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TELECOMMUNICATION NEEDS OF SMART POWER SECTOR IN INDIA

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ABSTRACT

The demand for reliable electricity is increasing and the integration of variable renewable energy sources is an imperative. These forces combine to impose new stresses and requirements on an aging T&D infrastructure. To satisfy both the increasing demand for power and the need to reduce carbon dioxide emissions, the electric system needs to manage these challenges in a sustainable, reliable and economical way. This requires even more intelligent solutions to design and operate the power system, generally referred to as the "smart grid". Smart grid is envisioned to pace energy requirements in a sophisticated manner with real time approach by integrating the latest digital communications and advanced control technologies to the existing power grid. This paper presents the use of different Communications Technologies (CTs) for implementation of smart grid in a systematic way.

Keywords: Smart grid, Communications, Smart Grid nodes, AMI, AMR.

I. INTRODUCTION

The power system network is categorized into Generation, Transmission and Distribution. The transmission network transfers the stepped up Generated voltage in the generating station to the substations through high voltage over head transmission lines. The distribution network step-down the voltage, into different levels and distributed it to different consumers through low voltage power lines. The transmission and distribution lines are the back bones of power system network. Therefore monitoring and protection of lines is very important. Based on protection and monitoring it is classified into two categories.

- Power infrastructure
- Information infrastructure

The power infrastructure comprises of electric power system, which is a network of electrical components used to generate, transmit, distribute and use electric power. Electric power system is the network that supplies power to the Residential and Industrial load with power for sizable regions, this power system is known as grid. It can be broadly divided into generators that supply power, transmission system that carries power from generating centers to the load centers and the distribution system that feeds power to the nearby homes and industries. In this entire system of generating, transmitting and distributing network, the protection and monitoring of the network plays a major role. Whenever a fault occurs in complex system network, the information is communicated through information infrastructure. Protective relays used for fault sensing at each end of the line

must communicate to monitor the flow of power into and out of the protected line section so that faulted equipment can be quickly de-energized and the stability of the system is restored. For protection and control of such a large & complex electrical network, perfect and effective communication system is required, which is used to transfer the data & information from control centers to sub-stations located at same station or at different place, also to consumer ends. In order to fulfill the aforementioned task in the system the Electrical communication systems are designed to send messages or information from a source that generates the messages to one or more destinations. There are many protective schemes and technologies available to identify and transfer information regarding disturbances occurring in power system network. These techniques have been quite successful but are not adequate for the present time varying network configurations.

II. PARTICIPATING NODES IN INFORMATION NETWORK

Communication Technologies has given a thrust to the idea of Smart Grid and has started to evolve more rapidly with its enhancement. With the advancements in both wired and wireless communication technologies, two way communications is a key aspect in realizing Smart Grids and is easily possible. The Smart Grid has proved as an end to end system and has made possible to manage direct interaction and communication among multiple entities like consumers, devices other grid users and energy supplier. Smart Grid, as commonly understood, covers three out of four major components in power markets: generation, distribution and consumption. These components are referred to as the nodes. The nodes participating in the information network are categorized into different kinds of utilities/agencies.

A. Generation Utilities

Generation utilities in India exist at different levels; they exist at national, regional and at state level. At the regional level, there are centrally owned interstate generation stations (ISGS); for example, the NTPC, National Hydro Power Corporation (NHPC), and Nuclear Power Corporation (NPC) plants. There are private generating units at the regional level in the form of ultra-mega power plants and independent power producers. The generation companies at the regional level supply their power in the regional power pool through the central transmission utilities. The local level comprises all the sources of distributed generation and renewable energy. Every generator has an associated substation where the power is stepped up and evacuated to the grid. The real-time operational information on all these generators is measured and is available at these substations via their remote terminal units (RTUs). Thus, the substation RTU forms important source nodes in the information network. The RTUs report to the control centers.

B. Transmission Utilities

India inherits a hierarchical transmission utilities system. Power Grid Corporation of India Limited (PGCIL) is the central transmission utility at the regional and national level, while there are independent state transmission utilities (STUs) for each state. These central transmission utilities and STUs form sources and sinks of information. The information on availability, maintenance, and scheduling of the entire transmission infrastructure is exchanged frequently between the transmission utility and its respective system operator. Similarly, real-time operational data on the entire transmission grid is obtained from substation remote terminal units (SS-RTUs). To form a separate path for real-time phasor information reaching the control centers, phasor

measurement units (PMUs) and phasor data concentrators (PDCs) are also being installed at various locations in India.

C. Distribution Utilities

The restructured Indian State Electricity Boards, have resulted in the emergence of many public and private distribution utilities. Distribution utilities also need a well-connected interoperable network to achieve remote operation capability and automated billing via deploying AMI and AMR.

In India, the unified load dispatch and communications scheme is used as a structure for organizational coordination and to monitor, operate, and control the regional power grid in a unified, consistent, and coordinated manner. The unified load dispatch and communications scheme has improved grid reliability by ensuring data availability, visibility, and transparency.

III. DIFFERENT TECHNOLOGIES FOR COMMUNICATION AND PROTECTION

Broadly there are two types' of technologies that can be used for protection and monitoring of network that are wired and wireless communications.

