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Review Paper

Microgrid and its current status in India: a review

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Abstract

The traditional power systems globally depends upon the conventional method of power generation by the combination of fossil fuels, but these fuels are being exhausted rapidly and in future it will create huge fuel crises. The global research activities therefore have already initiated to find out the alternatives source of energy through the maximum utilization of renewable energy resources. The individual capacity of renewable energy resources such as, Photovoltaic Generator, and Wind turbine, etc. are small compared to the traditional generation technology such as thermal power station. In this scenario microgrid system is emerging as a probable solution for the power crises. The microgrid is an interconnected system of different types of energy resources such as photovoltaic, wind energy, Biomass, small hydroelectric generation statics, fossil fuel etc. which needs proper coordination for satisfactory operation to meet the load demands. To achieve this coordination, microgrid itself requires good infrastructures so that it can operate in grid and Islanded mode as well as in the situation while faults have occurred in the power network. This paper presents a literature review on the microgrid, its components and its current status in India.

Keywords: Microgrids, DER distributed energy resource, DG Distributed generation unit.

Introduction

In the present work a detailed Literature survey has been performed to identify the latest advancements, as suggested by numerous researchers and IEEE/IEC standards.A formal definition of microgrid from the "Conseil International Des Grands Réseauxélectriques" or (CIGRÉ) states:

"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 islanded".

Microgrids and minigrids are good tool for power supply in emergency cases as they are capable to change between off-grid and on-grid modes.

Control and protection and power quality aspects are measure issues in microgrids, a hierarchical control is basically applied in it. Clean energy microgrids offer consistent, affordable, reliable, flexible and resilient local energy generation and delivery[1,2,3]. Since a microgrid is localized, it can mitigate power disruptions by continuing to operate providing electricity to its local customers when the macrogrid is unable to serve the microgrid customers. A microgrid can either operate as an island (generate power just to its own customers) or as an integral partner into the macrogrid. It serves as a resource for faster system response and recovery[2].

Microgrids add another dimension to the benefits of energy generation by increasing efficiencies and reducing energy losses during transmission and distribution. The ability to produce power locally when the macrogrid is down enhances community resiliency during extreme weather events, protects the safety of the public and reduces incidents leading to economic losses and infrastructure failure[4].

The Distributed Generators

Power Generation methods applied to the microgrid may comprise developing technologies like (Combined heat and power (CHP), mini wind turbines, PV, micro-turbines, fuel cells) and certain common generating techniques (three-phase and single-phase induction generators, diesel generators or micro hydro). It should be noted that CHP (which generate both heat and electricity concurrently, also known as cogeneration) and wind energy system has shown significant progress in technology and usage, and have gained solid points to be used in microgrids.

Existing energy scenario is changing and the demand of reliable, cleanand affordable energy production is increasing day by day. The aging of conventional energy structure, which may become more susceptible along the growing energy demand, needs some economical and environmental friendly solutions as the erection of new transmission corridors are highly limited by the right of ways and environmental considerations. A lot of energy policy

makers globally, have replied to these demands with appropriate plan modifications that promotes renewable and distributed energy production.

Energy storage system

The storage devices are one of the crucial components for successful operation of a microgrid. Its role is to become a care taker in matching the energy demand with energy generations. The ESS performs this function in the following three essential steps. i. The power balance is assured by this in a microgrid, even with transients and load variations as distributed generators have low inertia and absence of capacity to fast respond the disturbances, ii. It gives ride-through capacity when dynamic deviations in micro sources are there and permits the DGs to work under the specified limits. iii. The initial energy requirement is supplied by this for a smooth transition between on-grid to/from islanded mode of microgrids.

Out of the existing energy storage techniques, batteries and super-capacitors are more appropriate for microgrid type of applications[22].

