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Introduction, Status and Challenges to MICROGRID : A Review Paper

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ABSTRACT

Microgrids are becoming increasingly attractive to consumers and as such in the future, a great number of them will be installed at consumer's sites. Micro grid system is formed to provide reliable electricity and heat delivering services by connecting distributed generations and loads together within a small area. Micro grids can cause several technical problems in its operation and control when operated as autonomous systems. This paper is a review of three technical challenges on micro grid with respect to voltage and frequency control, islanding and protection of microgrids. This paper is also a review of different topologies for operation of microgrids. The focus of the paper is centered around the encountered and foreseen issues, enabling technologies and economics for encouraging the deployment of microgrids in India
Keywords : Microgrid, Frequency Control, Islanding, Voltage Control, Protection.

I. INTRODUCTION

Distributed generation (DG) has gained increase popularity in the energy sector primarily driven by the rising concern of climate change and energy security. In addition, the lack of sufficient energy resources, the increase of public awareness in reducing pollutant gas emission and also the liberalization of electricity market have given rise to the use of DG. This in turns create the concept of smart grids and micro-grids. [1]

The microgrid concept, involving small transmission and distribution (T&D) networks, efficiently makes use of all the location specific distributed generations (DGs) and distributed energy resource (DERs). These are self-sustained power systems mainly based on loads fed through radial distribution systems and can operate either interconnected to the main distribution grid, or even in isolated mode. [3]

The microgrids advantages are as follows: i) provide good solution to supply power in case of an emergency and power shortage during power interruption in the main grid, ii) plug and play functionality is the features for switching to suitable mode of operation either grid connected or islanded operation, provide voltage and frequency protection during islanded operation and capability to resynchronize safely connect microgrid to the grid , iii) can independently operate without connecting to the main distribution grid during islanding mode, all loads have to be supplied and shared by distributed generations. Microgrid allows integration of renewable energy generation such as photovoltaic, wind and fuel cell generations. [2] After implementation, all the advantages of a microgrid may not become apparent right away because of higher cost of energy as compared to the cost of grid power.[3]

The microgrid concept enables high penetration of distributed generation without requiring re-design of the distribution system. Distributed generation and corresponding loads can be autonomously separated from the distribution system to isolate the microgrid's load from the disturbance during disturbances. It will intentionally disconnect when the quality of power from the grid falls below certain standard. [2]

Normally, in grid connected mode, the microsources act as constant power sources, which are controlled to inject the demanded power into the network. In autonomous mode, microsources are controlled to supply all the power needed by the local loads while maintaining the voltage and frequency within the acceptable operating limits [2] Autonomous operation is realized by opening the static switch, which disconnects the microgrid from the main grid as shown in Figure-1. Once the microgrid is isolated from the main grid, the microsources supplies to the system are responsible for maintaining the voltage and frequency while sharing the power. [2]

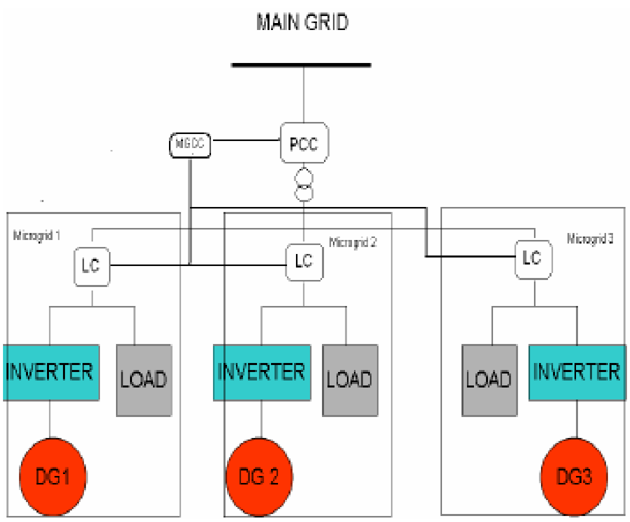

Figure 1 : Microgrid Architecture

II. METHODS AND MATERIAL

III.

A. Mode of operation of microgrid convreters

Normally, converters are used to connect DG systems in parallel with the grid or other sources, but it may be useful for the converters to continue functioning in stand-alone mode, when the other sources become unavailable to supply critical loads. Converters connected to batteries or other storage devices will also need to be bidirectional to charge and discharge these devices.

