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MICROGRID: AN OVERVIEW

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ABSTRACT

Every year India faces power cut problems due to overloading on main grid. Microgrids turn out to be the best solution to combat this problem. They are mini versions of electrical grids. Microgrid is a local and independent energy system network where aggregation of loads and DERs (Distributed Energy Resources) within defined electrical boundaries act as sole controllability identity with respect to main grid. It addresses the need of supply in remote sites and critical loads. Microgrid is a distributed level microcosm of broader energy network. Microgrid can be operated in various modes which can pose protection problems. Several schemes to overcome protection issues are incorporated, among them implementation of adaptive protection system is the most successful method of protection. When operated as autonomous system, microgrids face technical challenges in its operation and control, which can be eradicated by adopting efficient solutions. This paper discusses the overview of microgrid, challenges and protection issues and way forward to mend them.

Keywords : Adaptive protection system, DER, Microgrid, Microcosm.

I. INTRODUCTION

Microgrid is a small network of electricity users with a local source of supply that is usually attached to a centralized national grid but is able to function independently.

Most of the power in India comes from coal fired power plants. As fossil fuels are prone to depletion, it has necessitated to switch on renewable energy resources [1]. Renewable energy resources (like solar and wind) are best alternatives to get rid off daily blackouts. Microgrids can work in integration with renewable energy resources and have capability to operate in grid connected and islanded mode [4]. In grid connected mode, it act as a single aggregate source. Using different energy resources for operation of network, improves power quality, lowers the cost of supply, reduces pollution , etc[11]. Inspite of its tremendous applications, microgrids have certain issues to overcome like voltage and frequency control, islanding and protection in micrOgrids [8]. Moreover to overcome problems arising due to bidirectional power flows, methods are adopted which provide safe and reliable operation of microgrid.

II. COMPONENTS OF A MICROGRID :

- **PCC (Point of common coupling) :** Single point of connection to the utility grid.
- **Power flow controller :** It regulates the power flow level prescribed by energy manager.
- **Sensitive loads :** Loads having local generation resources.
- **Non sensitive loads :** Loads with no generation resources.
- **Circuit breaker :** It operates the energy manager to supply the power.
- **Static switch :** It is used to connect or disconnect the main grid.
- **Energy manager :** It supplies power to power controller to regulate it at a constant level. If there is any change in the load, the output is increased or decreased by local resources to maintain constant power flow [12, 13].

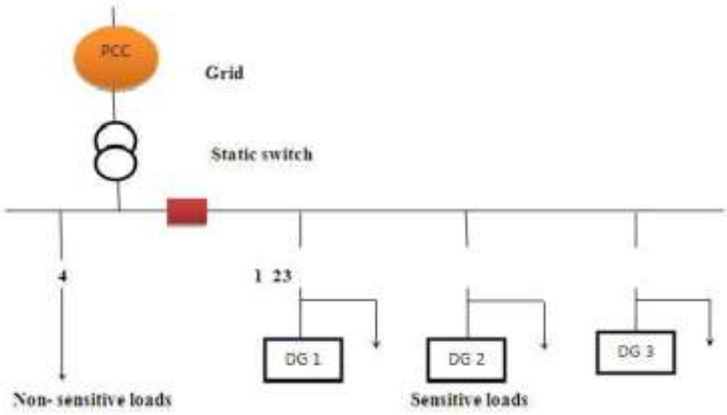

Fig. 1 Schematic view of Microgrid

III. OPERATING MODES :

- **Island Mode:** In this mode, static switch is open. Feeders A, B and C are sensitive loads supplied by microsources and feeder D is non sensitive load i.e, it is dead [10]. Energy manager stores excess energy and supply load when this energy is low.

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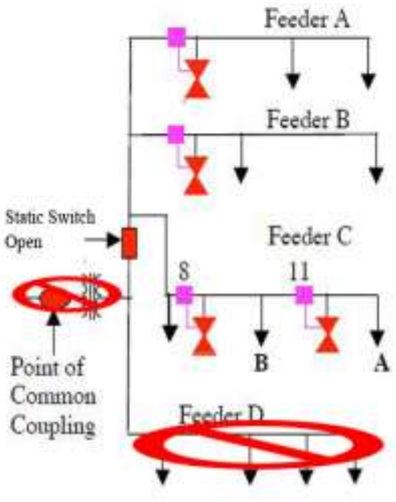

Fig. 2 Islanding Mode

- **Grid Connected Mode :** In this mode, static switch is closed. All feeders are applied by microsources [10]. Its output is limited by capacity of transmission line between microgrid and utility grid.

