



MICROGRID IN POWER DISTRIBUTION SYSTEM

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Abstract

Power is a very important instrument to the development of economy of a nation and it must be stable and available and to meet the demand of the consumers at all times. The quest for power supply has introduced a new technology called microgrid. Micro grids are regarded as small power systems that confine electric energy generating facilities, from both renewable energy sources and conventional synchronous.

Generators, and customer loads with respect to produced electric energy. It can be connected to grid or operate in islanding mode. On the other hand, the grid's dynamics and its stability rely on the amount of stored energy in the micro grid. In a conventional power system with a large number of synchronous generators as the main sources of energy, the mechanical energy in the generators' rotors, in the form of kinetic energy, serves as the stored energy and feeds the grids in the event of any drastic load changes or if disturbances occur. Microgrid is an alternative idea to support the grid, it can be applied in a street, estates, community or a locality (towns and villages), organizations and establishments. Load forecasting can be further extended to Organizations, Local Government, State and country to determine the energy consumption.

Keywords: Microgrid; Power; Distribution.

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1. Introduction

Power supply is becoming more complex as a result of increasing population, expansion and development in some locations. The rate of development and the use of some equipment called for modelling of microgrid.

Microgrid is an aggregation of loads and micro sources operating in as a single system providing both power and heat. The majority of the micro sources must be power electronics based to provide the required flexibility to insure operation as a single aggregated system. This control flexibility allows the microgrid to present itself as a single controlled unit which meets local needs for reliability and security. In addition, microgrids have the capability to isolate themselves from the

utility power grid in case of faults in the grid, in order to protect the micro sources and loads within the microgrid. This operation is called the islanded mode, in which the microgrid operates independently until stability is restored in the utility grid. Microgrid contains an energy manager within them which is responsible for maintaining balance between energy demand and supply within the microgrid by the use of energy management strategy, while making sure certain criteria such as minimizing operating cost, fuel consumptions, emissions etc are met. A microgrid is a collection of distributed power generators and loads acting together, (Lasseter *et al.*, 2002).

Micro grid is a power supply network in which a cluster of small on-site generators provide power for a small community such as homes, parks, and office buildings. The increasing interest in micro grid is changing the dependency on the conventional centralized power system. In a centralized power system, power is transmitted from a large source to several utilities through a transmission line and a centralized control and hence can create shortcomings in the efficiency power supply. During disturbances, the generation and the loads of a micro grid can be separated from the main distribution system to isolate the loads from the disturbance and thereby maintaining the continuity and reliability of the service without harming the main transmission grid, (Robert and Paolo, 2004). Modern micro grids are regarded as small power systems that confine electric energy generating facilities, from both renewable energy sources and conventional synchronous generators, and customer loads with respect to produced electric energy (Smallwood, 2002). They can be connected to the main grids or operated as isolated power systems (Katiraci *et al.*, 2005). In the micro grids, alternative energy sources such as renewable can be integrated with local consumptions (Katiraci *et al.*, 2005) and are more efficient and initiate less environmental issues. This, in turn, enables performance optimization and enhances the supply reliability (Moldernik *et al.*, 2010). Furthermore, since micro grids are to be on or near the site which they are to supply, losses due to transmitting electricity is relatively minimized, which makes micro-grids even more useful (Marshall, 2004). Finally, micro grids can be modified according to the needs of the site it will be servicing. For example, it can be used only for lighting purpose or for working on big machinery.

As discussed earlier, micro grid encourages the use of renewable energy sources. Although renewable energy resources, such as wind and solar, enhance the generation capability of a micro grid and address the environmental concerns (Leite da Sila, 2010 *et al.*), they impose economic operation and stability challenges to the micro grid due to their unpredictable nature. Power fluctuations caused by intermittent nature of the renewable should be smoothed to serve the demand more appropriately and competently.

A general form of microgrid is depicted in Figure 1, where it includes a wide variety of distributed energy resource (DER) units up to 1 MW, which may be connected through a low voltage grid with different types of users. The DER units involve distributed storage (DS) units and distributed generation (DG).

