

Role of Smart Grid For Rural Electrification

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Abstract The Smart Grid (SG), as described by the Institute of Electrical and Electronics Engineers (IEEE), encompasses the integration of power, communications, and information technologies for an improved electric power infrastructure that serves end-use applications and loads.” In Indian power scenario; the Smart Grid can improve resilience to outages and security threats, lower operating costs, and allow the integration of cleaner energy sources. Smart Grid technologies offer the promise of increased responsiveness by grid operators, reduced blackouts and line losses, and greater insight for consumers about their own energy use and its costs. The Smart Grid can be viewed as the infrastructure component of smart energy, which includes two other components: smart power, the efficient and clean production of electricity using a variety of resources including renewables and energy efficiency; and smart choices, programs that help customers make use of current and emerging electro-technologies.

A Smart Grid can be achieved through system flexibility, large-scale integration of communications and advanced controls, and interoperability of a greater diversity of technologies and end-use applications. The Smart Grid is moving towards improved interoperability by incorporating highly automated electric power systems. In addition to supporting infrastructure, these systems have the ability to monitor and manage power availability, power quality, and immediate and predicted load demands. Including myriad monitoring and control activities will enable a two-way flow of electricity and will communicate information about energy production, transportation, and consumption. This level of interoperability will improve communication throughout all areas of the Smart Grid operating with end-use applications and loads. To be successful in India, a Smart Grid must be secure and operationally sound. A secure, flexible grid, such as a Smart Grid, is more resilient to physical and cyber-attacks and is able to minimize both significant service disruptions and time to restore service.

Furthermore, in rural India a Smart Grid can assist in providing a cleaner environment by enhancing grid efficiency and enabling greater use of all energy resources including distributed and intermittent resources. Smart meters and other devices and software systems can provide energy price signals that reflect the true cost and value of energy to customers that influence demand and enable both energy efficiency and demand response.

Key Words: Smart grid(SG), Cyber attack,

INTRODUCTION:

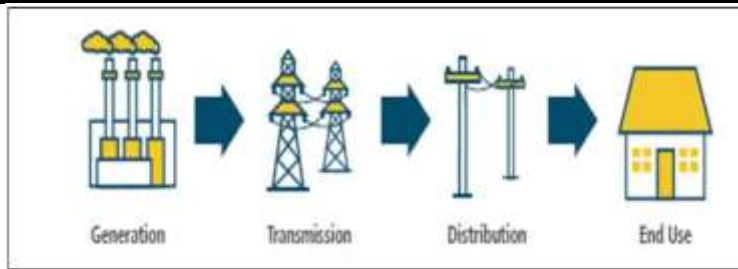
When the term Smart Grid is used, it refers to the entire electrical system, including generation, transmission, distribution and customers, but also operation, market and service providers that make the grid “smarter”. The distribution system (generally either 25 kV or 15 kV) is the largest and most complex part of the entire electrical system. For some large urban utilities that also have transmission and generation facilities, is sometimes the most neglected part of the system regarding its planning, operations and maintenance. For the smaller rural utilities, it receives much more attention. In addition, some feel that for rural parts of the distribution system, Smart Grid technologies cannot be utilized. If we speak today of Smart Cities, why not apply it to rural?

Rural Smart Grid consists of applying innovative solutions to the electrical generation in the countryside. Many of these networks are being promoted by Agriculture and Environment Departments or the rural communities. The idea is to deploy smart grids to harness energy that can be generated in the territory, improve power quality and energy efficiency. At the same time, they are used as a strategy for the growth and the creation of social and agro industrial opportunities in rural areas, reinvesting in a benefit to the whole society.

The electrical grid comprises all of the power plants generating electricity, together with the transmission and distribution lines and systems that bring power to end-use customers. The “grid” also connects the many publicly and privately owned electric utility and power companies in different states and regions of the United States. However, with changes in federal law, regulatory changes, and the aging of the electric power infrastructure as drivers, the grid is changing from a largely patchwork system built to serve the needs of individual electric utility companies to essentially a national interconnected system, accommodating massive transfers of electrical energy among regions of the United States.