Grid Connection Mode:

In this mode of operation, the converter connects the power source in parallel with other sources to supply local loads and possibly feed power into the main grid. Parallel connection of embedded generators is governed by national standards [5]. The standards require that the embedded generator should not regulate or oppose the voltage at the common point of coupling, and that the current fed into the grid should be of high quality with upper limits on current total harmonic distortion THD levels. There is also a limit on the maximum DC component of the current injected into the grid.

The power injected into the grid can be controlled by either direct control of the current fed into the grid, or by controlling the power angle. In the latter case, the voltage is controlled to be sinusoidal. Using power angle control however, without directly controlling the output current, may not be effective at reducing the output current THD when the grid voltage is highly distorted, but this will be an issue in the case of electric machine generators, which effectively use power angle control. This raises the question of whether it is reasonable to specify current THD limits, regardless of the quality of the utility voltage.

In practice, the converter output current or voltage needs to be synchronized with the grid, which is achieved by using a phase locked loop or grid voltage zero crossing detection. [5] The standards also require that embedded generators, including power electronic converters, should incorporate an anti-islanding feature, so that they are disconnected from the point of common coupling when the grid power is lost. There are many anti-islanding techniques; the most common of these is the rate of change of frequency (RoCoF) technique.[5]

Stand-Alone Mode

It may be desirable for the converter to continue to supply a critical local load when the main grid is disconnected, e.g. by the anti-islanding protection system. In this stand-alone mode the converter needs to maintain constant voltage and frequency regardless of load imbalance or the quality of the current, which can be highly distorted if the load is nonlinear.

A situation may arise in a microgrid, disconnected from the main grid, where two or more power electronic converters switch to stand-alone mode to supply a critical load. In this case, these converters need to share the load equally. The equal sharing of load by parallel connected converter operating in stand-alone mode requires additional control. There are several methods for parallel connection, which can be broadly classified into two categories: 1) Frequency and voltage droop method [4], 2) Master-slave method, whereby one of the converters acts as a master setting the frequency and voltage, and communicating to the other converters their share of the power [5].

Battery Charging Mode

In a microgrid, due to the large time constants of some microsources, storage batteries should be present to handle disturbances and fast load changes [5]. In other words, energy storage is needed to accommodate the variations of available power generation and demand. The power electronic converter could be used as a battery charger thus improving the reliability of the microgrid.

B. Indian renewable energy scenario and status of microgrids in india

In the past several years India has seen significant growth in renewable energy generation. Fig. 2 shows installation of various energy resources as in the year 2009 and projected installed capacity in the year 2032.

The growth in this renewable energy installation is a combined effect of regional energy development agencies, ministry of new and renewable energy (MNRE), and private sector participation. Supportive government policies are also driving renewable energy installation. [3]

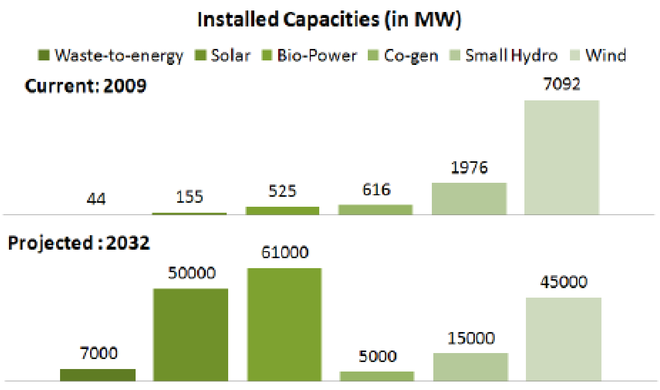

Figure 2. Renewable energy scenario in India

The term 'Smart' Microgrid reflects a new way of thinking about designing and building smartgrids. Smart microgrids are at the end-user side and have faster implementation. Smart microgrids are to create a perfect power system with smart technology, redundancy, distributed generation and storage, cogeneration or combined heat and power, and consumer control. This is to work together with the bulk power grid or system as an integrated whole to provide its consumers with maximum economic and environmental benefits, reliability and efficiency. The smart microgrid makes smart decisions about what clean energy source to run at what times, links to smart appliances, and regulates energy demand. It can optimize all of the above for cost reductions, energy savings and $CO2$ emission reductions. The integration of multi microgrids at the distribution level will complement the goals of smart grids.

