

SMART ELECTRIC GRID - 20AO2605

UNIT-I Introduction to Smart Grid

Working definitions of Smart Grid and Associated Concepts - Smart Grid Functions - Traditional Power Grid and Smart Grid - New technologies for Smart Grid - Advantages - Indian Smart Grid - Key Challenges for Smart Grid.

Definition:-

Smart Grid is defined as the interconnected network connecting the generating station to the end user via transmission and distribution system

(or)

An electric grid is an interconnected network for electricity delivery from producers to the consumers.

- power grid consists of power stations - produce or generate power often located near energy grid away from heavily populated areas.
- electrical substations to step-up voltage or step-down voltage
- Electric power transmission to carry power to a long distance.

→ Electric power distribution to individual consumer where voltage is stepped down again to the required service voltage.

Grid failures:

- 1) Brown out
- 2) Block out
- 3) Load shedding

Brown out:

Rising of the voltage and frequently automatically change the load

Block-out:-

A Block-out is a total crash of power grid due to an imbalance between power generation and power consumption.

A selective

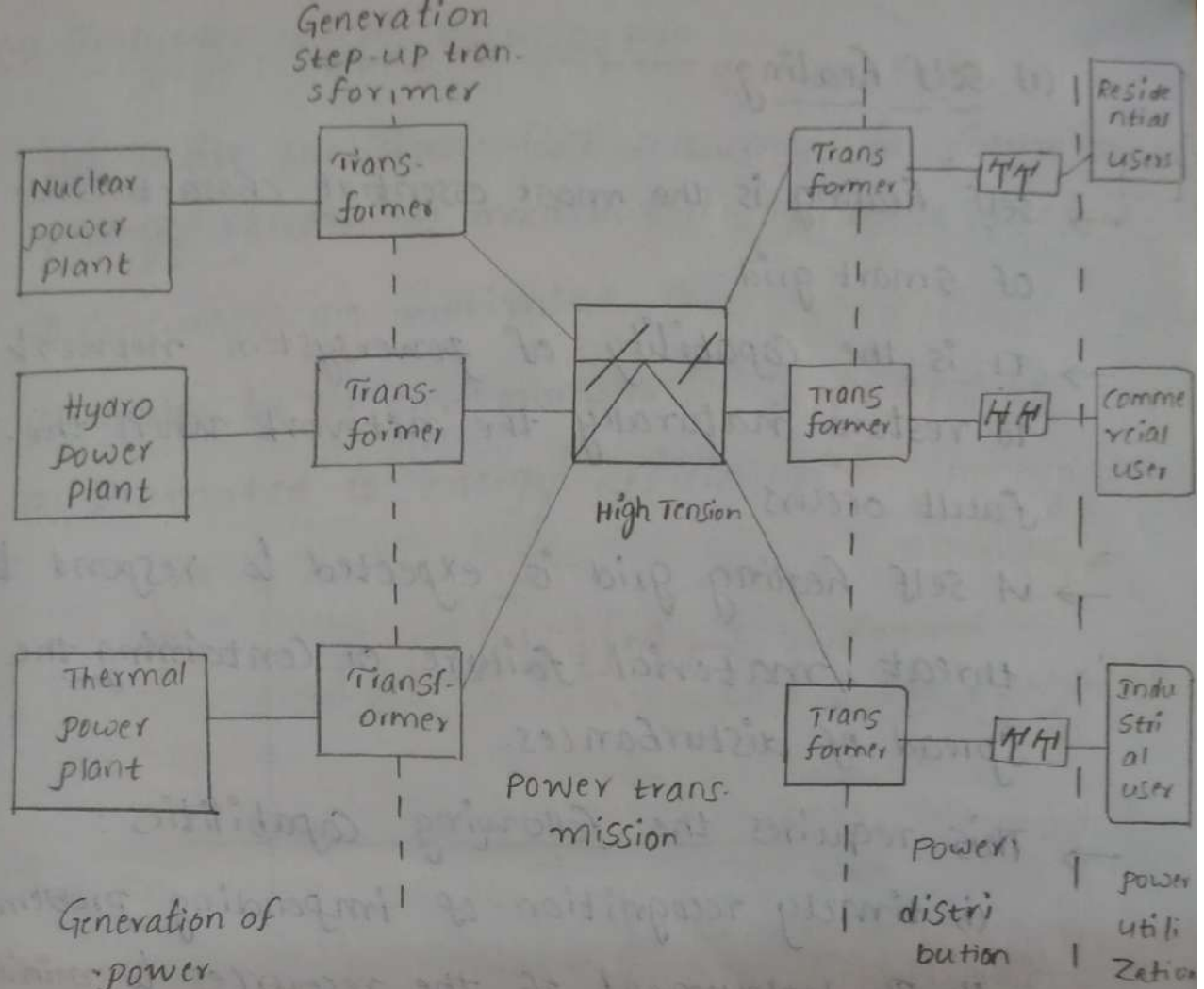
A selective power is a controlled shut down of the power supply in a given area

