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Review paper on Smart grid technology: The Future of the electrical energy system

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ABSTRACT
With the advancement in technology, there is an immense increase in the demand of electrical energy that has not only become challenge for its production but also its distribution. So this rising demand is growing the complexities of power grids by increasing requirement for greater reliability, efficiency, security and environmental and energy sustainability concerns. These feature in a power grid towards smartness which eventually known as a today's concept of ''Smart Grid". This is a conceptual technique in which all smart features are implemented in order to increase the distribution system of electricity efficient, more reliable and sustainable. In this article an overview of ''Smart Grids" with its features and its different aspects on power distribution industry has been presented. It is also explained that how these technologies change and have more potential to evolve and strength the distribution system.
"Smart Grid" is a concept with many elements where monitoring and control of each element in the chain of generation, transmission, distribution and end use allow our electricity delivery and use more efficient.

I. INTRODUCTION

Network created through the combination of information technology, communication technology and electrical power system. Or, in simple word it is a electricity delivery system which integrated with communications and information technology. In numerous electrical companies may no longer be the source provider for both industry purpose and home application purpose. There was price differences bound to influence consumer choices. The larger power plants have generated most of electricity due to economic and scale merits. They have generated and transmitted electric power over long-winded and at different voltage levels. To control, product and maintain of distribution system these hierarchical operations have done. Traditionally it is assumption that electrical energy simply always flows from substations to the end of the feeders. However distributed generator is introduced under deregulated environment which results in reversal of power flow and troublesome voltage profiles in the distribution system. Therefore it is essential to modify the planning and operation techniques in the distribution system. Another term Grid computing is an important factor. It differs from traditional method in order to achieve goal on large scale resource. Hence the advancement of grid computing deals with programmers to exploit this technology.

An advancement with grid introduces wireless sensor networks which have become ongoing improvement in smart grid technology. These sensors make a provincial decision and the information is collected to generate a comprehensive model of its environment. The strength of sensors make nodes to cooperate like in sampling, data aggregation and status monitoring. Further there is adoption of Grid paradigm to implement an extensible multimedia server. The objective of this technology is to support coordinated different resources in virtual organization. Current grid systems are built on X.509 public key infrastructure. Today security management is an important issue. So smart card technology is employed to prevent data from unauthorized users.

Various technologies collectively are gathered into the phrase distributed computing. These computing systems give backing the future of power and energy services distribution system. An automatic meter reading is also installed to make competence for power consumption reading of users. It is dependent on various communication techniques for transferring data over far distances. The realization of smart grid hinges on steady data transmission by virtue of information and communication structure. So power line communication technology is installed to enlarge power communication network to customers.

II. OVERALL CONCEPT OF ENERGY METER

Became known over a decade ago and are essential in the digital transformation of the electricity sector. An introduction with definitions, trends and essential characteristics of smart grids. big data analytics and IoT technologies are important technology drivers in smart grids whereby analytics shift to the edge, as in edge

computing. Smart grids leverage more technologies but aren't just about IT or even technologies.

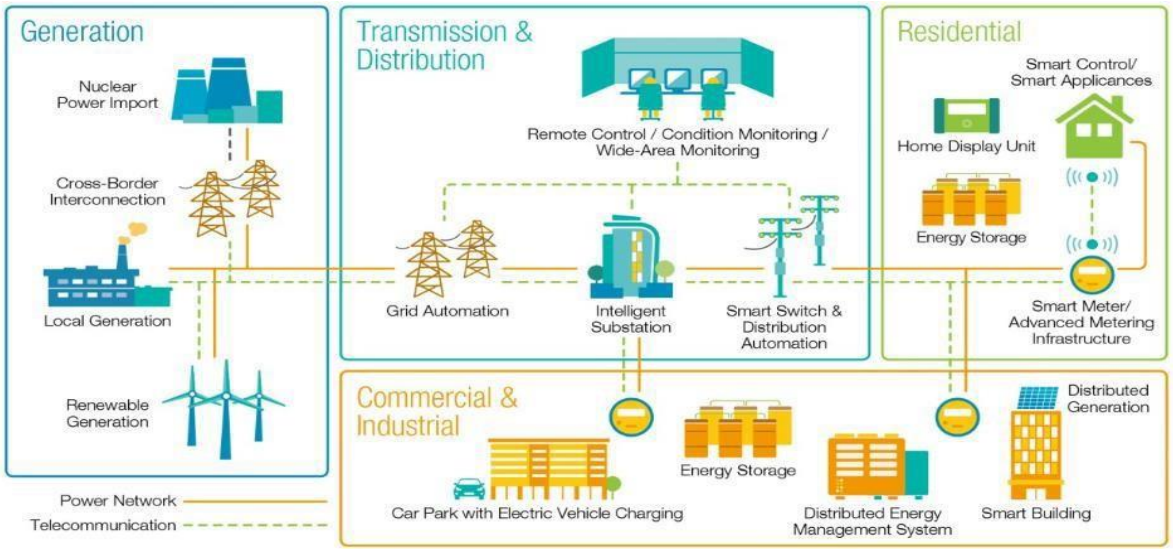
A smart grid is an electricity network enabling a two-way flow of electricity and data with digital communications technology enabling to detect, react and pro-act to changes in usage and multiple issues. Smart grids have self-healing capabilities and enable electricity customers to become active participants.

