UNIT - II

SMART GRID TECHNOLOGIES

Introduction:-

A smart grid is an electrical network that uses digital and other advanced technologies to monitor and manage the transport of the electricity from all generation sources, to meet the varying electricity demands of end users

Characteristics or features of smart grid technologies:

1) Real time monitoring.
2) Automation outage management and faster restoration
3) Dynamic pricing mechanism
4) Better energy management System
5) Inhouse display.
6) web portals and mobile applications.

Real time monitoring:-

Smart grid is an electrical grid with automation, communication and information Technology (IT) system that can monitor power flow, from point of generation to point of consumption, and control the power flow in real time.

(2) Dynamic pricing mechanism:-

Dynamic pricing also referred to as

1) demand pricing
2) Surge pricing
3) Real time pricing, is a pricing strategy in which business set flexible price per product or service based on current demand market.

(3) Automation outage management and faster restoration:

Outage management system provide instant alert.

→ They also record the history of outage through out the operation and provide real time insight into the system.

→ And also provide customer assistance and status of repairs.

(4) In house display:-

→ It is a small electronic screen which shows the energy usage in kilowatt hour.

→ It updates for every 30 minutes.

(5) Better energy management System

It is also conincludes optimization power flow, which ensures a reduction in the cost of generation.

- It ensures that the stability between the supply and demand is maintained while respecting all system constraints for economical and reliable operation of the electrical system.

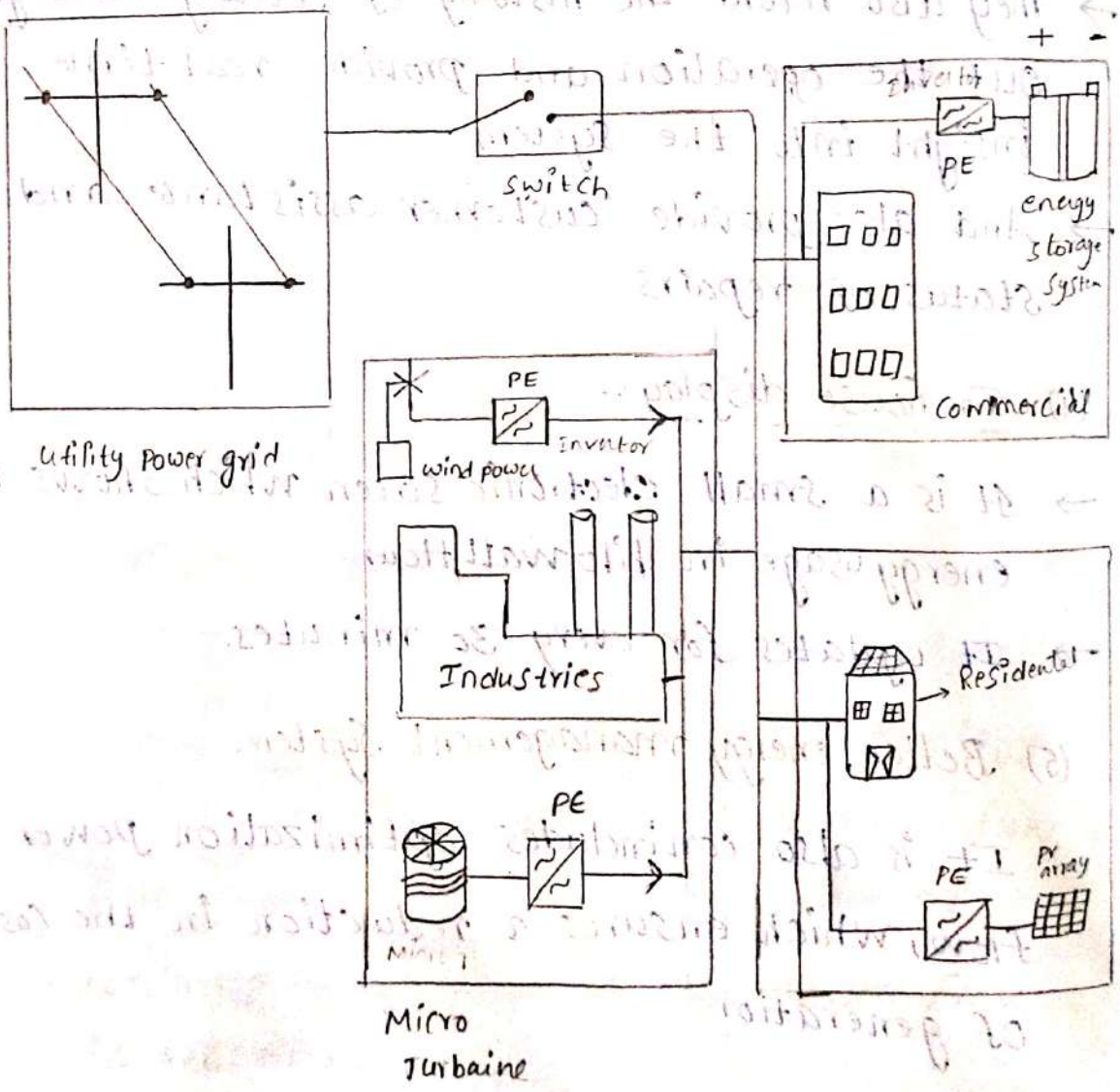
(6) Web Portals and mobile applications :-

It provides or creates awarness of a smart grid like energy management system, energy saving and electricity bill pricing etc.

Eg: APSPDCL, power grid etc---

10M

Micro grid :-



PE → power electronics
PV array → photo voltaic array

embedded energy production
distributed grid
decentralized

Introduction:

A micro grid is a small scale power grid that can be operated independently or collabaratively with other small power grids.

→ The practice of using microgrid is known as DG (Distribution Generation), decentralized, embedded energy production.

→ Any small scale localized power station that has its own generation and storage resource and definable boundaries can be considered as a 'microgrid'.

