Review on Microgrid Technology

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ABSTRACT
The usage of renewable energy sources (RES) to meet demand for electrical energy is acquiring attention as solution to the problem where lack of electrical energy occurs. Application of RES in electricity generation system is done in many configurations as compared to others in microgrid system. Various advantages from user as well as from electric utility provider are provided by implementation of microgrid system.

Microgrid offers lots of advantages such as power quality is better, more environments friendly so development of microgrid is carried out in various countries. Microgrid development is related to microgrid architecture, control system, protection system and technology generation.

In this paper various technological developments regarding microgrid system and case study for development in microgrid system with the use of grid tie inverter (GTI) is reviewed. Implementation of microgrid system is done using GTI, transfer of power occur from GTI to grid when GTI has excess power and when power shortage is there grid supplies power to GTI.

Keywords
Microgrid architecture, microgrid, microgrid technology, grid tie inverter (GTI)

1. INTRODUCTION
Nowadays the usage of renewable energy sources (RES) to meet increasing demand of electrical energy is putting attention for solution to problems where there is lack of electrical energy especially for areas which are unable to reach existing power grids. Many developments concerned with use of RES continue. Starting with optimization of use of energy sources, development of power conversion system to the electrical power system architecture. RES application in electricity generation systems is to perform in many configurations, starting with more simple system like utilization of PV in solar home systems (SHS) to RES application in microgrid system.

Depending upon the source of sun received at time electrical power production from RES like solar power generation greatly varies which comes to the problem of generated power quality [1].The above problem can be overcome by making addition of another generation systems more controlled like formation of hybrid system by making addition of diesel generators or micro turbine or adding energy storage systems (batteries) [2].

Microgrid 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. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode."

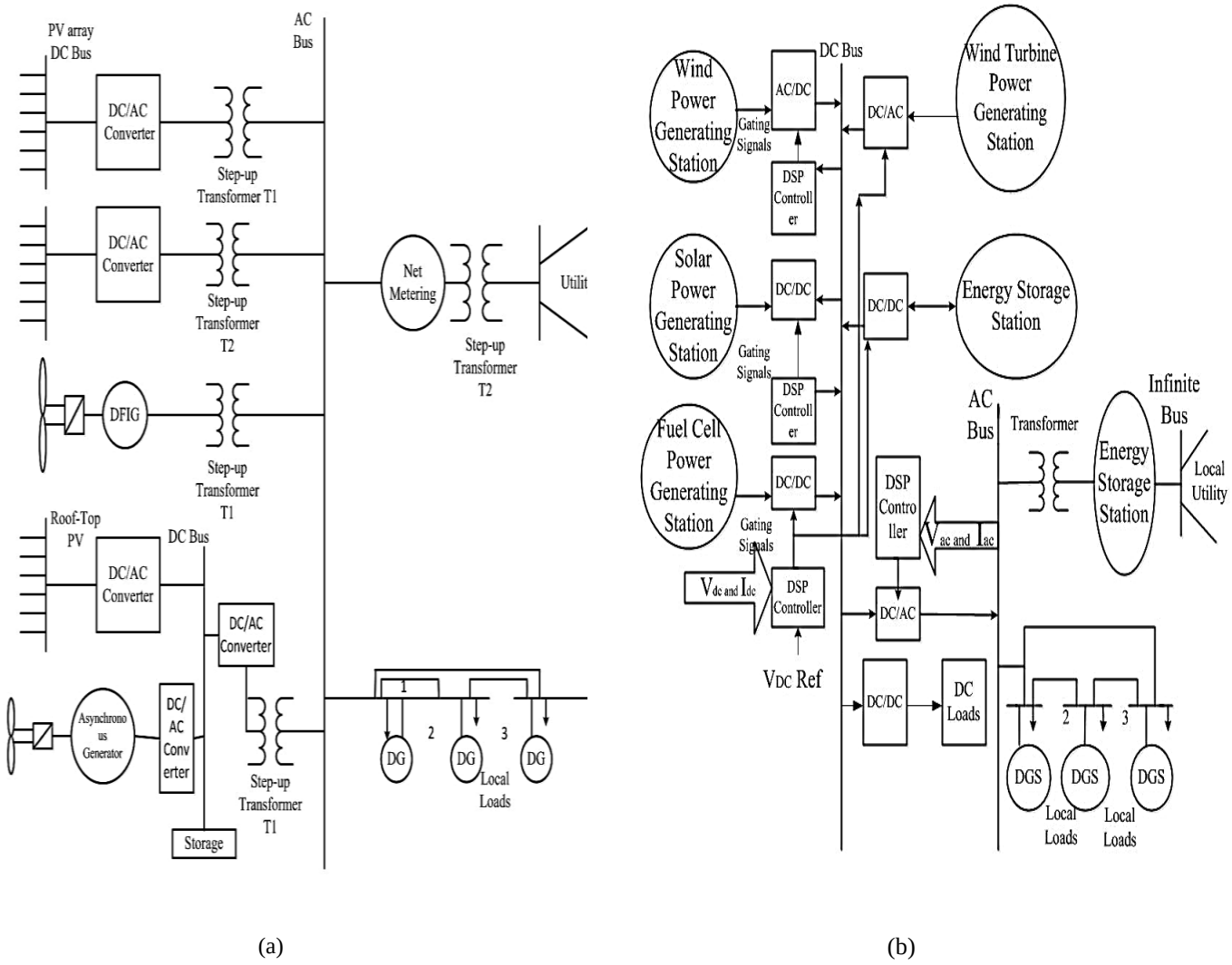
Microgrid system implementation provides several advantages not only from user but also from electric utility provider. Microgrid can reduce emission; it can improve quality of network and also reduces cost incurred by user. Microgrid can reduce load on the network and also helps to repair network in case of error [3]. Microgrid system implementation helps in improving reduction of emissions as well as climate change threat.

