Smart Grid Technology in Distribution System

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***Abstract*: The conventional distribution system is not much automated. It needs a lots of updating functions with new power electronic device those are facing new changes in their structure, with the advancement of the power electronic devices and it need to be integrate with Distributed Generation (DG) sources (mostly from renewable) at the main supply, the energy storage systems (ESSs) working alongside wind farms and solar plants and with Advanced metering infrastructure which allow the power grid automation and control. This is a review paper on Smart Grids researches, focusing on important topics such as security, demand response, Energy Storage System, Power quality, Management and automation control.**

***Keywords*: Smart Grids, ESSs, Distributed Generation, Advanced metering infrastructure, Automation control.**

1. Introduction

The conventional grid term used for electrical system that may support majorly four operations: electricity generation, electricity transmission, electricity distribution and electricity control. The conventional power systems were conceived to have unidirectional power flow only, therefore the consumers were supplied exclusively by distribution substations. So, most of the distribution systems were constructed in a radial topology and this scheme has several advantages, that the direction and value of the flowing current are always well-known. It simplifies the system operation and protection, also makes the power flow control much simpler [1]. However, the fusion of distributed generators at the power distribution grid raised new concerns for the utilities, as they have to maintain their systems with a bidirectional power flow. The system protection have to consider the current provided by the distributed generation (DG), which influences the protection devices settings. Also, as the distribution network may rearrange his topology, the system protection has to be well-coordinated to isolate a fault and properly recover the system [2]. Therefore, this original system operation and network topology is not best suited with the fusion of these new distributed resources. Additionally, the system needs a more complex operation and, to better control the distribution system, it is necessary to establish a monitoring system along the feeder, besides the substation. The understanding of the Smart Grid (SG) concept compose all the new technologies and resources that have been incorporated along the power grid [3]. A smart grid (SG), also known smart electrical or power grid, intelligent grid, future grid, is an enhanced version of the twentieth century power network. The power carrying from a few central generators to the large number of users or consumers is one of the main and general usage of the conventional power grids. In contrast, the smart grid uses a two-way flows of electricity and information to create an automated control and distributed advanced energy delivery network. Using this newly introduced information technologies, the SG is capable of delivering the power in more adequate ways and respond to the wide range conditions and events. The SG also could respond to events that take place anywhere in the power grid, such as power generation, transmission, distribution, and consumption, and record the corresponding predefined strategies [4]. The DG, Energy Storage Systems (ESSs), and AMI, are the basic elements of the power grid expected for the 21st century. However, for the SG complete characterization it is necessary to implement one intelligent system to maintain the entire network and its resources [5]. Smart Grid communication will also help to improve quality of power. It also allow easy integration of renewable energy sources into the grid, forward innovation to enable new products, services, and markets, assist in optimization of assets, and improve operating efficiency. We specifically explore the smart energy subsystem, the smart information subsystem, and the smart communication subsystem for the smart infrastructure system. Since smart grid systems are more self-ruling and increase the effectiveness of energy supply, also benefits organizations that can utilize existing foundation and limit the need to produce more power stations and substations. Renewable power source are allowable assets to associate safely to the system to incorporate the power supply with distributed generation energy and storage. This paper tries to display a summary of the smart grid system with its features of intelligent technologies [5].

2. Distributed system

In this era a new trend of renewable is growing there are number of wind farms and solar plants of considerable installed power and the distribution systems are starting to feature a transmission system, they should include the bidirectional power flow, with the increased fault current duty, the capacity of a distribution network to operate islanded from the main supply, the ability for relieving optimal power flow constraints, and also the ability of a distributed generation to operate in conjunction as a virtual power plant. With these new emerging sources the integration between the loads and the grid needs to evolve, since there are sources which are in limited quantity (diesel and gas generators) and renewable (wind, solar, and tides), that provide energy only when natural sources are available. The Smart Transformer devices which are suitable for these requirements, and may improve the grid operation providing reactive power support in medium voltage (MV) grids, DC connectivity at both the medium voltage (MV) and low voltage (LV) levels, and load control in the LV side [6].