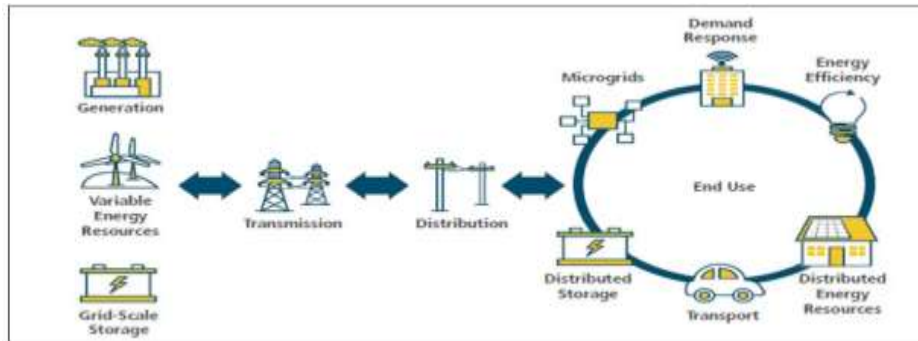
The modernization of the grid to accommodate today’s power flows, serve reliability needs, and meet future projected uses is leading to the incorporation of electronic intelligence capabilities for power control purposes and operations monitoring. The “Smart Grid” is the name given to this evolving intelligent electric power network, with digital technologies increasingly replacing analog devices, thus enabling Smart Grid hardware and software functions.

We can describe the Smart Grid as “an intelligent electricity grid—one that uses digital communications technology, information systems, and automation to detect and react to local changes in usage, improve system operating efficiency, and, in turn, reduce operating costs while maintaining high system reliability.



(Fig-1.0 Traditional “One-Way” Power Flow in Grid)

Smart Grid technologies are seen as necessary to handle the more complex power flows on the modern grid. The grid was originally designed by electric utilities to serve customers within the same state, and as shown in Figure-1, electricity flowed in one direction from power plants to customers. Over time, the grid expanded as utilities formed power pools to interconnect their transmission systems to share power generation resources. In the closing decades of the last century, with the advent of competition in the electricity industry and power marketing and the development of regional transmission organizations serving multi-state areas, large regional power flows began to dominate transmission systems.



(Fig-2.0 Emerging “Two-Way” Grid Infrastructure)

Now, with increasing two-directional power flows (as illustrated in Figure-2), the grid is being augmented with new technologies to manage an evolving system with many potential points for electricity generation, demand response, and energy storage.

Smart Grid technologies as being able to “monitor, protect, and automatically optimize the operation of its interconnected elements, including central and distributed generation; transmission and distribution systems; commercial and industrial users; buildings; energy storage; electric vehicles; and thermostats, appliances, and consumer devices.” These technologies will include both new and redesigned technologies, such as phasor measurement units and advanced meters, which are expected to increase electric system reliability, flexibility, and grid resiliency.

Smart Grid Technology Scenario in India

Due to the consequence of cutting edge technology, buzzwords like energy conservation and emission reduction, green energy, sustainable development, safety factor, reduction of T&D losses, optimal utilization of assets, have turn out to be the core of discussion. As India is struggling to meet its electricity demands, both in terms of Energy and Peak Load, Smart Grids can help better manage the shortage of power and optimize the power grid status in the country. A “Smart Grid” is a perception of remodeling the scenario of the nation’s electric power grid, by the convergence of information and operational technology applied to electrical grid, allowing sustainable option to the customers and upgraded security, reliability and efficiency to utilities. The elite vision of Smart Grid (SG) Technology allows energy to be generated, transmitted, distributed and utilized more effectively and efficiently.

