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A Review Paper on Smart Grid and its Requirement in India

Pirmahamad Jamalbhai Vasovala¹, Mujahidmahedi Iqbalbhai Mirchiwala², Risil Jayantilal Bhagat³, Mayank Yogeshbhai Vyas⁴, Purvesh Arvindbhai Valand⁵

¹M.E.Electrical (power system), Lecturer in Parul Institute of Engineering & Technology Diploma Studies, Vadodara

²B.E.Electrical, Lecturer in Parul Institute of Engineering & Technology Diploma Studies, Vadodara

³B.E.Electrical, Lecturer in Parul Institute of Engineering & Technology Diploma Studies, Vadodara

⁴M.E. Electrical (power electronics), Lecturer in Parul Institute of Engineering & Technology Diploma Studies, Vadodara

⁵B.E.Electrical, Lecturer in Parul Institute of Engineering & Technology Diploma Studies, Vadodara

Abstract: *India, a developing country, is facing many problems in growth at every point of electrical energy system. In such cases, smart grid is the only solution which provides an open market of electricity generation, transmission and distribution. Indian power sector has taken some steps for framework of smart grid with various regulatory and standards' organizations. India is having various constraints such as financial, geographical etc. for development of smart grid. The term "smart grid" represents a vision for a digital upgrade of distribution and long distance transmission grids by using robust two-way communications, advanced sensors, advanced metering, automation, communication, distributed generation, distributed storage and distributed computers to improve the efficiency, reliability, self-healing, energy management, real-time pricing and safety of power delivery and use. The next-generation electricity grid, known as the "smart grid" is expected to address the Major shortcomings of the existing grid.*

Keywords: *Smart Grid, the Bureau of Energy Efficiency, Green house gases, Energy Storage Systems*

I. INTRODUCTION

The Republic of India is the seventh largest country by Geographical area and the second largest by population. India is world's sixth largest energy consumer, accounting for 3.4% of global energy consumption. Per capita energy consumption is a key aspect development of society. To enhance power system operation, performance and efficiency; research in power system must be carried out because of exponentially growing demand. Over the last few years, electrical energy consumption has continually increased but investment in the T&D infrastructure has not correspondingly increased in India. Traditional solutions for upgrading the electrical system Infrastructure have been primarily in the form of new power plants, new transmission lines, substations, and associated equipment's. However, as experience has proven, the process of authorizing, locating, and constructing new transmission lines has become extremely difficult, expensive and time-consuming. As a result, the power grid is under stress, resulting in compromised reliability and higher energy costs. Majorities of existing traditional electricity power grids are neither designed to comply with the rapid climate changes and high energy-efficiency nor use the latest technologies. The existing grids have many problems such as limited delivery system, supply shortfalls, high technical and commercial losses, peak load Management, limited use of renewable energy, high cost of power outage and power quality interruption etc. The current total power generation of India is 163669.80 MW. It is estimated that 56 percent of rural households and 12 percent of urban households are still without adequate access to electricity and there is peak power shortage of around 15 percent. According to Indian Power Ministry around 40% of power is stolen from the grid by informal and illegal hook-ups to the overhead or underground network, putting further strain on a system that is already struggling to meet existing demand. One of such incipient technology, Smart Grid (SG) plays a very vital role in achieving the key technical benefits like power loss reduction; refining quality of supply, peak reduction, economic load dispatch etc. Smart Grid technology has been a high priority topic of research and development in many developing as well as developed countries. This technology also has a dynamic role in remodeling the energy scenario of the global market. Factors like policies, regulation, efficiency of market, costs and benefits and services normalizes the marketing strategy of the Smart Grid technology. Other concerns like secure communication, Standard protocol, advance database management and efficient architecture with ethical data exchange add to its essentials. Such technology has a potential to prolific other technologies like Flexible AC Transmission System (FACTS) and Wide Area Monitoring (WAM) to redefine the capability of power system engineering and unite the necessity of the

rural, suburban and urban regions across the globe under single roof . In addition, the technology employs the reduction of carbon footprints and foot-dragging the Greenhouse gas emission.