Load shedding:

The loss occurs due to load demand.

// (Smart Grid functions:)

Layout of Smart electric grid



Layout of Smart electric grid

Smart grid functions:

The functions of the smart electric grid are:

- 1) Self healing
- 2) Consumer active participation
- 3) Resist attack
- 4) Accommodate generating options and storage
- 5) Enable electricity market
- 6) Optimization assets
- 7) High quality power
- 8) Enable with penetration.

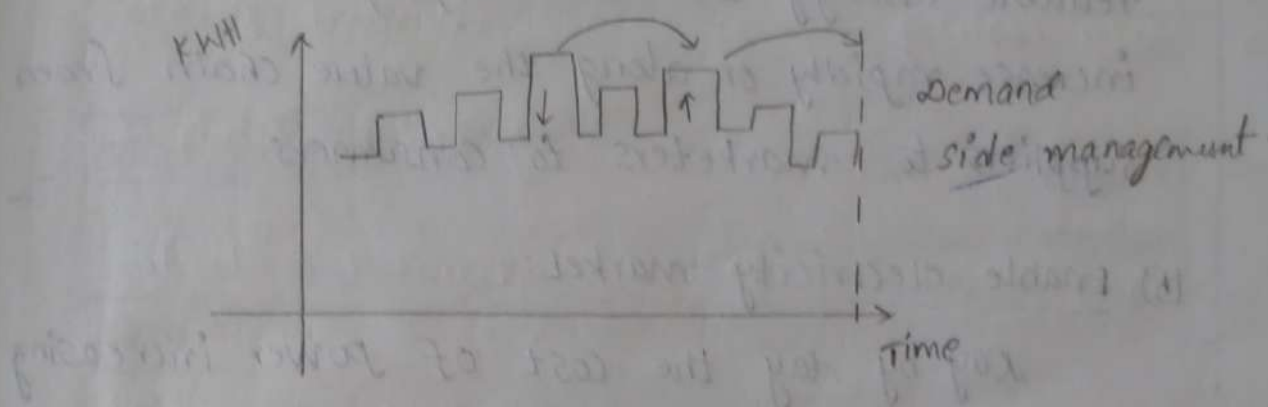
(i) Self healing:

- self healing is the most essential characteristics of smart grid.
- It is the capability of powersystem network to restore naturally the network when the fault occurs
- A self healing grid is expected to respond to threat, material failure or containing the spread of disturbances.
- This requires the following capabilities:
 - (i) timely recognition of impending problem
 - (ii) Re-deployment of the resources to minimize impact
 - (iii) A fast and co-ordinate response to the evolving disturbances.
 - (iv) minimization of loss and service
 - (v) minimization of time to reconfigure and restore service.
 - (vi) A smart grid automatically detect and responds to routine problems and quickly recover if they occur, minimize down time and financial losses.
- (viii) self healing concept is important to the energy infrastructure.

