INTELLIGENT MICROGRIDS

Sahil Bharaj[1]
[1]B.Tech Student
sahil.bharaj@gmail.com

Mahima Goel[2]
[2]Assistant Professor
24.mahima@gmail.com

Shilpa Mehta[3]
[3]Assistant Professor
Shilpa.frnd1155@gmail.com

K. R. Mangalam University, Gurgaon

Abstract: The Renewable energy market has increased in last few years. The increase in use of renewable energy is helping in power sector and meeting the deficit power requirement. A Micro grid is the power distribution system that comprises of distributed generation, distributed storage and dispersed loads. The paper discusses the distributed generation in the MG based on photovoltaic array, small wind turbines and fuel cells. The energy storage in the intelligent MG is based on systems which uses various power electronic technologies. The MG can be used in grid connected and island mode. In this paper architecture, Gird connected / Off Grid connected mode, benefits and challenges faced by Micro-Grid has been discussed. The paper emphasis on various control methods and stability issues in grid and off- grid connected systems.

Keywords: Micro Grid, Grid connected, Island mode.

1. Introduction

Since its origin power systems have extensively popularized by amalgam of each new power generation station to the interconnected power systems to provide reliable power to consumers and additionally for economic reasons. As a result, power system networks became huge, connecting hundreds of generators, transmission lines and other devices. It is clear that these huge interconnected power systems has an impact on the environment, now every nation is looking for alternative ways of electricity generation by using renewable energy sources such as sun, wind, biomass and fuel cells. These distributed energy sources are integrated with power generators, distribution system and local loads to form local energy network, called Micro grids. Generally, a micro grid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. It can be connected to the grid to operate in grid connected mode and disconnected to operate in island mode.

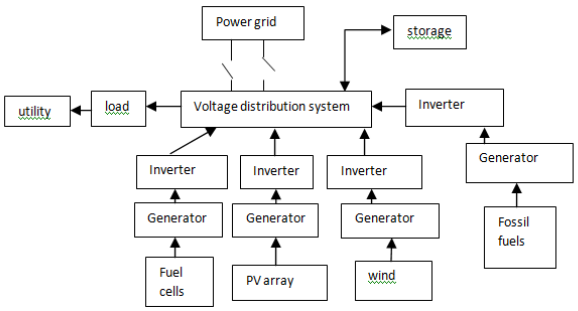


Fig.1 shows the basic block diagram of MICROGRID.

2. Types of Micro Grid

REMOTE MICROGRIDS: Low and no impact on utility grids, Independent system for remote electrification, Suitable for remote areas and islands
COMPLEMENT MICROGRIDS: Little impact on utility grids, Complement mainly for important loads, Mature and large utility grid area is suitable

SUPPORT MICROGRIDS: High and huge impact on utility grid, Support for power systems, Suitable in rapidly developed renewable energy area.
Types of storage in micro grids: Electrochemical energy storage (batteries & super capacitors), Superconducting magnetic storage, Thermal storage, Kinetic energy storage
Advantages of micro grids : Energy efficient, Minimization of energy consumption , No impact on environment, Improved reliability of energy system, Network benefits, Cost efficient

3. Grid connected Micro Grid

When a group of interconnected loads and distributed energy system is parallel connected with utility grid or main grid, to draw or supply power to the main grid, then the micro grid is said to be grid connected.

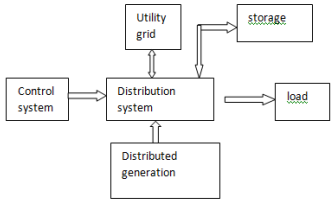


Fig.2 shows the grid connected mode of micro grid.
Conditions for grid connected operation: MG connected parallel to the main grid to draw or supply power to grid, Should not actively regulate voltage, Harmonics and DC

current injected to grid should be below required levels, Should satisfy all of its load requirement.

4. Off grid/Islanded Micro Grid

When a small scale distributed energy system is disconnected to the main grid with a switch and provide power to the local loads only and not able to draw & supply power to the utility grid, then the micro grid is said to be in off grid/island mode.

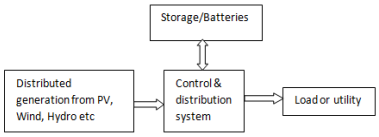
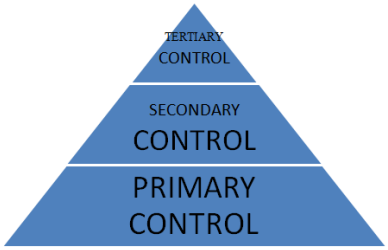


Fig.3 shows the islanded mode of operation of a micro grid.
Conditions for islanded mode of operation : Disconnected from main grid due to abnormal conditions in grid or planned switching, Voltage and frequency management should be done, There should be a balance between supply & demand, Power quality should be managed, There should communication among MG components.

