

A Review on Microgrid: Architecture, Model and Existing Ventures in India

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Abstract: In the latest design set up for existing power system as to make the system more efficient and reliable we have started using the concept of combining individual distributed generators which eventually include non-conventional and conventional sources of energy to produce the electricity. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a "Microgrid". This concept has been brought up in the existing systems because this helps in providing the system a back-up during occurrence of any disturbance on the system. It includes a simpler configuration but with proper engineering steps which makes it the latest architectural design for a new power system. In India, there are many upcoming ventures some are in active state whereas some are in the under-developing stages. In this paper some of the existing ventures of microgrid are discussed.

Index Terms: Microgrid, Basic Architecture of Microgrid, Models of Microgrid and Examples over Microgrid Ventures in India.

I. INTRODUCTION

The basic concept of microgrid can be understood as a whole system of small electrical power system being collaborated in one system which has both conventional and non-conventional sources which includes generators such as photovoltaic, wind turbine, hydro, gas turbine altogether. As by the combination of the system we can easily provide the supply to almost all types of consumers present in the market. These systems help the main controlling system to have lower emission and respectively the potential in respect to cost decreases. Since economically, technically and environmentally the changing face of electricity generation and transmission are facing many problems. Therefore it becomes a necessity to develop a system which can provide a better reliability to the system.

Earlier the application of individual distributed generators were causing problems such as voltage dip, have higher cost and sometimes exceeds the thermal limit in certain lines and transformers. Later when we use microgrid concept all these related problems are being resolved. When the system is constructed then it is very much important to configure the system properly by using the power electronic devices to provide proper interfacing and control in between the system for better flexibility so as to operate all the generators in one system and making them work synchronously to maintain power quality and energy output of the system.

The major benefit of microgrid is that it combines the individual benefits of generators combined within it by reducing the carbon generation technologies and making the high efficient combined heat and power system. When a microgrid is being constructed it is to be noticed the climatic condition and topology for the selection of individual generators are made a priority. Since when we combine the different distributed generating station then the efficiency improves to 80% in comparison when the system works individually.

II. ARCHITECTURE OF MICROGRID

The main components which can be broadly classified are the Main Substation, Smart Meter, Battery Storage System, Cogeneration System and Distributed Generators. Figure 3 explains the complete architecture design.

II.1. Main Substation: The end system from where the supplies are provided to the respective consumers depending upon the different usage of the consumers. These supplies are provided with the help of different types of distribution system which are broadly classified into two categories which are DC lines and 60/50Hz AC line.

Since DC line does not have issue of poor power quality and many of the distributing generators produce energy in DC power that is the companies are planning to go for DC lines only but a major disadvantage with these lines is that the equipments used by the consumers are of AC power that is there becomes an issue in introducing the system whereas in

AC lines with the use of inverters the DC current has to be transformed to a range to set it according to the frequency in which the supply is to be provided into the lines.

II.2. Smart Meters: Since in India the microgrids which are working in different parts of the nation are based on solar power plants as solar energy is considered to be the most efficient ample of energy from where the energy could be efficiently be produced in the country so related smart meters are used to evaluate the readings efficiently. As the major advantage for the companies which produces the energy, is that these meters are to be recharged and then according only that amount of energy will be used by the consumers who are in actual need. Once recharged, the meters can be used to operate a variety of household appliances or even higher power water pumps for irrigation.

II.3. Storage Devices: It becomes a necessity to store the energy in different storage devices as when any type of load is introduced in the system then there is a kind of frequency disturbance, so as to balance the short term power and energy demand with generation we need to have reliable battery back-up which is the main concept involved in "Microgrid". This advantage of microgrid helps the system to become more reliable and flexible.

