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The Smart Grid and Renewable Energy

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Abstract

To stipulate modernization in the sustainable energy sector there is a necessity to deregulate the power sector. microgrid allows to maintain the power quality by supplying it through renewable energy sources (RES) mainly involving the interventions through power electronics. The usefulness of devices of power electronics are that they stimulate the heterogeneous loads, stores energy in devices and integrate various forms of RES. The smart grid has made a transition from the conventional grid to a grid which is more modernized that functions responsively and cooperatively. To achieve an economically feasible, to secure and an efficient supply, the consumers, generators and the users may be judiciously integrated with respect to the grid. The benefits of SG are it fosters sustainability, reliability, improves efficiency in the systems involving power flows. According to the National Institute of Standards and Technology (NIST) the smart grids are classified into seven parts which comprises of applications and actors. Actors consist of data-exchange, stakeholders, programs, control systems, smart meters and other devices. This paper deals with the structures of smart grid; technologies associated with it. The various technologies which can be included here are the Demand Side Management (DSM), Wide Area Management System (WAMS), System of outage Management, System pertaining to geographical information. It also explains the advantages of transformation of the smart-grid, the components of smart grid and smart grid data management. The article concludes by stating that there is a great need for renewable sources of energy involving smart grids. There are two factors which limit the usage of grids, one is its variability and the other one is the limited usage of those resources. Hence, there is a need for addressing this widespread usage. Now, the systems in the electric power, has been linked to smart grid. Thus, there is a necessity for alternative renewable sources of energy. This would benefit the developers and the policy makers; also, for the practitioners as well.

Keywords: microgrids, smart grid data management, smart grids structures

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Introduction

To stipulate modernization in the sustainable energy sector there is a necessity to deregulate the power sector. The powerful way to achieve this is the way of using microgrids. Microgrids are the powerful networks of electrical distribution which consists of renewable or non-renewable generators having heterogenous loads that function in islanded modes or grid-connected with a very powerful electronic devices using devices that stores energy Microgrids (MG) are possible only in the remote communities where it becomes a problem for interconnecting the utility networks. The most prioritized and popular integrations towards sustainable and renewable power generations are hydrogen technologies, hydro-power, wind and solar photovoltaics. Thus, microgrid allows to maintain the power quality by supplying it through renewable energy sources (RES) mainly involving the interventions through power electronics. The usefulness of devices of power electronics are that they stimulate the heterogeneous loads, stores energy in devices and integrate various forms of RES. To diversify and enable MGs to successfully manage the energy flow and power are various topologies and various configurations related to power electronics. To maintain its efficiency, there is a need to monitor the frameworks to facilitate and support the load sharing and power sharing. There is no definite explanation to describe the Smart Grid (SG). But in simple terms, it can be defined as "an intelligent network that is automated and able to store, communicate and make decisions". According to the US Energy Independence and Security Act 2007, "The Smart Grid is a modernization to the electrical network such that it monitors, increases grid resiliency to disruptions and automatically optimizes grid operation of interconnected system components starting from central generating units and distributed generation through transmission networks up to load centers". The US National Institute of Standards and Technologies (NIST) has described the smart grid as "a modern grid that adopts bi-directional flows of energy and utilizes two-way communication and control capabilities that lead to a wide range of new functionalities and applications. It adds, unlike today's grid in which the energy is delivered from generation centers to demand centers, Smart grids allow a two-way flow of energy and data".

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The US based Electric Power Research Institute (EPRI) has defined the smart grid as "the transition from the current grid where the flow of power is permitted from the central generation to load locations into a grid where there is a peer-to-peer consumer interactions, distributed generation and control centers". The Australian Government has defined the Smart grid as "a novel and a highly intelligent way of supplying electricity. It incorporates advanced communication infrastructure, innovative sensing, and metering technologies with the electrical network to create a two-way, interactive grid". Smart grid technologies aid in achieving a less disruption in grid and outages. At the same time smart metering helps the consumers effectively to decrease the billing costs; thereby managing the consumption of energy. The smart grid has made a transition from the conventional grid to a grid which is more modernized that functions responsively and cooperatively. To achieve an economically feasible, to secure and an efficient supply, the consumers, generators and the users may be judiciously integrated with respect to the grid. The benefits of SG are it fosters sustainability, reliability, improves efficiency in the systems involving power flows. It also incorporates infrastructure related to bi-directional flows for enhanced communications and also distributed intelligence. The SG combines services which are highly automated and integrated capabilities relating to digital computing which provides a proper infrastructure for the power system. The Conventional Grid features are slow response actions, less security problems, helps in manual control, a reduced monitoring capability, very few sensors, radially connected, generation of centralized power, unilateral and are operated mechanically. But the SGs are they respond fast, more vulnerable related to the issues dealing with the security, automated control, highly monitored, dispersed, distributed generation, bi-directional and are digitized.

