A MULTI-PURPOSE MINI HYBRID FUEL CELL-BATTERY-SOLAR PORTABLE DEVICE FOR RURAL APPLICATIONS: LABORATORY TESTING

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ABSTRACT

In this study, a novel multipurpose portable PEM fuel cell-solar-battery system was custom designed, constructed and laboratory tested, specially aims for applications in the rural areas remote from conventional electric power grid. We obtain encouraging results which show the applicability of such system for used as a multipurpose kit for portable applications. Our study shows that various power sources namely solar cell, battery and PEM fuel cells can combine harmoniously to obtain higher power voltage, whilst maintaining their individual advantages – such as good startup performance. Our typical results show that the maximum power of the PEM fuel cell/solar/battery with load is in the range of 2.4W-2.7W which can be maintained continuously. Apart from good cold start characteristic, the portable system also exhibits stable voltage, compact in size and acceptable in weight, hence suitable for rural power application at places remote from conventional grid.

Keywords: *Applied hybrid energy, Multi-purpose energy systems, Energy resources, Fuel cells, Solar energy*

1. INTRODUCTION

It is a growing concern that there is a lack of grid-based electricity supply to rural areas in developing countries [1-2] and that alternative energy sources such as solar, wind and biomass must be developed [2, 3]. Broader application of fuel cell technology promises significant contribution to sustainable global economic growth, but requires intelligent improvement to size, cost, fuel flexibility and operating flexibility [4-5]. Also, for fuel cell to be sustainable, one of the feasible solutions is that the hydrogen (H_2) fuel must come from water using alternative energy to generate it.

Fuel cell of its definition is an electrochemical device that produces electricity via inverse electrolysis. A chemical reaction and electrical charge transfer occurs within the fuel cell. This is very similar to the way a battery produces electricity. Unlike a battery, a fuel cell produces electricity as long as there is a continuous supply of fuel [2, 6]. Simple definition of a fuel cell is that it is an electrochemical device that reacts hydrogen and oxygen to produce water and electricity.

A 2.24 kW hybrid photovoltaic (PV)- Proton exchanged membrane (PEM) fuel cell generation system employing an electrolyzer for hydrogen generation was designed and simulated by El-Shatter [7]. The system was reported to be applicable for remote areas or isolated loads such as pumping for irrigation. Shapiro et al. [8] investigated a system consisted of a PEM electrolyzer, high-pressure hydrogen, oxygen storage and a PEM fuel cell, without battery. This system was reported to be able to provide reliable, environmental benign power of around 4 kW to remote installation. The hybrid fuel cell systems mentioned above, however, are mainly designed for non-portable applications.

Lee et al. [9] studied and analyzed a 40W direct methanol fuel cell (DMFC) combined with battery hybrid power for portable application. The DMFC was used for main power source at average load while the battery was applied for auxiliary power at overload. The experiments were done on hybrid DMFC using a lead-acid battery, Ni-Cd battery and Ni-MH battery. Typical result shows that a stable transient characteristic for some seconds in the beginning of