Here in this concept the storage devices which are mainly used are of three categories that are Battery, Flywheel and Supercapacitor, wherein battery has an advantage of having less cost in the infrastructure but gives a bad impact on the environment whereas the other two devices are costly but are environmental friendly. The energy produced from various sources are produced in ample amount, so during less requirement of energy some amount of energy is left, thus to store that energy as well as to reuse it again during the deficiency we store the energy in these devices. The system which has storage devices inbuilt in it has an improved efficiency of about 90-95%. We can even use fuel cells as storage device which converts the chemical energy into electrical energy. The advantage with these devices are that it does not gets discharged even though energy is not provided as it needs proper supply of hydrogen and oxygen.

In India, batteries are used as the storage devices as this concept of microgrid is famous in rural areas of the nation that is why it becomes affordable for the consumer to use this as their backup storage. The following table explains the feature briefly:

Table 1: Basic Features of Storage Devices in Microgrid [1]

Basic Features	Battery	Flywheel	Supercapacitor
Continuous Power(W/kg)	50-100	200-500	500-2000
Typical backup time	5-30m	10-30s	10-30s
Losses at Standby	Very low	Variable	High
Environmental impact	Med-High	Low	Low
Maintenance	1/yr	1/5yr	None
Charging Efficiency (%)	75-95	90	85-95
Current energy price(\$/kwh)	150-800	3000-4000	4000-5000
Service life(year)	5	20	>10

II.4. Distributed Generators: Microgrid is the concept of combining many different conventional and non-conventional sources of energy producing the electricity wherein we have majorly four sources of energy which are solar energy, wind energy, micro hydro plant and diesel energy. Microgrid focuses more on the concept of usage of conventional energy source. As well as the Distributed-power applications favour natural-gas technologies due to the potential of low air emissions. Reciprocating engine technology has been driven by economic and environmental pressures for power density improvements, with increased fuel efficiency and reduced emission. Emission of natural gas engines have improved significantly through better design and control of the combustion process [6].

Among distributed generation plants, the plant which has been examined to have the better quality of energy produced is the diesel plants as we know that this is a non conventional source of energy that is why we try to built our concept more on the conventional sources. So, the designing of the microgrid on software are done on solar panelled plants, Wind Turbine and Mini-Hydro plants.

II.4.1. Solar Panelled Plants: These plants work on the energy received on the solar panels through the sun's rays. Due to the continuous supply of the energy almost throughout the year we prefer to use these plants. Due to the development done in the inverters which invert the energy in the correct form which could be transmitted this source of energy is known to be the distributed energy resources.

The advantages with this plant is that there is sustainable amount of solar energy received, does not give a bad effect on the environment, longer life time, less maintenance is needed and has silent operation. The energy produced through this is in DC form so suitable converters are needed to change it into AC form. The disadvantage with it is that, requires a larger space for the installation of the plant, low energy efficiency and has restriction over few location where solar energy is not efficient, installation cost is more. The uses of this plant are for providing energy in remote areas, roof projects for heating, lightening, etc. India is considered to be the country which has its second largest amount of conventional energy from solar plant, which is working and providing the energy to the grid is of about 50 MW and most of the plants are working on solar energy only.

