A review on issues, challenges and various optimization techniques in microgrid

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Abstract. A drastic change in the increase of carbon emission and green-houses gases has increased the demand of the use of Renewable Energy Sources (RESs). The integration of renewable energy in a power system network is due to the fact that the available natural resources are depleting at a faster rate. Microgrid with different configurations along with the development of smart grids ensures a paradigm shift from centralised to decentralized control. The installations done at the demand side of distributed generation marks change in the forthcoming years in the electricity markets both at the generating and distribution end. With the introduction of Microgrid the hedging of investment is done in different sectors of the electric industry such as generation operations, etc., easily. This review paper gives an idea about fundamental definition of a Microgrid (MGs); classification of Microgrid, issues, and challenges associated and optimization techniques for the overall stability and security of the grid.

1. Introduction

Many people today are facing the problem of access to electricity. The access problems approximates to one in seven [1-10]. Mainly people living in developing countries of Africa and South Asia. Poverty in energy sector reduces income, growth of nation and retards all round development of Humans. Increase in global climatic issues resulted in effective usage of distributed energy resources like wave tidal, wind, solar, combined with different energy storage Technologies [11-15]. The problem shortage of power leads to the load shedding. This led to the development of Microgrids [16-20]. Microgrid is an individual group of electrical sources and the load, the concept of Microgrid was first put by Consortium of Electric Reliability Technology Solutions (CERTS). The power supply control and operation of Microgrids is done by power electronic devices [16-28]. Even Microgrids are found to be efficient compared to that of traditional methods of electrical systems of involving transformation transmission losses blackouts and lost productivity [29-35]. Fig 1 shows the typical line diagram of MG.
MGs are generally operated in two modes i.e., on grid mode and off grid mode (Islanded mode). In grid connected mode it operates as normal DG and during off-grid modes it operates as independently providing reliable power supply. During the condition on grid mode MGs operate normally under the fault condition the breaker isolates at a point of common coupling. When MGs operated off-grid many researchers have shown that fault level of Microgrid varies abruptly in the different modes of conditions.

During the on grid condition even the fall current is very high the protections can be easily done by conventional Protection Scheme but during off grid condition the drop in the current is very sharp and even zero crossing does not occur the problem will be serious if the Microgrids are inverter interfaced.

2. Types of microgrid

Microgrid choice depends on its stability, connectivity, available source and available infrastructure. MGs which is serving thousands of customers in a single local community and restricted only to that community is called a local community MGs they may be AC MGs or DC MGs and even they may be centralized or decentralized. MGs that operate completely in a decentralized independent islanded mode i.e., off grid mode are known as remote off grid MGs. These types of MGs came to existence because of the economic conditions or due to geographical limitations. Remote off grid MGs many depend on the distributed energy resources. Microgrid can be broadly classified as AC Microgrid, DC Microgrid and Hybrid Microgrid.

In MGs connectivity plays an important role. Usage of AC equipment’s results in AC MGs. The grid operates with the AC power. Fig 2 shows the block diagram of A MGs. Most of the equipment’s used installed and loads connected will work with AC power. The sources in the grid and the load are connected through common point of coupling (PCC). Exchange of power between loads and source takes from for Common Point of Coupling. Regulation of active and reactive power and the stability of the grid are maintained by using advanced power electronic converters. In AC MGs convection sources like DC generator is used to maintain stability of grid under the disturbance condition. Advanced power electronic converters convert DC power from distributed energy resource to AC for effective usage of de power. AC MGs can be classified into Coupled AC MGs and decoupled AC MGs. AC MGs directly connected to utility through transformer is known as AC Coupled MGs. AC MGs connected to utility loads through power electronic converters are called as decoupled AC MGs.
Island operation of electrical systems prefers DC Microgrids. DC Microgrid usually preferred due to low voltage DC operations of equipment and because of its high stability and low losses. The block diagram of DC MGs shown in the figure 3. The major generation of power is from the renewable source like photovoltaic cells which generator DC power. The islanded mode of operation in electrical systems usually prefers DC MGs. The DC load will be usually low voltage power rating equipment’s. The connection of load in DC MGs can be done directly from the DC sources with the fewer interfaces of converters. There are many advantages of DC MGs like low power loss reduction, less voltage drop and increase in the electric line capacity. DC Microgrid are broadly classified as monopolar DC MGs, bipolar DC MGs and homopolar DC MGs configuration.