Demand Side Management (DSM) is an essential practice for optimized and effective use of electricity, particularly in the developing countries like India where the demand is in excess of the available generation. Such kind of non-technical losses can be overcome by electricity grid intelligence, which focuses on advanced control and communication protocols integrated with the utility providing a complete package for the requirement of “Smart Grid”.

With the introduction of the Indian Electricity Act 2003, the APDRP was transformed to restructured APDRP (R-APDRP) which has improvised the operation and control, and has attempted a seamless integration of generation (including distributed energy resources (DER), transmission and distributed system through usage of intervening information technology (IT) that uses high speed computers and advance communication network, and employing open standard with vendor-neutrality is deemed a cornerstone for embracing the up-and-coming conceptualization of Smart Grid for India scenario.

A vivid study of the power scenario has been illustrated each classified rendering to the timeline in brief. Introducing with the power strategy management in the past, the whole system was monitored and controlled using telephonic medium which was purely a blue-collar job. The system was solely dependent on a single generation unit or the interconnected substations. On further progress in science and technology, the system is monitored round the clock using advance data communication protocols. As well the substation has the islanding facility with immediate power backups to maintain the grid stable. India as a developing country, the scenario of the power system changes in exponential basis. Moreover the system is expected to be more reliable and flexible with its advancement in data communication and data analysis facility.

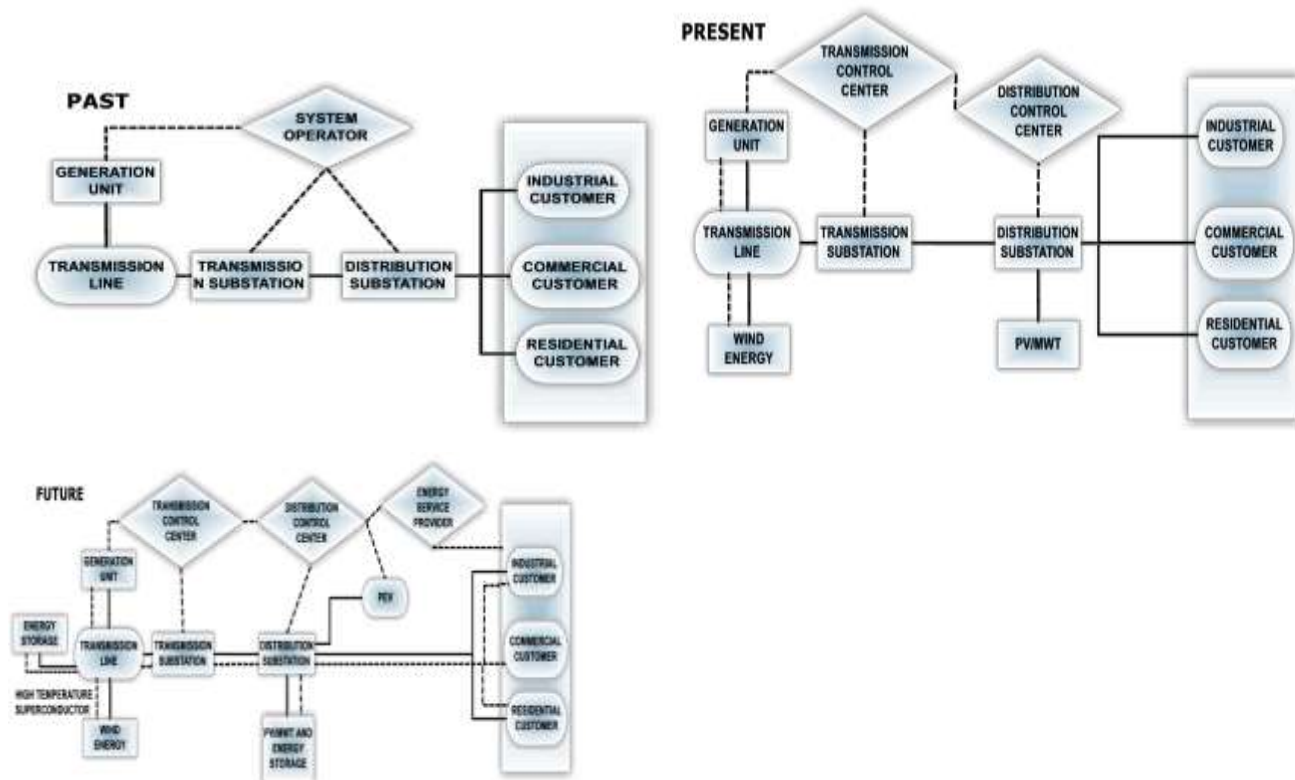
Micro-grids will provide improved electric servicere liability and better power quality to end customers and can also benefit local utilities by providing dispatchable load for use during peak power conditions and alleviating or postponing distribution system upgrades. The major difference between urban and rural micro grids is that rural are connected to weak distribution networks. This means that rural micro-grids, expected to be capable of delivering big amounts of power to the distribution network, result to operate in quasi-isolated mode.