3. Energy storage system

The infrequent nature of the renewable sources requires the combination of generators and energy storage systems, which can act as energy support when the natural source is not available. The applications of energy storage systems in the Smart Grids depend on the necessity. For power applications like frequency/area regulation, voltage support, electric service reliability, power quality (PQ), among others, there is a requirement of high-power bursts that could last from a few seconds to a few minutes. In these cases, flywheels and advanced lead-acid batteries are the appropriate solutions. However, for energy applications, such as energy time-shift, distributed energy storage, load flowing and renewable integration, there is a need for a large storage capacity and a discharge over a longer period of time. For these applications, Sodium-sulphur, flow batteries, and Li-ion (lithium-ion) have been used as potential storage devices [7]. With the development of the Consumers can use solar panels and micro-turbines to generate electric energy, and sell the extra amount for utility. The residential consumers compose significant part of the power demand. The energy storage systems advances allowed the growth of an important technology each more present in the people's lives: the electric vehicle. Henceforth, management systems should consider the integration of this technology into the grid for charging/discharging purposes [8].

4. Advanced metering infrastructure

For a proper Smart Grid infrastructure there is a need for a measurement system and a communication infrastructure to send the collected data for a central of treatment and processing of the information, to permit the control of the Smart Grid. This is a centralized approach for the smart grid control. However, another strategies could be applied, such as decentralized or hybrid distributed, and which one of them provides an excellent performance is a pending issue for complex interactive systems like the Smart Grids [9].A Multi-Agent Systems is to provide intelligence to a smart grid located at the distribution level. The proposed system was able to detect upstream outages and automatically change from grid connected to an isolate operation mode. In this context the future challenge is to create a smart grid which is able to act against the several situations in an autonomous manner, making the system self-healing and reliable, that is, with immediate response and recover capacity from material failures or outages [10]. AMI introduces the two-way communication control to permit the customers and public services to get the real-time cost and energy consumption of their residences, also specifies the energy losses and the location of the electrical theft. AMI also provides customers with the needed data to decide on smart options, the ability to decide on those options, and various options for the benefit of the customer. Meanwhile, the system can improve public service operations and help in developing the data management to enhance real time monitoring. AMI provides link fixed between the networks, consumers with their loads, and generation as well as storage space resources through integrating the different technologies such as intelligent evaluation, starting zone systems, coordinated exchanges, Data management applications, and institutionalized programming interfaces. AMI can easily interface with residential, commercial and industrial customers. Energy efficiency services (EESL) has installed over 5 lacs smart meters in Uttar Pradesh, Delhi, Haryana, Bihar and Andhra Pradesh. These meters have been distributed under the Smart Meter National Programme (SMNP). "The smart meters operational in these states aim to enhance consumer convenience and rationalize electricity consumption" an EESL statement said. The Smart Meter National Programmed that aims to retrofit 25 crore conventional meters with smart variants will lead to 80-100 per cent improvement in billing efficiency. These meters are installed as per the guidelines issued by the Central Electricity Authority. With the execution of AMI, the risk of communication, which is an important aspect, builds up in the smart grid and evil the national economy, general security, Government conviction, and public protection with environmental reliability. The hazard to the economy and confidence in the administration could increase from low to direct, where present is a reasonable conflict between drivers and public services and when the rates of private customers have expanded. As a result, the system security requirement must be advance and discriminate the intelligent network security goals are planned to be awaited [11].

5. Smart security system

One of the most concerning and specific topic is the security of smart grid, their communication channels and facilities. Cyber-attacks could be very dangerous and harmful, especially when they interfere with important command data, in which the failure could lead to catastrophic events [12], [13].As the advance communication system fixes on the grid, the Smart grid also has some disadvantages that is it gets that never occurred in traditional systems. Cyber-security problems should be taken with excellent care so that it can be prevented from interfering the power networks with an improper setting or adding messages. Also focuses on the apple of automatic energy Recovery network Technologies must conscientiously consider for the tragic event and physical attacks [14], [15]. Security, is one of the important all aspects of the Smart Grid and it will require meaningful research. There are many fracture in the security that will need to be fill and we will need to consider how different communication media can influence security and how can be reliability improved through multiple superfluous channels. With the multiple communication media, protocols, and architectures which simplify into fundamental principles is required in order to easily understand and analyses the different aspects of communication in the power grid.