As microgrid gives several advantages like more environments friendly and better power quality development of microgrid is done by various countries. Also we have the opportunity to make use of waste heat from the engine generator using a combined heat and power (CHP) [4]. This can be used as an alternative generation system in future.

2. MICROGRID TECHNOLOGY
Microgrid is the recent technology in the field of power system and is centralized electric systems small-scale version which is capable of achieving some goals such as increased power supply reliability, reduced carbon emission in the environment, saving of money, generating of employment and many more such goals. Microgrid is perfect and ideal way to integrate renewable energy sources to the main grid and allow the customer's participation in the newly growing energy market.

Microgrid system has many distributed energy resources and operates at lower distribution voltage. The system has also capability to operate connected to the grid (on grid) or disconnected to the grid (islanded/ off grid) [5].The microgrid structure contains many types of distributed energy sources (DER) like wind turbines, solar panels, micro turbines, thermal power plant each in form of distributed generation (DG), with energy reserves from battery (Distributed Storage /DS).

Electrical connection points from microgrid areconnected with low voltage network in the PCC (Point of Common Coupling) connected to DS, DG and loads,such as commercial building, campuses. As shown in Fig.1, microgrid architecture organized as AC microgrid (AC bus) or DC microgrid (DC bus) or combine of both [6].



(a) (b)

Fig 1: Microgrid Architecture (a) AC microgrid (b) DC microgrid

3. MICROGRID WORKING

There are two operating modes of the microgrids which are grid-connected mode and stand-alone mode/islanded mode/isolation mode. When microgrid is connected to the main utility it is in grid-connected mode and when isolated from the main utility it is in the islanded mode. The microgrid is isolated from the main grid due to faults occurred by transients, increase of load, it may be intentional otherwise unintentional. In intentional islanding microgrid is disconnected from main grid by itself may be due to some kind of maintenance and repair work or to protect the micro sources from the instability on the main grid side. Unintentional islanding is natural and can be caused by faults, etc. Utility-connected microgrids can operate in parallel with the local utility or islanded seamlessly with a fast switch when necessary to preserve the reliability of critical loads in microgrid. Once the disturbance occurs, the microgrid can reconnect to the utility without disturbance to critical loads. The microgrid is single system with particular load and generation characteristics which are dispatched to provide a controllable load and generation profile to interconnected utility.

3.1 Grid Connected Mode

Most of the renewable energy sources like wind and solar power technology mainly depend on the weather and environmental conditions therefore producing unpredictable output characteristics. Other renewable sources like fuel cells, micro turbines, etc. have very slow responses which hardly meet the dynamic local load demands despite of the fact that they are independent on the weather and environmental conditions. As these sources largely depend on the weather conditions their output is comparatively weak. So lots of sources are combined together with the recent technologies to produce reliable power supply and required results.

The single energy supply system go through issue of instability and the need of the hybrid energy system to address the problem of instability and acquire desired output with advantages like enhanced efficiency of individual energy sources by using different characteristics of various micro-sources and at the same time improving the quality and reliability of the power supply. In such system i.e. hybrid energy system, the problems faced are the design, topology, modeling of key components and control strategy used.

1) Structure and selection of main components in Distributed hybrid Energy System (DHES):
The power electronic devices like rectifier is not used in the nearby supply system where the load is located near to the generation source as it uses DC bus to supply the local load and for the loads which are located at far off places the hybrid energy system structure uses AC bus to supply them so this type of system uses AC DC dual bus system. Special study is done while selecting the components of the system like energy storage system and their properties like capacity and structure are selected and modeled accurately.