Components of micro grid:-

A micro grid having some important components

(i) DG - Distribution Generation
(ii) Load (Demand)
(iii) Storage
(iv) Control
(v) PCC - Point of Common coupling.

Distribution Generation - Renewable energy sources like solar, wind, hydro.

↓

utility, generator

Load - constant

↓

110 V AC, 220 V AC

Storage – the microgrid having energy storage equipments like:

(i) capacitors
(ii) batteries
(iii) fuel cells

Control – Load levelling, charge control, power flow control, power point tracking.

PCC (point of common coupling) – DC to AC

↓

Invertor

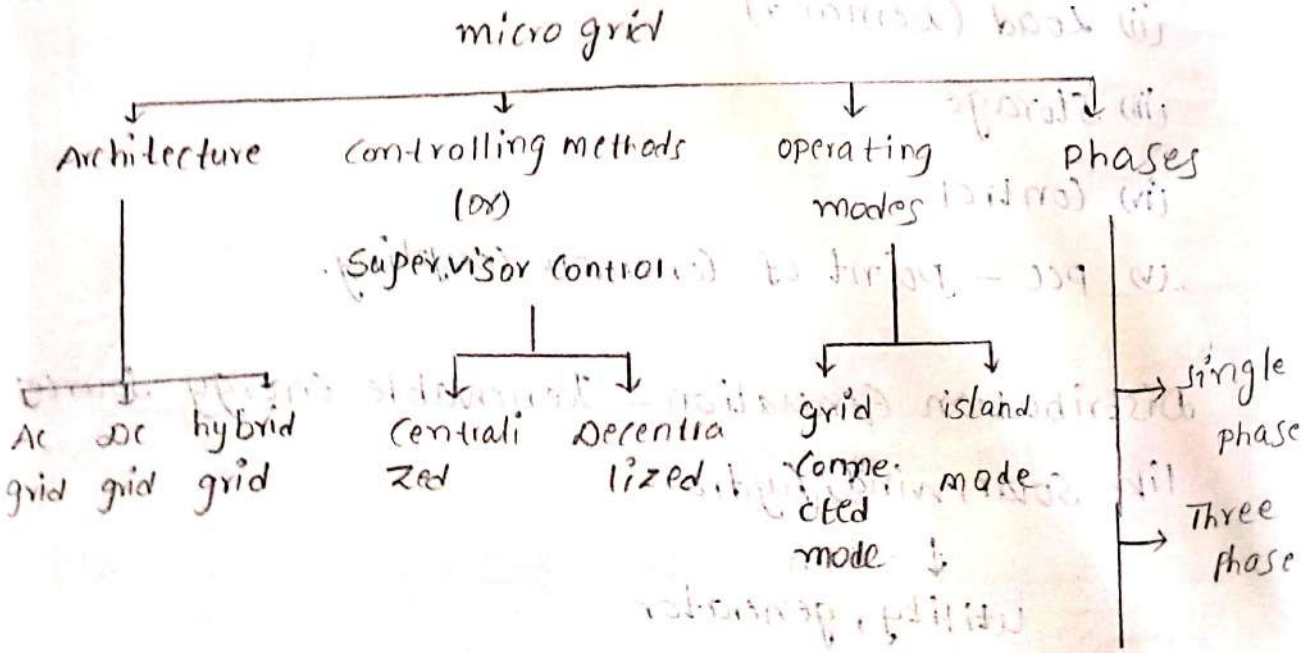
(convertor, chopper also)

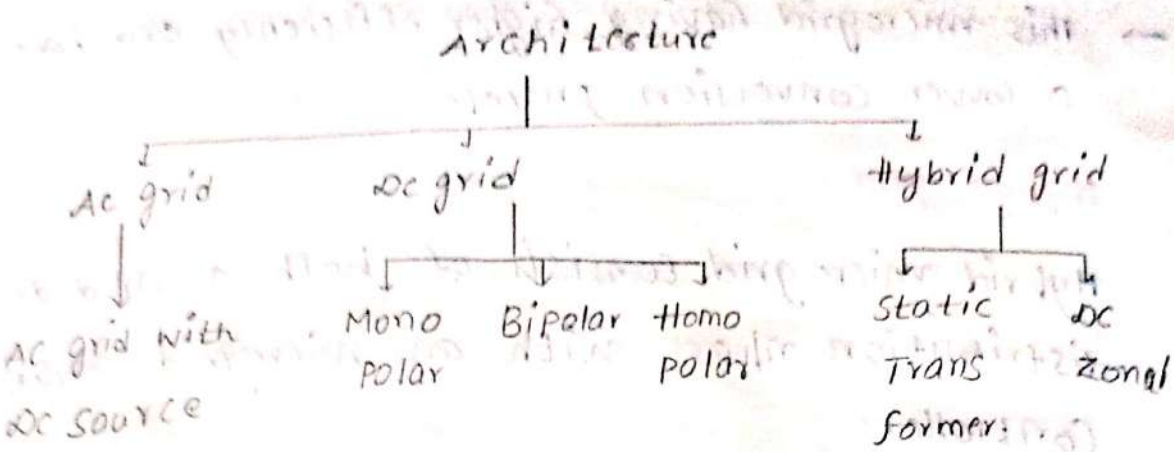
↓

variable dc to fixed dc)

classifications of microgrid:

classifications of micro grid depends on the quality power inject in distribution network.





Ac Grid:

→ Ac microgrid represents the Ac power supply in a distribution network.

→ They can be easily connected to an existing grid or utility grid without special requirements such as convertors, inverters etc...

→ This is because of well established Ac power network with compatible modes of electrical devices like 1) electrical vehicles,
2) Battery vehicles
3) Battery management system
4) Hybrid electric vehicles.

Dc Micro grid:

The concept of Dc Microgrid which has used as "short circuit protection" with enhanced efficiency.

→ The availability of environmental friendly dc source (solar, wind, hydro, fuel cells).

→ The dc grid used in commercial applications.
(i) Telecommunication System
(ii) Electrical vehicles.
(iii) Digital Signal processing (DSP).

