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Review Paper on Microgrid System

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ABSTRACT

The concept of integration of distributed energy resources for formation of micro grid will be most significant in near future. The latest research and development in the field of micro grid as a promising power system through a comprehensive literature review is presented in this paper. It shows a broad overview on the worldwide research trend on micro grid which is most significant topic at present. This literature survey reveals that integration of distributed energy resources, operation, control, power quality issues and stability of micro grid system should be explored to implement micro grid success- fully in real power scenario. Microgrids are electricity distribution systems containing loads and distributed energy resources, (such as distributed generators, storage devices, or controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while is landed.

Keywords: DER, Integration DG RER RESs , Micro Grid Control, Micro Grid Protection & Micro Grid Stability

I. INTRODUCTION

A Microgrid refers to distributed energy resources and loads that can be operated in a controlled, coordinated way; they can be connected to the main power grid, operate in “islanded” mode or be completely off-grid.

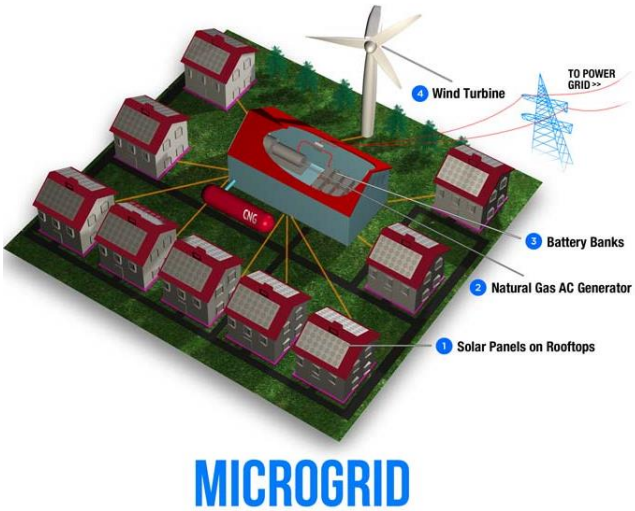

Figure 1. Distributed Power Supply System In Microgrid

Microgrids are low- or medium-voltage grids located at or near the consumption sites. They can generate power from both renewable and conventional sources and although they are mainly electrical systems, they can also incorporate a thermal energy component, such as combinedheat and power. Microgrids are increasingly being equipped with energy storage systems, as batteries become more cost competitive. The system is controlled through a microgrid controller incorporating demand-response so that demand can be matched to available supply in the safest and most optimized manner. A flywheel or battery-based grid stabilizing system can be included to offer real and reactive power support.

The concept of a microgrid is not new: the earliest electricity networks were essentially microgrids before they were joined into regional and national grids. What is new is their changing and expanding role, in the face of rising power demands, the falling cost of renewable sources, and the increasing need for

supply resilience and autonomy – both on- and off-grid.

II. BASIC STRUCTURE OF MICROGRID

1) Storage in Microgrid:

Microgrid can have storage as backup while operating in stand-alone mode of operation. When there is renewable source of power, excess power from renewable (after the load demand is fulfilled), can be stored in batteries. This can then be used as backup when needed.

From a brief introduction of components of microgrid, a visualization of microgrid can be viewed as following fiugure:

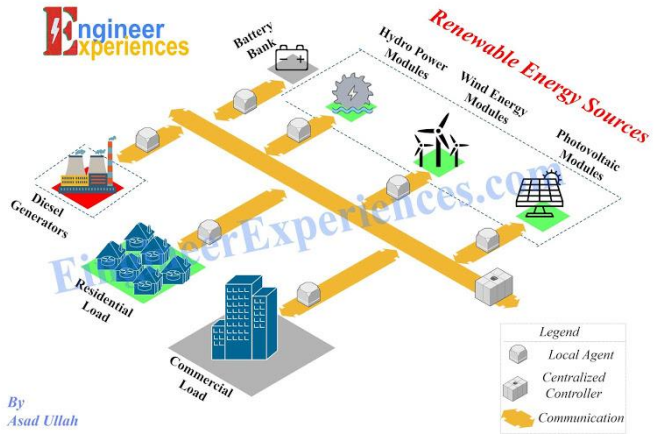

Figure 2. Basic Structure Of Microgrid

This figure has multiple load centers (commercial and residential) and multiple type of generation (conventional and non-conventional). The microgrid has distributed sources and local controllers also whole microgrid is monitored by centralized control unit. There is also a battery bank for storage of excess renewable power.

This is stand-alone operation of a microgrid.