2) Circuitry design and modeling of different components:
The parameters of circuit design and various components are applied and examined. Depending on study and observation of various characteristics of the energy storing devices, micro sources equivalent circuit diagram, performance equations, mechanical and electrical equations are brought up. At the same time advanced power electronic devices are studied and discussed to get the best possible control system for the distributed hybrid energy system.

3) Problem of control coordination of the micro sources:
Good coordinated control strategy is needed for distributed hybrid energy system because various micro-sources are joined to AC or DC bus of the distributed hybrid energy system and with the involvement of the advanced technology in power electronic devices. Each of them is having their own frequency-power and voltage-current characteristics, and each having different time constants.

Due to the connection with main grid, load demand and power reliability are met at each time so the main objective is to increase the revenue from the hybrid system as per the market. To save our environment and to have clean and green energy wind and solar energy are used.

3.1.1 *Why microgrids are integrated to main grid?*

1) The main power grids behave like backup source for microgrids.

2) The direct connection with main grid helps for stable operation and power reliability.

3) It decreases the need for energy storing devices, while using renewable energy sources.

4) It helps in reduction of investments and increase the revenue from system i.e. grid- connected mode.

5) Planning of microgrid is such that if there is large amount of energy which is not required to meet our load demands, it can be given to the main grid helping in generation of the revenue.

6) Grid interconnection grants for reducing operational cost of fuel by providing choice for the customer when they want to use power from the grid especially when cost is low.

3.2 Islanded Operation

The most important characteristic of microgrid is its ability to get separated, or isolate itself from the main utility grid. The microgrid is designed in such a way that it has got the capability of operating independently; also the shifting from grid connected mode to islanded mode is challenging task. In various applicationsit is seen that if main grid is lost the microgrid is expected to shut down for a short time and for meeting the local load demands it starts acting like a backup source.

Uninterrupted power supply is needed for those loads where there are more voltage disturbances and the microgrid can prove very useful in such cases and is very promising, will act like power supply backup. The isolation of microgrid from the main grid is due to faults caused by transients, increase of load, it may be intentional or unintentional. In intentional islanding microgrid is disconnected from the main grid by itself may be due to the some kind of repair and maintenance work or for protecting the micro sources from the instability on the main grid side. Unintentional islanding is natural and can be caused by faults, etc

4. MICROGRID TECHNOLOGY

Microgrid system operation cannot be separated from technologies which support each part which makes microgrid system, as source of energy (distributed generation), interconnect switches, energy storage and microgrid control system. Energy sources distributed generation technology contains renewable energy sources utilization like photovoltaic, fuel cells and wind turbines. Improvement in many power systems efficiency is done by using flue gas with CHP technology (Combined Heat and Power) as like micro turbine.

Energy storage technology in microgrid systems includes super capacitor, battery and flywheels. Microgrid system energy storage is used for:

- Stabilizing microgrid system with load changes and fluctuating energy sources.
- Enabling operation of load sharing in microgrid system.
- Reduces electrical interference and load spikes.
- Backup energy source.

The technology used in microgrid system is switch interconnection which is a digital technology which uses Digital Signal Processor (DSP) which is equipped with communication devices. For improving the response speed semiconductor switch uses technologies like thyristors and IGBT, Figure 2.

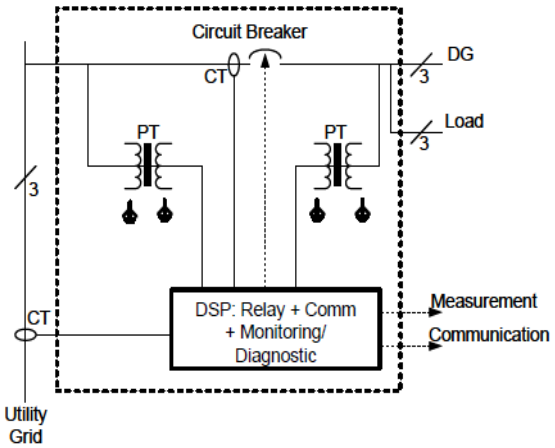


Fig 2: Circuit breaker schematic diagram on connection to the grid

Control systems technologies in microgrid are grouped in two modes of operation are isolated mode (islanding) and network mode. The control system has to regulate microgrid operation stability specifically frequency and voltage for maintaining

stability w.r.t changes in load and interconnection with other networks. In order to regulate active and reactive power supply to apply droop control and frequency control the control system is applied for power converter technology.

