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Design of a Sustainable Residential Microgrid System with DC and AC Buses Including PHEV and Energy Storage Device

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Abstract. A sustainable residential microgrid composed of two distributed generation sources (photovoltaic panels and biofuel generator), one energy storage device (battery bank), and able of supplying both AC and DC loads, including a plug-in hybrid electric vehicle, is proposed. The microgrid can operate in grid-connected mode and island mode. It is composed of a main DC bus and also an AC bus. The characteristics of the system, the operation modes description and some results are presented in this paper.

Key words

Microgrid, distributed generation, renewable energy, sustainable house.

1. Introduction

Electrical energy consumption has been considerably increasing in recent years. The population growth has direct influence towards this fact. Therefore, it is essential to increase the electric power generation. Besides, once fossil fuels (the actual dominant energy production source) produce enormous amount of pollution and are becoming scarce, other sources for electric power generation, mainly clean and renewable ones, have been receiving more attention and importance lately. Among these renewable sources, the most studied are wind, solar, biomass, and fuel cells.

Distributed generation (DG) technologies have been gaining interest due to benefits, such as: high reliability and high power quality, along with the fact that they are environmental friendly. Moreover, the next benefits are also associated to DG [1]: modularity, efficiency, reduced or absent emissions, security and load management. However, the uncontrolled use of individual DG units can cause various problems compromising their benefits [2]. Difficulties to connect these units directly to the bulky AC system due to their variable and intermittent power generation, voltage oscillation in the line to which the sources are connected and protection issues are some of these problems.

A better way to apply the benefits and potential of DG is through the system approach in which the generation units and loads are associated in a way that they are seen and analyzed as a subsystem or microgrid. This approach has been gaining big notoriety recently. The microgrid or smart grid comprise a group of loads, renewable energy sources and energy storage devices operating as a single controllable system, capable of supplying energy to a local area [1]. They are also formed by a bus to which the elements are connected through static power converters, which are generally arranged in parallel connections. One of the most important advantages of the microgrid is the fact that the energy sources and the entire system increase the reliability of energy supply to the connected loads [3]. This occurs due to the presence of various generation sources and also energy storage elements.

Regarding the connection methods of the distributed energy sources, energy storage devices and different types of loads in a microgrid, basically three alternatives can be adopted, which are: interconnection DC bus, interconnection AC bus or interconnection high frequency AC bus. The DC bus is the most simple and common interconnection bus. This system has no frequency and phase control requirements, high efficiency and high reliability compared to the AC interconnection bus [4]. Moreover, it has low distribution and transmission losses, low cost, possibility to operate in long distances and dispenses the use of transformers, leading to volume and cost reduction [1].

Small scale microgrid residential systems have been studied [5]-[9], and some of them include the possibility