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SMART GRID :A TWO-WAY COMMUNICATION BETWEEN UTILITY AND ITS CUSTOMERS

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Abstract — *Usage of Smart grid ensures that energy from renewable power sources like wind farms, solar plants, can be stored safely and distributed where and when needed . Smart meters, a common form of smart grid technology, are digital meters that replace the old analog meters* **.** *It combines information technology with power transmission to benefit the customers and facilitates real-time troubleshooting. Due to smart metering the occurances of brownouts, blackouts, and surges decrease***.** *More control over the power bill is attained .Smart grid takes us towards a clean energy future.*

Keywords*-Smart meters ,renewable sources, scada, wams, pmu.*

I. INTRODUCTION

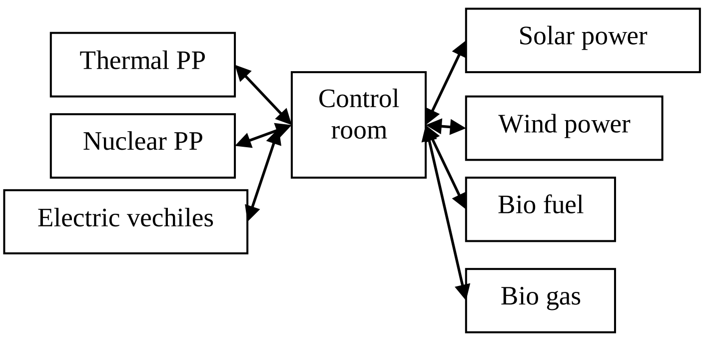
Electricity has to be used the moment it is generated. The grid represents the ultimate in just-in-time product delivery. One of the principal challenges in operating an electricity system is ensuring that the demand for electricity is always exactly equal to the supply. It is difficult to store electricity. Thus electricity system must continually adjust the output of power plants to match demand. Present grid make it one way of interaction makes it difficult for the grid to respond to ever changing and increasing energy domains

1.1 Solution is Smart Grid

An application of computer intelligence, microprocessor-based measurement and control, communications, computing, and information systems and networking abilities to non communicative traditional_electricity distribution system incorporating renewable energy recourses notably wind and solar PV ,plug-in electric vehicles (PEVs). The smart grid is the next generation electric grid which merges information and communication technologies (ICT) and control systems that provides continuous sensing and actuation capabilities vital to achieving the responsiveness needed for grid operations The grid becomes “smart” when it fully supports two-way information and communication flows and two-way energy flows that are efficiently controlled based on real-time information. It is being more adaptable to the consumers requirement/demand. Smart grids thus achieves the integration of renewable energy more effectively thereby improving the reliability, quality and security of supply.

When a power outage occurs, Smart Grid technologies will detect and isolate the outages, containing them before they become large-scale blackouts .It gives grid operators new tools to reduce power demand quickly when wind or solar power dips, and it will have more energy storage capabilities to absorb excess wind and solar power when it isn't needed, then to release that energy when the wind and solar power dips . Solar and wind power plants exhibit changing dynamics, nonlinearities, and uncertainties— challenges that require advanced control strategies to solve effectively.

In the event that a power line needs to be removed from service, control software could reroute the power in a way that causes minimal disruptions to the grid. Aptly called "self-healing" grid. Smart meters (net metering) provide the interface between customer and the utility. Smart meters will see how much electricity is used, when it is used, and its cost. Combined with real-time pricing, this will allow to save money by using less power when electricity is most expensive As consumers move toward home energy generation systems, the interactive capacity of the Smart Grid will become more and more important.



“***Figure 1. Two way Interconnectivity***”

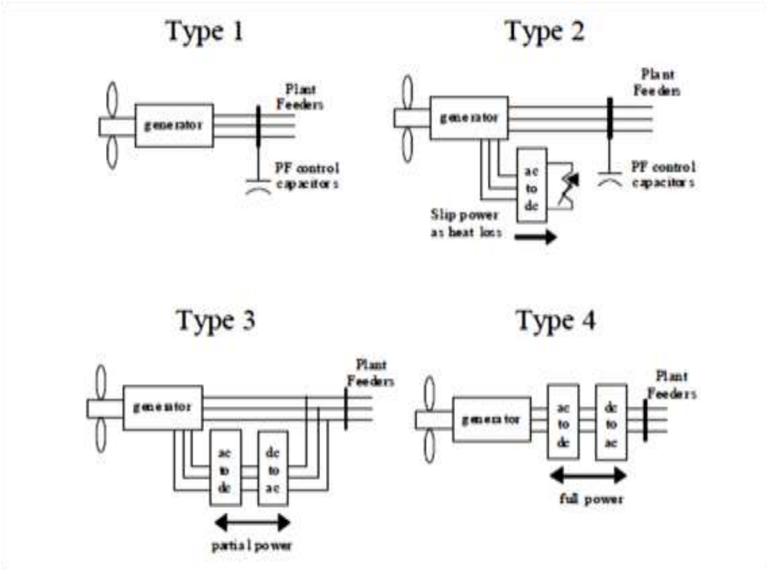
The Smart Grid, with its controls and smart meters, effectively connect all renewable mini-power generating systems to the grid, provide data about their operation to utilities and owners to know what surplus energy is feeding back into the grid versus being used on site. i.e. Smart Grid will allows the consumer to use their power solar array to keep the supply on even when there is no power coming from a utility. Called "islanding," it will allow a home to get power from "distributed resources," such as local rooftop solar, small hydropower, and wind projects, until utility can bring the grid back online.Thus allowing the consumers to play a part in optimizing the operation of the system