→ This microgrid having higher efficiency and have a lower conversion process.

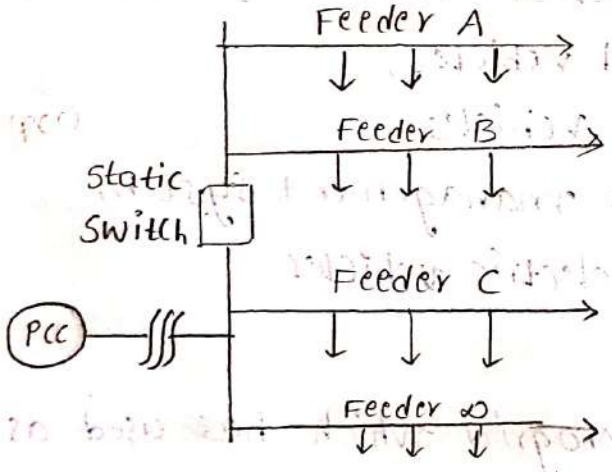
Hybrid grid:

Hybrid microgrid consists of both ac and dc distribution n/ws with an microgrid central controller.

→ The purpose of hybrid microgrid is to minimize the conversion stages, reduce cost, reduce interfacing devices and overall increase in the efficiency and reliability of the n/w.

Operating modes:

(i) Grid Connected mode:



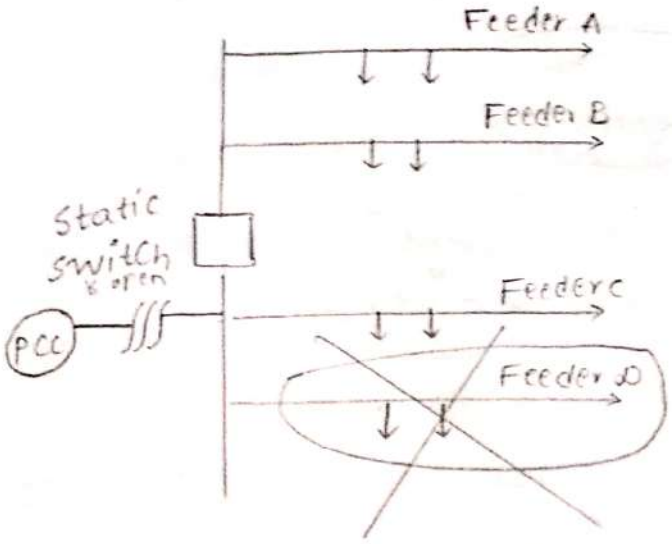
The microgrid can exchange power with the external grid as to maintain the supply in the local grid, through the power flow of microgrid is bidirectional.

→ From the above figure, the utility grid is active at any time.

→ static switch is closed.

→ All feeders are being supplied by utility grid

(ii) Island mode:



The microgrid can is said to be in island mode, the utility grid from it is disconnected from the main grid and it is operated independently with micro source and load.

→ From the above figure, the utility grid is not supplying power.

→ static switch is open.

→ Feeder A, B, C are being supplied

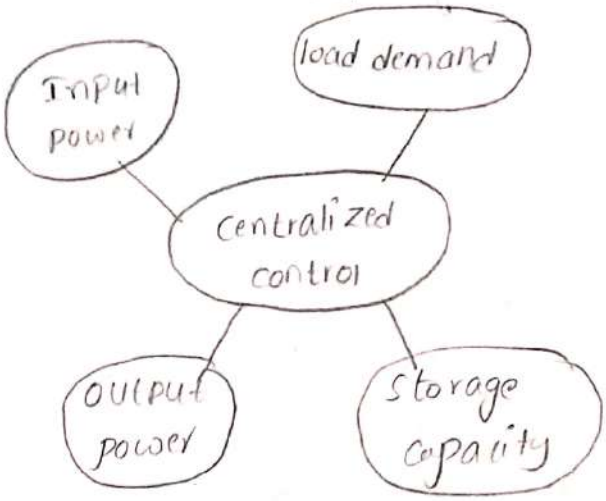
→ Feeder D is dead.

Supervisory control:

(i) Centralized control:

The main of concern of Centralized Control is to control load demand, input power, output power and observing the storage capacity of power in microgrid.

→ The microgrid Central Controller assign the set points to the load, distribution operation and Storage unit in order to attain the



microgrid goals.

(ii) De-centralized

The decisions are taken locally and the negotiations can take place in order to control each micro grid against the voltage fluctuations, voltage deviations, voltage sag, voltage swell.

→ And it is power management of dc microgrid.

2M Benefits of micro grid :-

→ It provides power quality, reliability and security for end user and operator of the grid.

→ Enhance the integration of distributed and renewable energy sources.

→ Enable smart grid technology.

→ Increased customer participation.

→ Cost competetive and efficient.

Renewable Energy Sources

Renewable energy is the energy that is produced from natural process and continuously replenished. A few examples of renewable energy are sunlight, water, wind, tidal, geo thermal, heat and biomass. The energy that is provided by renewable energy resources is used in 5 important areas such as air & water cooling / heating, electricity generation, the rural sector and transportation.

⇒ Some examples of renewable energy sources are

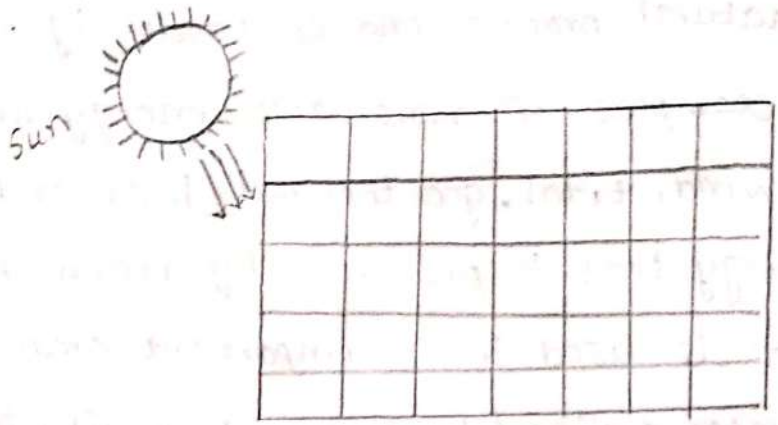
1) wind energy
2) Solar energy
3) Geo-thermal energy
4) Hydro power
5) Biomass energy

⇒ The sources of renewable energy are known to be less polluting and therefore the whole world is looking forward to new carbon emission norms where carbon will play a major role in developing new factories and industries.