5. TECHNICAL CHALLENGES ON MICROGRID

Microgrid implementation faces many difficulties. Unfavorable government policies and less understanding about microgrid is the problem to apply microgrid technology. Microgrid technology can be used as solution for electricity in remote areas. It is used as electrical solution to offices, urban, residential complexes, schools and others. As compared to building of new transmission and distribution network, microgrid technology implementation will provide advantages. Advantages and disadvantages to apply microgrid technology are:

5.1 Microgrid Advantages

- Microgrid have capability to separate as well as isolate itself from utility seamlessly with small or no disruption to loads within microgrid during disturbance from utility grid.
- By reducing load on grid, microgrid can prevent utility grid failure in peak load periods.
- Environmental benefits are possible by using low or zero emission generators in microgrid.
- Microgrid can mitigate electricity costs to its users by generating some or all of its electricity needs.

5.2 Microgrid Disadvantages

- Microgrid system requires more space and maintenance because electrical energy is stored in battery banks.
- It is difficult to resynchronize with utility grid.
- Protection of microgrid is important challenge facing the implementation of microgrid.
- Issues like standby charges as well as net metering have problems for microgrid.

6. MICROGRID DEVELOPMENT USING GTI

Development of microgrid systems is done with the help of grid tie inverter (GTI). The disadvantage of this system is that whenever no grid is there, system does not work because GTI works when there is a power from grid which is used as reference for GTI operation. Microgrid trials using GTI are conducted in the laboratory. The proposed system is as shown in Fig.3.

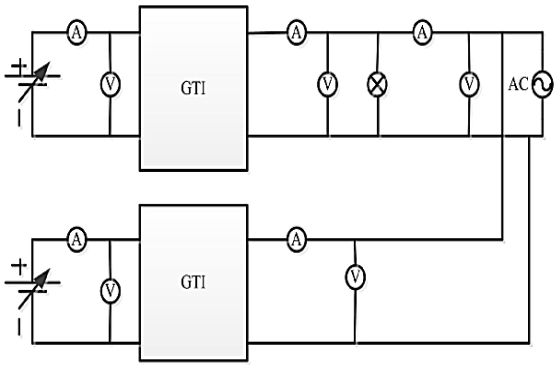


Fig 3: Microgrid system using GTI

In the proposed system it uses a local load and 2 GTI. To see the distribution of power flow of each GTI measurements are done and power flow from PLN for meeting need of power demanded by load.

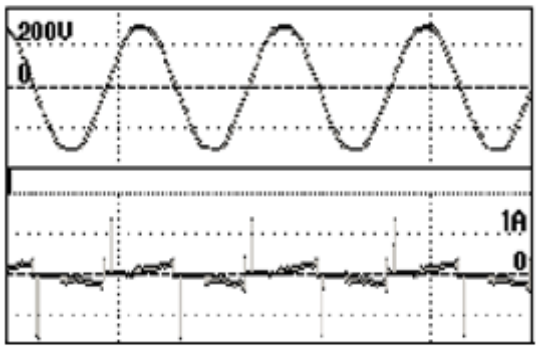


Fig 4: GTI output voltage on grid condition

The results of GTIoutput voltageis shown in Fig. 4. Power measurements are done on each inverter output, line to PLN and load. The measurement starts by activating GTI without connecting to PLN, by putting value of PLN, by putting value of PLN power = 0W as shown in table.

Table1. Power flow in Microgrid system

P_{GTI1}(W)	P_{GTI2}(W)	P_L(W)	P_{Pin}(W)
0	0	0	0
122	0	170	55
120	40	170	14
120	40	0	-158
0	0	0	0

When there is no supply from PLN then both GTI doesn't generate power to load. When GTI1 (PGTI1) supplied power to load and GTI2 (PGTI2) has not been issued, then power to load (PL) supplied by GTI1 and PLN (PPLN). When GTI2 start generating power then the power of the PLN decreases in proportinal to the input power of GTI2. When load is disconneted i.e. there is no power supplied to load both GTI power is supplied to PLN. Minus sign denotes direction of power flow towards PLN grid. When the source of PLN disconnected (isolated/islanding), PLN Power =0W, then both GTI has no output power again. The measurement results show that the number of power does not show balance of

power, this can cause each power output measurements performed using different tools.

7. CONCLUSION

Microgrid system is an alternative electricity network which is used to meet the electricity needs of the future. Microgrid system consists of multiple power sources that use renewable energy sources. Working of microgrid system is autonomous so it requires complex control system for regulating microgrid operation.

Microgrid implementation is done by using inverter GTI. Transfer of power to/from grid is done by microgrid with GTI. Transfer of power occurs from GTI to grid when GTI has excess power and grid supplies power to GTI when GTI power shortage. Power sharing between parallel GTI based oninput power of each GTI, if there is power shortage will be supplied from grid.

8. FUTURE SCOPE

Combination of different RE systems along with storagehas a potential future because ithelps to store the clean energy whenever available. The advancement in storage and battery systems looks promising in terms of cost and technology. Though initial system cost and operation and maintenance cost (O&M) may be higher, considering the requirements of demand side management and maximizing the use of available RESs, μG with storage devices could be a viable option in the near future.

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