A smart grid serves several purposes and the movement from traditional electric grids to smart grids is driven by multiple factors, including the deregulation of the energy market, evolutions in metering, changes on the level of electricity production, decentralization (distributed energy), the advent of the involved 'prosumer', changing regulations, the rise of microgeneration and (isolated) microgrids, renewable energy mandates with more energy sources and new points where and purposes for which electricity is needed (e.g. electrical vehicle charging points).

In practice it is a highly interconnected network with several components such as substations, transmission lines and wiring, distribution lines, transformers and more.

III. OVERVIEW OF RECENT RESEACH

The smart grid can be defined as a smart electrical network that combines electrical network and smart digital communication technology. A smart grid has capable of providing electrical power from multiple and widely distributed sources, like from wind turbines, solar power systems, and perhaps even plug-in hybrid electric vehicles.



Smart Grid is an Electrical Grid with Automation, Communication and IT systems that can monitor power flows from points of generation to points of consumption (even down to appliances level) and control the power flow or curtail the load to match generation in real time or near real time. Smart Grids can be achieved by implementing efficient transmission & distribution systems, system operations, consumer integration and renewable integration. Smart grid solutions helps to monitor, measure and control power flows in real time that can contribute to identification of losses and thereby appropriate technical and managerial actions can be taken to arrest the losses.

Smart grid solutions can contribute to reduction of T&D losses, Peak load management, improved quality of Service, increased reliability, better asset management, renewable integration, better accessibility to electricity etc. and also lead to self-healing grids.

IV. COMPARISON ANALYSIS OF EXISTING GRID AND SMART GRID

EXISTING GRID	SMART GRID
1. It is electromechanical.	1. It is digital.
2. One way communication.	2. Two way communication.
3. Centralized generation.	3. Distributed generation.
4. Few sensors.	4. Sensors throughout.

5. Manual monitoring.	5. Self monitoring.
6. Manual restoration.	6. Self healing.
7. Failures and black out.	7. Adaptive and intelligent.
8. Limited control.	8. Pervasive control.
9. Few customer choices.	9. Many customer choices.
10. Less energy efficient.	10. More energy efficient.

This is the comparison of smart grid or existing grid, the smart grid is more faster and more advancen and more economical better than existing grid.

V. REQUIREMENT OF A SMART GRID

1. RELIABILITY-Success of the grid system depends upon the customer need which is measured as reliability. This mean as flaw less and error less system with continuous supply of electric power. Smart Grid has a potential to detect any fault and allow the self-healing of the system. Conventional grids have issues regarding interaction of renewable resources, micro grid and demand response. With increase the size and complexity of these grids with demand it makes more difficult to analyze its reliability. But these issues are very well addressed by Smart Grids. For this, Smart Grids have capability to monitor and store all the data and estimate its service reliability. It may also possible to monitor remotely for hybrid generation and management of the grid whichenhance
its reliability. Technologies like Dynamic Stochastic Optimal Power Flow (DSOPF) helps in estimating and optimizing the flow of power in Smart Grid. Therefore, Smart Grids can have better reliability with the advancement in communication system.