⇒ They will be rated according to the carbon emission and the products that they are producing will be rated accordingly.

Types of renewable energy:-

(1) Solar energy:-



Solar energy

⇒ The radiant light and heat energy from the sun is harnessed with the use of solar collector

⇒ These solar collectors are of various types such as photovoltaics, concentrator photovoltaics, solar heating, concentrated solar power (CSP), artificial photosynthesis and solar architecture.

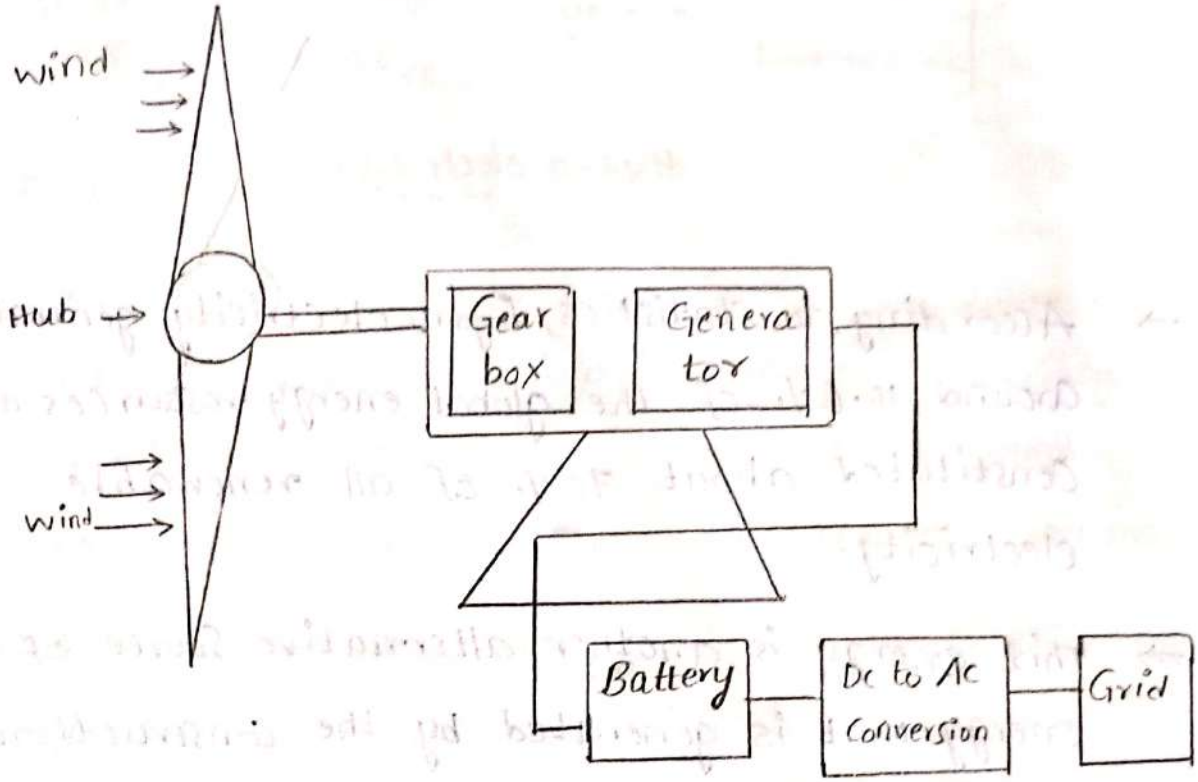
⇒ This collected solar energy is then used to provide light, heat and different other forms of electricity.

2) Wind Energy:-

⇒ The energy we get from winds is known as wind energy. For this windmills have been used for hundreds of years to pump out water from the ground

⇒ We use large tall wind turbines that allow winds to generate electricity. The natural air flow on the surface of the earth is used to run the wind turbines

⇒ The modern-day wind turbines range from about 600 kilowatt to 5 Megawatts, for commercial purposes these are rated with an output power of 1.5 to 3 megawatts.