2.1 Integration of renewable sourses

Out of total installed electricity generation capacity in India, about 14% is renewable generation (wind, hydro, solar, biomass generation) Government of India is having an ambitious plan to achieve 1,00,000 MW Solar and 60,000 MW Wind generation in next five years. But these renewable energy recourses have variability that affects those power systems with high connectivity of renewable energy sources operate

2.1.1 Wind energy: Type 1,2,3 of wind turbine generator are fixed speed, Variable slip Induction generator with variable rotor resistance, Variable speed doubly fed asynchronous generators with rotor side converter. All three types are Induction machines which during their operation always absorb reactive power from the grid. They cannot supply reactive power to grid in any condition at their own. Fourth type is: Variable speed generator with full converter interface (which is a synchronous machine) Synchronous machines have capability to supply reactive power to the grid as well as absorb reactive power from the grid during different operating conditions

Various types of wind turbine generator are classified as



"*Figure 2. Types of wind turbine generator*"

Wind plant Integration issues

1. Whenever a fault occurs near to a wind generation plant, voltages of surrounding buses drops including wind pooling station and electrical power supplied by generator also decreases instantaneously. But mechanical power input to the generator does not reduced instantaneously. Under this situation, the speed of generator increases drastically. To avoid this, inbuilt protection system in generator disconnects it from the grid and wind turbine is stalled effecting supply to the grid.

2 If a wind generation plant (Induction generator) keeps absorbing reactive power from the grid, then voltage at interconnection may drop further. To avoid such situation, wind generation plants are disconnected from the grid instantaneously when the voltage at interconnection point falls below 0.85 pu (protection setting) as per the information received from wind IPPs. This issue is termed as Low Voltage Ride through compliance. This may become major issue, if such contingency arise near large capacity wind farm. In such situation, loosing of large capacity may impact reliability of power supply due to load generation mismatch and affect grid stability

Thus wind turbines have to adapt to those variations, so their efficiency and reliability depend heavily on the control strategy applied. As wind energy penetration in the grid increases, additional challenges arise as quick response to grid disturbances, active power control and frequency regulation, reactive power control and voltage regulation, restoration of grid services after power outages, and wind prediction etc

2.1.2 Solar plant Integration issues

Solar energy: The solar PV plant model is largely based on Variable speed generator with full converter interface (synchronous machine). PV panels are decoupled from the grid by a power converter which is actually connected to the grid. From the point of DC link to grid connection, both PV and Variable speed generator with full converter interface (synchronous machine) use similar control and inverter technology to inject power to the grid. Transient Stability Analysis includes: Rotor angle stability, Voltage Stability, frequency stability.

2.1.3 Hybrid vehicle integeration

Plug-in electric vehicles: PEVs play an important part in balancing the energy on the grid by serving as distributed sources of stored energy. EVs can be plugged into the electric grid when not in use. Generally in electric vehicles, regenerative braking is used. Regenerative braking is a good source of green renewable energy in which kinetic energy converted into electrical energy and injected back to the power grid