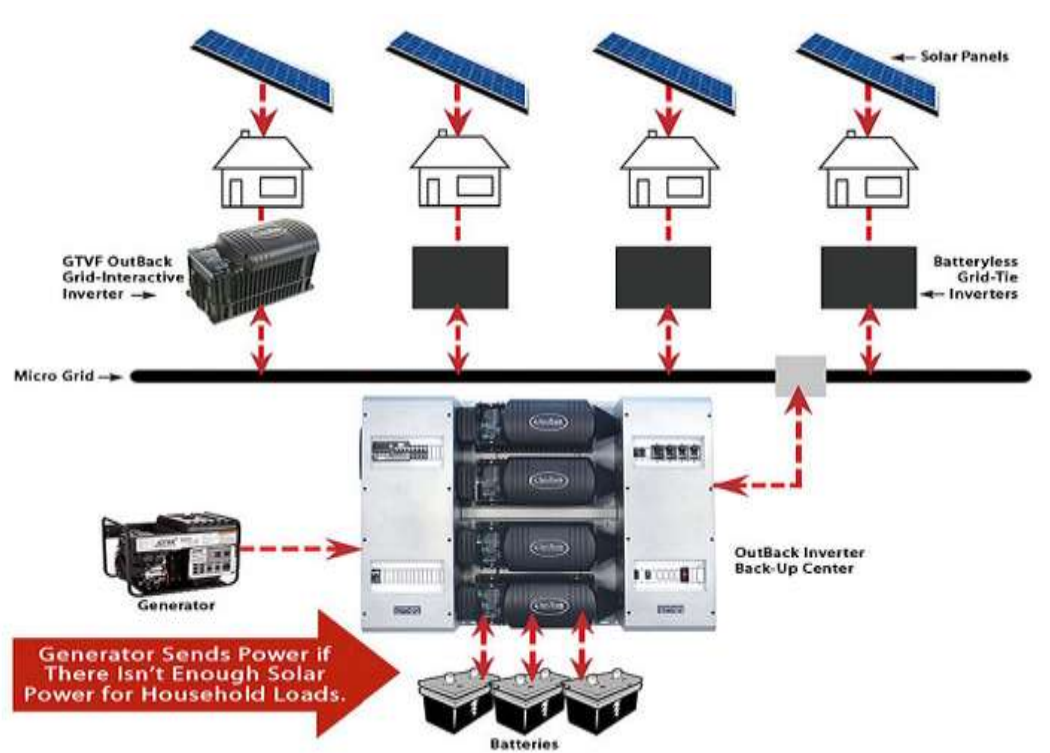


Figure 1: Microgrid system with PV and storage [1]

II.4.2 Wind Power Plant: Plants installed near the sea shores of huge towers with attached shafts and engines to generate electricity from wind and convert it from wind energy to electrical energy is known to be wind power plants. A wind turbine in engine captures the kinetic energy of wind through rotor blades and then transfers that energy to inductive generator through the gearbox. The generator attached with the shafts is driven by the turbine in built in it to generate the electric power. India has been recognised to be the largest and strongest country in terms of wind power plants.

As till 2013 the installed capacity of wind power in India was 19933.68 in which many states like Tamil Nadu, Gujarat, Karnataka, Rajasthan, Madhya Pradesh, Kerala, Orissa, Maharashtra, West Bengal and other states (3.20 MW) are producing the electricity for the nation. Since, this type of energy is restricted to flow of wind and can be provided only to those states which are nearby to the sea shore that is why we usually not prefer these plants as they also need large areas for the plant installation.

II.4.3. Micro hydro Plants: These plants use the flow of water as its source to produce the electricity by constructing the dams on huge heights and giving the water on the turbine over hundred of feet as the height. This source of energy depends on the flow of water and the annual rainfall in the area over the area. Run off water is basically used for micro hydro plant as there is continuous flow of water in the plant as this depends on the amount of water collected. The cost of hydroelectricity is relatively low, making it a competitive source of renewable electricity. Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of the green

house gas carbon dioxide (CO₂) than fossil fuel powered energy plants. In India such plants are not made used for microgrid as due to issues of water flow in the plant.

II.5. Cogeneration System: The need for this context are being necessary in the development and researching of a distinguished group of electrical micro-generation technologies, which can show energetic benefits highlight so as to show global index of efficiency in microgrid concept.

During the proper working of the system as microgrid, there is some amount of energy which is in excess amount which is known as excess heat in the system, so by the help of different microturbines(such as natural gas, hydrogen, and biogas), Stirling engines and IC engines , the system permits the optimum usage of the energy by capturing the excessive heat from the working process of other system therefore by achieving the maximum efficiency of the system to approximately more than 80% compared to other individual system. With the proper utilisation of the excessive heat in the system we grow the system's ability so stay consistent and reliable.