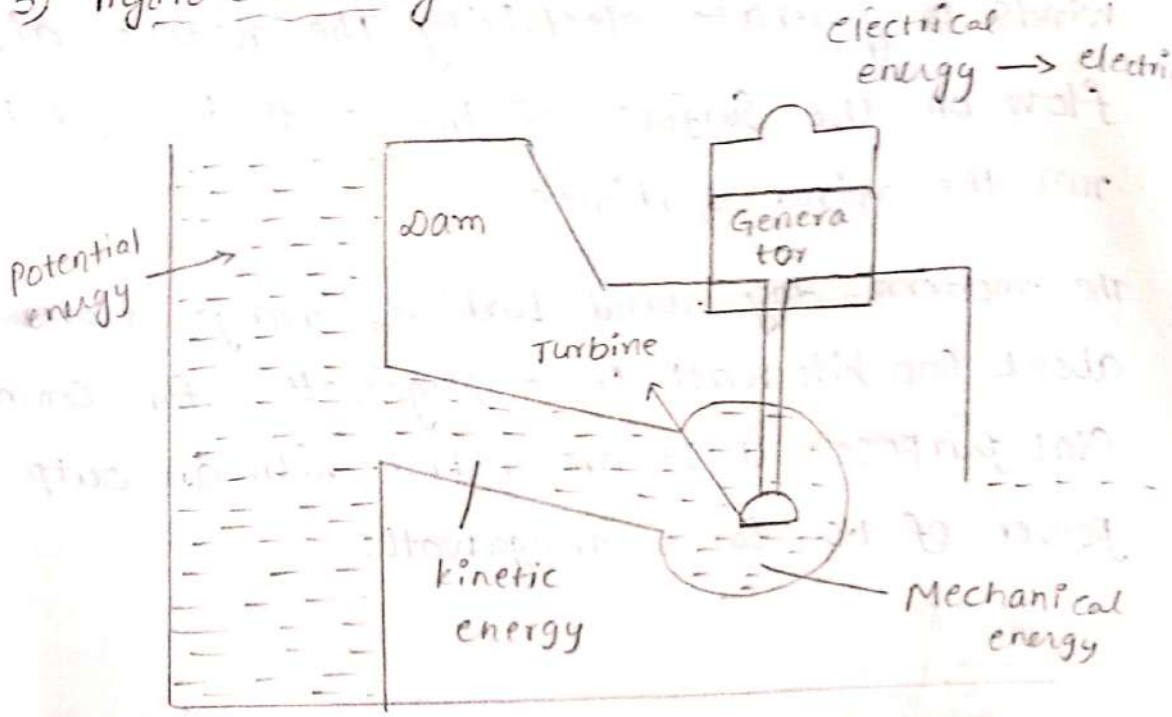


Wind energy

⇒ The most preferred locations for these wind turbines to be installed are the areas which and strong and have constant air flows on off shore and sites are at high altitudes

⇒ The power generated from wind energy in 2015 met 4% of global energy consumption.

3) Hydro electricity



Hydro electricity

⇒ According to statistics, hydro electricity generated around 16.6 % of the global energy resources and constituted about 70 % of all renewable electricity.

⇒ This energy is another alternative source of energy that is generated by the construction of dams and reservoirs on the flowing water, the kinetic energy from the flowing water is used to run the turbine which generate electricity.

⇒ Tidal power converts the energy of tides and wave power which captures the energy from the surface of the ocean waves for power generation.

⇒ These two forms of hydropower also have huge potential in electric power generation.

4) Geothermal energy:-

It is the energy that is generated from the thermal energy which is stored in the earth

⇒ The heat energy is captured from sources such as hot springs and volcanoes and this heat is directly used by industries for heating the water and other purposes.

5) Bio mass energy:-

⇒ This type of energy is derived from biomass which is a type of biological material derived from living organisms and plant-derived materials which are called lingocellulosic biomass

⇒ Biomass can be directly used via combustion to produce heat and indirectly it can be used to convert to biofuels.

⇒ Biomass can be converted to other usable forms of energy such as transportation fuels like ethanol, bio-diesel and methane gas.

** Building blocks of a micro grid

A microgrid will contain ;

(i) Physical system
(ii) Control system
(iii) Interface with the other system at the utility.

Physical system:-

→ A microgrid is composed of large of self physical components.

→ The physical components under any advanced control scheme that create a microgrid application

→ This include the following.

(i) Sensors
(ii) switches
(iii) Energy storage
(iv) Power electronics
(v) generators
vi) metering
vii) Protection equipment

Sensors :-

→ sensors, and more generally information input are required to determine whether the criteria for island mode or grid connected mode.

→ Sensors are eyes and ears of the microgrid.

Switches:-

→ Switches are an important part of the microgrid
→ They allow quick reconfiguration of the components in the microgrid.
→ Switches allow the microgrid to electrically disconnect or connect with the grid

Power electronics:-

→ power electronics allow for AC to DC or DC to AC conversion, as well as voltage changes for DER (Distributed Energy Resources) components

Energy storage:

→ Energy storage help smooth rapid changes due to external characteristics of DER, in the microgrid.
For example: if any case, grid is black out, energy storage can help to the system or a grid while generator start up.

Generators:-

→ Generators can take a variety of forms but are most commonly diesel or natural gas

Protection equipment:

→ protection equipment is always necessary, regardless of whether or not the DER, in reconfiguration in the microgrid.

⟹ Control system for protection equipment will also have to be modified.

⇒ These are used in fault detection and protection

Metering:-

→ Advanced metering must be in the place at the substation and powerflow can be monitored in real time.

Control System:

Local controller necessary to control individual components of the microgrid.

→ There are three types:

(i) Load Controller

(ii) Energy storge Controller.

(iii) Micro generation source Controller

→ These Controllers response to order sent by the microgrid Controller and react to real time Conditions (detection of a fault).

→ Local micro grid Controller provide real time monitoring and control functions for all the components within their control boundaries.

Interface with the other systems

The micro grid controller relies on the other system to deliver information to it, as well as execute some of its requests. In some cases, the utility can use its system to deliver Commands to the microgrid Controller.

2M

Smart grid drivers and functions

1) Increasing demand
2) High aggregate technical and non technical losses
3) Aging assets
4) Grid to carry more power
5) Billing and collection.
6) energy mixing.
7) Deliver sustainable energy.
8) Empower Consumer.
9) Increase in efficiency.
10) Improving reliability.

Increasing demand

- Information and communication technology, measurement and control demand response.

High aggregate technical & non-technical losses

- technical → 18 %.
  Non technical → 62 %.

Aging assets :

1. Transformer
2. Feeders

Grid to carry more power :-

Need for reliability and good security.

Billing and collection :-

profit of distribution companies

Energy mixing :-

Renewable Energy Sources - wind, solar, tidal, biomas,

geo thermal to reduce Carbon emmission.

Deliver Sustainable energy:-

voltage and volt-Ampere resistor, control, resource, planning analysis and fault detection, identification and restoration. (FDIR)

Empowel Consumer:-

Consumer education and awarness, residential Consumer energy management, information & Communication technology.

Increasing efficiency:-

Direct load control, distributed energy resources, energy Storage, advanced metering infrastructure.

