NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN: 2394-3696 Website: ijiert.org
VOLUME 8, ISSUE 7, July. -2021

MICRO-GRID INTEGRATION

Manya Lal
Department of Electrical Engineering, RCEW, Jaipur, India.

Akanksha Malhotra
Department of Electrical Engineering, RCEW, Jaipur, India.

Vivek Kumar Chauhan
Department of Electrical Engineering, RCEW, Jaipur, India.

Apurva Vashishtha
Department of Electrical Engineering, RCEW, Jaipur, India.

ABSTRACT
Hybrid energy systems are becoming attractive to supply electricity to rural areas in all aspects like reliability, sustainability, and environmental concerns, and advances in renewable energy technology; especially for communities living far in areas where grid extension is difficult so generation of renewable energy resources like solar and wind energy to provide reliable power supply with improved system efficiency and significant cost reduction is best way. Besides this, the demand for renewable energy source in large urban cities is increasing, and their integration to the existing conventional grid has become more fascinating challenges. So the future requires stable and reliable integration of renewable distributed generators to the grid, and the local loads are close to distributed generators. The chapter will provide a complete overview of micro grid system with its complete operation and control.

Keywords: Distributed generation (DG) , micro grid, grid integration and control, renewable energy.

INTRODUCTION
The conventional power network comprises large generating stations with extra high voltage links, which connect transmission substations with distribution system for delivering power to end users. Therefore, the basic concept in traditional power system is the central controlling with unidirectional energy flow for transmitting power to load centres.
Renewable sources of energy are becoming the most important sources for supplying electrical energy straight to the customer without traditional distribution system, especially for communities living far in areas where grid extension is difficult so generation of green sources such as photovoltaic (PV) and wind power for providing reliable energy for improved system efficiency and significant cost reduction is best way. Therefore, renewable energy sources are the most sustainable remedies for producing energy and heat. The main advantages of the renewable energy sources are the instant availability, less dependence on fossil fuels, low cost variation, and no transportation cost for higher economic efficiency.

MICRO GRID POWER SYSTEM
Micro grid system is a configuration of single or multiple renewable energy sources with even non-conventional sources as main energy generation source, so that the capacity shortage of power from one source will substitute by other available sources to provide sustainable power. Additionally, it incorporates energy storage and power electronics circuitry.

2.1.Micro grid power systems configurations
Micro grid is configured based on the following technical topologies to couple the available renewable sources and to meet the required load. Here, voltage and the load demand are the determinant factors. Accordingly, any power system configurations are grouped in the following forms.

2.1.1.AC/DC-coupled micro grid systems

Different configurations are described for the micro grid, which contains wind turbine, PV system, a diesel generator, and a battery storage system. Generally, for micro grid technological configurations , three established classes are there and are discussed below.

2.1.1.1.Micro grid systems: AC-coupled

In this configuration, various renewable sources and the energy storage system are linked at the AC bus with the demands. For this type of configuration, two subcategories are available.

2.1.1.1.1.Centralized AC-coupled micro grid

All the elements are linked to the AC bus. AC power producing elements are connected to AC line in direct manner or with the help of AC/AC converter for getting even component coupling topology. For controlling the energy flow to the battery and from the battery to the load, the master inverter required. Furthermore, DC electricity can be provided from battery if needed. Figure-1 depicts centralized AC-coupled hybrid system configuration.

