Chapter 27
Modeling and Simulation of a Stand-Alone Hydrogen Photovoltaic Fuel Cell Hybrid System

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ABSTRACT

In this Chapter, a hybrid Photovoltaic-Fuel Cell (PV-FC) generation system employing an electrolyser for hydrogen generation is designed and simulated. The system is applicable for remote areas or isolated loads. This system has been simulated via a developed general dynamic mathematical model which analytically describes the electric subsystems. Some interesting simulation results are presented in this chapter. Specific attention is paid to the investigation of the dynamic analysis of the photovoltaic, fuel cell, and electrolyser system at the connection. The objective of this study is to evaluate the performance of an autonomous stationary power generation and thermal coupling a PV array and a storage system for hydrogen, consisting of an electrolyser, a storage unit of gas, and a fuel cell of high temperature. Hydrogen is the only means that stores electricity. Stationary applications of a few kilowatts are evaluated by numerical simulation in MATLAB/SIMULINK.

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INTRODUCTION

The development and use of renewable energy have experienced strong growth in recent years. In the near future, all sustainable energy system will be based on the rational use of traditional sources and increased use of renewable energy. Naturally decentralized, it is interesting to exploit the place of consumption, transforming it directly into electricity as needed. Decentralized electricity production by renewable energy sources provides greater security of supply for consumers while respecting the environment. However, the intermittency of these sources requires the use of multi sources that enable a continuous electricity production.

The depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to meet to the present day demands. Alternative energy resources, such as solar and wind energies, are clean, inexhaustible and environment friendly potential resources of renewable energy options. It is prudent that neither a standalone solar nor a wind energy system can provide a continuous supply of energy due to seasonal and periodical variations (Borowy et. al., 1994, 1996; Celik, 2002).

To solve these drawbacks conventional battery storage has been used. But batteries can store a limited amount of power for a short period of time. For long term storage electrical power produced by PV arrays can be converted into hydrogen using an electrolyser for later use in fuel cell. So these conventional batteries can be replaced with fuel cells as non-polluting and high efficiency storage devices (Esmaeili et. al., 2012).

A management system is designed for a PV-Fuel cell hybrid energy system to manage the power flow between the system components in order to satisfy the load requirements (El-Shatter et. al., 2006). A simple and economic control with DC-DC converter is used for maximum power point tracking and hence maximum power extraction from the wind turbine and photovoltaic arrays. In order to insure continuous power flow a fuel cell was also proposed in this chapter (Das et. al., 2005).

The main objectives of this study are to investigate and develop an autonomous system of clean energy to power of about 5 kW (Figure 1) (Ulleberg, 1998). Using hydrogen as the sole energy storage medium. This PV-FC is solar hydrogen systems without batteries. In this chapter, a methodology to design each configuration analytically is proposed. It is found that panels solar photovoltaic modules in parallel and in series, each of 5 kW_P along with a 5 kW electrolyser and a 5 kW SOFC fuel cell unit. The integration of solar photovoltaic, electrolyser and fuel cell system with greenhouse can pave the way for sustainable cultivation in

Figure 1. Concept of an autonomous system of energy based on hydrogen technology