(2) Consumer active participation

The active participation of consumer in future smart energy system is motivated by some factors:

- (1) Consumers are motivated.
- (2) Enable by the environment
- (3) Promoted to energy efficiency



(3) Resist attack

(i) Cyber attack

- 1) computer security incidents are increasing.
- 2) According to the government accountability office in 2002, 70% of energy and power companies experienced some kind of severe cyber attack to their computing or energy management system

(ii) Physical attack

Physical attack against key elements of the grid or physical attack combined with cyber attack can't be discounted.

From a terrorist view point, damage from a physical attack.

4) Accomodate generation and storage option:-

A smart grid will be needed to accomodate not only large centralized power plant but also emerge wide range and a great no. of DER (Distributed Energy Resources).

The distributed energy resources include reliable energy and their deployment will increase rapidly or along the value chain from Suppliers to marketers to consumers.

5) Enable electricity market:-

Day by day the cost of power increasing rapidly in the market.

The cost of power totally depends on the load demand.

6) Optimization assets:-

Assets optimization seeks to find the balance between the efficiency and reliability.

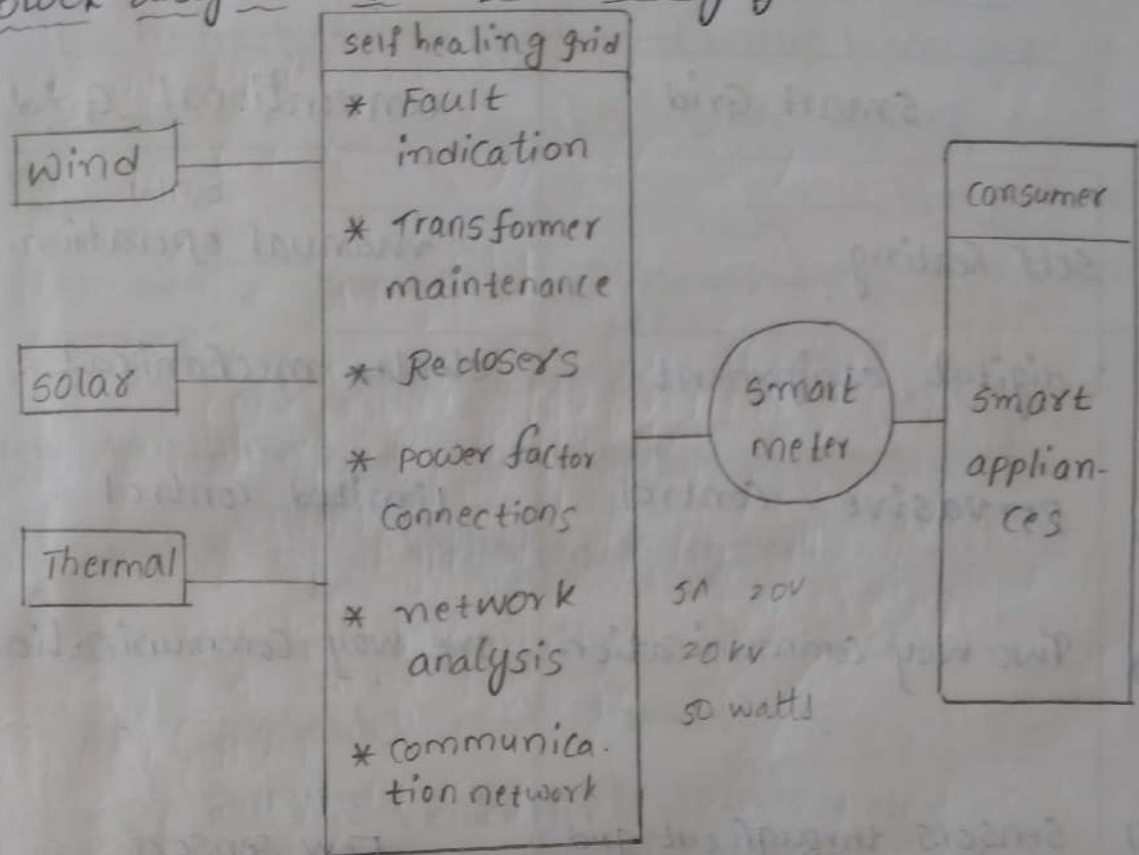
Reduce operation and maintenance cost and improve reliability without sacrificing safety or customer satisfaction.