6. Power quality

With the implementation of smart grid structure all over the world, we see one of the concerns of security but one more issue is power quality. Although this is not a new research topic, there are much logic that motivates the studies of power quality. As there is expansion of automation in industrial processes it also increases the number of sensitive loads, which may present poor operation in ramification of power quality problems such as voltage sags and harmonics. Also the expanded installation of renewable generation, energy storage systems, and non-linear and single-phase loads there is increase in the harmonic level and it produces asymmetrical voltages in the power grid. The quality of power can be improved through advanced metering infrastructure using the information and communication technology (ICT) so that it raises the quality of service and product 16], [17].These services enhances the relation with consumers, offering the customers many benefits and additional utility. One more major thing that ICT permits the distribution system automation, and functionalities such as self-healing from electric faults so that there is decrement in the time of system restoration and increment, of the quality of service. In addition of that the automation allows an intelligent and automatic voltage regulation services so that the voltage at distant buses can be controlled within acceptable limits. Many papers addressed the Power Quality issue within Smart Grids context. It is one of the major challenges to deal with power quality issue which is being monitored by AMI, but there is another hurdle which difficult the power quality assessment, mainly in low voltage consumers, is high cost associated with the power quality measurement device [18]. As the use of renewable energy is increased with the time, Electric vehicles verified to be a renewable solution to the electric grid; it reduces the power quality on smart grids because of their battery chargers and nonlinear load harmonics. Therefore, in order to decreases the costs related to generation and losses associated to the grid and bus total harmonic distortion (THD) a new charging conclusions was planned for coordinating EVs [19].

7. Management system

The smart management system is defined as the subsystem in smart grid that provides advanced management and control services and functionalities. The main reason behind this advance and intelligent network is it can reform the network which is explosion of functionality based on smart infrastructure. With this development of new management applications and services that can leverage the technology and capability upgrades enabled by this advanced infrastructure, the grid will keep becoming “smarter.” There are number of advantages of smart management in smart infrastructure to pursue various advanced management objectives. Most of these objectives are related to improvement in energy efficiency, supply and demand, emissions control, reduced operating costs, and optimization utility. A broad area of monitoring and control of all the parts of the power schema and continuous execution through interconnection inside extensive geographic areas and also it enhances the segments of the power framework, exercises, and execution to help the framework administrators to understand them. The developing working framework equipment, including the vast area of situational mindfulness, broad area monitoring frameworks and broad area versatile security, control and computerization, keep up a separate vital power outages and encourage the mix of variable sustainable power source assets. Also, the information created by the monitoring, estimation and control frameworks of the expanded area could also boost the activity of the structure together with [20].

- broadcasting on the decision-making process;
- Depletion is extended area dispersions;
- enhanced transmission capability with reliability.

8. Challenges to achieve a comprehensive smart grid

The main objective of the Smart Grid is to improve the capacity to use more at cheaper rate, and also it improves the standard-of-living of all people on Planet Earth, so that this transition must be cost effective. The key performance metrics should be pursue which continuously and automatically score improvements generated by the Smart Grid, if the effort is tenable over the 20 to 30 years then it will require a full conversion in to a comprehensive Smart Grid in the country and this development requires the formation of an initial baseline for all major features of the existing grid, and then continuous measurement of the impact of new construction and implementation against that baseline. The major advantage from this documentation will be that it gives an Adaptive Stochastic Controllers of the Smart Grid that will alter load around blockage, manage peak demand, weather and equipment problems that will defeat the need for expensive new power plants and substations. Internationally, Adaptive Stochastic Controllers are conducting by the computers at every level of the new Smart Grid could eventually save the need to build Terra-watts of new generation worldwide. It is expected that with the time the Smart Grid will improve the capacity factor of the electric system through more optimal supply and demand management. It allows for the re-use of existing hardware infrastructure in a more adequate manner by adding modern controller to the existing system. Understanding the risks and consumer impact of using the available resources optimally should allow Smart Grid utilities to lower peak demand and reduces Capital and O&M costs by mitigating emergencies of all kinds during peak load periods. It is a joint task for an industry to maintain the tracking metrics worldwide to document that these predicted benefits are actually realized by the Smart Grid implementation. Best practices should be shared easily and adequately.

A. There are many Challenges to the future success of the smart grid, such as

1) Consumer buy-in

Consumers have to see real savings and efficiency improvements

2) Better regulation

Governmental control must stay up to date technologically and in touch with consumers.

3) Cost justification

Smart Grid components must be individually as well as systemically cost effective.

4) Education

Service companies and universities must produce educated consumers as well as a new generation of electrical engineer savvy in computer sciences and systems engineering

5) Technology

New inventions and technologies must be easily adopted and adapt into the Smart Grid since it will evolve over the next 20 to 30 years [21].

9. Conclusion

In this study, the advantages of smart grid are more than the traditional grid but it requires a proper management and security but it has a problems of cyber-attacks therefore it needs a complex system for proper security, it gives a real time management and also it is a profitable system for both consumer and suppliers. Therefore, we need to advance or develops the grid system for reducing losses and improves the quality of the system.

