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Microgrid: An Introduction

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Abstract A microgrid is a localized energy grid that can automatically connect and disconnect from the traditional grid (or macrogrid). It consists of small modular distributed generators, energy storage systems, and low-voltage loads connected to the main traditional grid at the point of common coupling. It can operate in grid-connected or islanded mode. Microgrids will be of the main constituents of the future smart power grids. Since a microgrid can operate while the main grid is down, it can strengthen grid resilience. This paper provides a short introduction to microgrid.

Keywords microgrid, macrogrid, smart grid

Introduction

A microgrid (MG) is a localized group of power sources that are connected and synchronized with the traditional centralized power grid (or macrogrid). It is a low to medium voltage network of small loads with distributed generation (DG) sources and storage. A microgrid can be as small as an individual house (called a nanogrid) or as large as a college campus or a business park. It operates at a smaller generation capacity (1 to 50 kW) and enables local electricity generation, transmission, distribution, and consumption. It is ideal for remote locations and for rural electrification where connectivity to the macrogrid is not feasible [1].

Microgrid is rapidly being developed due its advantages of high reliability, flexibility, and less pollution. It can effectively integrate various sources of distributed generation (DG). The term "distributed generation" (DG) has been devised to distinguish this concept of generation from centralized conventional generation. DGs constitute non-conventional and renewable energy sources like solar PV, wind turbines, fuel cells, and tidal and wave generators. Due to growing power demand and increasing concern about the environmental pollution, the distributed generation concept is attracting attention all over the world.

How Microgrid Works

Traditional power systems typically generate electricity by burning fossil fuels (such as coal, gas, diesel, nuclear fuel), which pollute environment. The grid connects buildings to central power and supplies electricity to appliances. Apart from natural disasters such as earthquakes, flood, and hurricanes, the power grid is vulnerable to terrorists and electromagnetic pulse (EMP) attacks. Because of this, the power industry started developing a more intelligent power grid known as "smart grid" [2]. Smart grids and microgrids bring intelligence and innovation to power grid. Development of microgrids and the integration of renewable energy resources are the catalysts in the transition from the traditional grid to smart grid.

A microgrid can connect and disconnect from the main grid to enable it to operate in both connected or island-mode. In other words, MG is capable of changing between two modes (island and grid-connected) and handling the transition between the two modes. A microgrid connects to the grid at a point of common coupling (PCC). A microgrid that does not have a point of common coupling is known as isolated microgrids [3]. A microgrid can be powered by distributed generators, batteries, and renewable sources. It provides backup for the grid in case of emergencies, and can also be used to reduce costs. Under normally condition, the MG operates the battery storage to restrain the long-term power fluctuation in the PCC. Under faulty condition, the battery storage will act as a backup support.

Where are Microgrids?

Microgrids may be regarded as the modern small-scale smart grids that can be implements small communities, hospitals, schools, and commercials areas [4].