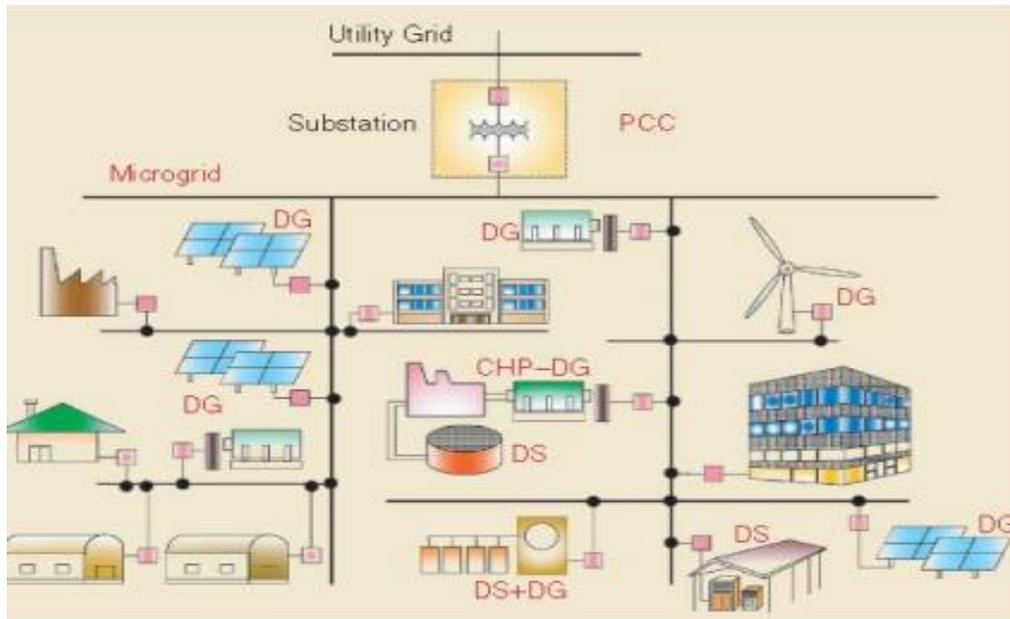


Figure 1: The general form of a microgrid (Katiraei,2008)

Microgrids Structure and Operation (Stamatia,2015)

Microgrids can be divided in four categories:

- 1) The off –grid microgrids: they include islands, remote sites and other systems not connected to the local main grid
- 2) The campus microgrids: they are fully interconnected with a local electricity network, but at the same time, they can independently keep and provide some level of service in isolation from the grid, like in the case of a utility outage. Some examples of this category are university campuses, military bases.
- 3) The community microgrids: they are integrated into utility networks, support multiple customers and services inside the community and secure a resilient power supply for vital community assets.
- 4) The nanogrids: they consist of the smallest discrete network units with the capability of independent function, as it can happen in a single building.

2. Energy Storage

The use of energy storages can improve the balance between generation and demand trends, and thus, will have a significant impact on the grid's economic operation. On the other hand, the grid's dynamics and its stability rely on the amount of stored energy in the micro grid. In a conventional power system with a large number of synchronous generators as the main sources of energy, the mechanical energy in the generators' rotors, in the form of kinetic energy, serves as the stored energy and feeds the grids in the event of any drastic load changes or if disturbances occur.

In micro grids, energy storage will have significant stabilizing effects on the system due to the low kinetic energy stored in the micro grid's generators such as wind turbines and small synchronous generators. Consequently, the effective dynamic power flow control and stabilizing mechanisms, which engage energy storage, are of paramount importance.

Accordingly, the rising problem of imbalance between energy production and demand presented by the sporadic nature of solar and wind resources can be resolved using energy storage (Moslehi, 2010). Storage devices can be used to store the excess energy when the production is high and the demand is low, and utilize the stored energy when the produced energy cannot meet the high demands of the consumers. Various storage technologies have emerged to fill the gap and accommodate the net demand variability (Molderink, 2010). The addition of storage technologies such as ultra-capacitors, conventional batteries, and heat storage can improve the economic as well as the environmental appeal of a micro grid's distributed energy resources (Stadler, 2008). Storage devices tend to make the net demand profile flatter and improve reliability. Among the various storage devices, the most common ones are electric and thermal energy storage.