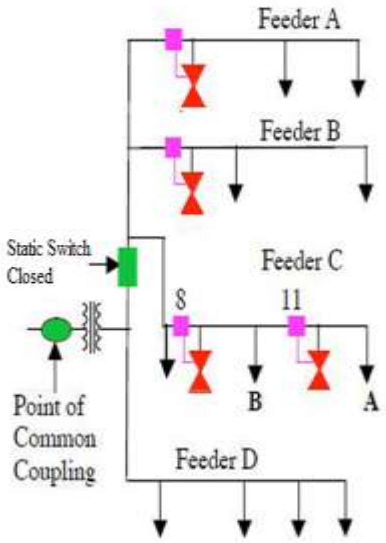

Fig. 3 Grid Connected Mode

IV. TYPES OF MICROGRIDS

- **Campus/institutional grid :** Main focus of campus grid is aggregating existing on-site generation with multiple loads particularly those located in tight geography where owner can easily manage them. [8].
- **Remote / Off grid :** They are globally operating microgrids with smallest average capacity. They are never connected to macrogrid, instead operate in an island mode always due to economical and geographical issues.
- **Military base grid :** These grids are deployed to focus on physical and cyber security to assure reliable power without relying on Macrogrid . Mobile grids are also advantageous for the forward operating bases.

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- **Commercial and Industrial grid :** It is a multi owner grid principally driven by security and affordability.
- **Community/Utility grid :** It predominantly includes residential customers and driven principally by security and affordability.