Interfacing the DERs

Distributed energy resources (DER) comprises both energy storage techniques and DG. So many evolving DER technologies needs an inverter for conditioning the power and making it compatible with grid AC power. The interfacing unit may be a converter or inverter or both, depending upon the applications. This solid state or power electronic interfacing units will be equipped with filter circuits and necessary protection devices. DER units support the microgrid operation only due to these interfacing units as they have the capacity to convert the voltage as well as frequency to the desired value which is suitable for grid.

Microgrid loads

The customers like residential, commercial and industrial all types are served by a microgrid. Usually, the critical loads are industrialand commercial users, and service continuity is very essential for them, and also they requires a very good reliability and power quality. To attain the desirable operating strategies, this type of segregation of loads are important in the microgrid: i. It assist the load and generation shedding in the microgrid to make balance between the net import/export power in the on-grid mode. ii. It assists load and generation shedding to stabilize the voltage and frequency in the off-grid operation. iii. It improves the reliability and power quality of critical and sensitive loads. iv. The peak load is reduced by this to optimize the ratings of DER.

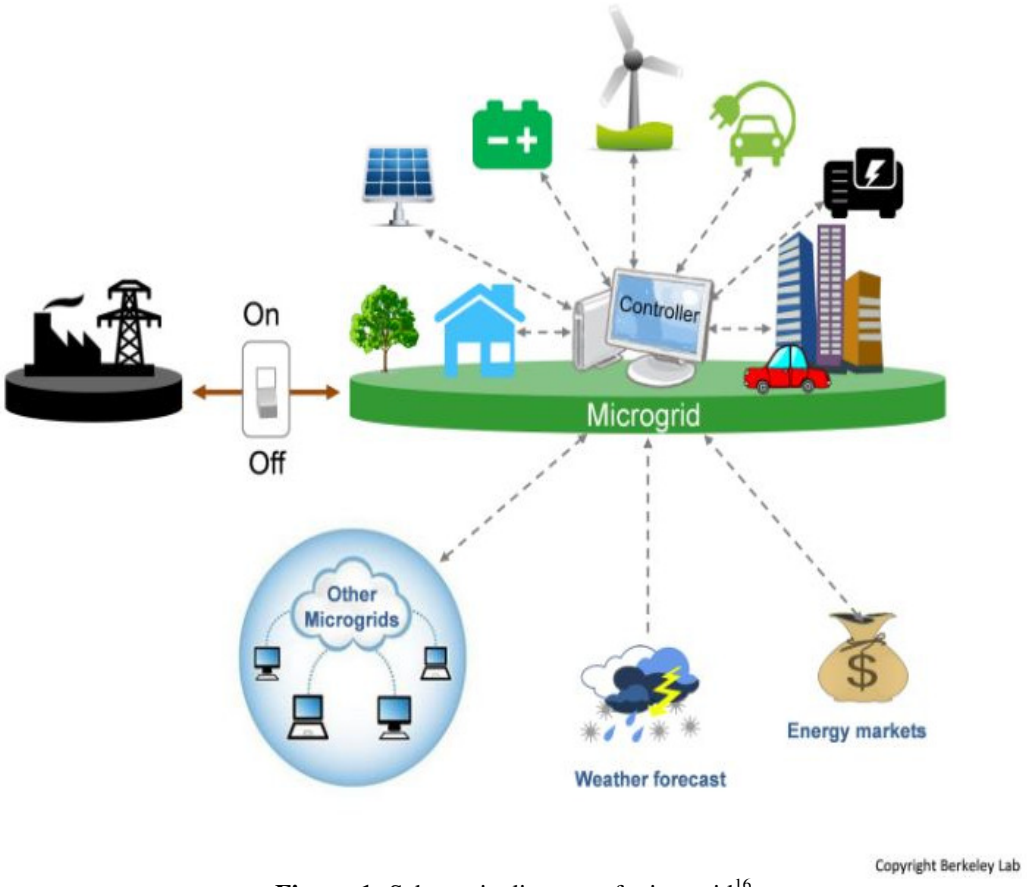

Figure-1: Schematic diagram of microgrid[16]

Operation and control of microgrid and power quality

The microgrid, a unified form of DERs, within this power electronic inverters are normally used to interface with utility grid and loads[23]. It may work in both off-grid and the on-grid manner. In on-grid manner, either it can take or supply power from or to the conventional grid, on the basis of generation and load with appropriate market policies. The microgrid can be isolated from the conventional grid whenever any power quality disruption issue in the central grid occurs[24].