A. Wired communication

Wired communication refers to the transmission of data over a wire-based communication technology. It offers more secure and reliable connection since data is not being transmitted through the air. The traditional wired communications are:

- Supervisory control and Data Acquisition (SCADA) which has limited bandwidth, 75bits/s to 2400bits/s. Higher bandwidth is necessary for monitoring (detection of abnormality), control and management tasks.
- When feeders are considered, PLC is well-suited, because it is a medium that is available throughout the distribution system. PLC has potential to transmit data at a maximum rate of 11 Kbit/s; when the PLC has sufficient robustness and reliability, this maximum data rate can be achieved only in a narrow frequency range of 9-95 kHz. This low rate of communication is not ideal for secure communication. Therefore, if more information has to be sent from all the components in a feeder, higher bandwidth is required.
- Dedicated wired communication is another option. Interference and attenuation is one of the main problems with copper wire connections. A fiber optic cable is the solution for interference but increases the cost.

B. Wireless communication

The wireless communication acts as a medium for feeder level communication. Wireless sensor network for secure energy infrastructure has overcome the limitations of wired communication.

- PLC-Power Line Communication (PLC) represents an economic, versatile and dependable tool for power system applications. All power line communication systems operate by impressing a modulated carrier signal on the wiring system.

- ARSEL PLC based AMR System-Each customer kwh meter is equipped with a PLC transmitter that converts the meter disk movement into an equivalent reading. Then the meter reading is added by a customer code and sent to a central receiver located in the distribution transformer.
- SCADA-SCADA stands for Supervisory Control and Data Acquisition. It focuses on the supervisory level consists of one or more computers connected by a communications system to a number of RTUs placed at various locations to collect data. It is positioned on top of hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules.
- Fiber-Optic- An optical fiber is a flexible, transparent fiber made of a pure glass (silica) not much thicker than a human hair. It functions as waveguide or light pipe to transmit light between the two ends of the fiber. The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher band widths than other forms of communication. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. The process of communicating using fiber-optics involves the following basic steps: Creating the optical signal involving the use of a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, receiving the optical signal, and converting it into an electrical signal.

IV. ADVANTAGES OF WIRELESS COMMUNICATION OVER WIRED COMMUNICATION

At certain points, wireless communications have some advantages over wired technologies, like low cost infrastructure and ease of connection to difficult or unreachable areas. However, the nature of the transmission path may cause the signal to attenuate. On the contrary, wired solutions do not have interference problems and their functions are not dependent on batteries, as wireless solutions do. Basically, two types of information infrastructure are needed for information flow in a smart grid system. The first flow is from sensor and electrical appliances to smart meters, the second is between smart meters and the utility's data centers. Wired Communication will have some drawbacks like, require physical connections and will reduce the flexibility. Further when a pole goes down, the communication link will be broken and may result in poor performance. Wireless communication will transfer the information over a long distance without the use of electrical conductors or wire. It provides more flexibility than wire based means of communication and continues to play a significant role in the modernization of the electric power system. Wireless technologies have significant benefits over wired, such as improved protection, control, speed outage restoration, substation monitoring and management, power system operation analysis, maintenance, planning and also have low installation and maintenance cost, rapid deployment, mobility, etc. Several activities are going on in many areas of power system using this technology. Interference in the presence of buildings and trees is the disadvantage of wireless communication which could result in multi-path; using improved receivers and directional antennas can overcome this drawback, which will increase the cost. Another problem is security issues. This can overcome by using secure protocol, encryption and decryption technologies.

V. SMART GRID COMMUNICATIONS REQUIREMENTS

The communication infrastructure between energy generation, transmission, and distribution and consumption requires two-way communications, inter-operability between advanced applications and end-to-end reliable and secure communications with low-latencies and sufficient bandwidth. Moreover, the system security should be robust enough to prevent cyber-attacks and provide system stability and reliability with advanced controls. In the following, major smart grid communication requirements are presented.

- Security-Secure information storage and transportation are extremely vital for power utilities, especially for billing purposes and grid control. To avoid cyber-attacks, efficient security mechanisms should be developed and standardization efforts regarding the security of the power grid should be made.
- System Reliability, Robustness and Availability -Providing the system reliability has become one of the most prioritized requirements for power utilities. Aging power infrastructure and increasing energy consumption and peak demand are some of the reasons that create unreliability issues for the power grid. Harnessing the modern and secure communication protocols, the communication and information technologies, faster and more robust control devices, embedded intelligent devices (IEDs) for the entire grid from substation and feeder to customer resources, will significantly strengthen the system reliability and robustness. The availability of the communication structure is based on preferred communication technology. Wireless technologies with constrained bandwidth and security and reduced installation costs can be a good choice for large-scale smart grid deployments. On the other hand, wired technologies with increased capacity, reliability and security can be costly. To provide system reliability, robustness and availability at the same time with appropriate installation costs, a hybrid communication technology mixed with wired and wireless solutions can be used.
- Scalability- A smart grid should be scalable enough to facilitate the operation of the power grid. Many smart meters, smart sensor nodes, smart data collectors, and renewable energy resources are joining the communications network. Hence, smart grid should handle the scalability with the integration of advanced web services, reliable protocols with advanced functionalities, such as self-configuration, security aspects.
- Quality of Service (QoS)- The communication between the power supplier and power customers is a key issue of the smart grid. Performance degradation like delay or outage may compromise stability, therefore, a QoS mechanism must be provided to satisfy the communications requirements (for example high speed routing) and a QoS routing protocol must be applied in the communications network.

VI. CONCLUSIONS

The introduction section discusses the importance of Information and Communication infrastructure in complex Smart Grid for its effective protection and energy monitoring. It mainly focuses on power system network and various nodes where these communication technologies are applied. Further it gives the detail of different communication technologies like wire and wireless communication infrastructure, and the advantages of wireless communication technologies. Some further work will be done to examine the applications of various wireless communication technologies on power system control, protection and monitoring.

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