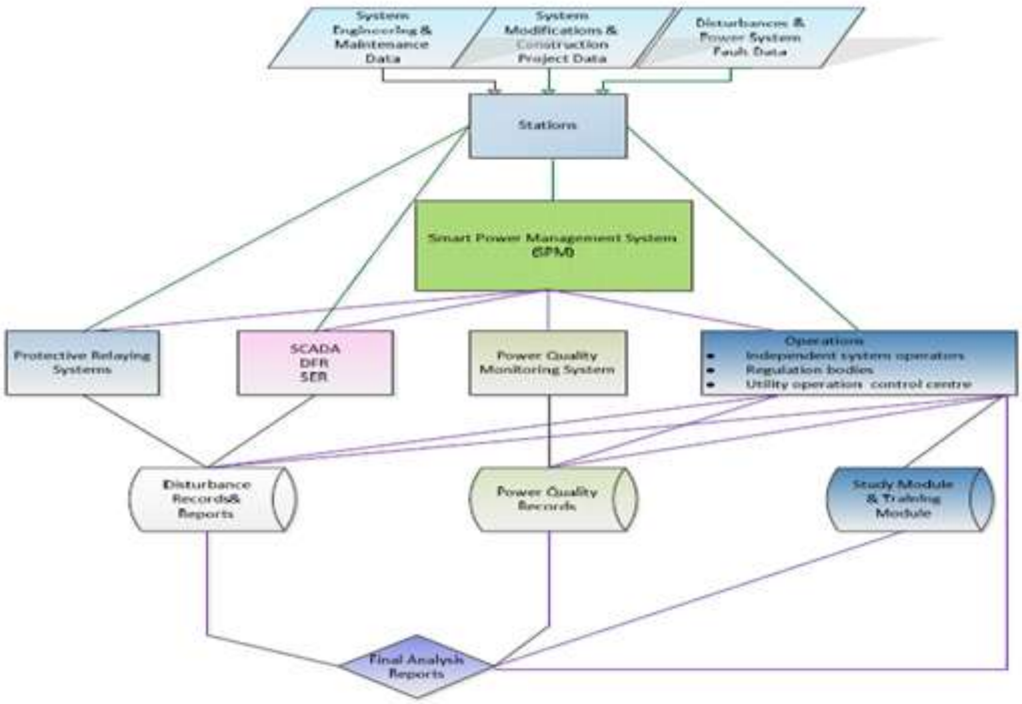

Fig.12. Smart Power Management System Communication Network

1.10.1.The smart grid makes use of technologies that improve fault detection and allow self-healing of the network without the human intervention

1. SCADA (supervisory control and data acquisition system)
2. EMS (energy management system)
3. DMS (distribution management system)
4. GIS (geographic information system)
5. SER (sequence event record system)
6. DFR (digital fault recorder system)
7. Smart metering data
8. Operation event data
9. Power quality (voltage, Frequency)
10. Protection system fault data (fault currents, voltages, phase angles…etc.)
11. Asset management data
12. Demand response
13. Power system operation
14. Operator training
15. Station maintenance data
16. Engineering data

GIS already provides most comprehensive inventory of the electrical distribution network components and their spatial locations. GIS can provide a spatial context to the analytics and metrics of Smart Grid. With GIS utilities can track the metrics over time and provide a convenient means of visualizing trends [19].

1.10.2. Need for fibre optic based communication system: For planning, implementation and maintenance of dedicated high band width, fiber optic communication network is used. For connecting the existing and new substations and power plants under central sector, the mandate should address the communication requirements in power sector in all associated areas such as Smart Transmission Grid, Protection, data, speech, audio/video etc. [8].

1.10.3. Automation

(i) To address the natural calamity, fire in substation, for quick restoration **Emergency Restoration System (ERS)** for substations is necessary. Design and deployment of mobile substation is considered necessary for implementation.

(ii) P**rocess bus technology** over the conventional station bus technology is used. Process bus technology has the advantage of reduction in huge copper wiring, integration of any number of IEDs at bay level etc.

(iii) Demonstration project of IEC 61850 substation automation comprising of both process bus and station bus, along with interoperability.

1.11. System performance improvements by [9].

1. **The condition based maintenance on-line diagnostics techniques will be developed**.
2. **Condition monitoring of polymer insulators** :
3. **Robotic inspection of transmission system:-**
4. **NIFPES:**
5. **Development of controllers for FACTS devices**

1.12. **Advanced Technologies in Transmission[5].**

Gas Insulated Transmission Lines, EHV Cables and Submarine cables. These technologies would help power sector in meeting the projected load demand.

(i) Gas Insulated Transmission Lines: are means for bulk power transfer at EHV/UHV levels. The application of GIL is viable option in densely populated areas or in environmentally sensitive regions, and where application of cables is not possible or reaches technical limits. This uses SF6 tubular conductor technology, which has been around for several decades.