2) Mode of Operation of Microgrid:

Microgrid can work with the main power supply from the utility to feed the load and provide power to the main grid when it has excess power. It can work as island of load units and generation when other parts of whole power system is under maintenance or have bug in it. Control unit is also responsible of successful connection and disconnection of microgrid from main grid. and operation must not be disturbed by this.

Basic Structure and Elements in Microgrid:

As stated in start that microgrid is home for a lot of components according to requirements of stakeholders (consumer, investor, market). All components join together to form structure of microgrid. From the definition, we can conclude that basic elements in microgrid are:

- Distributed Generating units
- Load Centers
- Distribution network
- Control Unit(s)
- Electric Power Storage (optional)

The distributed generation units could be conventional, non-conventional (renewable or alternate sources) or combination of both. Main objective of these generating units is to meet the demand of local load centers. Load centers can also have own generation, partially dependent to the supply or total demand is fulfilled by the generating units through distribution network.

3) Control in Microgrid:

Control unit is one of major component of microgrid. The flow of power from generation to the load centers should be monitored, controlled and managed properly. Even before, the generation of electric power must have controller to maintain power quality (voltage, frequency and sin wave within limit).

4) **Synchronization and control** of single type of generation in microgrid is relatively easy and less complex. And this can be controlled by single central controller. But microgrid can have multiple type of generation (by its nature) at single place to feed the single load center. So, the control of such diverse type of generation becomes very complex and Control in Microgrid:

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TYPES OF MICROGRID:

Community Microgrids can serve a few up to thousands of customers and support the penetration of local energy (electricity, heating, and cooling).[8] In a community microgrid, some houses may have some renewable sources that can supply their demand as well as that of their neighbors within the same community.i

1.Community Microgrid

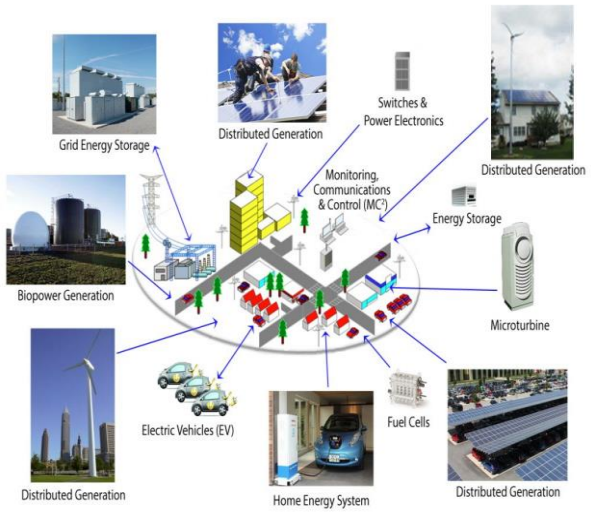

Figure 3. Community Microgrid

Community Microgrids can serve a few up to thousands of customers and support the penetration of local energy (electricity, heating, and cooling).[8] In a community microgrid, some houses may have some renewable sources that can supply their demand as well as that of their neighbors within the same community. The community microgrid may also have a centralized or several distributed energy storages. Such microgrids can be in the form of an ac and dc microgrid coupled together through a bi-directional power electronic converter.

2.Remote Off-grid Microgrids

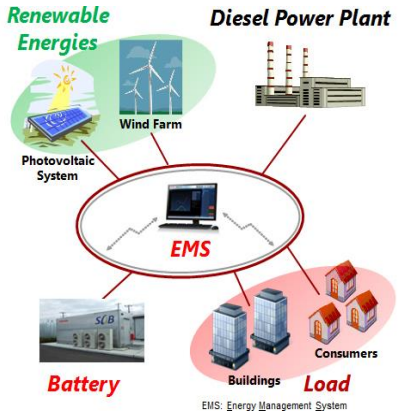

Figure 4. Remote Off-Grid Microgrid

These microgrids never connect to the Macrogrid and instead operate in an island mode at all times because of economic issues or geographical position. Typically, an "off-grid" microgrid is built in areas that are far distant from any transmission and distribution infrastructure and, therefore, have no connection to the utility grid.[6][10] Studies have demonstrated that operating a remote area or islands' off-grid microgrids, that are dominated by renewable sources, will reduce the levelized cost of electricity production over the life of such microgrid projects.[

Large remote areas may be supplied by several independent microgrids, each with a different owner (operator). Although such microgrids are traditionally designed to be energy self-sufficient, intermittent renewable sources and their unexpected and sharp variations can cause unexpected power shortfall or excessive generation in those microgrids.

3.Commercial and Industrial (C&I) Microgrids.