7) High Quality Power:-

High electrical voltage is a sine wave that measures exactly what is expected in both voltage and frequency.

A high quality electrical source is the one that can deliver all the electrical energy needed without changing the voltage.

Block diagram of self healing grid:-



The self healing grid is a system comprised of sensor, automated controls and advance software that utilize real time distribution data to detect and isolated from fault and to reconfigure the distributed network to minimize the customer impacted.

One of the main goal of self healing grid is to improve system reliability.

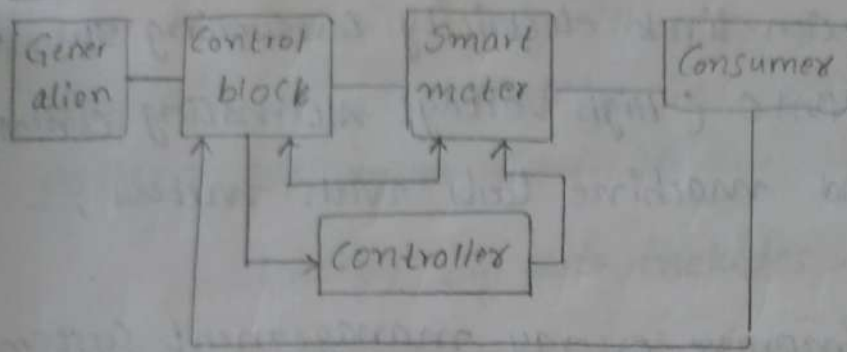
This can be accomplished by reconfigure the switches and reclosures installed on the distribution feeder and re-establish the service

to as many customers as possible from alternative source or feeders.

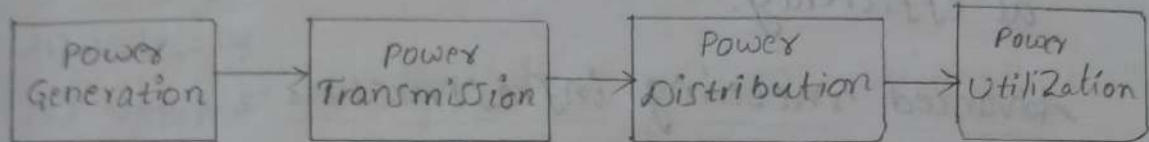
Differences between smart grid and Conventional grid

Smart Grid	Conventional Grid
(1) Self healing	manual operation
(2) digital equipment	electro mechanical
(3) pervasive control	Limited control
(4) Two way communication	one way communication
(5) Sensors throughout grid	Few sensors
(6) Remote checking	manual checking
(7) many customer choice	Few customer choice
(8) Extremely quick reaction time	Slow reaction time.
(9) Energy storage option	No Energy storage option
(10) Increased customer active participation	Total control by utility

Smart grid



Conventional grid



New technologies for smart grid:-

1. EMS (Energy Management system)
2. AMI (Advanced Metering Infrastructure).
3. BD (Big data)
4. EV (Electric vehicles)
5. IOT projects (Internet of Things)
6. Demand Response

A smart grid is an electricity network based on digital technology that is used to supply electricity to consumers via two way digital communication.

1) Energy Management System:-

A smart energy management system is a computer based system that monitors, controls, measures and optimize energy use or any other type of facility.

- The system can link electricity consuming structures such as HVAC (high voltage Alternating current), lighting and machine tools with meters, detectors.
- This may improve energy management system a prime example of smart grid solution aimed at efficiency.

Advanced metering infrastructure:-

AMI is an integrated system of smart meters, data management system and communication network that allows utilities and consumers to communicate in real time.

- AMI gives electric power providers two-way communication from the control center to the meter.

AMI provides remote consumption control, remote integration or disconnection of users, theft identification.

Having these features implies being able to better regulate the efficiency and quality of power grid.

