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Technical Note

Unit sizing and cost analysis of stand-alone hybrid wind/PV/fuel cell power generation systems

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Abstract

An economic evaluation of a hybrid wind/photovoltaic/fuel cell (FC) generation system for a typical home in the Pacific Northwest is performed. In this configuration the combination of a FC stack, an electrolyser, and hydrogen storage tanks is used as the energy storage system. This system is compared to a traditional hybrid energy system with battery storage. A computer program has been developed to size system components in order to match the load of the site in the most cost effective way. A cost of electricity, an overall system cost, and a break-even distance analysis are also calculated for each configuration. The study was performed using a graphical user interface programmed in MATLAB.

Keywords: Unit sizing; Hybrid wind; Photovoltaic; Fuel cell power generation systems; Economic evaluation

1. Introduction

Hybrid wind/photovoltaic (PV) power generation systems have been studied extensively. Energy storage is needed in these systems due to the intermittent nature of wind and solar energy. Traditionally, deep-cycle lead acid batteries have been used as the means of energy storage. However, there are environmental concerns associated with the use of batteries; thus other alternatives are sought for this application.

Fuel cells (FCs) in combination with an electrolyser (for hydrogen generation) and hydrogen storage tanks have been considered for energy storage [1–5] and implemented

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[6–8]. However, a detailed economic analysis has not been carried out for these systems. In this paper unit sizing and economic analysis are performed for a wind/PV system with a FC/electrolyser system and the results are compared with a wind/PV system with battery storage. A graphical user interface (GUI) program has been developed in MATLAB for sizing the components of a hybrid wind/PV system (with hydrogen storage and battery storage) to match the load of a typical home in the Pacific Northwest that is not located near the electric grid. The electrolyser in the FC/electrolyser storage system is used as a part of dump load. Fig. 1 shows the system configuration used. When there is excess wind or solar generation, the electrolyser turns on to begin producing hydrogen, which is delivered to the hydrogen storage tanks. If the H_2 storage tanks become full, the excess power will be diverted to another dump load. When there is a deficit in power generation, the FC will begin to produce energy for the load using hydrogen from the reservoir tanks. For the wind/PV system with battery storage, the combination of FC/electrolyser, H2 reservoir tanks, and their associated DC/DC converter are replaced with battery banks.

Fig. 2 shows the flow chart of the decision algorithm for the wind/PV system with FC/ electrolyser hydrogen storage system. The flow chart for the battery storage system can be obtained by replacing the ''Use FC to meet load'' block with ''Battery discharging'', the ''Operate electrolyser'' block with ''Battery charging'', and the ''H_2 tanks full?'' block with ''Battery storage full?''

The number of wind turbines is used as a free input parameter to the computer program, and the number of PV panels is calculated using the Loss of Power Supply Probability (LPSP) technique [9–12], to match generation with load. The LPSP technique is used for sizing both the conventional battery storage system and for the FC/electrolyser storage system. The cost of electricity (COE), and the total annual cost are then calculated for both configurations.

A break-even distance analysis is also performed for each system. This analysis determines how far the site of the stand-alone alternative energy system should be from the existing utility line so that the system is cost effective (breaks even) when compared to using conventional grid power.

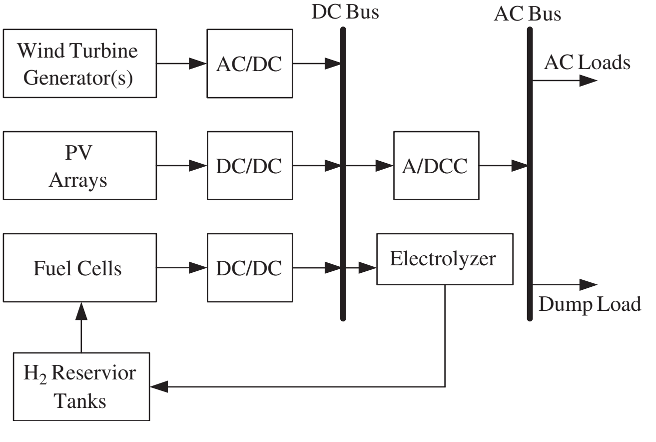

Fig. 1. Proposed wind/PV system with FC/electrolyser storage [5].