Integrated Smart Grid solutions combine advanced technologies, to provide enhanced services for the end users. India’s power ministry Smart Grid solutions, including distribution automation, demand side management, demand response, distributed energy management and advanced metering infrastructure, allow utilities to identify and correct a number of specific system issues through a single integrated, robust, and scalable Smart Grid platform.

As a result, these solutions increase the efficiency and reliability of the electric grid while reducing the environmental impact of electric usage benefiting utilities, their customers, and the environment.

II. WHAT IS SMART GRID?

According to the US Department of Energy, "Smart Grid uses digital technology to improve reliability, security and efficiency (both economic and energy) of the electrical system from large generation, through delivery system to electricity consumers and a growing number of distributed generation

and storage resources". In other words, "The Smart Grid is the use of sensors, communications, computational ability and control in some form to enhance the overall functionality of electrical power System delivery".

At this moment, there is no consistent definition of "a smart grid" or "the smart grid". The term "smart grid" refers to a way of operating the power system using communication technology, power electronic technologies, and storage technologies to balance production and consumption at all levels[9]. Principle functionality characteristics of Smart Grids are active consumer’s participation, seamless accommodation of all generation and storage options, provision of new products and services, opening of new markets, power quality, optimization of asset utilization, anticipation and response to system disturbances etc. The Smart Grid, which combines a number of technologies, end-users solution and trying to address many policy and regulatory drivers. Following are the key technical features of the smart grid:

- A. Absolute reliability, quality and efficiency of supply
- B. Optimal use of bulk power generation with distributed generation
- C. Minimum environmental impact of electricity production and consumption.
- D. Resiliency of supply and delivery from physical and cyber attacks
- E. Monitoring and controlling of all critical component of power system etc.

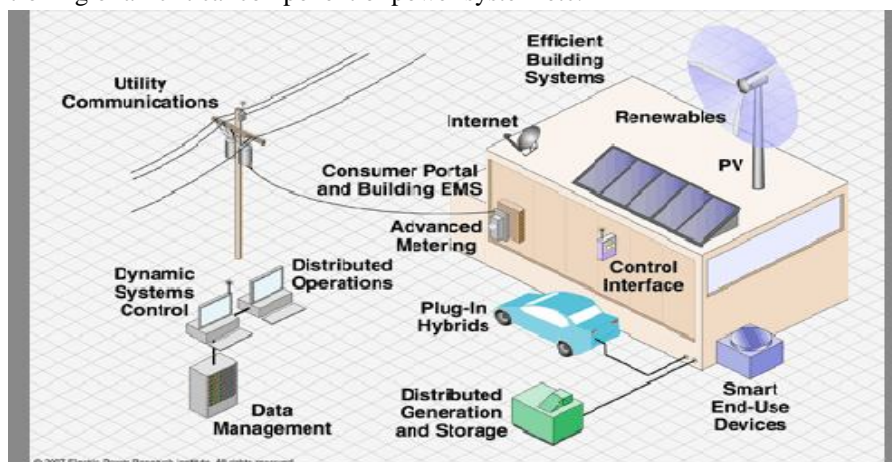


Fig. 1: Different parts of a smart grid

The National Energy Technology Laboratory (NETL) has proposed the following five key technological areas (KTAs) for a smart grid:

- 1) Integrated communications
- 2) Sensing and measurement
- 3) Advanced power electronic components
- 4) Advanced control and protection
- 5) Improved interfaces and decision support

The smart grid influence all parts of a power system. The generation side will change with a widespread integration of renewable and distributed generation sources. The transmission system in a smart grid will be revolutionized with the help of new technologies like Phasor Measurement Units (PMUs). With PMUs, advanced communications and computing techniques it will be possible to precisely measure the state of a power grid. It will be useful in preventing cascading blackouts. Today's power system operators take action in the multi-second to multi-minute time frame, but

PMU based system can make and execute decisions in the 100 millisecond time frame. With PMUs dispersed throughout the system, the power transfer capacity of lines can also be increased. Advanced FACTS devices will be used in the smart grid to manage power flow in a more controlled way. The most dramatic change will take place on the distribution side which is the most neglected part in the conventional system. Smart grid will utilize smart meters based Advanced Metering Infrastructure (AMI) to not only measure, store and communicate loads and other crucial statistics in real time but it will be a controller also with connect and disconnect capability for better grid management.