Big data:

A huge quantity of data is collected from various sensors, wireless transmission, all of the data collected from generation to consumption.

is used by various algorithm to predict and will also aid in completely in understanding the pattern of power used.

Energy Big data includes not just data collected from meters, but also a quantity of environmental data. It involves 4 V's and

- (1) velocity
- (2) volume
- (3) value
- (4) variety

3 E's

- (1) Energy
- (2) Exchange
- (3) Empathy

Electric vehicle

Electric vehicles are favoured answer to global-warming concern, given the evident modernization of the transportation industry.

In future of innovative smart grid technology, the arrival of hybrid electric vehicles (or) plug-in electric vehicles bring with difficulties and opportunities and ^{for} power grid.

Smart grid future advance communication, smart metering and controlled technology.

IoT Projects

IoT projects include machine learning applications are already in IoT industries

Examples:

(1) Cipla

(2) Cisco.

Machine Learning is well known for its ability to work with large data set

(6) Demand Response:

- Demand Response programs are new and growing demand side management applications.
- Demand response applications in grid technology have been facilitated by the creation of energy regulatory bodies with open market.
- Customers change their electricity usage response time varying pricing set by their utility agency in order to maximize the power.

Indian Smart grid

Transform the Indian power sector into secure, sustainable and adaptive digitally enable ecosystem that provides reliable and quality energy for all with active participation of consumers.

- (1) distribution (including distribution generation)
- (2) transmission
- (3) policies, standard, Regulations
- (4) other initiatives

1) Distribution

It provides access to electricity for all with uninterrupted life line supply (8 hrs/day minimum peak hours) and electrification of 100% by 2017 and continuous improvement in quality of the supply.

This project in distribution utilities to reduce AT&C (Aggregate Technical and Commercial) losses to below 10% by 2027.

Modernization of distribution substations, & conversion of substation in all urban areas.

Development of micro grids, storage options, solar photo voltaic grid and building to grid technologies in order to manage peak demand.

2) Transmission

Development of reliable, secure 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 WAMs (Wide Area

monitoring system), PMU (Phasor measurement unit) for the entire transmission system.

This project in transmission utilities to reduce transmission losses to below 4% by 2017 and below 3.5% by 2022.

50000 kilometers optical fibre cables to be installed over transmission lines by the year 2017 to support implementation of smart grid technologies.

14) policies, standards, regulations

Formulation of effective customer outreach and communication program for active involvement of consumer in the smart grid implementation.

Finalization of framework for the cyber security assessment, audit of power utilities by the end of 2012.

Policies supporting improved tariffs such as dynamic tariff, variable tariff etc.

Other initiatives:-

New energy product, energy option and program to encourage participation of consumer in the energy market that make them

producers and consumers by 2017.

Creative and effective information exchange platform that can be shared by all market participants including consumers in real time, which will lead to the development of energy market.

Development of the power grid skill centers because of creating awareness about utilization of power (energy).

Key challenges for Smart grid:

- 1) Policies and Regulations
- 2) Ageing & outdated Infrastructure.
- 3) Lack of Integrated Communication platform
- 4) High initial and operating cost.
- 5) Big data handling.
- 6) Compatibility for older equipment.
- 7) Lack of Standard inter operability
- 8) Smart grid cyber security
- 9) Lack of Smart Consumer

	Technologies	challenges	Obligations
1	Self healing	1. security	Exposed to internet attacks, question of national security
		2. Reliability	Failure during natural disaster, system outage and total block out
2	Renewable energy Source	1. wind/solar generation	Long term and unpredictable intermittent source of energy, unscheduled power flow.
		2. optimization power flow	Transmission line congestions and huge investment.
		3. power system stability	Decoupling causes system stability issue, causes reduced inertia due to high level wind penetration
3	Energy storage system	1. Cost	Expensive energy storage systems by capacitors
4	ND	2. complexity	Complex customer design module and network
		3. not flexibility	unique design for all individual network
4	Consumer motivation	1. security	malware, data corruption and illegal power handling.
		2. Privacy	Sharing of data cause privacy
		3. Consumer awareness	Power Corruption and system threats
5	Power quality	1. Disturbance Identification	Grid disturbance due to local faults in grids, load centers or source
		2. Harmonics	voltage imbalance or fluctuation cause harmonics

6. Reliability

1. Grid automation

2. Grid reconfiguration

Need of strong data system, control and communication

Generation demand equilibrium and power system stability.