Alas, the objectives mentioned above have not been planned taking into consideration, the altitude of the student's potential. The students hail from diverse cultural and linguistic backgrounds. Students emerging from the English medium are instructed in English have learnt it for 12 years, while others who have received instructions in provincial language have learnt English for almost 7 years, and the students in particular from Bihar and Jharkhand board study English (as optional subject) barely for 2 years and as a consequence their aptitude level in learning English also varies accordingly. But irrespective of such differences, all the students have to pursue a universal syllabus and the teachers tag along a one-size-fits-for-all approach, to teach these courses.

Alternatively, the student at the beginning of their fresh year in college is in no temperament to work on English. They crave to be exposed to advanced learning familiarity rather than to apparently immaterial English writing and grammar. Their focal point shifts to basic sciences and technical subjects leaving a little significance on learning English. It is merely in the third year onwards that the students turn out to be conscious of their needs and are then dreadfully looking for help, which becomes complicated and nearly unattainable due to syllabus formation and no freedom of time.

In addition to this, the courses approved by the technical Universities are trained by professors with M.Phil or Ph.D credentials. The majority of these professors have accomplished their master's degree in English literature. ESP or CLT are non recognizable terms among numerous English professors as a good number of them are not trained in ELT methodologies. The conventional methods of teaching and the stress of carrying out the recommended syllabus within three months steals the luster of learning a language with motivation and makes the sessions insipid and fruitless. Consequently, many engineering students retreat from learning fresh skills that are mandatory to make them employable.

Furthermore, where the present course outline of Communication Skills in all the Engineering Colleges claims to be premeditated principally to assemble student's existing and potential language and communication skills but there is no precise and elite textbook prescribed, rather, numerous reference books casing some of the contents of the syllabus are recommended as coaching and reading material for students as well as teachers. There is no detailed course book designed or approved, rather isolated syllabus contents focus on developing vital skills obligatory to execute professional requirements of the job market.



(Fig-3.1,3.2 & 3.3 shows Earlier, Present and Future SG System)

Fig-3.1,3.2 & 3.3 illustrates about the advancement and its immediate results during its implementation in future.

Smart Grid Initiatives in India

As it has been acknowledged earlier that, Smart Grid Technology has a widespread overview of transforming the Indian power grid from technology based standard to performance based standard. The Ministry of Power (MoP) participated in the SMART 2020 event with "The Climate Group" and "The Global e-Sustainability Initiative (GeSI)" in October 2008 which aimed to highlight the reports relevant to key stakeholders in India. Unfortunately, the possible "way forward" has not yet been drilled out and is still a question mark for the Government. But to facilitate demand side management distribution networks has been fully-augmented and upgraded for IT enabling, which has enhanced the grid network with amended customer service. Some of the initiative which has been taken under the supervision of many government and private bodies and allies like Power Grid Corporation Of India Limited (PGCIL), Crompton Greaves Limited (CGL), North Delhi Power Limited (NDPL) etc.