II.5.1. Fuel Cell: A fuel cell can be explained as an electrochemical device which is capable of converting chemical energy of the reagents (a fuel and an oxidant) directly into electrical power of low voltage. This conversion is introduced by means of an electrochemical reaction, in which, the oxidant usually is air or oxygen. In fuel cells the chemical energy comes from a fuel that is supplied from outside. Its method is the contrary to the electrolysis. So now fuel cells are used in place of batteries because of its eco-friendly characteristics and better reliability.

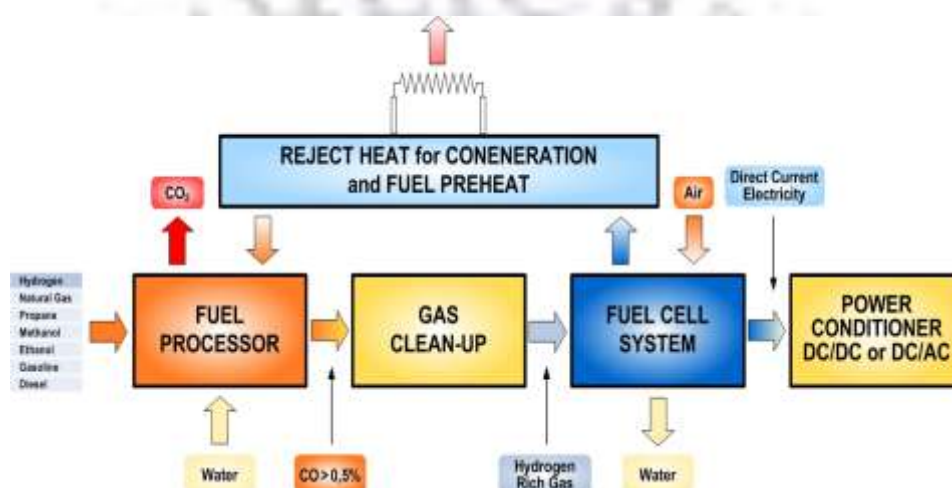


Figure.2. Cogeneration system in fuel cell [6]

The table shown below clarifies this:

Table 2: Typical characteristics of common DG Sources [1]

Characteristics	Solar	Wind	Microhydro	Diesel	CHP
Availability	Geographical condition dependent	Geographical condition dependent	Geographical condition dependent	Any time	Source dependent
Output Power	DC	AC	AC	AC	AC
GHG Emission	None	None	None	High	Source Dependent
Control	Uncontrollable	Uncontrollable	Uncontrollable	controllable	Source Dependent
Typical Interface	PE controller (DC-DC-AC)	PE controller (AC-DC-AC)	Synchronous	None	Synchronous Generator
Power Flow Control	MPPT & DC link Voltage (+P,+/-Q)	MPPT & Pitch & Torque (+P,+/-Q)	Controllable (+P,+/-Q)	Controllable (+P,+/-Q)	AVR and governor (+P,+/-Q)