Improving reliability

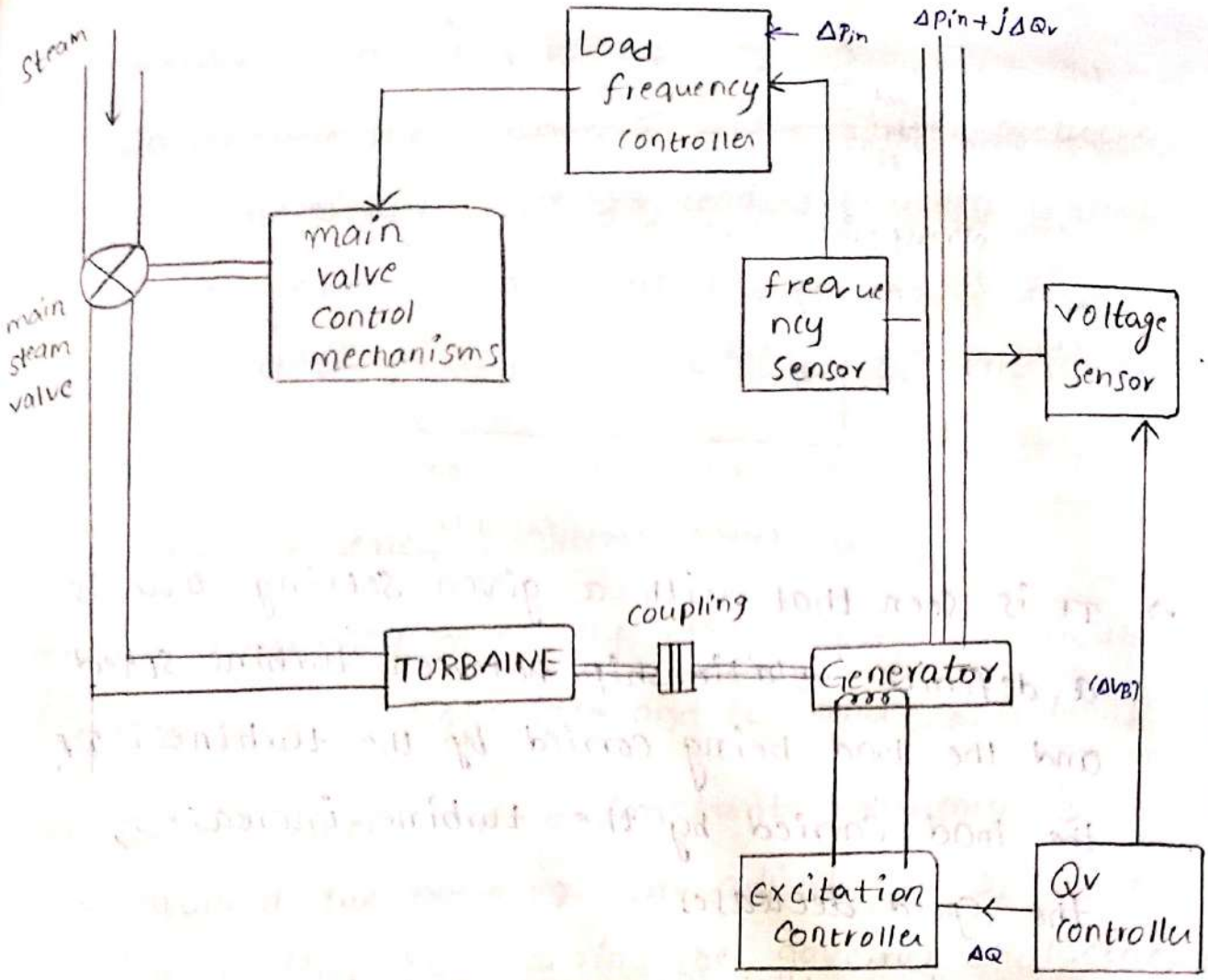
system wide monitoring, measurement and control, distributed energy resources, advanced metering infrastructure.

*** LFC (Load Frequency Controller)

Introduction:-

⇒ Load frequency control is the basic control mechanism in the power system operation.

⇒ whenever there is variation in load demand on a generating unit, then for a short time an Occurence of unbalance between real-power input and Output, which is supplied by the stored energy of the rotating parts of the unit.

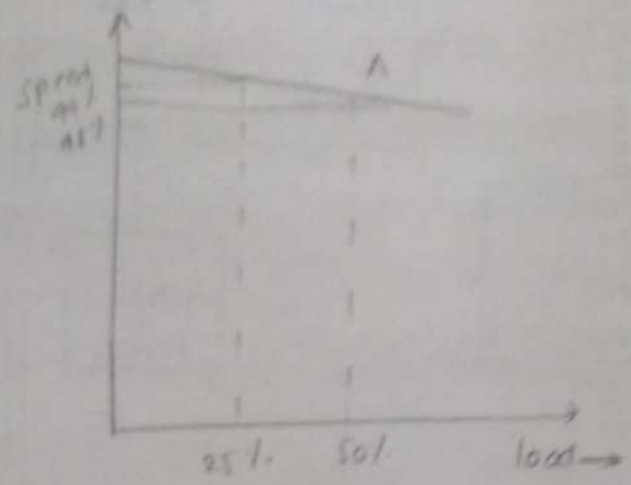


Schematic diagram of L-f & Q-V regulators

⇒ Load Frequency control (LFC) is being used for several years as part of the Automatic Generation Control (AGC) scheme in electric power systems.

⇒ One of the objectives of AGC is to maintain the system frequency at nominal value (50 Hz).

⇒ Since the control of system frequency and load, depends upon the governors of the prime movers, we must understand governor operation



Governor Characteristics

⇒ It is seen that with a given setting there is a definite relationship between turbine speed and the load being carried by the turbine. If the load carried by the turbine increases, the speed decreases.

Concept of load frequency Control

⇒ If power demand fluctuates in the system then variations occur in speed & frequency accordingly. Therefore the control of load frequency is essential to have safe operation of the power system.