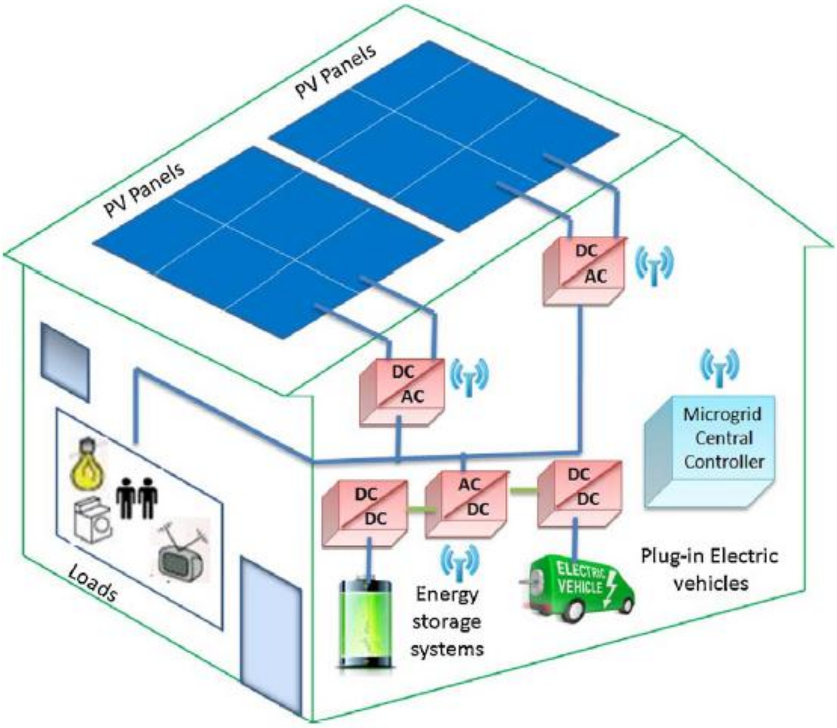

Figure 1: A residential microgrid [5]

A typical microgrid is shown in Figure 1 [5]. It enables local electricity generation, distribution, consumption, and storage and can operate independently of the traditional power grid. It manages them with advanced monitoring, control, and automation systems. Surplus energy from the microgrid can be sold to a utility company, while the microgrid gets energy from the utility company during energy shortage.

To realize the energy sharing, microgrids are interconnected using different natures of electricity transmission. The line technology can be DC or AC [6]. Homes are connected to a single DC power line. DC microgrids are systems consisting of DC sources, loads, and interconnecting lines. These DC microgrids can be deployed in areas where an AC microgrid is already in place. This creates a hybrid microgrid [7]. An DC/AC converter is often used for interfacing the DC microgrid to AC utility grid; DC/AC converters have to be equipped with every distributed source in AC microgrid.

The US Department of Defense has been the leader in microgrid deployment due to the concern that a military facility relies heavily on local utility power which may not be adequately reliable. The SPIDERS (Smart Power Infrastructure Demonstration for Energy Reliability and Security) has been implemented to connect clean energy sources to a microgrid that operated when commercial power to the military base is interrupted Europe also leads the world in adapting distributed generation and microgrids [8].

The inclusion of communication network in microgrids enables information exchange between microgrids.

Benefits and Challenges

The key feature of a microgrid is its ability to island itself from a utility's distribution system and operate autonomously during brownouts and blackouts. Microgrids constitute as a key component of the smart grid for improving power reliability, increasing efficiency, and providing grid-independence to users. Microgrids offer other benefits including dramatic capital reduction, improved resiliency, reduction in transmission losses, and reduction in environmental pollution. They are regarded as one of the most promising solutions to integrate renewable distributed generation into the traditional electric power system. They are viable solutions for enhancing the power system reliability, resilience, economics, security, and sustainability [9].

Microgrids also face a number of challenges such as control and protection. Stability control ensures the reliable and efficient operation of microgrids. Protection is the major obstacle to maintaining healthy grids. We must ensure that the loads, lines and distribution generators will be protected while running in islanded mode of operation. The challenges in microgrid protection and control include bidirectional power flows, stability issues, low inertia, and uncertainty [10]. Integrating distributed energy resources (such as microturbines, fuel cells, PhotoVoltaics) units in microgrids introduces some operational challenges due to the heterogeneous characteristics of sources and loads. Although the use of renewable energies is rising in microgrids, achieving a stable system is very difficult because of their intermittent nature.

These challenges must be addressed in order to realize the potential benefits of distributed generation (DG) units.

Conclusion

A microgrid is the modern, small-scale version of the centralized traditional power grid. It is the building block for a smart grid. Microgid is attracting increasing attention due to the development of distributed generations, such as gas turbines, wind power, photovoltaic and fuel cells. Currently, the global microgrid is witnessing deployment in various countries such as the US, Canada, Germany, the UK, Netherlands, China and India. For more information on microgrid, one should consult [11-12] and similar books in Amazon.com that are exclusively devoted to it.

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