3.1 WAMS

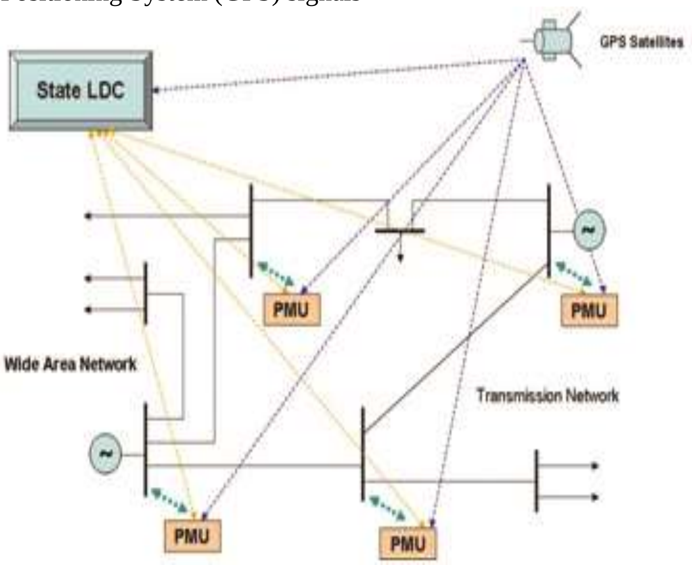
Supervisory Control and Data Acquisition system (SCADA) is being used to collect the data. But it cannot measure the phase angles of bus voltages of power system network in real time, due to technical difficulties in synchronizing measurements from distant locations .i.e cannot monitor correctly the dynamic behavior of the power system. Controlling centre cannot know the dynamic operation states of the system and instant action cannot be taken in case of failures .Implementation of **Wide Area Monitoring Systems** (WAMS, using Phasor Measurement Units, or PMUs) is an advanced measurement technology to collect information for the entire transmission system. It collect the data and gets value from it, analyze it using several signal analysis tools and algorithms

WAMS covers three interconnected sub-processes including data acquisition, data transmitting and data processing

Data resourses (instantaneous measurements of voltages, currents, phasors and breaker status ,	Communication system SCADA	WAM (Power line based communication,Radio Microwave,satellite) WAM applications: **Generation applications** **Transmission applications** **Distribution applications**	FIELD SITE

"*Figure 3. WAMS subprocesses*"

PMU(phasor measurement unit) and PDC(phasor data concenterator) are two Components of WAM . PMU provide real time synchronized measurements in power system with better than one microsecond synchronization accuracy, which is obtained by Global Positioning System (GPS) signals



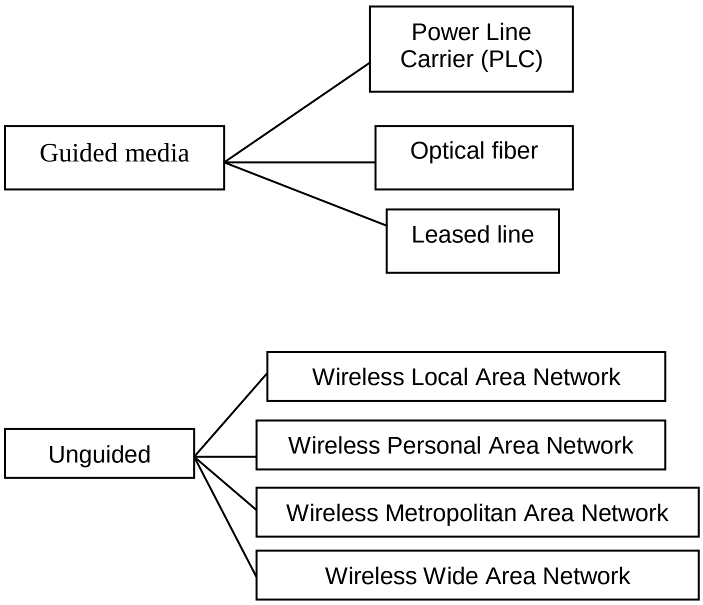
"*Figure 4. Optimal PMU placement on busbar*"

PMUs are time synchronized, high speed measurement units that monitor current and voltage waveforms at widely dispersed locations with respect to global positioning system in the grid, convert them into a phasor representation through high end computation and securely transmit the same to centralized server. As per definition of IEEE, PMU is defined as device that produces synchronized phasor, frequency and rate of change of frequency estimates from voltage and/or current signals and time synchronizing signal. PMUs provide real time synchronized measurements with great accuracy in power system and provide measurement of time stamped positive sequence voltages and currents of all monitored buses and feeders.
PDC gathers data from several PMUs, reject bad data, align the time-stamps and create a coherent record of simultaneously recorded data from a wider part of the power system

Synchrophasors: **S**ynchronized Measurements:
A Phasor measurement which is time stamped against GPS universal time it is called synchrophasor. A synchrophasor system is wide deployment of PMUs and dedicated high speed communication to collect and deliver synchronized high speed grid condition data –along with analytics and other advanced online dynamic security assessment and control application.
Also other Data resources of WAMS are Digital Fault Recorder (DFR), Digital Fault Recorder (DFR), Digital Protective Relay (DPR), Circuit Breaker Monitor (CBM)

3.1.1 Communication infrastructure of WAMS

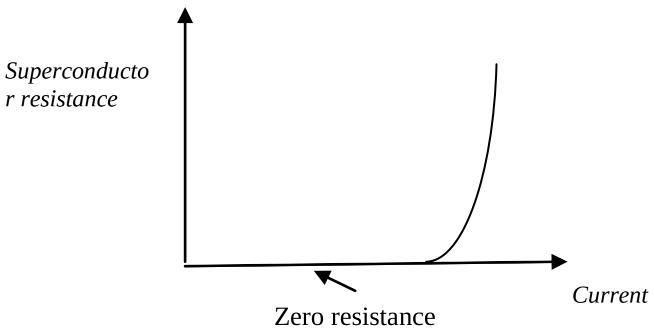
Communication networks,namely the home area network (HAN), the local area network(LAN), and the wide area network (WAN) are implemented.