Figure 5. Commertial And Industrial Microgrid

These types of microgrids are maturing quickly in North America and Asia Pacific; however, the lack of well –known standards for these types of microgrids limits them globally. Main reasons for the installation of an industrial microgrid are power supply security and its reliability. There are many manufacturing processes in which an interruption of the power supply may cause high revenue losses and long start-up time.[6][10] Industrial microgrids can be designed to supply circular-economy (near-)zero-emission industrial processes, and can integrate combined heat and power (CHP) generation, being fed by both renewable sources and waste processing; energy storage can be additionally used to optimize the operations of these sub-systems.

Challenges

Microgrids, and integration of DER units in general, introduce a number of operational challenges that need to be addressed in the design of control and protection systems in order to ensure that the present levels of reliability are not significantly affected and the potential benefits of Distributed Generation (DG) units are fully harnessed. Some of these challenges arise from invalid assumptions typically applied to conventional distribution systems, while others are the result of stability issues formerly observed only at a transmission system level.

- Bidirectional power flows: The presence of distributed generation (DG) units in the network at low voltage levels can cause reverse power flows that may lead to complications in protection coordination, undesirable power flow patterns, fault current distribution, and voltage control.
- Stability issues: Interaction of control system of DG units may create local oscillations, requiring a thorough small-disturbance stability analysis. Moreover, transition activities between the grid-connected and islanding (stand-alone) modes of operation in a microgrid can create transient stability. Recent studies have shown that direct-current (DC) microgrid interface can result in significantly simpler control structure, more energy efficient distribution and higher current carrying capacity for the same line ratings.
- Modeling: Many characteristic in traditional scheme such as prevalence of three-phase balanced conditions, primarily inductive transmission lines, and constant-power loads are not necessarily hold valid for microgrids, and consequently models need to be revised.

- Uncertainty: The operation of microgrids contain very much uncertainty in which the economical and reliable operation of microgrids rely on. Load profile and weather forecast are two of them that make this coordination becomes more challenging in isolated microgrids, where the critical demand-supply balance and typically higher component failure rates require solving a strongly coupled

problem over an extended horizon. This uncertainty is higher than those in bulk power systems, due to the reduced number of loads and highly correlated variations of available energy resources (limited averaging effect).

Microgrid protection and coordination issues:

Short circuit fault is frequent in power system and the same is harmful for the power system components, consumer's equipments as well as personnel too. As per traditional philosophy of existing power system protection, microgrids are to be protected from large amount of short circuit currents, excessively high or low voltage due to abnormal conditions occurring on the utility grid side fault or fault in the microgrid itself. To provide proper protection and to avoid damages of microgrid and customer's equipments; protective relays are to be installed to detect the abnormal conditions and to initiate circuit breakers to isolate the fault. Since proper action is required within a few fundamental cycles, decisions are generally made autonomously based upon local information like magnitudes of abnormal voltage, current etc. . In utility grid, the synchronous generators are inherently capable of withstanding large fault current which is sensed by the relays and interrupted by the circuit breakers. So cost of the power system protective devices like circuit breakers, transformers, current limiting reactors are increased due to direct interaction with that severe fault current. Another important point in this context discussed in, is the fast limitation of fault current which is a unique capacity of power electronics based interfacing of DGs that can further provide a great benefit due to reduction in rating, as well as cost of the expensive current carrying equipments and current interrupting circuit breakers. Also the fast response characteristic of the solid state power electronic interfaced relays can provide good protection coordination among all related protective devices in the microgrid system.

Stability analysis of microgrid :

The stability of a microgrid, which is interconnection of several distributed energy resources, is its ability to return to normal or stable operation after having been subjected to some form of disturbance. Conversely, instability means a condition denoting loss of synchronism or falling out of normal operation. Stability considerations have been recognized as an essential feature of microgrid planning. For proper working of microgrid, the stability problems are to be taken care of considering the steady state, dynamic and transient condition. The study of steady state stability mainly concerned with computing maximum limit of DER loading while maintaining synchronism, however, if the loading is increased gradually . In a microgrid, dynamic instability more often occurs than the steady state one due to sudden fluctuation of load leading to the system oscillation which is required to be died out completely within a short period. Oscillations persisting for a long period may be a serious threat to the interconnection of DERs. Therefore, study of dynamic stability of a microgrid is essential.

Advantages of microgrid:

- Ability to disconnect from utility grid during disturbance and operate independently
- It reduces demand on utility grid thus prevents grid failure
- We can use both electricity and heat energy so that over all efficiency increases
- have much smaller financial commitments.
- use renewable resources hence are more environmentally friendly with lower carbon footprints.
- require fewer technical skills to operate and rely more on automation.

Disadvantages of microgrid:

- Voltage ,frequency and power quality should be at acceptable limits
- Requires battery tanks to store which requires space and maintenance

- Resynchronization to utility grid is difficult
- Protection is difficult

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