AC MGs are suitable for Grids with dynamic modes having voltage standards. DC MGs are suitable for optimised cost effective DERs. Hybrid Microgrid is has combined advantages over Convention AC MGs and recent developing DC MGs. The loads connected to these types of grids are of both ac and dc. The bus considered in grid will be usually AC bus. The power generation in the grid is from both renewable and conventional sources. Fig 4 shows the block diagram of Hybrid MGs.
3. Issues and Challenges in Microgrid

There are many challenges and issues faced by Microgrids. MGs should operate in both on-grid and off-grid mode. During these types of conditions switching over operations is performed, there is a chance of loss of stability of the MGs. And this may result in reliability of power supply. The controlling process of MGs has become a difficult task because of the connection of more and more distributed energy resources and leading to load supply fluctuations. The issue is overcome by proper design of high efficient power electronic converters [9].

The adoption of renewable energy sources results in necessity of usage of energy storage devices. There are many types of energy storage devices with each facing different problems. The mechanical energy storage devices face the problem of low energy density and high self-recharging for a short time. Electrochemical Energy Storage devices face the problem of low energy density, low life expectancy, environmental pollution, safety issues due to flammability. If we move towards the chemical energy storages using synthetic gases it will have low energy conversion efficiency of 40% to 50% and high initial cost with low security.

Because of the usage of power electronic components issue power quality is faced like increase of harmonic content, which causes the compromise of power quality. Another issue of power quality is due to voltage transient occurs in the renewable energy sources because of me power deviation occurs that is dc link used in between the converters causes electromagnetic interference in the system electromagnetic interference causes voltage fluctuation in the system also affect the functioning of other devices.

3.1. Protection Issues in Microgrid

The sources and energy storage will contribute to the total fault current and the difficult part here is in this system the absence of natural occurrence of zero crossing correct in DC MGs [12]. When MGs are protected using voltage based protection that generation should be converted to DC quantity using DC frames. Here they will use a communication link which will be deployed for identification of inner zone and Outer zone. And problems will be faced in the communication link and during the differentiation of zones, which in turn leads to the operation of protective devices.[2]Have identified the problems and discussed the Protection Scheme of solid circuit breakers so no natural zero current lower impedance system. But the coordination of the connected equipment’s in parallel and the direction for converters in a grid connected to DC MGs is a challenge. The problem of the fasting
voltage Restoration for improving the better quality of DC voltage in a DC Microgrid has been discussed [2].

3.2. Problems Encountered Due to Bidirectional Power Flow

The flow of power in MGs will take place in both the directions. Conventional methods of protection for these systems fail [8]. Protection schemes here fail to identify backward and forward faults results in undesired tripping of the system [3]. The usage of bipolar converter will result in causing the circulating current. Interruptions and isolation of short circuit faults. The problem of lacking common ground in a DC Microgrid are found due to the usage of bipolar converters. In bidirectional power converters interruptions and isolation of short circuit faults and the problem of lacking common ground in a DC Microgrid is studied [3].

The Control method for bidirectional power controller has been suggested [9]. The inner loop control method suppresses the inter-circulating current. Outer of control loop method to manage the DC voltage [4]. They are using voided of conventional d-q axes strategy of control and used the three axis d-q-0 control strategy. Hence the supress of circulating current in generated ac side is done by parallel multiple bipolar converts [10].