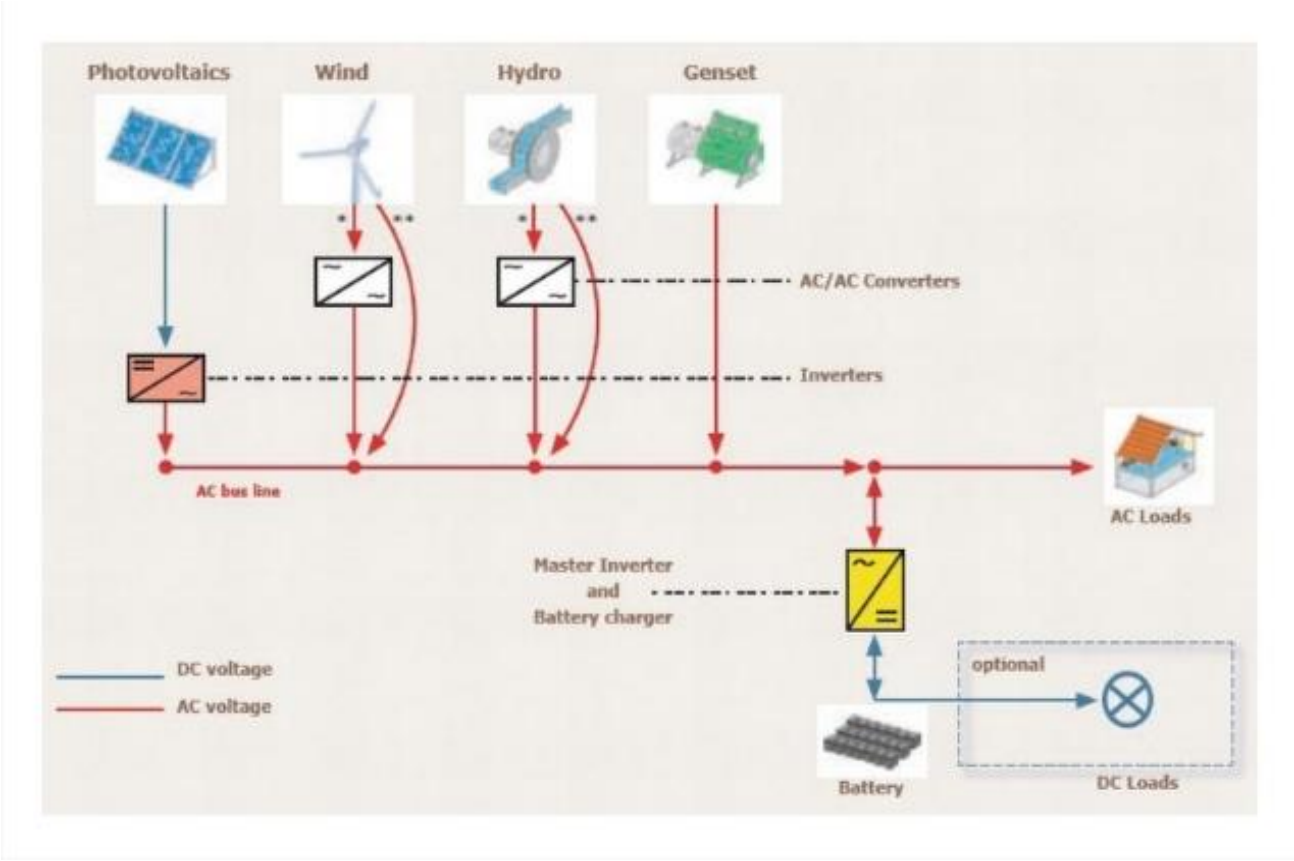

Figure- 1 :- AC-coupled centralized micro grids

2.1.1.1.2.Decentralized AC-coupled micro grid

In this type of architecture, all the technologies are not connected to any of the bus, rather they individually connect to the load directly as shown in Figure-2. The energy sources may not be situated in one location or close to one another and they can connect to the load from anywhere the renewable resources are available . The merit of such configuration is that the power-generating components can install from the location where renewable resource is available. Thus, comparing the two configurations, the centralized system is better due to its controllability than the distributed system.

