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A review on hybrid renewable energy systems

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ABSTRACT

The world is witnessing a change-over from its present centralized generation to a future with greater share of distributed generation. Hybrid energy systems are inter-connected with wind power, photovoltaic power, fuel cell and micro-turbine generator to generate power to local load and connecting to grid/micro-grids that decrease the dependence on fossil fuels. The hybrid system is a better option for construction of modern electrical grids that includes economic, environmental and social benefits. An overview of different distributed generation technologies has been presented. This paper puts forward a comprehensive review of optimal sizing, energy management, operating and control strategies and integration of different renewable energy sources to constitute a hybrid system. The feasibility of the different controllers such as microcontroller, proportional integral controller, hysteresis controller and fuzzy controller are presented. The controller is a closed loop feedback mechanism used for power regulation which achieves zero steady state error and the output signal generated from the controller produces desired output response.

Contents

1. Introduction

Energy demand is increasing day by day due to increase in population, suburbanization and industrial development. Since the rate of energy consumption is high and the supply from the energy sources is not sufficient to meet the load demand which leads to energy shortage. The large-centralized power generation utilizes conventional energy sources which are not only limited and inadequately distributed on earth's crust. Due to the rapid depletion of the fossil fuels like coal, oil and gas, these conventional energy sources show more impact on the environment with the increase in the CO_2 level that leads to the global warming. There is a need to utilize the renewable energy sources, the main problem with renewable energy sources is dependency on environmental conditions like wind speed and solar irradiance, the individual energy sources cannot provide continuous power supply to the load because of the uncertainty and intermittent nature. So renewable energy sources, like wind, solar, hydro, biogas and fuel cells can be integrated to form a hybrid system which is more reliable and environmental friendly. This type of renewable energy sources are named as distributed energy sources and the generation is termed as distributed generation [1], which is shown in Fig. 1.1.

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Hybrid system is defined as the combination of two or more renewable/non-renewable energy sources. The basic components of the hybrid system include energy sources (AC/DC), AC/DC power electronic converters and loads as shown in Fig. 1.2. There are different types of DC–DC converters, but most commonly used are buck, boost and buck–boost converters. The possible configurations of the hybrid system are namely DC coupled, AC coupled and Hybrid coupled system. Based on the application, particular configuration will be selected. For instance, DC coupled systems consists of DC sources and DC loads in which the main advantage is no need to synchronize the system that can be used for DC micro-grid. The AC coupled systems are further categorized into two types namely power frequency AC coupled system and high frequency AC coupled system which can be used for AC micro-grid and defence applications respectively. In power frequency AC coupled system both the sources and loads are AC which results in ease of protecting the system whereas the high frequency AC coupled system consists of AC sources operating at different frequencies and high frequency loads which leads to high efficiency of the system. Hybrid coupled systems comprises sources and loads that can be AC as well as DC which provides highest efficiency and it is more flexible compared to the earlier configurations [2].

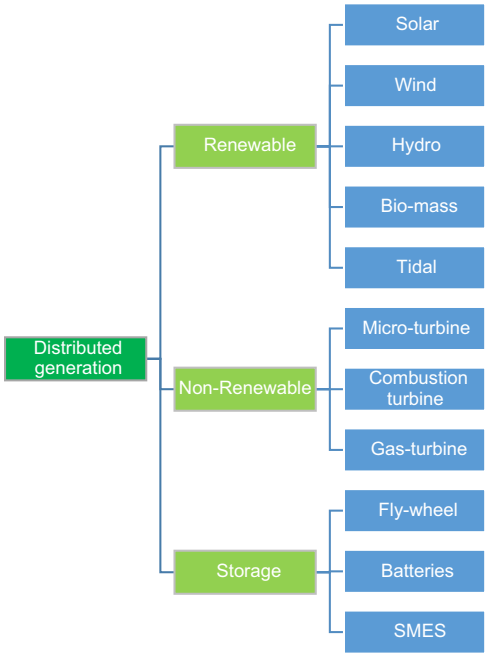

Fig. 1.1. Distributed generation.

2. Modeling and analysis of grid connected hybrid energy system

The authors proposed new integration scheme for wind/photovoltaic (PV) hybrid system which uses both the rotor and grid-side converters of doubly fed induction generator to inject the power into the grid from the PV array. The proposed method improves the system efficiency by blocking the circulating power during sub-synchronous condition and also maintains the system stability, leading to a cost effective solution for PV-grid integration [3].

In this paper, a single DC–DC converter has been implemented for both the sources instead of two power converters. In general, at full load condition the maximum efficiency of the DC–DC converter is about 95% but in the proposed scheme, the remaining 5% loss in efficiency has been eliminated by removing an additional power conversion stage. The wind/PV hybrid system is grid-connected in which maximum power point tracking (MPPT) controller and hysteresis controller are used to track maximum power from the renewable energy sources (RES) and to trigger the power converter respectively. The operation of these controllers is performed at different conditions and the performance of the system is evaluated for steady state and transient conditions through experimental and simulation results [4].

The authors investigated a hybrid system with PV and fuel cell technology, the power generated from the fuel cell is used to support the photovoltaic generation. A grid connected PV-fuel cell hybrid system is modeled in MATLAB/Simulink environment. In this system, using real data from a commercial PV module, a 160 W power PV module has been developed. A 5 kW fuel cell has been designed to support hybrid system DC bus. The output voltage obtained from the PV system is an unregulated DC power. The DC–DC boost converter has been used to control and maintain constant DC power [5].

The authors suggested a hybrid system which consists of PV, fuel cell, battery and a super capacitor system in order to get consistent power from the source and to maximize the reliability. The buck converter is used to regulate the output voltage of each component using type III compensator. The tracker determines the output voltage which is regulated via a compensator, to provide a fixed voltage level. The proposed topology has advantages like simple management system and inexpensive system controller. A prototype is developed and simulated, due to its effectiveness it is implemented on an emulator of real system [6].

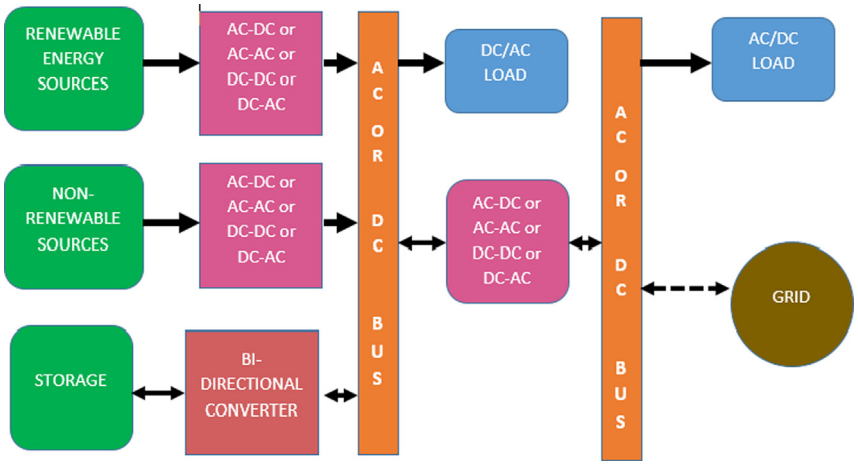

Fig. 1.2. Basic components of hybrid system.