SMART GRIDS STRUCTURES

According to the National Institute of Standards and Technology (NIST) the smart grids are classified into seven parts which comprises of applications and actors. Actors consist of data-exchange, stakeholders, programs, control systems, smart meters and other devices (SM & Hooshmand, 2017). Tasks are the applications which are performed by the actors itself within the

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designated category or between other categories. Actors belonging to the similar category may always mix with the actors of other categories and those which are placed in the specific category includes components of other categories. The various elements which are classified and grouped into smart grids are:

1. Customer- these are the end-users who consumes the electricity. The various sub-categories are industrial loads, commercial loads, large consumers and domestics consumers. Actors are those who can manage, store and generate.
2. Market- here assets are being interchanged. The main actors in the markets of electricity are participants and the operators.
3. Service provider- these are the organizations whose main task is to provide services related to the operations of the smart grids and lead to its establishment as per the demands of the people who consumes it and their utilities.
4. Operations – for a proper channel for the flow of power system, it is the managers who play a pivotal role.
5. Bulk Generation- the main task of bulk generation goes to actors who delivers the bulk electricity and these energies are also stored mainly for future distribution.
6. Transmission- here the excess of power is distributed from the generation centers finally reaching the distribution centers. Here the main electricity carriers are the actors who also involve in generating and storing the electricity.
7. Distribution- here it is the place where the consumers interconnect for transmission, storage and also involve in distributed generation of electricity. Here the prime role for these activities is done by actors who distributes the electricity to the final customers.

TECHNOLOGIES COMING UNDER SMART GRID

For a proper automation and successful monitoring of the smart grids, various technologies can be initiated (Olivares & Mehrizi-, 2014). Such technologies help in facilitating the change towards a well-developed infrastructure which comprises of the consumers and the grid designers. The various technologies which can be included here are the Demand Side Management (DSM), Wide Area Management System (WAMS), System of outage Management, System pertaining to geographical

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information. System related to management of energy etc. The main features of Smart Grids are:

1. Energy sources which are sustainable
2. Continuous grid operation leading to dynamic optimization.
3. To accelerate the efficiency and the reliability of the networks of the electricity it focuses on control technologies and digitized information system.
4. Must embodied the resources coming under the demand side and also possess Demand Side Response.
5. Smart Appliances which are integrable.
6. Must counterfeit the cyber threats.
7. Must possess technologies such as peak-shaving and devices having advanced storage capabilities which includes plug-in hybrid electric vehicles.

ADVANTAGES OF TRANSFORMATION OF THE SMART-GRID

Always encouragement is given for these utilities which effectively distribute and generate the electricity with a less negative effect into the nature. Many countries across the world, imposes a limit for excessive carbon emissions and provide incentives to transform the infrastructures into a new modernized network (Parhizi & Lotfi, 2015). In Europe, they have adopted a principle called "Cap and Trade" which seeks to limit the greenhouse emissions coming from factories and power plants. In the American country the production of electricity consumption leads to the emissions of the greenhouse gas up to 40 percent. Further, it has been estimated that by 20230, the applications of the smart grid devices would decrease the emissions of the carbon-di-oxide annually to 60 from 211 million metric tons (Justo & Mwasilu, 2013). Due to the usage of modernized network, the following benefits can be tangible in the nature:

1. Improves the quality and reliability of the smart grid
2. Enables for the backup plants to expand in future.
3. Improves the efficiency of the entire system.
4. Increases the system resiliency.
5. Incorporates the distributed resources.
6. Improves self-healing and enables the predictive maintenance capacities.

