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Modeling and Simulation of a PV/FC/UC Hybrid Energy System for Stand Alone Applications

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Abstract – *This paper describes dynamic modeling and simulation results of a small photovoltaic (PV)–fuel cell hybrid energy system. The dynamic behavior of the proposed hybrid system is tested under solar radiation and load demand conditions. The system consists of a PV, a proton exchange membrane fuel cell (PEMFC), ultra capacitors, an electrolyzer, and a power converter. The system is applicable for remote areas or isolated loads. The output of the PV is highly dependent on weather conditions, so the load is supplied from the PV with a fuel cell working in parallel. Excess PV energy when available is converted to hydrogen using an electrolyzer for later use in the fuel cell. FC power plant uses hydrogen and oxygen to convert chemical energy into electrical energy. Ultra-capacitor banks can be used for short-term energy storage due to their high cycling efficiency, convenience for charging/discharging, and additionally to meet the instantaneous load ripples/spikes. Besides, overloading fuel cell systems may cause gas starvation thus decreasing its performance and lifetime. As another feature, the load tracking delays and mismatches of the FCs should be compensated by an auxiliary system such as a battery or ultra capacitor bank. Power converter unit are proposed to generate AC voltage. PID type controllers are used to control the fuel cell system. MATLAB SIMULINK and Simpower Systems environment is used for the Simulation of this hybrid energy system.* ***Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved.***

Keywords: *Hybrid Energy Systems, Electrolyzer, Fuel Cell (Fc), Photovoltaic (Pv), Ultra Capacitor (Uc)*

Nomenclature

a	Ideality or completion factor
I_0	PV cell reverse saturation current [A]
I_{PV}	PV cell output current [A]
I_{SC}	Short-circuit cell current (representing insolation level [A])
K	Boltzmann's constant [$J/^{\circ}C$]
M_{H_2}	Molar mass of hydrogen [$kg\ kmol^{-1}$]
N_{H_2}	Hydrogen moles per second delivered to the storage tank [$kmol/s$]
N_P	The number of parallel strings
N_S	The number of series cells per string
P_b	Pressure of tank [$pascal$]
P_{bi}	Initial pressure of the storage tank [$pascal$]
q	Electron charge [C]
R	Universal (Rydberg) gas constant [$J/kmol\ K$]
R_S	Series resistance of PV cell [Ω]
T_b	Operating temperature [K]
T	PV cell temperature [$^{\circ}C$]
V_{PV}	Terminal voltage for PV cell [V]
V_b	Volume of the tank [m^3]
z	Compressibility factor as a function of pressure

I. Introduction

These Increase in global warming and decline in petroleum reserves have contributed to the need for research of new solutions to resolve large transportation energy. Stand-alone energy systems are typically employed in small scale power generation in remote locations (such as, data loggers, water pumping and irrigation applications), and marine transportation systems. A generic HES (hybrid energy system) consists of a primary renewable source (PV array, wind generator etc.) working in parallel with a standby secondary non-renewable module and storage units (fuel cells, battery etc.) Electric power can be generated from a variety of primary energy resources, such as fossil fuels, solar, wind, uranium and water. These sources are able to supply the energy needs of homes and communities reliably when accessed and designed correctly. Renewable energy technologies such as photovoltaic systems offer a non exhaustible and clean source of long-term power hence there is a growing demand for their

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