Valence Energy to Develop First Smart Microgrid in India [3]: This project is under contract with Palm Meadows, a 330 premium home neighborhood developed by SA Habitat. The Microgrid solution will include smart home technology and an extensive smart meter platform that intelligently connects 83 kW of solar power generation and 2 MW of diesel generation and also offers power conditioning and demand response. The system will ensure reliable and cost effective power for the neighborhood, and limit the impact of grid power failures.

IV. RESULTS AND DISCUSSION

A. Key Issues of microgrid

Technical benefits of the microgrid are an islanding implementation of distributed generation to improve the distribution system service quality and increased the power system reliability. Microgrid can be implemented to meet the increasing growth in demand and distributed generation is used to perform special task for microgrid operation such as reactive and active power control, ability to correct voltage sags and system imbalances [2]. This section is a review of three technical challenges on micro grid with respect to voltage and frequency control, islanding and protection of micro grids.

Voltage and frequency control

In electricity system, active and reactive power generated has to be in balanced condition with the power consumed by the loads including the losses in the lines. The unbalance condition happens from power generated is not equal to the power demanded. The unbalanced between both by the kinetic energy of the rotating generators and motors connected to the system, causing a deviation of the system frequency from its set point value (50/60Hz). The purpose of voltage and frequency control is to ensure that the both voltage and frequency remain within predefined limit around the set point values by adjusting active and reactive power generated or consumed.

In operation of the microgrid, a challenging task is to operate more than one distributed generation on the island; it is no possible to use the active and reactive power control. It is necessary to regulate the voltage during microgrid operation by using a voltage versus reactive power droop controller for local reliability and stability.

Islanding

Islanding is a small-scale representation of the future interconnected grid with a high density of distributed generations. The microgrid provides a benchmark between island and the interconnected grid. It is can be used in the large interconnected grid with the high penetration of distributed generation. The islanding control strategies are very important for the operation of a microgrid in autonomous mode. Two kinds of control strategies of islanding are used to operate an inverter [2]. The PQ inverter control is used to supply a given active and reactive power set point and the voltage source inverter (VSI) control is controlled to feed the load with predefined values for voltage and frequency. The VSI real and active power output is defined by depending on the load conditions. Its act as a voltage source with the magnitude and frequency of the output voltage controlled through droop.[2]

Protection

Microgrid protection is the most important challenges facing the implementation of microgrids. Once a microgrid is formed, it is important to assure the loads, lines and the distributed generations on the island are protected. The two alternative current limiting algorithms to prevent the flow of large line currents and protection of microgrid during utility voltage sags. [2] There are as resistance-inductance feedforward and flux-charge-model feedback algorithms, for use with a voltage-source inverter (VSI) connected in series between the microsource and utility grids.

The resistance-inductance algorithm function which was connected with the microsource and utility grids is to insert large virtual resistance-inductance impedance along the distribution feeder. As a result, the line currents and damp transient oscillations is limited with a finite amount of active power circulating through the series and shunt inverter.[2]

B. Future direction on microgrid research

Cost and size of the converter, particularly the filter components, remain an issue.[5] Future direction which require further investigation in the context of microgrid research are:

i) To investigate full-scale development, field demonstration, experimental performance evaluation of frequency and voltage control methods under various operation modes;
ii) Transition between grid connected and islanded modes on interaction phenomena between distribution generation and high penetration of distributed generation;
iii) Analysis the issue of black starting in an unbalanced system on the control, protection and power quality; and
iv) Transformation of microgrid system today into the intelligent, robust energy delivery system in the future by providing significant reliability and security benefits. [2]
v) The proliferation of inverter interfaced DG units is already raising issues related to coordination of protection relays both in grid connected and stand alone modes. This is currently an active area of research.
vi) The standards governing these converters are still evolving and practical implementation is continuously giving rise to new issues that need to be thought about and regulated. [5]

V. CONCLUSION

Microgrid is a prospective approach which integrates various distributed generation technologies into electricity distribution networks with known advantages like deferred network expansion, improved voltage profile, reduced losses etc. This paper reviews the microgrid features and operation. The three key issues of technical challenges on micro grid with respect to voltage and frequency control, islanding and protection is discussed that must be overcome for implementation microgrid effectively. In this context, integration of small-scale generation in the form of microgrids, supported by the application of power electronic converter, could potentially contribute to the improvements in service quality seen by end customers. India has just started their effort in this direction with two small microgrids. In the future power system configuration, the microgrid will providing clear economic and environmental benefits compared to traditional power system. The enabling technologies like smartgrid will play an important role in the success of microgrids.

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