The microgrid should detach itself from macrogrid on incidence of faulty situations and it should be shifted to the off-grid mode. When microgrid is switched to off-grid mode the alteration in frequency and voltage becomes more noticeable. In the on-grid mode the voltage and frequency of microgrid is determined by grid and in off grid mode voltage and frequency is adjusted to control intermediate or primary energy sources. If the frequency decreases and attains a less value, the loads from the microgrid is temporarily shaded off and frequency is improved by making a balance between load and demand. If the microgrid was initially in on-grid mode and switched to off-grid mode then. After a sudden fluctuation in either of generation or load secondary control actions should be applied for making a balance between consumption and generation of power in the islanded mode.

The microgrid should have an ample amount of power quality when functioning the islanded operation with adequate supply of reactive energy to reduce voltage sags. The storage devices must be able to reactrapidly to frequency and voltage change and exchange large amounts of real or reactive power. The microgrid do not consists spinning reserves as the usual macrogrids grid. When secondary voltage and frequency control implemented, most micro sources have late response. The operation of spinning reserve is expected to perform by the intermediary storage units and micro sources with built-in battery banks. The response of power electronic devices are very fast so as to adjust the power flow levels. Erection of communication channels among the different sections of microgrid is another feature which is considered when choosing the control method on an islanded microgrid[25].

The microgrid automation is carried out by modeling an intelligent and self-configurable microgrid system using automatic demand side and load management. Microgrid under this type of control, its central controller has all the controls so it can communicate with the loads and directs them to become isolated from main grid in real time to decrease overall demand on the system during peak hours. The integration of multiple power generating sources who have different characteristics produces the power quality problems whose mitigation and control is necessary for the successful operation of the microgrid. A computer based monitoring system can be used to provide a good power quality control to resist frequency fluctuation due to random load fluctuation in the hybrid system[26].

Renewable energy scenario and microgrid status in India: Renewable energy in India is undertaken by the Ministry of New and Renewable Energy (MNRE). The energy sources which are novel and renewable are aimed to develop tremendously, the prime focous is wind and solar energy. These ambitious objectives are going to take India among the top most countries which are pioneer in renewable energy use. and also it will put India at the center of its International Solar Alliance project promoting the development of solar power internationally to over 120 countries.