The popular electrical storage devices are batteries and ultra-capacitors. Batteries have higher specific energy than ultra-capacitors, and thus, can provide an extra energy for a longer period of time (Burke, 2007). The thermal storage, on the other hand, temporarily stores the thermal energy in the form of a hot or cold medium for later use.

Electric storage has attracted much attention recently due to their technological improvements and economic advantages (Mercier, 2009). In most proposed micro grid operation strategies, electric storage such as batteries is used to store energy when there is extra generation, then at peak times the stored energy is instilled to the grid through power electronic inverters (Oudalou, 2007). This will help make the generation trend flat which contributes to the use of the reserve generation capacity more economically.

Microgrids as Part of the Polygeneration System

The concept of polygeneration could be considered as an extension of the one of microgrid, including it at the same time. Polygeneration systems tightly integrate heating, cooling and electricity production processes. They include many different energy sources, like photovoltaics, wind turbine, storage devices, small scale hydro, micro-turbines, reciprocative engines, combined heat and power (CHP) resulting in much higher efficiency than the single-product systems, higher flexibility and profitability. They usually serve some additional services as well, like water purification and share the same benefits with microgrids, but more enhanced because of their wider character(Stamatia,2015).

General Background of Microgrid

Some related works that have been carried out on microgrid that addressed microgrid systems design, operation, economics, regulation and merits of microgrid. Some of these are discussed below.

Asumus (2009) and Del Carpio Huayllas et al. (2010) presented a concept of microgrid systems and also some alternatives of its control, namely, the relation of both power and frequency droop were presented. The control strategies (i. e active power versus frequency droops characteristic) to be used in a microgrid containing large amounts of small sized dispersed generation set in an islanded operation mode as well as a way to assist the power system restoration after a general blackout.

Lee and Han (2010) analyzed the operational analysis of a DC microgrid in which various types of distributed generation (wind power, photovoltaic, fuel-cell generation) feed a DC system. In King (2006), microgrid was addressed as the problems of environmental regulatory issues. The various costs and benefits that customers-generators can impose on electric utilities were also discussed.

Walling (2002), Oudalov (2009) and Feero (2002) talked about the protection issues related to microgrid intentional and unintentional islanding forms as well as some of the problems that must be dealt with to successfully operate a microgrid, when the utility is experiencing abnormal conditions.

Wara and Abayomi (2008) addressed optimal utilization of generators in Igbinedion University campuses. The load centres, energy demand, environmental effects, energy conservation and efficiency were considered.

3. Justification for Microgrids

The arrangement of a modern large power system offers a number of advantages.

Large generating units can be made efficient and operated with only relatively small number of personnel. The interconnected high voltage transmission network allows the generator reserve requirement to be minimized, the most efficient generating plant to be dispatched at any time, and bulk power to be transported large distances with limited electrical losses. The distribution network can be designed for unidirectional flows of power and sized to accommodate customer loads only. However, over the last few years a number of influences have combined to lead to the increased interest in microgrids schemes (Jenkins, 2000). The policy drivers encouraging microgrids are:

- 1) Reduction in gaseous emissions (Carbon monoxide).
- 2) Energy efficiency.
- 3) Deregulation.
- 4) Diversification of energy sources.
- 5) National power requirement (Faisal ,2008).

4. Conclusion

For effective maintenance and the various environmental impacts of running generators across the campus will be controlled. Energy efficiency, reliability, availability, conservation and optimization can be guaranteed by aggregating the generators in three proposed power houses.

Microgrid is an alternative idea to support the grid, it can be applied in a street, estates, community or a locality (towns and villages), organizations and establishments. Load forecasting can be further extended to Organisations, Local Government, State and country to determine the energy consumption.

Energy storage should be incorporated to the power network to cater for sudden energy demand increase.

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