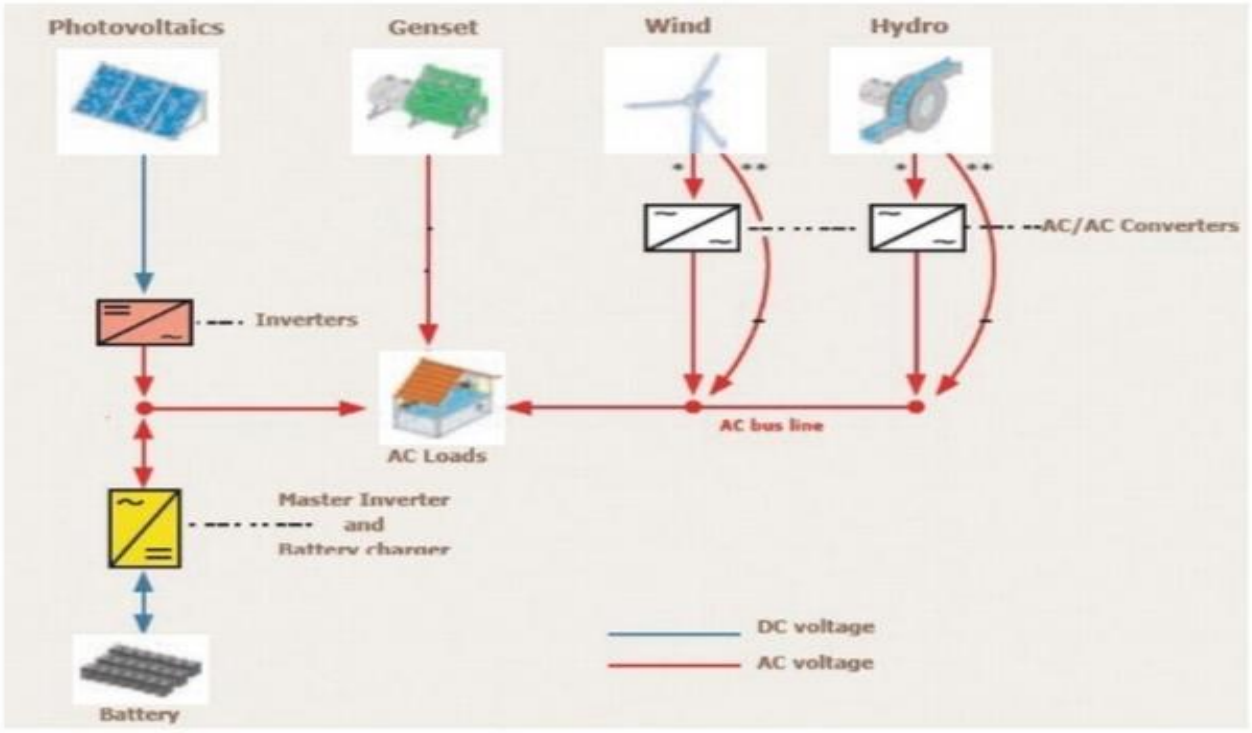

Figure-2: - Decentralized AC-coupled micro grid

2.1.1.2. Micro grid system: DC-coupled

In the direct current (DC) combination, all the energy sources are linked to the DC bus prior to connect the AC bus as illustrated in Figure-3. All AC power sources are converted to DC and then linked to the AC demand is met with no cut-offs. Despite the advantage of this, it has disadvantages of low conversion efficiency and no power control of diesel generator. Wind turbine and diesel generator produce AC voltage and need AC/DC converter to supply appropriate load to the DC bus.