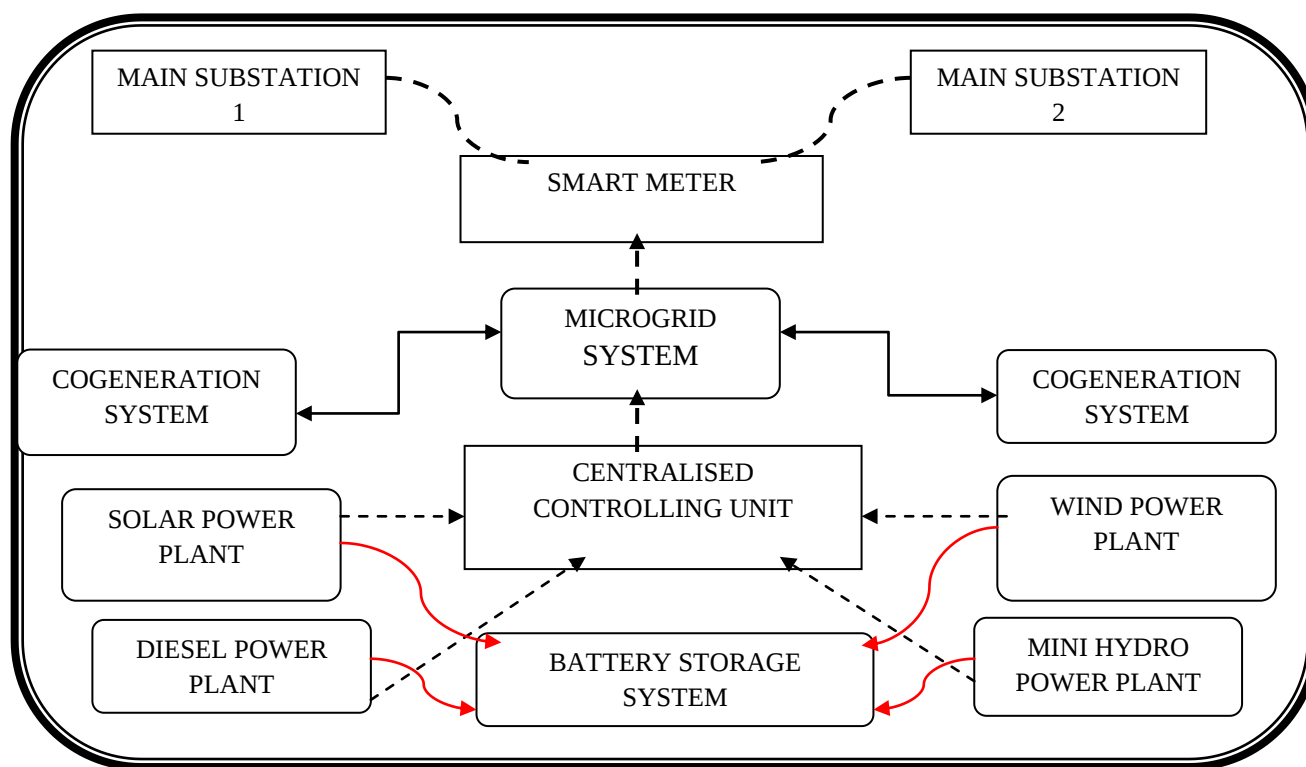


Figure. 3: Microgrid Architecture

III. MODEL OF MICROGRID

To review the proper working of the microgrid it becomes an important task for the engineering department to firstly, realise the actual potential of the individual system and later design an appropriate structure which may achieve the better functionality without creating any sought of customised changes in the system. Therefore, there are basically two models in which the system is constructed so as to achieve better reliability and flexibility in the system.

Here the first main model is the peer to peer concept that ensures that no individual component can be considered as master or slave or has any sought of controlling unit. This includes that even though any loss in the system is faced then also the overall system will continue working with the additional source of (N+1) and will ensure the proper working of the microgrid. The second concept introduced is the Plug-and Play, by the name itself we can understand that by placing any devices at any place in the system, the grid will continue to work. The plug-and-play model facilitates placing generators near the heat loads thereby allowing more effective use of waste heat without complex heat distribution systems such as steam and chilled water pipes [6]. This plug and play concept is used in the modelling as this provides more flexibility and becomes an easier concept with having a central controlling unit only the devices are needed to be placed with providing the energy.

IV. MICROGRID VENTURES IN INDIA

With latest advancement in upcoming microgrid technology there exists new ventures based on this concept in many of the states which faces a huge scarcity of electricity. Some of the companies which are regulating in these states are Husk Power System, Minda NextGen Tech, Mera Gao Power, Naturetech Infra, Gram Oorja and the solar pumps of Claro Ventures these are based in Uttar Pradesh and Bihar.

Tamkuha, West Champaran district, Bihar, is one of the microgrid stations which is working on biomass gasification and is in working condition since last seven years as well as is providing the energy to over two lakh people of the nearby region. India launched its first smart microgrid in 2012 in Tonk district of Rajasthan. Gram Power's site is the only village in the entire district receiving reliable 24 x 7 on demand power supply. Similarly, a microgrid has been proposed for Wani village, Maharashtra by Shaliwahana Green Energy Ltd, Chanaka and Rasoya power ltd, Wanjari Biomass generating plant each having installed capacity of 10 MW is installed. Each feeding to 33 KV bus at 66 KV sub-station. Figure.4. is the single line diagram for the project working in Maharashtra. On the other side the single line of smart microgrid of Rajasthan which is planned by Gram Power Company has been shown in the Figure.5.