III. NECESSITY OF SMART GRID IN INDIA

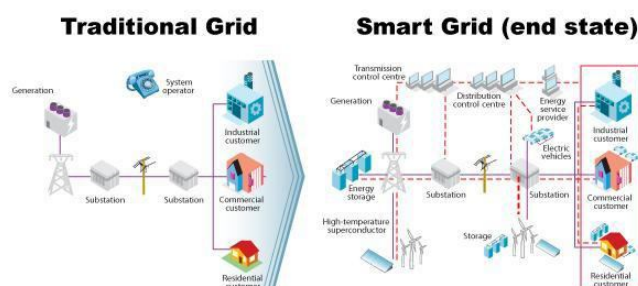
Along with this quantitative growth, the Indian electricity sector has also achieved qualitative growth. This is reflected in the advanced technological capabilities and large number of highly skilled personnel available in the country. While this must be appreciated, it must also be realized that the growth of the sector has not been balanced. The availability of power has increased but demand has consistently outstripped supply and substantial energy (7.1%) and peak shortages (11.2%) prevail in India. Apart from this, only about 56% of households have access to electricity, with the rural access being 44% and urban access about 82%. Reliability and quality are matters of great concern in the case of those who do have electricity. These problems are due to the disadvantages of existing grid. The existing grid have following problems:

- 1) inadequate power generation capacity
- 2) lack of optimum utilization of the existing generation capacity
- 3) inadequate inter-regional transmission links
- 4) Inadequate and ageing sub-transmission and distribution network leading to power cuts and local failures/faults
- 5) T&D losses, large scale theft and skewed tariff structure
- 6) slow pace of rural electrification
- 7) inefficient use of electricity by the end consumer
- 8) lack of grid discipline

This situation may change with the help of smart grid. According P. Uma Shankar, Secretary of Power, India, "The smart grid is not luxury (in India), but it's a necessity." A modernized smart grid would create electrical power system that:

- 9) will reduce peak loads and generate reserve margins
- 10) will delete capital costs of new T&D infrastructure as well as generating plants
- 11) will lower T&D line losses together with operation and maintenance cost
- 12) will redirect power flows, change load patterns, improve voltage profiles and stability
- 13) will enable loads, energy storage systems (ESS) and distributed generation (DG) to participate in system operations
- 14) will have much more information about system rising problems before they affect service, through extensive monitoring, quick communications, and feedback control of operations
- 15) provide system utilities with advanced visualization tools to enhance their ability to oversee the system.

SMART GRIDS



Smart grid technologies provide a range of solutions that can be tailored to the specific needs of each region. India is in a unique position as it is still building its most of its electrical infrastructure and thus will be able to leverage the maximum benefits of smart grids. Smart grids will not just help reduce theft, but also improve the network efficiency, consumer efficiency, and will be able to utilize dispersed energy resources like wind and solar to its optimum capacity.

Recently the Bureau of Energy Efficiency and some utilities have initiated work on designing a programme for smart grids. The smart grid will help in modernization of the transmission and distribution system through the integration of new information technologies that allow for new uses of the electric grid, both in operations and through new customer side applications. The price of electricity may be reduced through increased interaction of the consumer and supplier.

Green house gases (GHG) can be reduced by promoting smart grid in India. Promoting a more even deployment of renewable energy sources, and allowing access to more environmentally-friendly electricity generation will help for managing both socio-economic and environmental challenges of the country.