4. Optimization Techniques in Microgrid

The RESs connected are said to be intermittent in nature, which man’s the power output is entirely dependent on the distributed energy sources such as solar, wind etc., DERs play a vital role in the integration of the Microgrid. Distributed generation has few advantages such as reduction in the generation costs compared with generation done at large scale which tend to improve the power reliability, reduces blocking of grid, help in reducing transmission line losses and provide the support in case of reactive power. Most of the micro grids under operation contemplate partial load demand by preserving fossil fuels for the next generation and aiming at achieving zero carbon emission.

To overcome the limitations such as intermittent nature of the RESs, this causes unreliable operation to meet the load demand. The feasible solution would be employing a power electronics based Energy Storage System (ESS). Voltage and frequency of the system can be controlled to meet the generation and load demands. The benefits of using the ESS is to meet the excess load demands in certain cases and provide improved power quality and back-up power during power outages/shortages.

Suggesting a control technique for the established grid architecture tend to provide a stable and efficient operation. Some objective functions such as area of installation, Preference of the user, Power capacity of the Microgrid, equipment installed in the Microgrid, regulations and policies and types of tariffs.

Various mathematical optimization techniques can be employed for the control of the Microgrid through numerical simulations. Few are listed below:

4.1. Linear Programming

Two-dispatch optimizers [5] can be implemented for the management of energy systems. A Mixed integer linear programming [MILP] and improved genetic algorithm code can be used for the unit commitment and economic dispatch of such Microgrid units. To counter the limitations of the above said method, for non-linear loading constraints an improved algorithm with a novel technique can also be used.

A novel approach is used for the double layer coordinated control for management of energy in MGs. The schedule layer obtains the scheme of economic operation based on the load forecasting data available and the dispatch layer provides a real time data of the power controllable units [6].

In [7] a design approach which is based on formulation of Integer Linear Programming (ILP) has an acronym (CoSMNET). Cost aware Smart Microgrid communication network can allow power transactions to be economic among smart micro grids.
4.2. Nonlinear Programming
For Microgrid operating in Islanded mode an EMS algorithm based on MINLP is used for different scenarios. The performance evaluation of a hybrid renewable energy system can be measured by a framework for energy consumption and also technical challenges which arise in the system frequently. The capital and the operating cost annually can be minimized by considering the Non-linear mixed integer problem.

4.3. Dynamic Programming
An algorithm employing dynamic programming for energy optimization analysis and power management in Microgrid with diesel generators and renewable energy sources. Framework is suggested for control of Microgrid and performing operational planning for long term. Optimization of the unit commitment is done by a dynamic programming model.

4.4. Stochastic Programming
The energy and reserve scheduling method stochastic in nature is to meet demand responses which are different and facilitate the customers. To minimize the cost and maximize comfort preferences a multi objective dynamic stochastic Programming is preferred. Coordinated scheduling and day ahead cooling problems can be solved by improved Particle Swarm optimization (PSO) technique.

5. Conclusion
An ever-increasing load demand results in a need to generate more power. The thermal generation which requires fossil fuels that deplete day by day to meets most of the demand. To present fossil fuels for future generation and rising carbon emissions, alternate generation approaches are required to meet the demand for loads. Globally, in view of energy scarcity, Microgrid acts as the effective alternative to the conventional grid. Microgrid will greatly reduce the loss compared to the conventional centralized power supply network and save investment in transmission and distribution construction. This paper attempted to provide a review of Microgrid where it can efficiently use the energy in a cascade to higher energy efficiency, thus enhancing the protection and reliability of power supply. Microgrid will significantly minimize or remove the direct grid impact caused by access to distributed power supply, and offers a new path for the wide-ranging deployment of new and renewable energy in connected grid. Nearly 95% of the MG's are fitted with renewable energy sources. Due to the erratic nature of renewable integration various issues, consequences, and resolutions arrived have been discussed, off-grid and on-grid operating modes, and their interaction with appliances, and effective security schemes are provided. Different mathematical optimization techniques were discussed.

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