UNIT-III

Introduction to Smart Grid

The European Technology Platform [3] defines the Smart Grid as: "A SmartGrid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies."

A Smart Grid is an electricity Network based on Digital Technology that is used to supply electricity to consumers via Two-Way Digital Communication. This system allows for monitoring, analysis, control and communication within the supply chain to help improve efficiency, reduce the energy consumption and cost and maximise the transparency and reliability of the energy supply chain.

Smart Grid is a new electricity network, which highly integrates the advanced sensing and measurement technologies, information and communication technologies (ICTs), analytical and decision-making technologies, automatic control technologies with energy and power technologies and infrastructure of electricity grids.

Need for Smart Grid

• Opportunities to take advantage of improvements in electronic communication technology to resolve the limitations and costs of the electrical grid have became apparent.

• Concerns over environmental damage from fossil-fired power stations.

• Rapidly falling costs of renewable based sources point to a major change from the centralized grid topology to one that is highly distributed.

Functions of Smart Grid

• Exchange data on generators, consumers and grids over the internet and process this data by means of information technology.

• Integrate numerous new smaller electricity generation facilities.

• Balance out the fluctuations in electricity.

• Use a higher degree of network coordination to reconfigure the system to prevent fault currents from exceeding damaging levels.

• Real-time determination of element's ability to carry load based on electrical and environmental conditions.

• Automatic isolation and reconfiguration of faulted segments and independently operating portions of the T&D system.

• Online monitoring and analysis of equipment performance.

Opportunities of Smart Grid:

• Upgrading and expanding infrastructure to improve interconnectivity and communications.

• Build up smart tools and technologies to exploit DR, demand load control and energy efficiency.

• Promote smart grid investment and inform regulatory frameworks

• Build up infrastructure to guarantee cyber security and resilience.

• Regulations in communication, price and cyber security.

Local Opportunities of Smart Grid :

• **Integrated Communications**

– Data acquisition, protection and control and allowing consumers to interact

– Connect components in real-time for control and data exchange

– Scope for improvement

– Substation Automation, DR, Feeder automation, SCADA, EMSs, wireless mesh networks and other technologies, power-line carrier communications and fiber optics.

• **Sensing and measurement**

– Support acquiring data for healthy and integrity of grid

– Support faster and more accurate response

• **Advanced Components**

• **Advanced Control Methods**

• **Improved interfaces and decision support.**

Regional and National Opportunities of Smart Grid

- Provide high quality power
- Accommodate all generation and energy storage options
- Motivate consumers to actively participate in grid operations.
- Be self-healing
- Resist attack.

Global Opportunities of Smart Grid

- Run the gird more efficiently
- Enable higher penetration of intermittent power generation sources.
- Enable electricity market to flourish.

Key Challenges of Smart Grid

- Strengthening of utility grid – should ensure high and efficient transmission capacity to accommodate more energy sources
- Moving offshore – Effective and efficient connection of wind farms, tidal and wave energy
- Developing decentralized architecture – enable harmonious operation of small-scale electricity supply system with total system
- Communications – should allows the operation and trade potentially in single market
- Advanced Demand Side – Enable consumers to play active role in system operation
- Integrating intermittent generation – Finding best ways to integrate intermittent generation like residential micro-generation
- Enhanced intelligence of generations
- Advanced power monitoring and control – enable synchronized phasor measurements and control to achieve efficient synchronization
- Capturing the benefits of DG and Storage – Develop more advanced technologies for DERs.
- Ensure reliable operation of SPV-Wind, SPV-fuel cells etc.. In remote areas.
- Preparing for electric vehicles

Barriers of Smart Grid:

- The existing power delivery infrastructure is vulnerable to human error, natural disasters, and intentional physical and cyber attack.

• Investment in expansion and maintenance of this infrastructure is lagging, while electricity demand grows and will continue to grow.

• This infrastructure is not being expanded or enhanced to meet the demands of wholesale competition in the electric power industry, and does not facilitate connectivity between consumers and markets.

• Under continued stress, the present infrastructure cannot support levels of power, security, quality, reliability and availability (SQRA) needed for economic prosperity.

• The infrastructure does not adequately accommodate emerging beneficial technologies including distributed energy resources and energy storage, nor does it facilitate enormous business opportunities in retail electricity/information services

Comparison of Conventional Utility Grid and Smart Grid

Characteristics	**Conventional utility grid**	**Smart grid**
Active participation consumer	Consumers are uninformed and they do not participate	Consumers are involved ,informed and participate actively
Provision of power quality for the division of economy	Response to power quality issues are low	Rapid resolution of power quality issues with priority
Accommodation of all generation	M any obstacles exist for integration of DERs	Many DERs with plug-and-play option can be integrated at any time
Optimization of assets	Little incorporation of operational data with asset management – business process silos	Greatly expanded data acquisition of grid parameters ;focus on prevention ,minimizing impact to consumers
New products, service and markets	Limited and poorly integrated wholesale markets ; limited opportunities for consumers	Mature and well integrated wholesale markets ; growth of new electricity markets for consumers
Resiliency against cyber attack and natural disasters	Vulnerable to malicious acts of terror and natural disasters ; slow	Resilient to cyber attack and natural disasters ; rapid restoration capabilities

	response	
Anticipating responses to system disturbances(self-healing)	Responds to prevent further damage; Focus on protecting assets following a fault	Automatically detects and responds to problems ; focus on prevention ; minimizing impact to consumers
Topology	Mainly radial	Network
Restoration	Manual	Decentralized control
Reliability	Based on static ,offline models and simulations	Proactive , real-time predictions , more actual system data
Power flow control	Limited	More extensive
Generation	Centralized	Centralized and distributed . Substantial RES and energy storage
Operation and maintenance	Manual and dispatching	Distributed monitoring , diagnostics and predictive
Interaction with energy users	Limited to large energy users	Extensive two-way communications
System communications	Limited to power companies	Expanded and real-time
Reaction time	Slow reaction time	Extremely quick reaction time

Concept of Resilient

The Smart Grid Dictionary defines resilience as **"the ability to resist failure and rapidly recover from breakdown**."

Therefore, a Resilient Grid is able to supply power to its end users and appliances despite failures within the grid, so that these failures will not affect the power offer for the end users (for example, storing power excess generated during events with lower-than-usual demand that can be released when an unforeseen event happens).

Self Healing Grid :It is the ability of a grid to automatically eliminate the faulty section from the rest of the grid, in order to reduce the downtime in the non-affected zone.