Under the union government's power reforms scheme, the R-APDRP, the target is to reduce transmission and distribution losses from 33% to 15%. State electricity boards can appoint IT firms as consultants or act as implementation agencies to distribution companies. States like West Bengal and Rajasthan have already awarded IT projects, while others including Madhya Pradesh and Maharashtra are in the process of doing so. Experts say even the non-IT opportunity is large especially for small and medium manufacturing industries. In India, smart grid technology is still new, but is definitely gaining leverage.[25]A smart grid pilot project is to be implemented in the Bangalore's IT hub Electronics City under the public-private partnership model and the state plans to set up similar smart grids across the state. An Ahmadabad-based company also is in the process of implementing the first smart grid pilot in India. In an initiative that is untried in the country as yet, the state government will soon start a pilot project using smart grids produced by a company supported by the Indian Institute of Management-Ahmadabad in a city's neighborhood. North Delhi Power Ltd is also one of the utilities which have introduced this concept. Some Software giants are working with NDPL to bring these energy solutions to India. As a result of NDPL's automation strategy, the utility has already reduced losses from 54% to less than 18% over the past five years. The Report observes that India's power sector, in particular the distribution sector, must undergo a fundamental transformation to serve India's economic growth and societal needs. The report provides a technology trajectory for distribution illustrated in three steps:

- a) Advanced metering to reduce AT&C Losses that are at an unacceptably high level presently.
- b) Automation to measure and control the flow of power to/from consumers on a near real-time basis.
- 3) Moving to a smart grid to intelligently manage outages, load, congestion and shortfall.

IV. TECHNICAL CHALLENGES ARISE FOR DEVELOPING SMART GRID

This section presents the possible challenges that represent the main obstacles for development of smart grid in India.

A. *Integration of Renewable Energy in India*

This is very important research area especially in India. For better implementation of smart grid share of renewable energy sources must be increased to 30% to 40% of total generating capacity which requires large investment with high technical knowledge. Renewable energies such as small hydro plants, solar, wind, biomass, and tidal based generations have many technical and commercial challenges.

These are:

- 1) Wind forecasting and weather dependency
- 2) Reliability of renewable energy sources
- 3) Connection with grid and transmission of power as they are located away from load center
- 4) Power flow optimization and stability study with renewable generation
- 5) Reactive power compensation especially in inductor generator based wind generation
- 6) Design of power electronic devices with higher efficiency and less power quality problems

B. *Energy Storage Systems (ESS)*

As the use of renewable energy sources is increased, it is desirable that to integrate energy storage devices such as batteries, flywheel based energy storage, electrical vehicles etc. This will help in maximum utilization of renewable energy sources when available. Energy storage devices are not so popular in India. Hence extra attention is required for ESS. As a result, following challenges may arise:

- 1) Complexity and non-flexibility of ESS
- 2) Design problems of ESS
- 3) Conversion from AC to DC and DC to AC using power electronic circuits with higher efficiency.
- 4) Optimum use of ESS as initial cost is high.

C. Power Market Tools

To accommodate changes in markets of retail power, market-based mechanisms are need. This will offer incentives to market participants in ways that benefit all stake holders.

In India, there is lack of co-ordination in suppliers and service providers. Following are the challenges of power market:

- 1) Financial management
- 2) Open access of data
- 3) Development of data and communication standards for emerging market
- 4) Development of market simulation tools

D. Sensors, Software's and Hardware

The smart grid involves huge amount of data to be transferred and processed. It may be related to smart meter reading, outages, other service degradation and disruptions. This means that it will involve number of monitoring and controlling points. At every point of detection, smart sensors will require.

Old sensors and measuring equipment have many limitations while used in the development of smart grid. Without software's and hardware, it is not possible to design any smart grid. Following are the challenges in this area:

- 1) Smart sensors and actuators
- 2) Design of front and back office software
- 3) High speed hardware
- 4) High speed data recording
- 5) Information storage system
- 6) Exchange of data

V. CONCLUSION

The electrical power industry is undergoing rapid change. The rising cost of energy, the mass electrification of everyday life, and climate change are the major drivers that will determine the speed at which such transformations will occur. Hence

Smart grid is essential in India. While developing smart grid, various technical problems might occur as discussed above. The solution of these challenges is possible through a proper research direction. Research on smart grid should be undertaken by various universities and government to overcome its multiple challenges. India has a huge opportunity to capitalize on these solutions, to enhance profits, improve energy availability and security, support its rural electrification objectives and move towards a low carbon development pathway.

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