In the view of multitude that could be accrued, it is suggested that there should be ample Government regulatory support and policy initiatives to move towards Smart Grids. India is in its nascent stage of implementing various other controls and monitoring technology, one of such is SCADA. Further researches are being carried out in some of the elite institutes in the country in collaboration with some of the various multinational companies and power sectors across the nation.

Rural Electrification

Technologies are advancing day-by-day, Smart distribution technologies allowing for increased levels of distributed generation have a high potential to address rural electrification needs and minimize the erection costs, transmission losses and maintenance costs associated with large transmission grids. Rural Electrification Corporation Limited (REC) is a leading public infrastructure finance company in India's power sector which finances and promotes rural electrification projects across the nation, operating through a network of 13 Project offices and 5 Zonal offices. Along with the government of India has launched various programs and schemes for the successful promotion and implementation of rural electrification. One such major scheme is Rajiv Gandhi Gramen Vidyutkaran Yojana (RGGVY). Other schemes like, Pradhan Mantri Garmodaya Yojana (PMGY), Three phase feeders-single phasing and Smart metering, Kutir Jyoti Program (KJP), Accelerated Rural Electrification Program (AREP), Rural Electricity Supply Technology Mission (REST), Accelerated Electrification of one hundred villages and 10 million households, Remote Village Renewable Energy Programme (RVREP) and Grid-connected Village Renewable Programme (GVREP). Some of them have got a remarkable success but some of them got trapped in for their own interest due to various non-technical issues. Some of the key features of such projects are; to achieve 100% electrification of all villages and habitation in India, provide electricity access to all households, free-of-cost electricity to BPL households, DDG system, smart based metering, promote fund, finance and facilitate alternative approaches in rural electrification, single light solar lightning system for remote villages and its hamlets.



(Fig-4 Rural Distributed Generation)

The present rural electrification scenario in the nation is still uncertain, and is yet to be put on more exploration and verified by the Ministry of Power (MoP) and Ministry of New and Renewable MNRE).

Over 500,000 thousand of India's 600,000 thousand villages are deemed to be electrified. As in such case, the Indian Government and Indian businesses sector would need to invest on more such projects and schemes, for low-footprint technologies, renewable sources of energy, smart metering and resource efficient infrastructure.

Role of Smart Grid in Rural Electrification

Understanding electricity consumption is crucial for the effective planning and delivery of electricity services. Using survey data, this study finds that both rural households and enterprises use electricity for varied purposes. Most households use electricity for lighting, mobile charging and air circulation, with some also using it for entertainment and household chores. Rural enterprises use electricity largely for lighting and cooling purposes, and only few use electricity to power appliances of productive use.

Electricity consumption of rural households and enterprises is typically low, around 39 kWh per month, according to a survey report. It varies significantly across households and enterprises. It also varies with states, and with the type of electricity sources and appliances in use.

- Electricity demand of rural households is positively correlated to:

- » The economic and educational status of households
- » Reliable and longer hours of electricity supply
- » Access to salaried jobs or business.

- Electricity demand of rural enterprises is positively correlated to:

- » Reliable and longer hours of electricity supply
- » Scales of operation
- » The nature of the enterprise
- » Education levels of the owner.

- Increased ownership of appliances including those for air circulation could fuel electricity demand.

- Increased ownership and use of productive appliances can build enterprise demand. Currently, a majority of the enterprises that have moderate to high consumption levels are flour mills or shops providing technology-enabled services, including cybercafés and mobile repair shops.

- A third of rural households use irrigation pumps, of which 75% use Diesel-powered pumps; the remainder mostly use electric pumps.

- An average village in the surveyed sample has a total electricity demand of 1,826 kWh per day, with an estimated 52% contributed by households and 7% by enterprises.