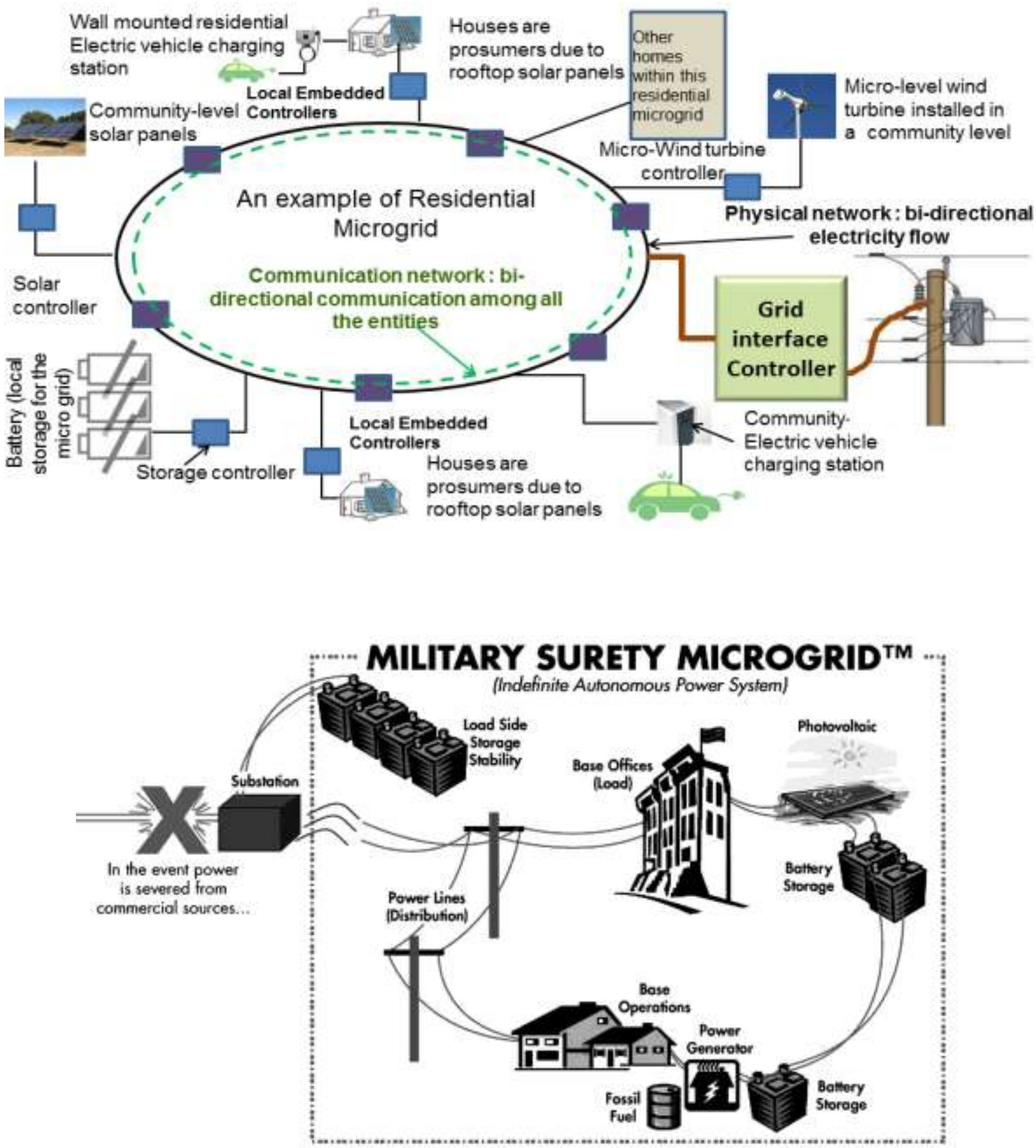

Fig. 4 Residential and military microgrid

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V. PROTECTION ISSUES

Modification in fault current level, device discrimination, reduction in reach of impedance relays, reverse power flow and sympathetic tripping are the key protection issues.

- **Modification in fault current level :** When inverter interfaced DG (Distributed Generators) are used, fault current is low and only some relays can detect this current while others don't trip, as a result of which fault current spreads out in the system and can cause damage to the equipment [3, 16].
- **Device discrimination :** Magnitude of fault current is used for discrimination [7].
- **Reduction in reach of impedance relays :** It depends upon distance between relay location and fault point (maximum distance means minimum fault detection). It affects the grading of relays and causes delayed operation [3].
- **Reverse power flow :** It can cause power quality issues resulting in variation of voltage [3].
- **Sympathetic tripping :** In Sympathetic tripping, relay operates along with another relay which actually senses the fault and trips it off.

VI. POSSIBLE SOLUTIONS FOR PROTECTION ISSUES

- **Differential protection scheme :** It will differentiate the fault current and overload current for microgrid to avoid nuisance tripping [3].
- **Balanced combination of different types of DG units :** DG units with synchronous generators, or inverter having high fault current capacity or both, are used for obtaining protection of an isolated microgrid.
- **Inverter controller design :** Inverter controller design should be such that it can actively limit the fault current.
- **Adaptive protection for microgrid :** It protect the microgrid in both modes. There is an automatic readjustment of relay settings when switching occurs from grid connected to island mode [2, 9].

VII. SOLUTIONS FOR TECHNICAL CHALLENGES

- **Voltage and Frequency control :** In an electric system, active and reactive power generated are balanced with the power consumed by the load and losses in the lines. Imbalance is created only when supply is not equal to demand thus deviating the frequency from its set point values. Hence it is necessary to maintain voltage and frequency controls at predefined values [5, 6]. For voltage regulation in islanded mode, power droop controller is used to decentralize the microgrid. Moreover for a successful islanding, fast and accurate control is needed. When switching from grid connected to islanding mode, transients are reduced by using inverter based distributed generation which not only enhance voltage quality but also damps the oscillations occurring in frequency work efficiently.
- **Power quality :** Premium microgrid design and power electronic converters are used to provide harmonic compensation to improve power quality [14].

- **Grid synchronization :** Control and instrumentation system, fast response storages enhance grid synchronization.
- **Microgrid control :** Microgrid control is needed to coordinate generation, storage and demand. Two approaches for microgrid control are :

Hierarchical approach : It has single point failure risk.

Multi agent approach : No risks.

- **Reliability :** To maintain reliability, facilities should be constructed underground and generator must possess black start capability [15].

VIII. ADVANTAGES

Microgrids include both monetized and non monetized advantages, viz

- Reduced fossil fuel use .
- Decrease in conversion losses and peak power costs.
- Provides consistent secure power.
- Gives Critical load protection .
- Reduces black out risks.
- Responsible for consumer and employee engagement.
- Power quality control.

IX. CONCLUSION

In today's power engineering architecture vernacular, microgrid is becoming more common. It is a concept of huge potential in specialized facilities and geographic footprints, but still in its infancy. With advent of new technology, microgrid is gaining experience in revolutionizing energy system. Several opportunities viz; connectivity management, distributed intelligence, security and privacy are future perspectives associated with microgrids.

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