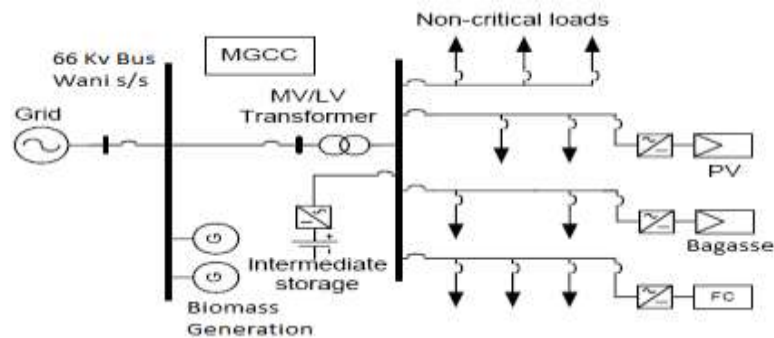


Figure. 4. Proposed Microgrid System in Maharashtra [4]

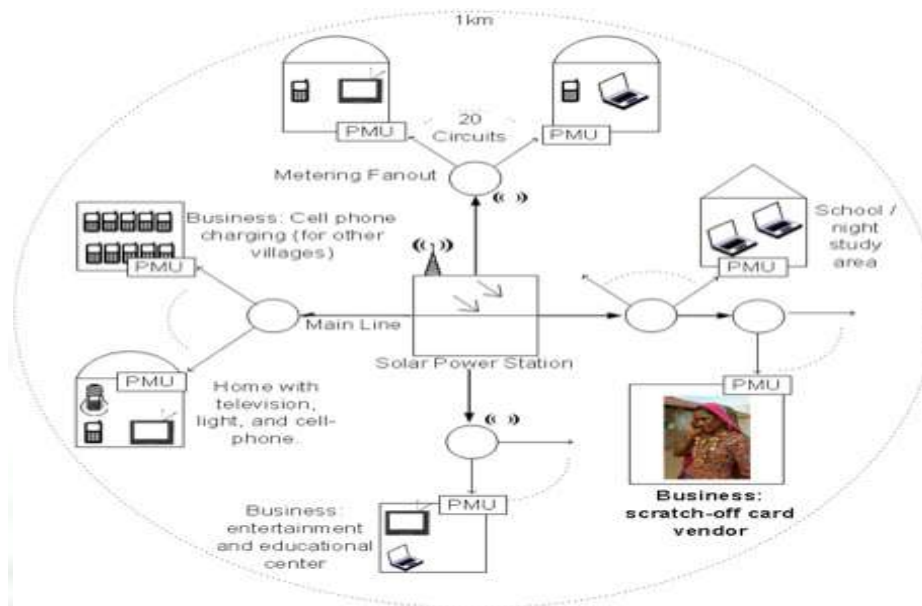


Figure. 5. Gram Power Company Microgrid Model in Rajasthan

V. CONCLUSION

Microgrid is one of the reliable and flexible models which is working efficiently in the rural areas and stretching its work in the urban areas as well with the better use of conventional sources of energy. By the combination of individual devices and in built storage devices the energy is stored which helps in the security of the supply to the consumer. The worldwide research is on for the distributed generation development and its potential have been utilizing for the application of microgrid.

From the point of view of consumer the price remains stable and does not fluctuate with market price, since conventional source of energy is used so non conventional sources could be reserved for a longer period of time, is protected from external forces and incursions, this integrate the storage, load shifting issues are resolved. In India, majorly microgrid is based on solar panelled plants as this is an energy which is present in ample amount for the production.

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