- Villages with alternative delivery models like private distribution franchises for grid-electricity have a higher share of households in higher consumption tiers of the MTM as compared to those without.

Another key driver of electricity demand in rural areas is the reliability of powersupply, measured as hours of electricity supply per day. This is because access to reliable and longer hours of electricity supply can facilitate the use of appliances for longer hours and incentivize customers to buy more appliances. On average, rural households and enterprises in villages that get longer hours of grid-electricity supply

have higher levels of electricity consumption. In the absence of a reliable power supply, 86% of grid-connected households use at least one additional source of electricity or lighting, with kerosene as the most popular backup source.

The use of non-grid alternatives is also high among rural enterprises. More than a third in Bihar and Uttar Pradesh use non-grid sources exclusively, which is reflective of the electricity demand unmet by grid-electricity.

Provision of reliable and adequate electricity supply can significantly contribute toward higher electricity demand in rural areas, by way of incentivizing the adoption of more appliances and their use for longer durations.

Smart Grid will fulfill the gap between the supply and demand in rural areas in India by promoting adoption of non-grid and renewable sources of energy.

Potential Smart Grid Benefits

- (1) **Allows Direct Participation by Consumers.** The Smart Grid consumer is informed, modifying the way they use and purchase electricity. They have choices, incentives, and disincentives.
- (2) **Accommodates all Generation and Storage Options.** The Smart Grid accommodates all generation and storage options.
- (3) **Enables New Products, Services, and Markets.** The Smart Grid enables a market system that provides cost-benefit tradeoffs to consumers by creating opportunities to bid for competing services.
- (4) **Provides Power Quality for the Digital Economy.** The Smart Grid provides reliable power that is relatively interruption-free.
- (5) **Optimizes Asset Utilization and Operates Efficiently.** The Smart Grid optimizes assets and operates efficiently.
- (6) **Anticipates and Responds to System Disturbances (Self-heal).** The Smart Grid independently identifies and reacts to system disturbances and performs mitigation efforts to correct them.
- (7) **Operates Resiliently against Attack and Natural Disaster.** The Smart Grid resists attacks on both the physical infrastructure (substations, poles, transformers, etc.) and the cyber-structure (markets, systems, software, communications).

Challenges for Development of Smart Grid in India

A proper coordination among the generation, transmission, distribution and utilization of the power is essential for proper and reliable functioning of the grid. For a developing nation like India, possible challenges that represent the main obstacles for development of smart grid in India are as follows:

1) Integration of RES 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 PV, wind, biomass, and tidal based generations have many technical and commercial challenges viz., forecasting and dependency, reliability, grid connection requirements, power flow optimization and stability issues, reactive power compensation, involvement of power electronic devices etc. To eradicate such issues the government and power agencies has amended an optimized grid connection codes for the reliable and flexible operation of RES and integration in to classical grid. This is explained in successive section in details.

2) Energy Storage System (ESS): With the incorporation of RES in forthcoming times, it is desirable to integrate energy storage devices such as batteries, flywheel, electrical vehicles etc. due to the intermittent behavior of the RES and uphold the endurance of the power network. Such increases the efficient and maximum utilization of renewable energy sources when available. Being at the prolific stage of development in India we often face issues like; complexity and non-flexibility, design considerations, high capital investment, and lack of technical conscience about ESS.

3) Consumer Participation: Active participation of consumers is the foremost concern for the development of smart grid. A smart grid incorporates consumers' equipment and behavior in grid design, operation and communication. A bi-directional data link enables consumers to better control of smart appliances and equipment in homes and business. Even though challenges in consumer's participation in smart grid implementations viz., lack of bidirectional communication data link between consumers and utilities, security of consumers, reliability of supply authority, awareness about the use of energy efficient smart appliance and energy management, complication in billing process and, high capital investment involved for designing smart building.