Advantages and Disadvantages of smart grid

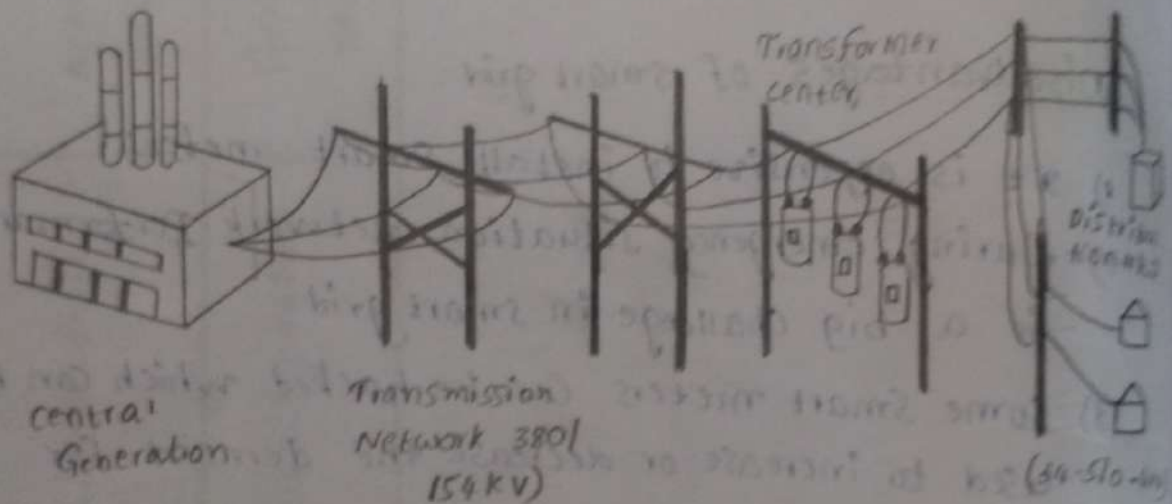
- 1) It reduce electricity theft
- 2) It reduce Electricity losses (transmission and distribution).
- 3) It reduces electricity cost, meter regarding cost, maintenance cost
- 4) It reduce equipment failure.
- 5) It reduce emission
- 6) smart grid is capable of meeting increased.

Disadvantages of smart grid:

- 1) It is expensive to install smart meters
- 2) During emergency situation, network performance is a big challenge in smart grid.
- 3) Some smart meters can be hacked which can be used to increase or decrease the demand for meter.
- 4) Continuous Communication network b/w Generation, Transmission, Distribution, Utilization.

Structure of Conventional Grid:

- The conventional grid is an interconnected network for delivering electricity from suppliers to consumers.
- Consists of generating stations that produce electric power, hi
- high-voltage transmission lines that carry power from distant sources to demand centers.
- And has distribution lines that connect individual customers.



There are 3 reasons to convert the conventional grid to Smart grid.

The increased energy demand

The energy demand is rapidly increased owing to new technologies such as electric vehicles.

Decreasing the losses and illegal usages:

The losses and illegal usages seen in transmission and distribution lines.

The increased producing and carriage capacity in the existing plants:

- In order to meet the increased energy demand.
- To integrate the distributed energy sources such as solar and wind to the system.

- 1) Explain the difference between conventional grid & smart grid
- 2) Explain neatly about the smart grid roadmap for India.
- 3) Discuss the challenges and benefits in smart grid.
- 4) Explain the new technologies for smart grid.
- 5) Explain the functions of smart grid.
- 6) Explain the concept of self healing grid.
- 7) Explain in detail about smart grid and draw the layout of smart grid.

2M

- 8) Define smart grid
- 9) What is smart substation
- 10)