⇒ To provide stability, a constant frequency is required which depends on active power balance

⇒ If any change occurs in active power demand or generation in power systems, frequency cannot be hold as its rated value. Hence, Oscillations increase in both power and frequency. Thus the system is subjected to a

Serious instability problem

⇒ To improve the stability of the power networks, it is necessary to design load frequency control (LFC) systems that control the power generation and active power at tie lines of interconnected system.

Load frequency problem

⇒ The frequency normally would vary by about 5% between light load and full load conditions

⇒ On the other hand if constant frequency is required the operator can adjust the speed of the turbine by changing the governer characteristics as and when desired

⇒ If a change in load is taken care of by two machines running in parallel as shown in the fig, the complexity of the system is increased.

Methods of Reactive power control:

Reactive power:

It is defined as the continuously bounce back and forth b/w source & load.

It is denoted by "Q"

$$\therefore \boxed{\text{Reactive power } Q = VI \sin\phi}$$

→ Control of voltage level is accomplished by controlling

the Production of reactive power flow at all levels in the system.

→ Generating units provide the basic means of voltage control.

→ Additional device to control voltage

(i) Static Source

(ii) Voltage regulation. Such as tap transformer

(iii) Dynamic source such as synchronous motor.

Static Source: Control of reactive power by using some methods:

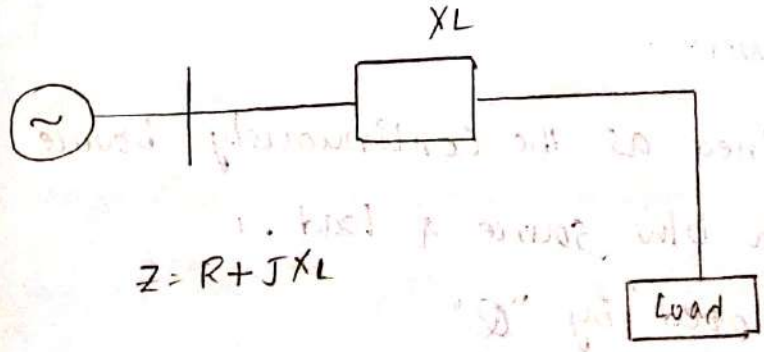
(i) Series compensator

(ii) Shunt compensator

(iii) Tap changing transformer

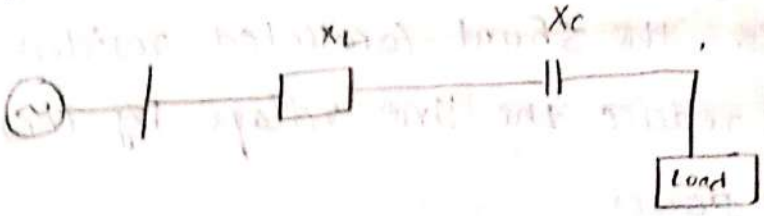
(iv) Static VAR compensator.

Series Compensator:-



→ Series compensation is the method of improving the system voltage by connecting

Capacitor in series with the transmission line.

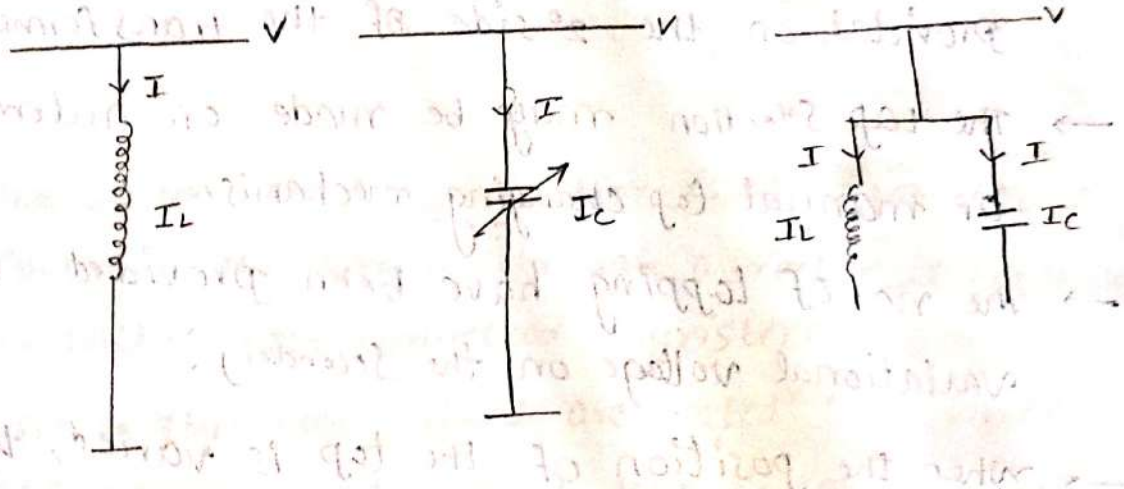


$Z = R + j(X_L - X_C)$

→ In series compensator, the reactive power is inserted in series with the transmission line improving impedence of the system.

→ It improves the power transformer capability of line.

2. Shunt Compensator:-



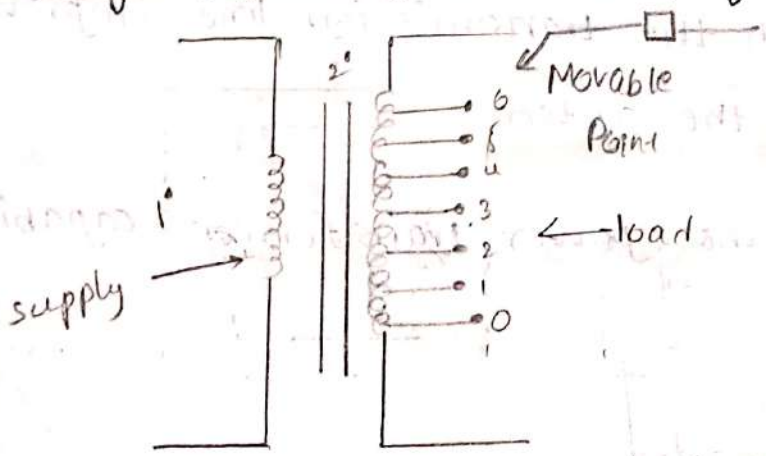
→ The device that is connected in parallel with the transmission line is called "Shunt compensator"

→ A shunt compensator is widely used in transmission system to regulate the voltage magnitude.