4) Automation, Protection and Control: Automation facilitates high level quality and reliable power for both consumer as well as utility sectors. For consumers, automation means receiving hourly electricity price signals and for utility sector, automation means automatic islanding of distribution feeder with local distributed energy sources in an emergency. In developing nation like India, million dollar investment is required with high design skills. Automation, protection and control will benefit for proper operational utilities of smart grid. Complex distribution network, lack of satisfactory sensors and actuators, communication link delay, aging of the devices etc. are few dire challenges faced by Indian power grid.

5) Intelligent Electronic Devices (IEDs): Intelligent Electronic Devices (IEDs) are the electronic based multipurpose meters used in existing grids. IEDs receive data from sensors and power equipment, and can issue control commands, such as tripping circuit breakers if they sense voltage, current, or frequency anomalies, or raise/lower voltage levels in order to maintain the desired level. Unlike other measurement devices, it issues challenges in IEDs like conversion from electromechanical to static metering, standardization in design, Fast data acquisitions and its management with advance state-of-art communication data wiring.

6) Telecommunication: The fundamental of the smart grid transformation is the use of intelligent communications networks or the implication of information and communication technology with systems as the platform that enables grid instrumentation, analysis and control of utility operations from power generation to trading, and from transmission and distribution to retail. In India such as power line carrier communication (PLCC), land line, and other wired and wireless communications are installed. The major challenges of telecommunication in smart grids are evaluation of system reliability, security and availability, collection of data, storage, design of architecture and monitoring system, physical and cyber security, threat defense and access control.

7) Power Quality: Proper knowledge of power quality issues and its low cost mitigation measures is required in India. The power quality problems are broadly classified into two categories viz. variations and events. As the advent of power electronic based circuits is essential part of smart grids, quality of power must be analyzed. The technical challenges of power quality like analysis of discharge of new devices connected in smart grid and its allocation, measurement of power quality indices, reduced voltage support and large problem of voltage sag, weak transmission system, lack of awareness in consumers, and high cost of mitigation methods are the foremost concerns.

8) Reliability: In India, due to lack of energy available, problems like blackouts and brownouts are common, which is required to reduce effectively within niche timeline. The following are possible challenges in achieving improved reliability; grid automation, grid reconfiguration, dwindling human interaction, high speed fault locators and repairing, preserving generation-demand equilibrium.

9) 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 stakeholder. In India, there is lack of co-ordination in suppliers and service providers. Following are the challenges of power market: Financial management, open access of data, development of data and communication standards for emerging market, development of market simulation tools.

10) Demand Side Management (DSM): DSM is widely recognized as a definitive and practical source of information. DSM is the planning, implementation and monitoring of those utility activities designed to influence customer use of electricity in ways that will produced desired changes in utility's load shape.

The challenges subjects are; smart metering, load research and dispatch, Load control and scheduling and development of software for DSM. As the existing power grid has professed aforementioned technical challenges and issues so to prevail such, 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 initiatives under the collaboration of government and state-of-art highly equipped skill test facility. In addition, power system engineers have to now be trained more deeply about the smart grid and its related challenges, which would able to resolve these technical challenges.

Extensive researches are being initiated by various universities towards this technology in order to overcome its multiple multi-levels challenges. Power system and design engineers are being trained, to understand and investigate about system variables and recon Fig. the power grids to a smarter way. Being a corner stone in future power system network configuration, it has been anticipated that a strong and viable solution can be envisioned to contempt the energy market challenges.

Conclusion

The rural environment is suitable for such applications, for having renewable resources and can be economically justifiable. This paper addresses benefits and some of the key technical challenges that are needed to overcome to achieve the smart grids in Indian rural areas. However, for this purpose rural smart micro-grids must be improved in design, simulation, protection, controllability and communication resources. In this line, there is still a lot of work to do in loads characterization, modeling of rural distribution networks, control of micro sources and customer loads, as well as in the development of benchmarks for rural grids.

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