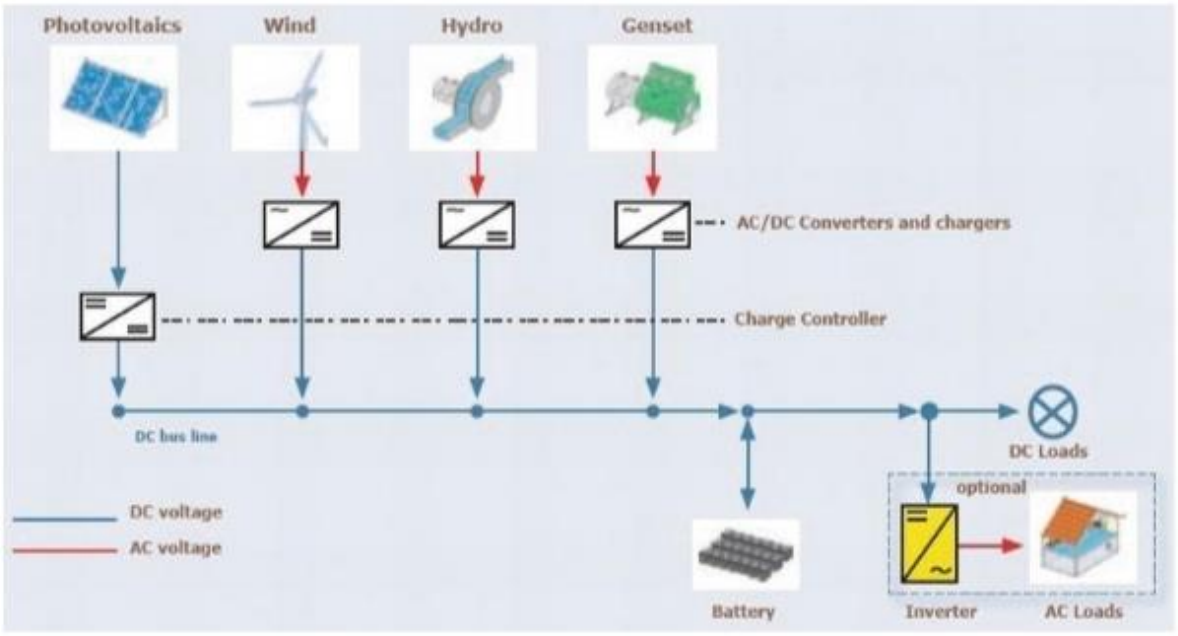

Figure-3 :- DC-coupled micro grids

2.1.1.3.Micro grid system : mixed coupled

There is a possibility to join AC- and DC-coupled micro grid systems. This type is called mixed-coupled micro grid system. In this kind of topology, some renewable is linked with battery storage at DC bus, while others are linked with DC at AC bus. Figure-4 presents such configuration.

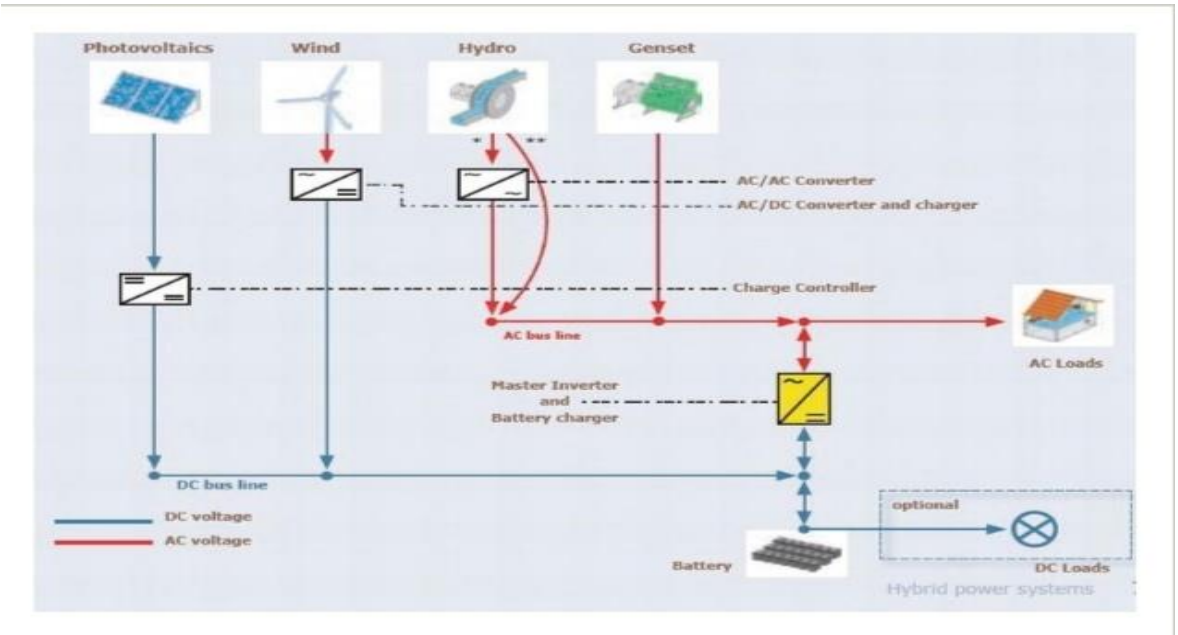

Figure-4 :- Mixed micro grids

2.1.2.Series/parallel micro grid system

Micro grid systems are also categorized on the basis of type of supply provided to the demands from renewables and diesel generators. Series and parallel hybrid micro grid are the two configurations and their detail discussions are given as follows.

2.1.2.1.Series micro grid power system

In this configurations, all the generated DC power supplied to the battery. Therefore, the energy produced by the PV, wind, and diesel generator is utilized for charging battery storage. Hence, charge controller is equipped with each component, other than diesel generator. Diesel generator is equipped with a rectifier. Afterwards, inverter converts the DC power into standard AC power and feed to the AC demands.