→ the shunt connected capacitors are used to maintain the voltage level by compensating the reactive power.

→ It can be provided by either a current source or voltage source, the shunt connected resistors are used to reduce the line voltage by consuming the reactive power.

voltage regulating tap changing Transformer



→ In this method, a no. of tappings are provided on the 2° side of the transformer

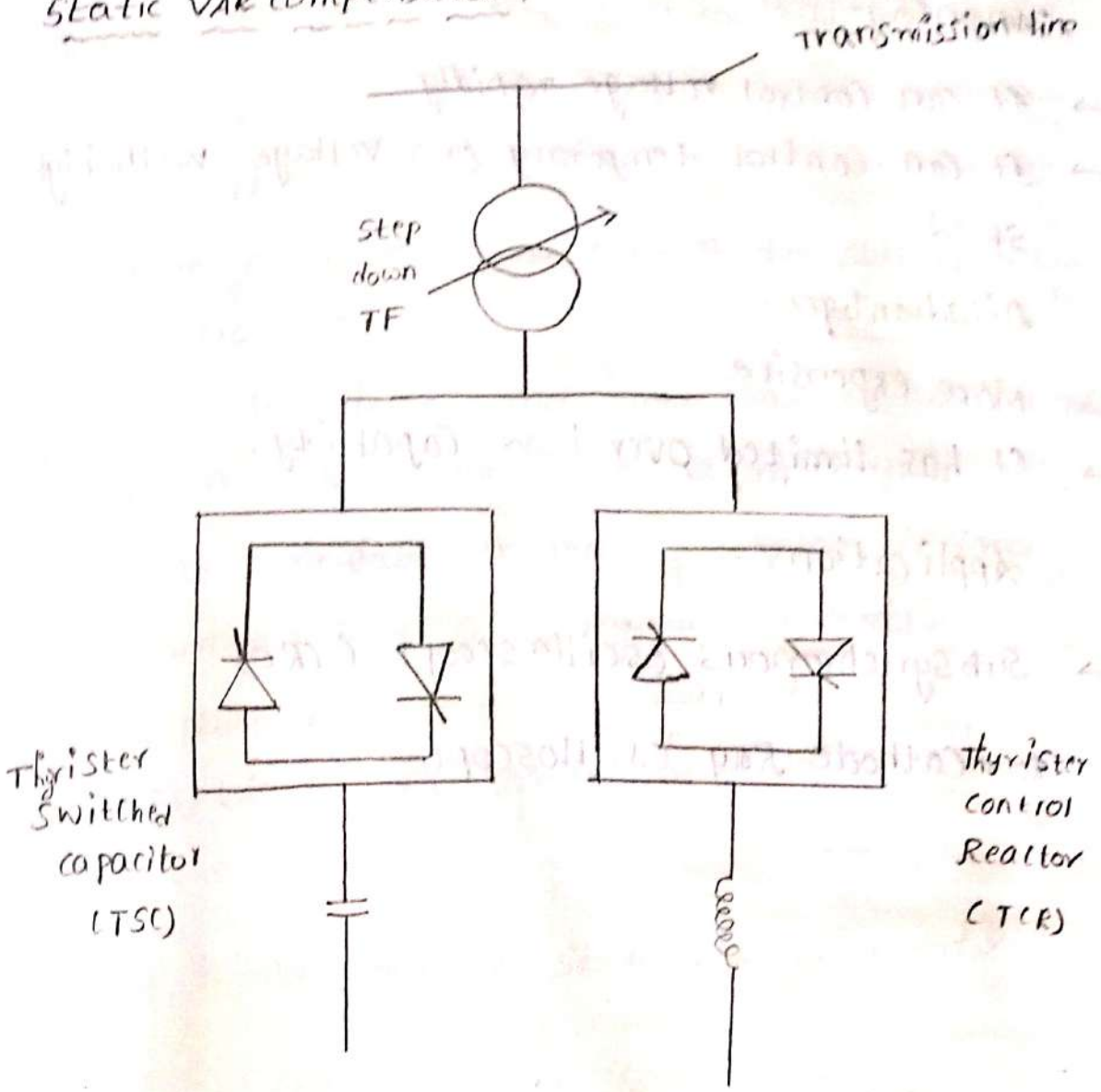
→ The tap selection may be made on automatic or manual tap changing mechanism.

→ The no. of tapping have been provided a variational voltage on the secondary.

→ when the position of the tap is varied, the no. of secondary tap is varied.

System voltage stability ↑ Compensative reactive power ↓

Static VAR compensator:



→ The static VAR compensation is a FACT device controller, the current through a rector is controlled by back to back connected Thyristers.

→ These Thyrister values are rated for v. lower voltage as the static VAR compensator is connected to a transmission line through a step down transformer.

→ The static VAR compensator is a combination of TSC and TCR.

→ The result in minimum switching transient.

→ It is reducing phase angle is varied from 180° to 90°, automatically control the reactive power.

Advantages:-

→ It can control voltage rapidly.

→ It can control temporary over voltage with high speed.

Disadvantage:

→ More expensive.

→ It has limited over load capability.

Applications:-

→ Subsynchronous oscilloscope. (CRO)

CRO - Cathode Ray Oscilloscope.

Questions

1) Define smart grid and explain the characteristics of smart.
2) Define micro grid and explain the classification of micro grid
3) Explain the drives and functions of micro grid.
4) Explain building blocks of a micro grid.
5) Define renewable energy and explain it briefly.
6) Explain the load frequency control (LFC).
   (i) Explain LFC
   (ii) Explain Reactive power control.

2M

1) What is the need of Static VAR Compensator.