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7. Reduces the greenhouse gas emissions.
8. Increases the consumer's assortments.
9. Enhances the system security by increasing its opportunities.

COMPONENTS OF SMART GRID

1. Distributed Generation (DG)

Due to the introduction of the distributed generation, the generation of power and its supply to the electrical grid has been disrupted (Kumari & Indragandhi, 2017). Due to the automation, shortage of fossil fuels and rise of greenhouse emissions has led to the change of the DG. Researchers have stated that the most vital role of DG is to form the electrical grid which would help for future along with demand response and the storage technologies. But the rate of change for the usage of power grid for future is ambiguous (Zavar & Garcia, 2019). The pivotal role of DGs is still under debate. To define DGs there is no clear definition to describe it adequately. DGs are units which are renewable- based and are small scale units which are located near those centers which are loaded. DGs may even consist of large-scale units which may not be resources which are friendly based. Usually, DGs resources are sources having small capacity which can be installed foreseeing the regular loads. By deploying the Renewable Sources of Energy, there is a need to counterplace those generators which involves the fossil fuels and mitigate its growing demands (Zhang & Callanan, 2010). To achieve this, there is a need for intelligent capabilities to control it. Through DGs, there can be a reduction in the emissions of the greenhouse gases. To motivate the loading of DGs, there is a need for market liberalization, governmental regulations and an upsurge of electrical demands. The usage of DGs, may help for technical benefits provided their operation, location and size are judiciously optimized. Also, DGs may also help to reduce the network losses if they are properly installed closely to those load centers which improves the voltage profile thereby enhancing the reliability of the systems and enhance the computational flexibility related to the management along the demand-side and its generation. DER is considered as the main backbone for the power grid infrastructure in future as they expand the sustainable resources. By 2026, it is expected that the capacity of DER would rise to 528.4 GW (Zhong & Weiss, 2011).

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2. Modern Grids assessment of the reliability of DGs

The power grids are highly integrated and is also very complex. If there is any failure in the parts of the network, it leads to bizarrie consequences. To assure reliability many terms are associated such as security, robustness, resiliency and vulnerability (Blaabjerg & Chen, 2004). There are different methods to measure the reliability at the distribution levels, generation system and transmission. To assess the reliability, there are many attributes to be considered such as:

- The DG's availability- due to failures, there is a restriction in the functionality of the units of distributed generations. Hence, there is a need for reliability models under various contingency scenarios. Such stochastic conditions can be rectified through probabilistic approaches.
- DG s operating mode- due to the limitations in the communication infrastructure, protection capabilities and deficiency of proper control, limits the islanded mode. To enhance the system's reliability, DGs are implemented too near towards the load centers, especially in the mode of grid connected. Hence, it has been imperative in- between the feeders to measure the exchange of power across the feeders.
- The source of energy (Non-Dispatchable and Dispatchable)-Dispatchable DGs have a fixed generated power. The wind and solar which are the examples for non-units which are dispatchable, it is the intermittent sources which depends on the power which are generated (Tabulla & Abundo, 2016).

3. Demand Response (DR)

The Demand Response has been defined as "the changes in electric usage by consumers from their normal consumption behaviour in response to new pricing schemes, elevated sense of responsibility and incentive pricings that are mainly designed to induce lower electricity consumption during high price periods or when system reliability is jeopardized". Through demand response the consumers benefit mainly leading from financial incentives as they can manipulate the consumption of electricity at peak hours. During contingencies, the DR contribute adequate capacity through restoring the system mainly involving shedding loads. The benefits of DR are it provides communication infrastructure, distributed generation and storage technologies. The benefits of smart

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grids are it helps to restructure the power grid. There are two main types of demand response mainly programs which are incentive- based and programs that are price-based. On the basis of party-in-charge the DR programs are divided into three categories namely demand reduction bids, rate -based programs and reliability-based. DR are those systems which carry the storage of virtual energy.

4. Technologies related to energy storage

The systems of energy storage are the main parts coming under the sources of renewable energy involving smart grids. These systems store the excess energy mainly during at off peak hours and supplies it back mainly at peak hours. It is the technologies involving conventional storage that provides various applications mainly in the power systems along with primary functions. The applications related to the energy storage requires further developments. In the same manner, the devices for energy storage are designed extensively for exclusive applications. Here a care has been needed to optimize the size carefully.