Overcharging of the battery storage by PV/wind is prevented by charge controllers. Similarly, deep discharging of the battery bank is also prevented by the charge controller. This topology is also called centralized DC bus configuration, because all the sources are linked to DC bus and load is fed through a single point. Figure-3 presents series micro grid power system.

2.1.2.2.Parallel micro grid power system

In this type of configuration, a part of supply demand is directly fed by the renewable sources and diesel generator directly. This configuration further classified into two subconfigurations:DC coupled and AC coupled, which are already discussed in this chapter in previous section.

MICRO GRID STRUCTURE

It is a distribution network which is supplied through low and medium voltage distribution lines. Various self-sufficient and independent distributed energy sources i.e., PV, wind, fuel cell, micro hydro, etc., and storage devices such as battery storage , flywheel storage, etc., along with demands , are incorporated and grouped inside micro grid structure. Figure-5 presents a typical overview of micro grid structure. Different distributed energy sources are integrated in micro grids by its corresponding bus bars equipped with power electronics converter. Point of common coupling (PCC) is the point where micro grid is connected to the network.

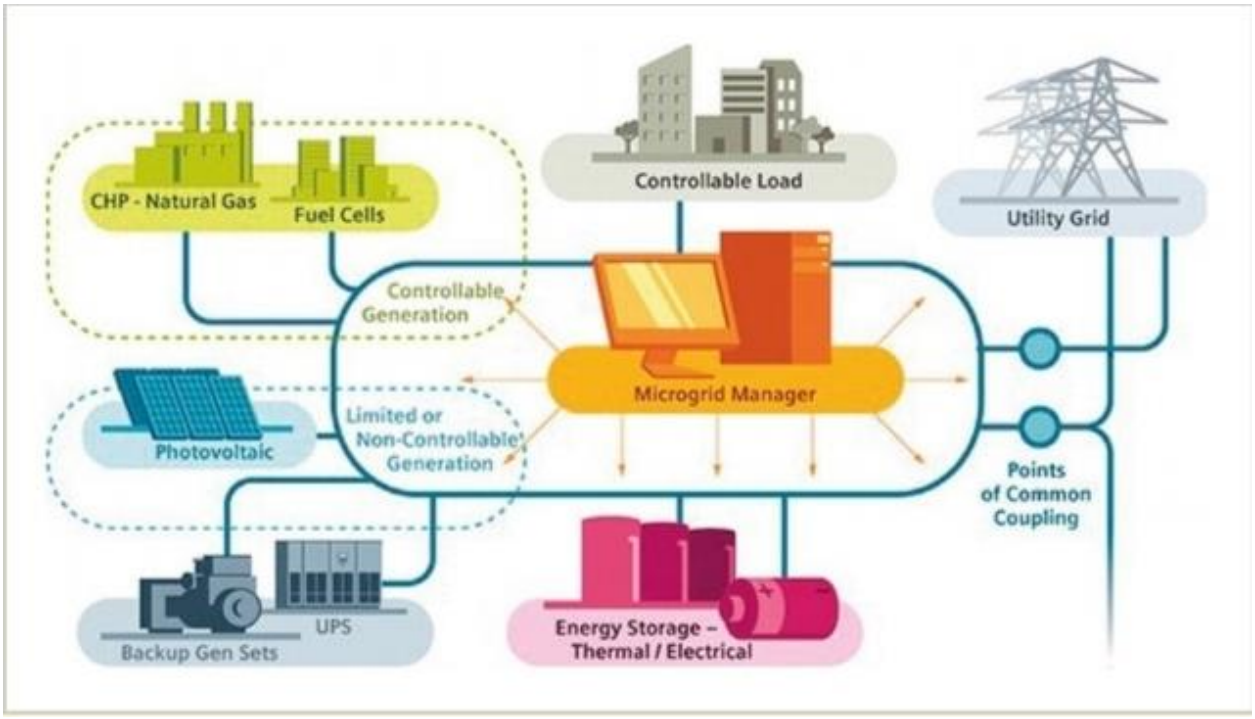

Figure- 5 :- Micro grid power system

There are two modes in which micro grids operate. The first one is the grid connected mode and another one is the stand-alone mode or islanded mode. In grid interfaced mode of operation, PCC is closed and micro grid is linked with the utility grid. Whenever there is any disturbance in utility grid or micro grid, PCC is opened and a micro grid is disconnected to the main grid, then the micro grid is operated in stand-alone mode.
There are two types of micro grids available. They are AC micro grid and DC micro grid, which are depending upon distributed sources and demands connected. DC grid has the advantage of easier control. Further, it does not require DC-AC or AC-DC converters; therefore, it provides lower cost and better efficiency. Figure-6 presents the massive DG's in the power system.