2. INTELLIGENCE- Because of the rapid revolution of the modern power system,more distributed smart grid components—including smart meteringinfrastructure, communication infrastructure, distributed energy resources, and electric vehicles—are tightly integrated into power system by encompassing a huge electrical power network with the underlying communication system. Massive amounts of data are generated by those components to automate and improve the smart grid performance by supporting vast applications, such as distributed energy management system state forecasting FD and cyberattack security. Because the conventional computational techniques do not have the sufficient ability to process the vast amount of data introduced by smart grid systems, AI techniques have received much attention. Many of the research efforts were put into studying these AI techniques to address the challenges, because they use large-scale data to furtherimprove smart grid performance.

At the distribution level, intelligent support schemes will have monitoring capabilities for automation using smart meters, communication links between consumers and utility control, energy management components, and AMI.

Inform power delivery centre.

3. TWO WAY COMMUNICATION- Two way communications allows energy consumers to receive accurate real-time prices and bills. The grid operator can receive consumers' real time information about the amount of the consumed energy.The reliable real-time information flow between all grids' components is essential for smart grid's successful operation. This can be implemented by a reliable and effective communication infrastructure which can be wired or wireless. The advantages of the wireless infrastructure compared to the wired infrastructure are low costs and simple connection to distant and unreachable areas. The disadvantages are interference with other signals and electromagnetic fields and dependence on batteries.

Electricity and data exchange occurs.

Distribution company may get more accurate data.

4. SELF HEALING- A smart grid automatically detects and responds to routine problems and quickly recover sif they occur, minimizing downtime and financial loss

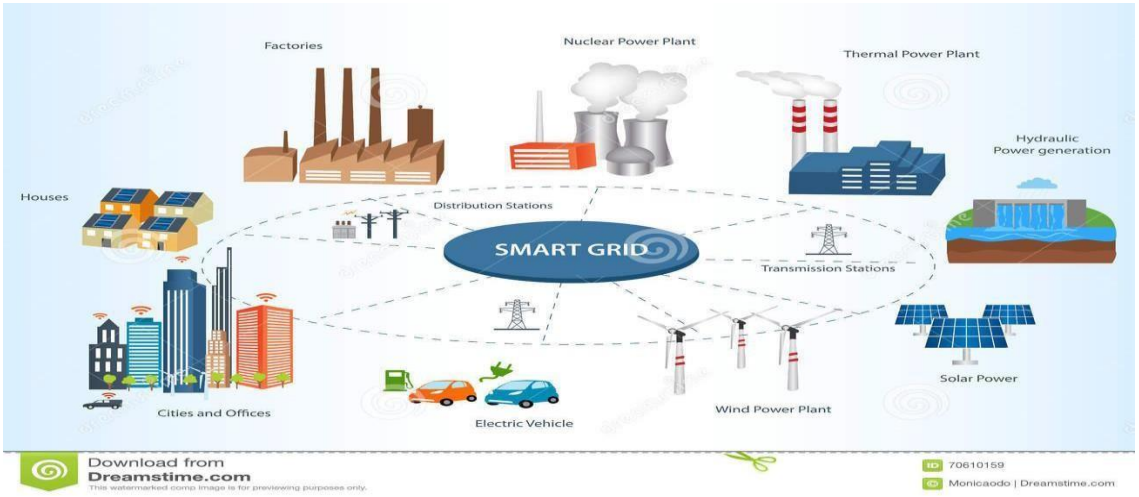
A secure ―architected‖ sensing, communications, automation (control), and energy overlaid infrastructure as an integrated, reconfigurable, and electronically controlled system that will offer unprecedented flexibility and functionality, and improve system availability, security, quality, resilience and robustness.

The Self-Healing Grid is a system comprised of sensors, automated controls, and advanced software that utilizes real-time distribution data to detect and isolate faults and to reconfigure the distribution network to minimize the

customers impacted.
One of the main goals of a Self-Healing Grid is to improve system reliability. This can be accomplished by reconfiguring the switches and reclosers installed on the distribution feeder to quickly isolate the faulted section of the feeder and re-establish service to as many customers as possible from alternate sources/feeders.
A smart grid automatically detects and responds to routine problems and quickly recovers if they occur, minimizing downtime and financial loss.