SMART GRID DATA MANAGEMENT

The main difficulty to use the smart grid is that it lacks resources. Smart grids have wide range of services like smart communication, waste management, smart education and smart transportation. All these are very important but the topmost hierarchy is the usage of smart grid as they are the backbone of all the smart cities because it relies on sustainable energy. To function properly, the smart grids depend on the systems of intelligent data. The smart grids are useful in capturing the real-time data. It includes online operations mainly the patterns of load profile, data relating to weather forecast, data comprising the dispersed sensors and data related to smart meter. When the data are gathered using these devices, there is a need for proper analyses in making the correct decisions. This helps the consumers to monitor the usage of electricity during high periods. The various stages of data management are:

1. Collection of data

The first step is the collection of data in the process of data management. Through data centers the information is collected. The final data source is called Advanced Metering Infrastructure (AMI) which collects the data from the premises of the end-users within 10-

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15 minutes, the AMI collects and measures the data. Using geographic information systems (GIS) the smart grids get valuable information which are used to activate specific tasks like distribution facilities, generation of data visualization, installing and identifying an efficient PV farm. Though there are some challenges like scalability, reliability, privacy, security and standards there has been immense continuous progress in these regions.

2. Preprocessing of data

Before the task of the analysis work, there are several processes through which the collected data must undergo. Sometime the collected data might need to be filtered out, inaccurate and incomplete which comes under the process called as data cleansing. There are five steps in the phase of the data-cleansing which involves modification, documentation, correction, identification and fully defined. But the collected data may face problems like repetition and redundancy which has to be firstly identified and then removed from it.

3. Integration of data

Before the data analysis, the collected data which are not same throughout, needs to be integrated appropriately.

4. Storage of data

In this phase, the data gets located and stored properly which helps to access it at any point of time. In smart grids, the enormous data contents need to be stored and allocated properly through online operations, there is a necessity to get input/output information which mainly depends upon the processing speed. From different spots, the data are collected through smart grids. Mainly in the real-time operations there is a necessity to access the collected data at a very high speed.

5. Data Analytics and Data Mining

The data are collected on a massive basis through smart grids. Later some applications are imposed on the collected data which includes fault analysis, state analysis and analysis of the end user's behaviour. While analysing the data, classification is done mainly on the basis of the response time. This includes customer analysis and load forecasting. For quick applications, smart metering data and faults analysis are been implemented.

6. Visualization of Data

Data visualization is very conducive for decision-makers as it is better for the assimilation of data analysis. The benefits of data visualization are that it consists of graph which is very easy to understand than that of

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the numerical data only. The most commonly used visualization tools are 3D and 2D vis tools which helps both the utilities and consumers to access the data.

7. Decision making through online

The features in the traditional grids are devoid of automated decision- making process and real-time as it is now found in the smart grids. Using the real-time analysis, it helps to identify the defective sections present in the smart grids and separate them and implement the correct measures to overcome such kind of issues.

8. **Challenges faced in the data management** Though the data collected in smart grids are accurate, still it is not devoid of various challenges. For a massive data, there is a need for a huge storage capacity. But at present, there is a lack of a proper skilled workforce to monitor such amount of collected data. So, for ensuring maximum utilization, there is a necessity for active participation by the end-users to face with the smart metering data. At the same time, there are other attributes such as scalability and reliability which are very much evident in building confidence and therefore trustworthy in the process of decision making.

CONCLUSION:

There is a great need for renewable sources of energy involving smart grids. There are two factors which limit the usage of grids, one is its variability and the other one is the limited usage of those resources. For proper connection involving the renewable sources of energy, many system operators and regulatory communities are established in grid codes. The Electric vehicles face challenges on controlling the power system, operations and planning networks. The fluctuations in the electric grid can be compensated by deploying the electric vehicles. For channelizing the energy resources, the best method is employing the technology of smart grid. Hence, there is a need for addressing this widespread usage. Now, the systems in the electric power, has been linked to smart grid. Thus, there is a necessity for alternative renewable sources of energy. This would benefit the developers and the policy makers; also, for the practitioners as well.

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