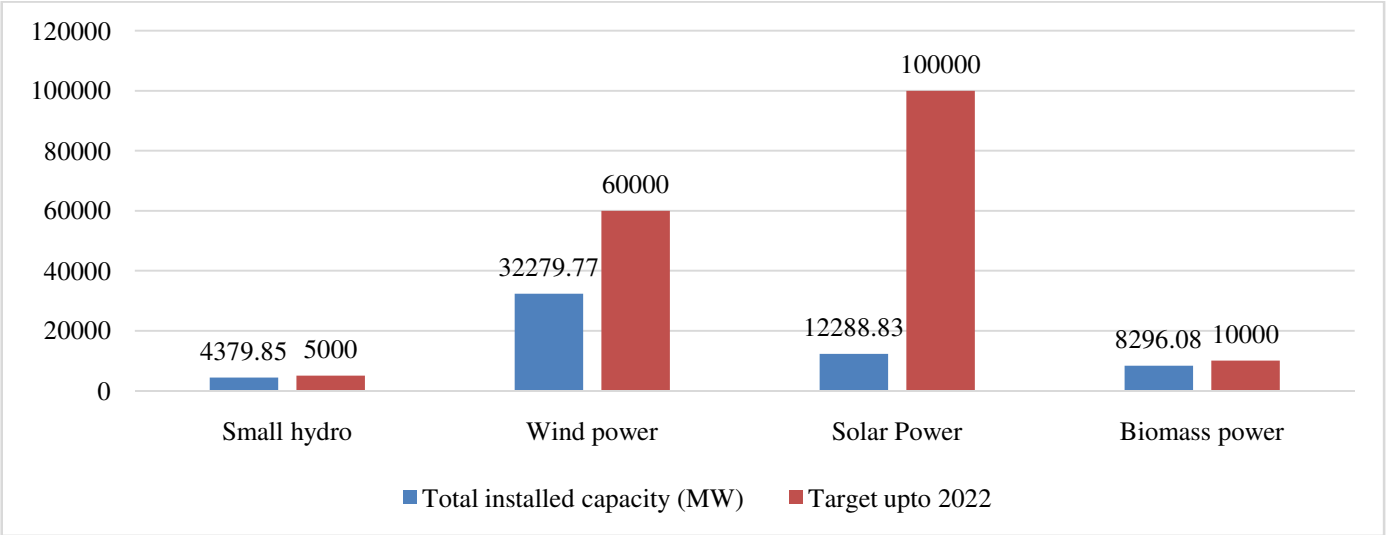

Figure-2: Total grid connected renewable energy generation Installed capacity (excluding large hydropower) in India as of 31 March 2017 (RES MNRE)[27,29].

The government of India set up a ministry called ministry of non-conventional energy resources (MNRE) to monitor the renewable energy resources and it was the very first nation in the world who compiled a ministry for renewable resources in 1980s.The total installed capacity of India has reached upto 329.4 GW, out of which 57.472 GW from renewable sources as on 14 June 2017. The contribution of wind energy was 61% out of total renewable energy, and contribution of solar is 19%[27].

The growth in this renewable energy installation is a combined effect of regional energy development agencies, ministry of new and renewable energy (MNRE), and private sector participation. From 2015 ministry of new and renewal energy began to putting plans down for the area of renewable energy as per its ambition to make a significant jump. The renewable electricity targets of MNRE have been up scaled to raise from 43 GW in April 2016 to 175 GW by the year 2022, including 100 GW from solar power, 60 GW from wind power, 10 GW from bio power and 5 GW from small hydro power[29].

According to ministry of power there is no additional capacity enhancement is required by the new coal based plants for the next 10 years, as numerous renewable energy projects of capacity upto 50 GW is on the verge of completion and they will be online upto 2022[30]. These ambitious targets will take india among one of the leading green energy producers globally. The government aims to reach 40% of the total electric power capacity from non-fossil fuel sources by 2030[29].

Wind power has achieved more than 50% of its targets while solar power has reached 87% of its target. The small hydro power is only 15% less than of its target, while bio energy was only 20% below of its targets. The total renewable energy installed capacity target of India upto 2022 is 175GW and it has achieved 33% of this target. The total grid connected installed capacities of different energy sources are as follows:

Table-1: Upto 28 February 2017 from all sources total installed capacity[28]

Sources	Installed Capacity (MW)	Share
Coal	189047.88	59.93%
RES MNRE	50018.00	15.86%
Large Hydro	44413.43	14.08%
Gas	25329.38	8.03%
Diesel	837.63	0.27%
Nuclear	5780.00	1.83%
Total	315426.32	100%

Conclusion

On the basis of the literature survey carried out on the microgrid it is realized that its feasibility has a lot of factors which should have to deal collectively. For successful execution, care to be taken for proper operation and control, protection and stability issues. This paper presents the existing conditions of microgrid and its status in India. The operations in a microgrid is described, and it is a novel type of power system. The technique is not mature till date and a lot of works have to be done before it can be put in the market. Some organizations have put efforts into it, although it is still under the research and experimental stage.

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