5. REAL TIME MONITORING AND CONTROL- This paper presents a low cost, low power consuming system that can be used for quick and accurate power system parameter monitoring under smart grid environment. The recent research on smart grid provides the approach for the real-time control and monitoring of grid power systems based on bidirectional communications. The designed system will continuously measures, processes and display the power system parameters like voltage, current, phasor difference, power factor, power consumption using ultra low power microcontroller. Measurement of power system parameters of resistive and inductive loads are monitoredusing PIC16F877A microcontroller.

6. INTEGRATED COMMUNICATION-.The key technology,
Smart Grid is designed to integrate advanced communication/networking technologies into electrical power grids to make them "smarter". Current situation is that most of the blackouts and voltage sags could be prevented if we have better and faster communication devices and technologies for the electrical grid. In order to make the current electrica...



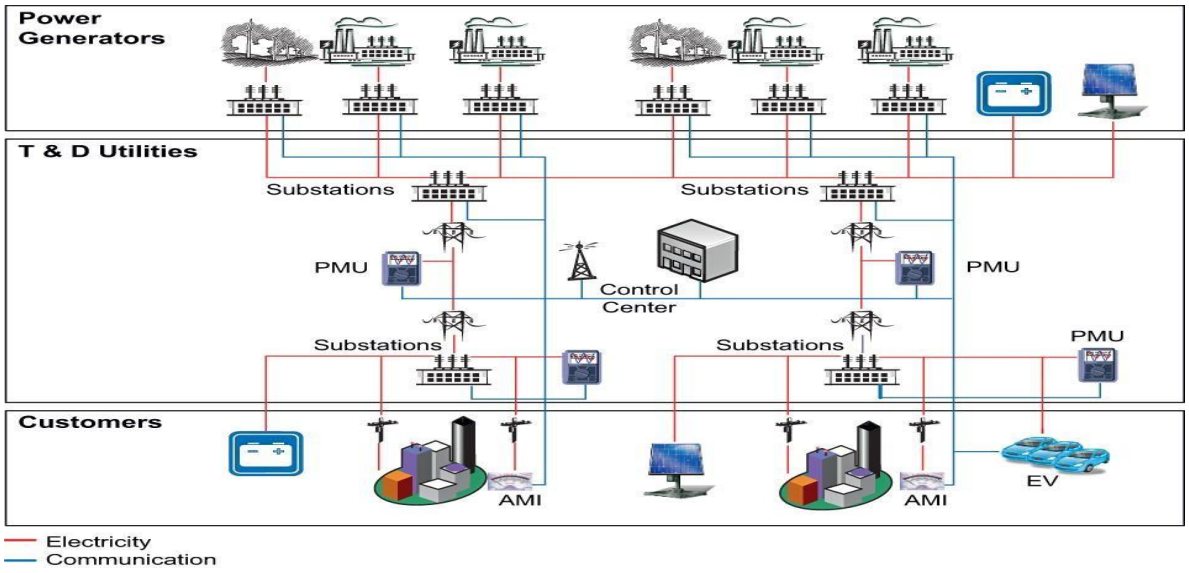
.Both wired(e.g., copper cable, fiber optic cable, power line carrier)&wireless(e.g.,celluler,satellite,microwave),

As mentioned earlier, Smart Grid networks can be divided into HANs, BANs, IANs, Neighborhood Area Networks (NANs), and Field Area Networks (FANs): wired and wireless networks that connect utility systems to customer premises in order to support a wide range of communication and control applications [178], including demand response and distribution automation. These networks potentially spread over wide geographic areas. Therefore, a range of wired and wireless technologies are relevant to these networks, including Cellular, RF Mesh, WLAN 802.11, WiMAX, ZigBee,
McMiLL, etc., which can potentially be applied to and integrated into Smart Grid networksFast enough

VI. DESIGN-

The current power infrastructure is in need of an update for better efficiency, reliability, and safety. Standards organizations and engineers have risen to the challenge, promising to solve many problems with the grid. The so-called "smart grid" embodies many of these solutions. Implementing a smart grid system offers significant design challenges to the engineer, as these systems must have longevity, from not only from a reliability standpoint but also performance and component availability.