Figure- 6 :- Massive DG's in the electrical network

The renewable energy production is further classified into dispatch able and non-dispatch able production. Dispatch able production is able to change their power production upon demand and by the request of grid operators. They are micro hydro and mega hydro power, ocean/marine current power and wave power, geothermal and ocean thermal energy conversion, biofuel biomass, etc. Non-dispatch able renewable energy – based generators are wind energy and photo voltaic, because wind turbine output depends on the wind speed and solar power available by the radiant light and heat of the sun.

The assumed simple structure of micro grid network will be radial with distribution feeders from different substations and a collection of loads and energy sources as illustrated in Figure-7.

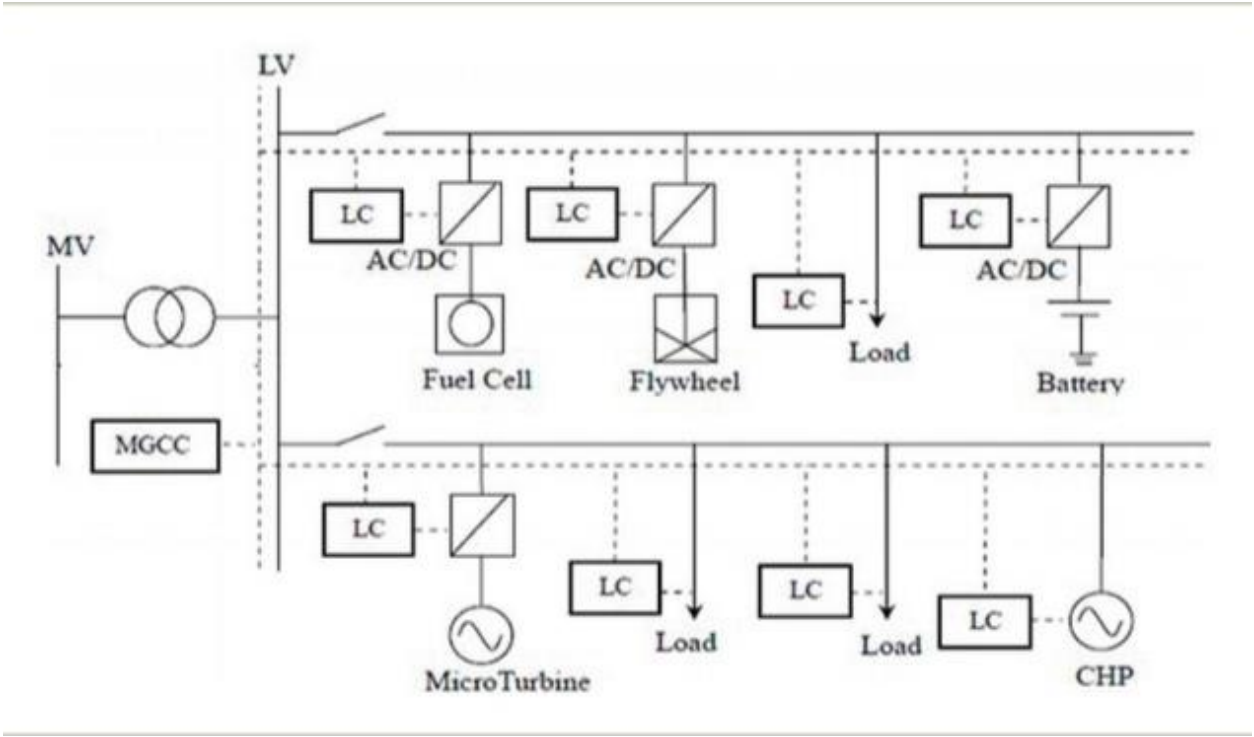

Figure-7 :- Basic micro grid architecture with an MGCC

The overall architecture of a micro grid consists of an LV network on the consumer load side (both critical and non-critical loads) , both non-controllable and controllable power generators , energy storage units , and a hierarchical energy management. The common relevant data in exchange include mainly information about MG switch orders that are sent by the MGCC to LC and the sensed voltage/current information to MGCC from each local capture; power and frequency reference setting for each source and the state charge and discharge of the energy storage, and the protection device conditions the system in the case of fault happening to isolate the abnormal zone of the system.