References

[1] X. Fang, S. Misra, G. Xue, and D. Yang, "Smart grid - the new and improved power grid: A survey," IEEE Commun. Surveys Tuts. vol. 14, no. 4, pp. 944–980, 2012.

[2] R. Brown, "Impact of smart grid on distribution system design," in IEEE Power and Energy Society 2008 General Meeting: Conversion and Delivery of Electrical Energy in the 21st Century, PES, 2008...

[3] V. Sood, D. Fischer, J. Eklund, and T. Brown, "Developing a communication infrastructure for the smart grid," in 2009, 2009.

[4] Zahran M, Smart grid technology, vision management and control. WSEAS transactions on systems, vol. 12, Issue 1, 2013.

[5] P. McDaniel and S. McLaughlin, "Security and privacy challenges in the smart grid," IEEE Security and Privacy, vol. 7, no. 3, pp. 75–77, 2009.

[6] L. Ferreira Costa, G. De Carne, G. Buticchi, and M. Liserre, "The smart transformer: A solid-state transformer tailored to provide ancillary services to the distribution grid," IEEE Power Electronics Magazine, vol. 4, no. 2, pp. 56–67, 2017.

[7] H. Rahimi-Eichi, U. Ojha, F. Baronti, and M.-Y. Chow, "Battery management system: An overview of its application in the smart grid and electric vehicles," IEEE Industrial Electronics Magazine, vol. 7, no. 2, pp. 4–16, 2013.

[8] J. Lopez, E. Pouresmaeil, C. Canizares, K. Bhattacharya, A. Mosaddegh, and B. Solanki, "Smart residential load simulator for energy management in smart grids," IEEE Transactions on Industrial Electronics, vol. 66, no. 2, pp. 1443–1452, 2019.

[9] S. Amin and B. Wollenberg, "Toward a smart grid," IEEE Power and Energy Magazine, vol. 3, no. 5, pp. 34–41, 2005.

[10] M. Pipattanasomporn, H. Feroze, and S. Rahman, "Multi-agent systems in a distributed smart grid: Design and implementation, "in 2009 IEEE/PES Power Systems Conference and Exposition, PSCE 2009, 2009.

[11] M. Amin, "Challenges in reliability, security, efficiency, and resilience of energy infrastructure: toward smart self-healing electric power grid," in IEEE Power and Energy Society 2008 General Meeting: Conversion and Delivery of Electrical Energy in the 21st Century, PES, 2008.

[12] Y. Yang, T. Littler, S. Sezer, K. McLaughlin, and H. Wang, "Impact of cyber-security issues on smart grid," in 2011 2nd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies. IEEE, 2011, pp. 1–7.

[13] P. Jokar, N. Arianpoo, and V. C. Leung, "A survey on security issues in smart grids," Security and Communication Networks, vol. 9, no. 3, pp. 262–273, 2016.Amam Hossain Bagdadee "To reduce the impact of the variation of power from renewable energy by using super capacitor in Smart grid" Published by World Scientific and Engineering Academy and Society in WSEAS

[14] Amam Hossain Bagdadee "To reduce the impact of the variation of power from renewable energy by using super capacitor in Smart grid" Published by World Scientific and Engineering Academy and Society in WSEAS

[15] Galli S, Scaglione A, Wang Z. Power Line Communications and the Smart Grid. In: Proceedings of the 2010 First IEEE int. conf. Smart grid community; 2010.p.303–308.

[16] . M. Guerrero, "Guest Editorial Special Issue on Power Quality in Smart Grids," IEEE Transactions on Smart Grid, vol. 8, no. 1, pp. 379–381, 2017.

[17] L. An, X. Qianming, M. Fujun, and C. Yandong, "Overview of power quality analysis and control technology for the smart grid," Journal of Modern Power Systems and Clean Energy, vol. 4, no. 1, pp. 1–9, 2016.

[18] M. Brenna, F. Foiadelli, and M. Longo, "The exploitation of vehicle-to-grid function for power quality improvement in a smart grid," IEEE Transactions on Intelligent Transportation Systems, vol. 15, no. 5, pp. 2169–2177, 2014.

[19] S. Deilami, "Online Coordination of Plug-In Electric Vehicles Considering Grid Congestion and Smart Grid Power Quality," Energies, vol. 11, no. 9, p. 2187, 2018

[20] Davood Mohammadi Soran and Houseln Hooshmandi Safra, "Smart grid in power system", 2015.

[21] Roger N. Anderson and Hamid Gharoni, Smart grid the future of the electric energy system," June 2018.