“***Figure5 Communication networks***”

4.1 Superconducting technologies

As the interconnections of the grid is increasing continuously, sources of distributed generation are added to an already complex system it is required to upgrade all the utilities and affected circuit breakers . Shunt reactors are used many times to decrease the fault currents. These devices have fixed impedance so they add as a continuous load, thereby reducing system efficiency and sometimes impair system stability.
Another approach is to use an SFCL to reduce the available fault current to a lower, level so that the existing switchgear can still protect the grid. Superconducting fault current limiters (SFCLs) utilize superconducting materials to limit the current directly. They remain virtually invisible to the grid under nominal operation, having negligible impedance in the power system until a fault occurs. And have the capability of rapidly increasing their impedance during fault condition, thus limiting it and quickly returns to its nominal low impedance state after the limiting action. Superconducting fault current limiter technology is a very much cost effective and reliable method of fault current limiting. It is one of the contributing components of the smart grid technology. In the cases of multiple circuit breaker and bus work up gradation, the cost increases but with SFCL cost is decreased and it also minimizes the outage time



"*Figure 6. Response curve of super conductive material"*

Different superconducting technologies are as under

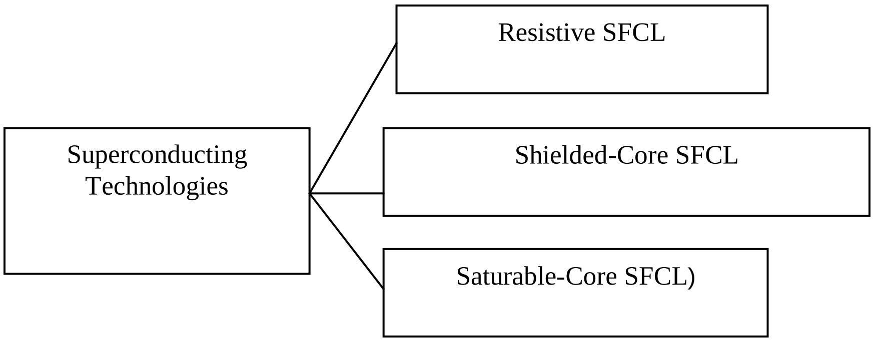


Figure 7 Types of super conductive material"

But there is Challenge for SFCL to be used in Transmission Level.

4.1.1 It's Impact on Protection Schemes & Test Standards .The characteristic of the SFCL impedance appearing only during the fault must be considered in the implementation of protective relay schemes.

4.1.2 Recovery Requirements: The time to return to a super- conducting state is typically termed the "recovery" period. The cool-down period is proportional to the amount of time that the material was heating up during the fault, both in terms of the duration and the magnitude of fault current.

4.1.3.Scale-Up to Transmission Voltage: Only the limitation these materials are unsuitable for high voltage application in cryogenic environment

IV. Inferences

Smart grid concepts includes a wide range of technologies and applications. Advanced metering infrastructure (AMI) for two-way meter/utility communication. Distribution management system (DMS) software mathematically models the electric distribution network and predicts the impact of outages, transmission, generation, voltage/frequency variation, etc. Wide-area measurement systems (WAMS) provide accurate, synchronized measurements from across large-scale power grids. Thereby managing the uncertainty and intermittency on the supply side along with real-time pricing for the optimization of pricing and integration of storage, distributed generation. But we have to deal with challenges of integrating variable RE into power grids

Because of uncertainty & reliably of Wind farms producing required power and variability of rooftop solar installation plants. Challenge is 'reverse power flow' ,Balancing supply and demand during generation scarcity and surplus situations is the essence of smart grid Better forecasting, Smart inverters, Demand response, Integrated storage ,Real-time system awareness and management are some of the areas are some of the emerging solutions for the smart grid . Development of Microgrids in villages/commercial hubs ,storage options, virtual power plants (VPP), to create EV charging facilities in the parking lots, quick charging facilities to be built in fuel stations and at strategic locations on highways. Optimally balancing different sources of generation through efficient scheduling and dispatch of distributed energy resources with the goal of long term energy sustainability are to be taken care of at the distribution end. Development of a reliable, secure and resilient grid supported by a strong communication infrastructure that enables greater visibility and control of efficient power flow between all sources of production and consumption. Implementation of Wide Area Monitoring Systems using Phasor Measurement Units, or PMUs for the entire transmission system ,to replace conventional cables with superconducting cables

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