A modern power delivery architecture has power generation, transmission and distribution, and end users. The smart grid differs from legacy systems in many ways, including incorporating renewable energy sources, energy storage, and instrumentation for consumer metering and grid performance analysis. Optimal control of the grid hinges on the presence of extensive communications, the close monitoring and control of grid parameters, and provisions to aid reliability and security.



VII. CONPONENTS OF SMART GRID

To achieve a modernized smart grid, a wide range of technologies should be developed and must be implemented. These technologiesgenerally grouped into following key technology areas as discussed below.

1. SMART SUBSTATION- substations are included monitoring and control non-critical and critical operational data such as power status, power factor performance, breaker, security, transformer status, etc. substations are used to transform voltage at several times in many locations, that providing safe and reliable delivery of energy. Smart substations are also necessary for splitting the path of electricity flow into many directions. Substations require large and very expensive equipment to operate, including transformers, switches, capacitor banks, circuit breakers, a network protected relays andseveral others.

2. SMART POWER METERS- The smart meters provide two-way communication between power providers and the end user consumers to automate billing data -collections, detect device failures and dispatch repair crews to the exact location much faster.

3. SUPER CONDUCTING CABLE- These are used to provide long distance power transmission, and automated monitoring and analysis tools capable of detecting faults itself or even predicting cable and failures based on real-time data weather, and theoutage history.

4. PHASOR MEASUREMENT UNIT- This is used to measure the electrical waves on an electricity grid using a common time source for synchronization. The time synchronizer allows synchronized real-time measurements of multiple remote measurement points on the grid.

5. NEW SENSORS- In smart grids, several parameters must be measured, such as voltage, current, temperature, and phase, to be able to detect any parameter fluctuation in near real time and manage the corrective actions to assure grid reliability under fault conditions. Furthermore, the measured data must be readable by intelligent devices and contain a timestamp as well as the sensor location to facilitate decision support in smart grid operation. The relay-based smart sensor proposed in this paper is a single device composed of several modules.

VIII. BENEFITS OF SMART GRID DEPLOYMENT-

Several groups of the society are provided with multiple benefits through the Smart Grid implementations. Such include utility, customers and the regulators while some of the benefits include:

1. Reduction of Transmission&Distribution losses.
2. Peak load management, improved QoS and reliability.
3. Reduction in power purchase cost.
4. Better asset management.
5. Increased grid visibility and self-healing grids.
6. Renewable integration and accessibility to electricity.

7. Increased options such as ToU tariff, DR programs, net metering.
8. Satisfied customers and financially sound utilities etc.

IX. CASE STUDY-

➢ **Smart grid projects under NSGM:-**

So far, following projects have been sanctioned under National Smart Grid Mission:

- CED, Chandigarh (Sub Division 5).
- CED, Chandigarh (complete city excluding Sub Div 5).
- KSEB, Thiruvananthapuram (Kochi).
- JBVNL,Jharkhand(Ranchi).
- OPTCL, Odisha (Rourkela).

➢ **Smart Grid pilot projects under IPDS:-**

The Smart Grid pilot projects sanctioned by Ministry of Power which are completed/under implementation are as follows:

- AVVNL, Ajmer.
- APDCL, Assam.
- CESC, Mysore.
- HPSEB, Himachal Pradesh.
- PED, Puducherry.
- TSECL, Tripura.
- TSSPDCL, Telengana.
- IIT Kanpur
- WBSEDCL, West Bengal
- UGVCL, Gujarat

X. CONCLUSION

Advancement of the technologies and devices can change the utilization of energy in an economical and environmental friendly way. Evolution of Smart Grid concept has potential to meet all the future needs of utilization of energy in best possible manner by reducing carbon emission and integrate with more renewable energy mix. It can bring a considerable change in the conventional grid and consumer behavior towards utilization of energy by improving reliability, efficiency and quality ofpower delivery. Governmental policies are needed to facilitate smart grid implementation. This article pointed out the need of modernization of conventional grid and how researchers are implementing smart grid concept for electric power distribution networks. Still there is a lot of potential available for improving and implementation of this concept as it is just the start of the new era of modern grid.

It is still difficult to predict that how far the research in smart grid is required to fully implement this concept but recent researches like smart meters, demand side management systems, selfhealing and big data are source of encouragement in Smart gridtechnology.