5. Hierarchical control level



- Primary control deals with the droop control, droop control is used to share loads between converters
- In secondary control, any steady state error introduced by droop control is to be removed
- Tertiary control deals with global responsibilities. It decides about the import and export of energy for the micro grid.

DROOP CONTROL
For power systems based on rotating generators, frequency and active power are closely interconnected. A load increase implies that the load torque increases without a corresponding increase in the prime mover torque, which means that the rotational speed and directly the frequency decreases. The slowing of frequency with increased load is what a droop control is trying to achieve in a controlled and stable manner. Droop control is used to create references for the voltage and frequency which are compared to actual values to create an error signal.
Droop control scheme can be expressed as

$$w = w^* - m (P - P^*)$$
$$E = E^* - n (Q - Q^*)$$

w* = amplitude
E* = output voltage

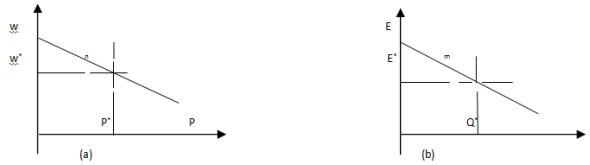


Fig.4 (a) & (b) shows P-w and Q-E grids scheme using P^* & Q^* as set points
This method increases the system performance because it is allowing the autonomous operation among the modules. In this method P/Q sharing influenced the amplitude and frequency output voltage through a self regulation mechanism which uses both active and reactive local power from each unit.

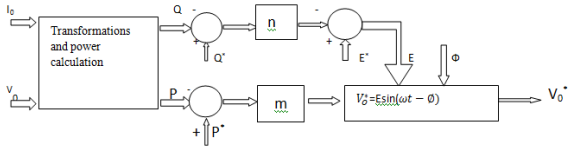


Fig.5 shows the droop control using P/Q

Indian scenario on the micro grid

Impact of blackout happened in India on 30th July & 31st July was India start emphasis on smart micro grid system. Since distribution and transmission lines are not able to provide power to the remote & rural areas of country, micro grid innovation is a hope for providing electricity to the rural areas. In Jan 2012 over one third of India's rural population had no access of electricity. Electricity supply to in the rural areas is economically not advantageous for government due to low consumption and high cost of transmission. In this regard, India start developing small power distribution system as named, micro grids for providing electricity to these rural areas, the main source of power generation in these micro grids are renewable sources such as solar, wind, biomass etc. The main Aim of these micro grids is to provide electricity to small local & remote areas with its own generation, so that there is no need to depend on the main power grid.

6. Indian scenario of Micro Grid

India's first smart microgrid

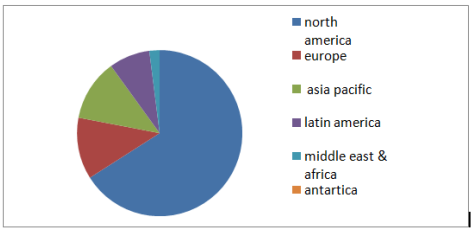
6.1. Installed in village Upari Babhan, Rajasthan
6.2. total generation is of 16 MW
6.3. total consumption is around 10 MW
6.4. mode of power generation is PV cells
6.5. power is provided to consumers on request basis for lighting, fans, mobile charging etc.

Micro grids in India with their potential & capacity
Grid Connected:- Off grid:-

Source	Estimated Potential(in MW)	Installed capacity (in MW)
Wind	48,500	16,179
Small hydro	15,000	3300
Bio mass	16,881	1142
Solar PV and thermal	50 MW/sq.km.	482
Waste	2700	73

Source	Capacity(in MW)
Wind	92.93
Bio mass	148.26
Solar	81.01
Aero generators	1.45

Total micro grid capacity, market share by region, world market 2014



7. Conclusion

This paper deals with the brief account about the micro grids system, and their controls. As it is shown that a number of distributed generation and distribution system units can perform a flexible micro grid, showing the different operating modes of a micro grid applying the concept of multilevel control loops. Fault detection and selective isolation are very challenging tasks in micro grids. Since it has been taken as an alternative idea to support the grid, the micro grid technology has drawn considerable attention from the energy sector in many countries. Some of public utilities are yet to be found it soon to integrate them to the network until this alternative becomes a bit mature. From micro grids integration to utility grid help to alleviate system overloads and blackouts.

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