3.2. Integration of micro grid to the main grid

Most of the small-scale DG sources in the load side are integrated at medium or low voltage network as low penetration fashion where they are connected as passive systems and they are not involving grid voltage controlling, frequency controlling, and stability activities. Power electronic is used to interfaces between the grid and the renewable power source of micro grid so that there are not any negative influences in reliability, stability, and power quality of the supply after the interconnection DER's to the grid.

3.2.1. Low penetration with existing grid

In low penetrated network, the distributed generator units are not involving in frequency control activities and voltage control activities of the PCC point. Grid operator is responsible for managing the overall system stability, and DG operators can send the maximum available power to main grid and local loads without major consideration of grid constraints.

The DG operators have to deliver the power based by grid synchronization via PLL systems with correct phase sequence. Whenever grid frequency exceeds the allowable limit, the inverters are required to disconnect from the grid. And it operates in power factor(PF) correction mode , where PF keeps closer to unity. Most of PV units and wind generators can inject the maximum available active power into the grid; most existing voltage source converter (VSC) is operating in power factor correction mode(zero reactive power).

3.2.2.High penetration with existing grid

When growing the renewable energy source, penetration causes complication in the system constraints due to the intermittency of RES ; that the percentage of the renewable power injected into the existing grid is relatively high as compared to the power assigned to the conventional power plant. Therefore, in such type of situation , the intermittent power sources cannot work as passive generators , but they have to actively participate in grid frequency and voltage control activities.

3.2.3. High penetration with smart grid concepts

The combination of different renewable energy generation resources (micro hydropower, photovoltaic arrays, geothermal , wind-turbine generators) in a micro grid can be integrating to the grid and increase the penetration of renewable energies to change the whole system into a smart grid with advanced technologies.

3.3.Micro grid control

The MGCC includes several key functions, such as economically managing functions and control functionalities, is the head of the hierarchical control systems, and communicates between network operators. The typical single-line structure of a micro grid control system is described in Figure-8. It is clear that a direct connection of the micro grid LV line to DGR's (PV, wind generator, micro turbine) and to the electrical grid network is not possible so power electronic interfaces (DC/AC or AC/DC/AC) are required due to the characteristics of the energy produced.