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(ii) **Application of EHV class cables** advantages, such as:
Reduced emission into the surrounding area, of electromagnetic fields and reduced space
(iii) **Application of submarine cable:** For power transmission becomes unavoidable where there is no feasibility of overhead lines. The application of submarine technology in the proposed India – Sri Lanka interconnection as an exploratory project would give big boost to transmission planners.

1.13. The major hurdles for smart grid project implementation are [19]:

- No proven commercial viability for large-scale smart grid roll outs
- Poor financial health of most state-owned T&D companies
- Low awareness of technological developments in the utility sector
- No coordinated national road map for smart grid deployment

1.14. PMUs Pilot Project in the Northern Grid

Phasor Measurement Unit (PMU) along with GPS clock at selected 08 substations in the Northern Region. Phasor Data Concentrator (PDC) and other associated equipment have been installed at Northern Regional Load Despatch Center (NRLDC), New Delhi. The data received from the PMUs has been used for events like the loss of 2000 MW of generation at Rihand on 1st June 2010 etc.[10]

1.15. MUs Installation in the Western Grid

(WAMS) project based on Phasor Measurement Units has been initiated by Power Grid Corporation. This project is aimed at developing algorithms for optimal placement of PMUs and installation of about 25-30 PMUs in western grid.[10]
India is planning to set up Renewable Energy Monitoring Centre's (REMCs) and Energy Storage Systems for grid integration of renewable generation
For power system enhancement, mutually agreed targets between Ministry of New and Renewable Energy (MNRE) and Ministry of Power (MoP) that integration of 30 GW renewable capacity by 2017, 80 GW by 2022, and 130 GW by 2027.

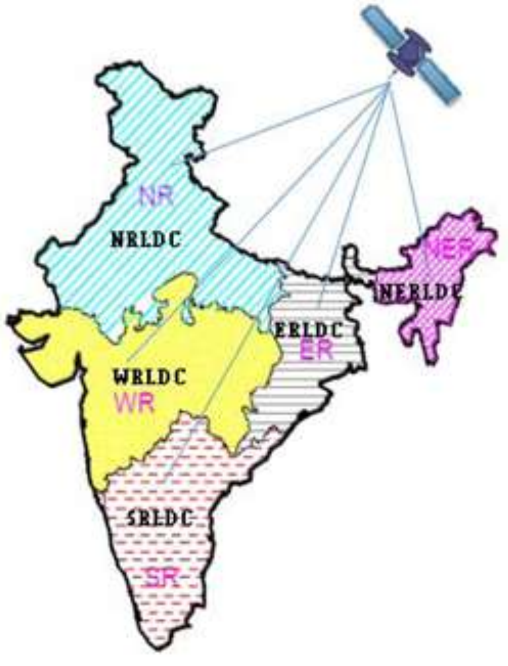

Fig.13. Future WAMS Structure in India.

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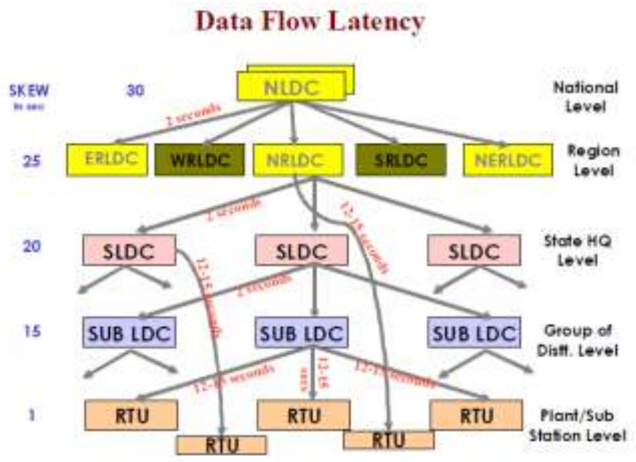

Fig.14. Data flow time in SCADA

TABLE I. INDIAN WMAS VISION

During 12thyear Plan	During 13thyear Plan	During 14thyear Plan
Deployments of WAMS including PMUs by CTU	Enhanced deployments of WAMS at all grid connected generation units and substations	Gas insulated EHV/HV and automated distribution substations in all urban areas by 2027

1.16. CONCLUSION

The paper presents issues & challenges in transmission & distribution systems. Various methods to overcome this issues in Indian Power Strategy is also studied. An overview on reasons of blackouts & possible techniques to overcome this issue is very much useful for implementation of smart grid study, hence discussed. This paper studied. Benefits of smart grid technology & its associated equipments with its characteristics, function & operation also studied. Some other advance techniques to improve the transmission system performance also studied. **Paper also discuss the Need for fibre optic based communication system, Advanced Technologies in Transmission &** major hurdles for smart grid project implementation. Thus paper gives overall methodology to improve the performance of transmission system.

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