Chapter 76
Study of Hybrid Sustainable Energy System Based on PEM Fuel Cells and Photovoltaic-Module Power Generator

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ABSTRACT

The computer is the greatest innovation of the 20th century. It has changed our lives. It executes tasks with precision. There is no limit with what we can do with software. Computers are seductive. Companies and students cannot work without them. They help students to perform mathematical computations. It is very important that mathematical ideas are expressed in computer programs in order to have theoretical results and to verify them practically. Nowadays, the development of new and non-polluting energy producing and energy-storage systems is a great challenge for scientists. An alternative to the nuclear and fossil fuel power is renewable energy technologies. Due to ever-increasing energy consumption, rising public awareness of environmental protection, and steady progress in power deregulation, alternative (i.e., renewable and fuel cell based) distributed generation systems have attracted increased interest. There is an accelerating world demand for environmentally friendly power. Among the renewable energy sources, the Photovoltaic (PV) energy is the most promising candidate for research and development for large scale users. Fuel cells have been receiving a lot of attention lately due to their potential of becoming a new energy source with a large range of applications. Fuel cells can be incorporated with other components to create high efficiency industrial power plants. Fuel cells permit clean and efficient energy production. The purpose of the work is to optimize the system's operation. The main reason to build described system is to supply stand-alone systems using renewable energy sources. Therefore, the power plant has to produce energy independent of any weather fluctuations. Integrating photovoltaic energy

DOI: 10.4018/978-1-4666-4852-4.ch076

sources with fuel cells, as a storage device replacing the conventional lead-acid batteries, leads to a non-polluting reliable energy source. In this chapter, an energy system comprising different energy sources, namely PV and fuel cells, is proposed. Photovoltaic cells coupled with electrolytic devices can be used to produce hydrogen and oxygen in a sustainable manner. With the produced hydrogen from the electrolysis process, it is possible to generate electricity through fuel cells. Photovoltaic panels in particular can provide a good source of producing green electricity. It is autonomous, its operation does not pollute the atmosphere, and it is an inexhaustible and renewable source with great reliability. The simulation program developed also allows the exportation of different configurations. The experimental system described has permitted the validation of the proposed method.

INTRODUCTION

Computers are great resources to own. They are everywhere and society depends on them to manage our world. The computers have unlimited applications. Many of these applications are benefiting society directly or indirectly. There exist other functions of these computers, such as their use for running simulations and calculating large, complex data sets. In this present work, a hybrid system, particularly a photovoltaic fuel cell one, in Algeria, is studied. The fuel cell power supply is a very attractive option to be used with an intermittent power generation source like PV power because the fuel cell power system is characterized with many attractive features such as efficiency, fast load-response, modular production and fuel flexibility.

Photovoltaic (PV) has emerged in last decades since it has the previously mentioned advantages and less maintenance. Photovoltaic panels have received increasing attention over the last decade as one response to the challenges of global warming, increasing demand for energy, high fuel costs, and local pollution. Solar modules have the disadvantage of high initial installation costs. So, different methods have been proposed in the literature to increase the photovoltaic generator (SCA: Solar Cells Array) efficiency. The method, proposed here is based on selecting in real time, the SCA optimum configuration for a given load and given working conditions. This method is supposed to be particularly convenient for all direct coupling between a photovoltaic generator and a load system such as a pumping system. Experimental results strongly confirm the effectiveness of the proposed method. The system is an environmentally friendly solution since it tries maximising the use of a renewable energy source.

GENERAL SYSTEM DESCRIPTION

The alternative energy system that we propose to study in Algeria, more precisely in Oran city, is represented in Figure 1.

The overall system includes:

- Photovoltaic field containing photovoltaic polycrystalline silicon cells;
- Fuel cells stack;
- Gas storage equipment;
- Electrolyser;
- Stand-by battery; and
- Power Management and Control device (PMU).

The load is fed by a photovoltaic field. Electricity excess supplies thus the electrolyser producing hydrogen and the oxygen. The gases are stored for a length or a short term. In the event of insufficient energy, the PV generator is adopted to feed the load. A battery is added to the system in the transitory moments where fast load's variations occur. The energy management (PMU) equipment is used to control the power between each compo-