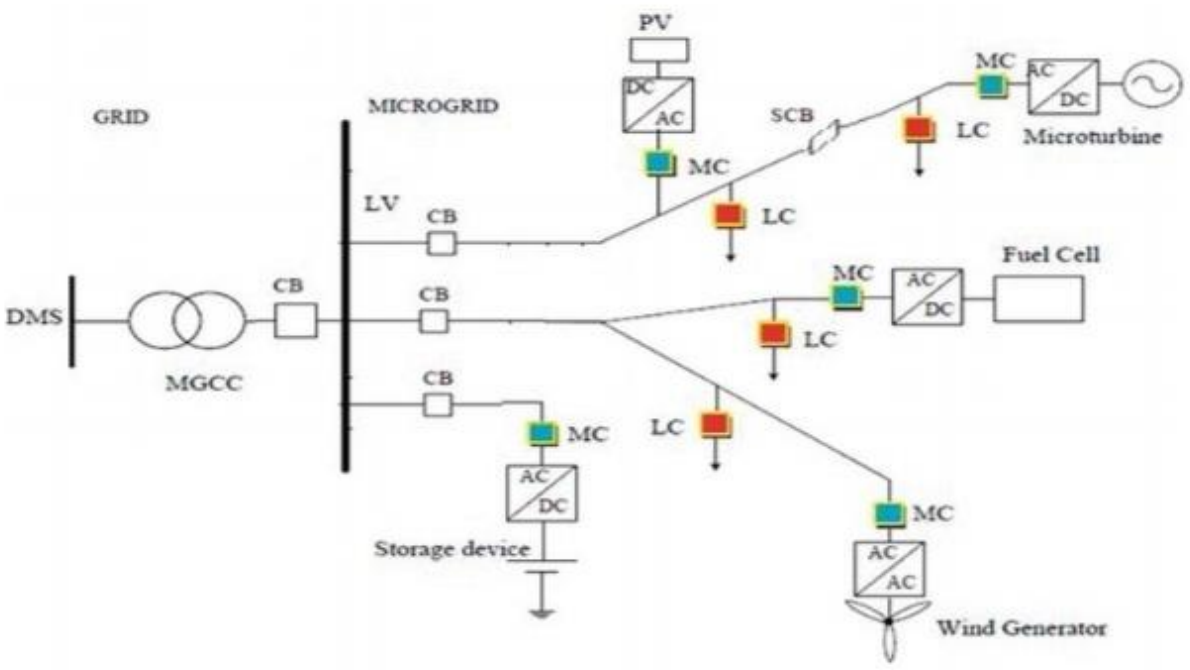

Figure- 8:- The micro grid control architecture

In the micro grid control system, there are main parts including: micro source controllers (MC's) on the consumer production side and load controllers (LC's) on the consumer demand side; micro grid system central controller (MGCC) on the middle of the main grid; and micro grid structures and distribution management system (DMS) in the grid network side.

The different DG sources and energy storage devices are connected to the low feeder lines through the micro source controllers (MC's) . MC has a function of controlling the power flow and bus voltage profile of the micro sources according to the load changes or any other disturbances. These feeders are also supplied with several sectionalizing circuit breakers (SCB's) which help in isolating a part of the micro grid as needed in case trouble. Power electronics interfaces and inverters (AC/DC, AC/AC, DC/AC) are important mean for controlling and monitoring the loads using load controllers (LC's).
So there are two task's : first one is micro grid-side controller (MC and LC) to take the maximum power from the input-side converter must be considered. Second part is that grid-side controller (MGCC & DMS) which is having the following main tasks : (a) input active power control derived for network; (b) control of the reactive power transferred between network and micro grid ; (c) DC link voltage control; (d) synchronization of network ; (e) assurance of power quality injected to the network.

3.4.Micro grid protection systems

The protection systems of micro grid are very challenging since there is bidirectional flow of power in the system ; in case of bulk power system , power flow is unidirectional. But with DG sources , the grid power flow become bidirectional ; from both utility substation to micro grid energy storage and load or from local DG sources to the main grid or other micro grid , so there is a consistent reverse flow of current from maximum energy production to high energy consumption.
Differential relays offer perfect for transmission lines. They have many features over distant relays. These relays have better sensitivity.

CONCLUSION

Micro grid is well known in North America and Europe and used in those developed countries ; however, there will be positive progress in less developing country to build their electricity and power infrastructure in a futuristic micro grid and smart grid model, one know that there is big financial obstacle and skill gap in those country but if there is willingness from the government to transform their development plan into small-scale micro grid in power and heat demand.

ACKNOWLEDGEMENTS

The authors are obliged to the authorities of Rajasthan College of Engineering for Women (RCEW) , Rajasthan Technical University (RTU), Jaipur, Rajasthan, India for providing the enabling environment and support to carry out this work.

REFERENCES

1) Aguirre, Julio. (2014). Impact of rural electrification on education: a case study from Peru. Retrieved from http://udep.edu.pe/cceeee/files/2014/07/1b_3_agurrire.pdf
2) IEEE.(2015). IEEE Standard 1547.7. Retrieved from http://standards.ieee.org/news/2011/15744.html.
3) International Agency Emergency. (2014). World Energy Outlook. Retrieved from http://www.worlenergyoutlook.org/resources/energydevelopment/definingandmodellingenergyaccess/
4) Of gem . (2017). Review of distributed generation. Retrieved from https://www.ofgem.org.gov.uk/ofgem-publications/52326/review-distributed-generation.pdf
5) SE4ALL.(2013). Global tracking framework-universal access . Retrieved from http://www.se4all.org/wb-content/uploads/2013/09/7-7-gtf_ch2.pdf.
6) World Bank, International Energy Agency . (n.d.) Progress toward sustainable energy-global tracking framework 2013.
7) Saviva Research Review. (2013). Micro grids and Distributed Energy Research Software. Retrieved from http://www.savivaresearch.com/wp-content/uploads/2013/05/April-2013-DERMS.pdf.
8) Matthew man , Steve, and Hugh Byrd . (2014). Blackouts: A Sociology Electrical Power Failure. Social Space, 1-25.