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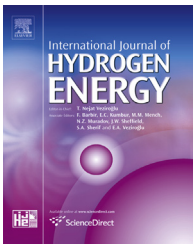

Design and simulation of a solar-hydrogen system for different situations

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ABSTRACT

In recent years, hybrid photovoltaic–fuel cell energy systems have been popular as energy production systems for different applications. A typical solar-hydrogen system can be modeled the electricity supplied by PV panels is used to meet the demand directly to the maximum extent possible. If there is any surplus PV power over demand, and capacity left in the tank for accommodating additional hydrogen, this surplus power is supplied to the electrolyser to produce hydrogen for storage. When the output of the PV array is not sufficient to supply the demand, the fuel cell draws on hydrogen from storage and produces electricity to meet the supply deficit.

In this study, solar-hydrogen systems and their application areas have been examined with emphasizing importance of renewable energy sources for electrical energy production. A hybrid system consists of solar cell and fuel cell have been designed and simulated in Matlab–Simulink. Firstly, the models of fuel cell, solar cell, electrolyser, DC–DC converter and inverter have been constituted separately in Matlab–Simulink. Then, system model have been obtained with combining of these models. Characteristics of output voltage and current have been investigated with using the acquired model for different loads.

1. Introduction

The use of fossil fuels for generation of electrical energy is more than the use of renewable sources. With decreasing oil reserves in the world, the potential for fossil fuels as a future resource of energy is decreasing. Due to limited reserves of fossil fuels, their changeable prices and irreparable harmful effects, the interest in renewable energy sources has significantly increased. Therefore, a transition from fossil fuels towards renewable fuels for electrical energy generation is unavoidable. However, the change must occur slowly because of its cost.

Solar energy is widely available and completely free of cost for especially in rural areas and developing countries where it is usually difficult to have access to the conventional electric grid. The production of a solar system is also affected considerably by the varying meteorological conditions. Because of its nature of intermittency, to continuously supply power, other supplemental power sources such as storage batteries are usually needed. A possible solution consists in adding a fuel cell [1]. The most used type of fuel cell is proton exchange membrane (PEM) fuel cell.

Recently, hydrogen, which is most popular of the renewable fuels, has been obtained from various environmentally friendly sources. Fuel cells may be considered as continuous

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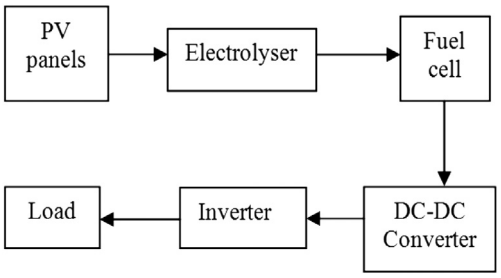

Fig. 1 – A solar-hydrogen power system.

chemical reactors which convert fuel and oxidant chemical potential into electrical energy. The key advantages of fuel cells compared to the conventional electrical power generation technologies are: higher efficiency, especially when the waste heat is used for co-generation, quiet operation suitable for residential applications, and almost zero levels of produced pollutant gases. These advantages are due to the fact that power generation in fuel cell systems is not based on combustion techniques and temperature gradients [2].

In this study, general information about the PV–fuel cell hybrid system has been mentioned. Additionally, design and simulation of a PV–PEM fuel cell hybrid system have been performed.

2. PV–fuel cell hybrid systems

Renewable hybrid energy systems are the systems where the renewable energy sources as wind, hydrogen, solar, etc. have been utilized simultaneously [3]. The term "hybrid power generation system" refers to all systems that combine different energy technologies (Wind, Hydrogen, Biomass etc.) in order to meet the required electrical and thermal loads of the consumer [4].

Among the renewable energy resources, the energy through the photovoltaic effect can be considered the most essential and prerequisite sustainable resource because of the ubiquity, abundance, and sustainability of solar radiant energy. Recently, photovoltaic array system is likely recognized and widely utilized to the forefront in electric power applications. It can generate direct current electricity without environmental impact and contamination when is exposed to solar radiation [5]. Economic and environmental concerns over fossil fuels encourage the development of PV energy systems. Due to the intermittent nature of solar energy, energy storage is needed in a stand-alone PV system for the purpose of ensuring continuous power flow [6]. PV technology provides a technologically feasible solution to the current environmental challenges created by current reliance on fossil fuel-based electrical power generation. PV energy production, which is a large net energy producer and thus CO_2 emission reducer, represents an environmentally beneficial and sustainable method of maintaining an energy intensive standard of living [7].

Integrating a stand-alone fuel cell stacks with renewable energy sources for hydrogen production might represent a suitable solution for insulated consumers, primarily due to the reliability of supply. A growing interest has been observed for small-scale power generation in buildings situated in remote areas, which cannot be easily served by the public grid; fuel cells could be used to supply all the required electricity or represent a convenient option to cover the base-load, eventually in integration with other small units covering load

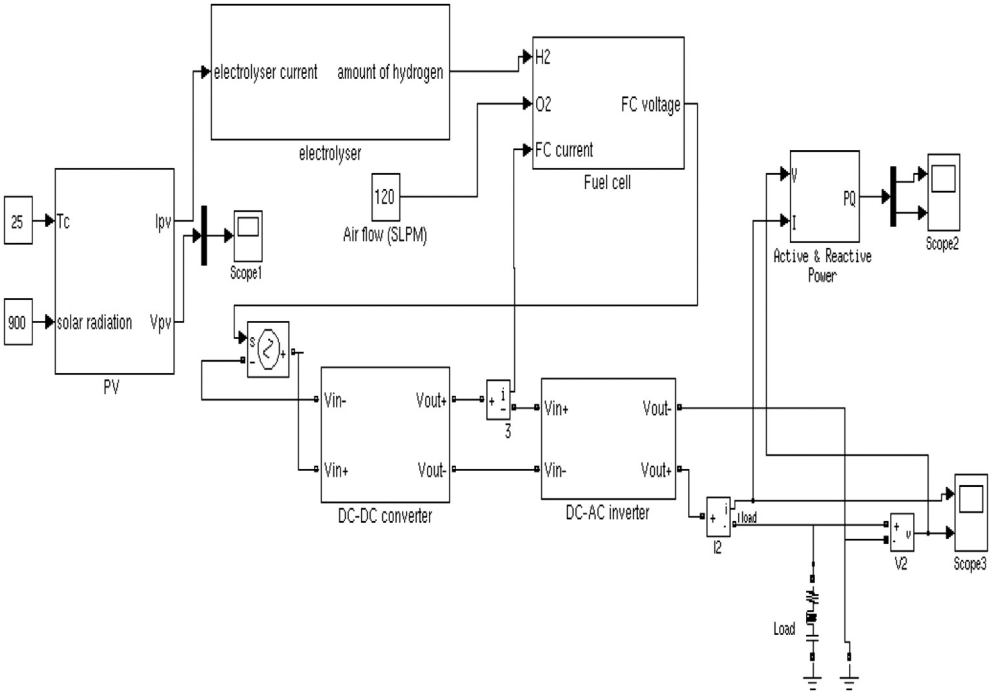

Fig. 2 – The model of a solar-hydrogen system.