

Project # 4: Renewable Energy System

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Abstract

Energy production in a friendly environmental way is expected to dominate the efforts of great number of scientists and engineers during the 21st century. The automobile industry is seriously challenged worldwide to adopt the new environmental standards demanding reduced carbon pollution and fuel consumption. Fossil fuel and especially oil use creates uncomfortable geopolitical “energy dependence” for many nations that rely on imported supply of oil.

The State of Ohio with its Third Frontier Fuel Cell Program aims to position Ohio as a national leader in the growing fuel cell industry. In addition, the U.S. Government's call for energy independence is urging the scientific community to come up with alternative energy sources and those in academia to train and prepare the work forces that will practice these technologies in the state of Ohio. The University of Cincinnati's College of Engineering and Applied Science has integrated these realities into the current teaching and research programs giving more emphasis to Renewable Energy Systems. The major goal of this project is to deliver advanced theoretical and experimental knowledge to the participating teachers in environmentally friendly approaches for power generation, which mainly refers to fuel cell and solar cell technologies in this project. In addition, relevant information on Nanotechnology related to Energy will be also provided. In this project a theoretical module of core lectures related to renewable energy technologies will be presented followed by an experimental module of four separate experiments that will be conducted using the lab facilities described below. Each module will be taught by the faculty mentor in-charge with the help of a graduate student mentor.

The proposed study involves four experiments related to the renewable energy. First Hydrogen Fuel Cell, shown in Figure 1, will be introduced. The participants will learn about the principles of a Proton Exchange Membrane (PEM) hydrogen fuel cell and be required to measure, calculate and plot the current, voltage and energy efficiency of a PEM fuel cell, during which they can prove experimentally the high efficiency of the PEM fuel cell and the advantages of the hydrogen technology for power generation.

The second experiment (Hydro-Genius Professional System) will illustrate how the solar energy can be converted into hydrogen by electrolysis of water (see Figure 2). This way the sunlight is stored in the form of hydrogen fuel. The electrical power needed to split the water into oxygen and hydrogen in the electrolyzer is provided by a silicon-based photovoltaic cell, which is irradiated with light. The oxygen and hydrogen produced are stored separately and used in a hydrogen fuel cell for power generation. The generated electricity powers a fan and the electrical parameters are registered and recorded.

In the third experiment, the participants will be required to make titanium oxide solar cells (see Figure 3) of their own and test their performance by building a small circuit (see Figure 4). They will compare the efficiency of cells made from natural dye and industrial dye as well as the influence of light source wavelength.

The fourth experiment will employ a commercial photovoltaic solar panel that will be used by the students to characterize the performance of a silicon solar cell displayed in Figure 5.

Possible Ideas for Classroom Implementation

The hydrogen fuel cell powered cars can be used as a classroom implementation material related to renewable energy sources. Assembling the car in the class and setting it into operation will attract and be a rewarding experience for the high school students. They will learn through this exercise three major topics: (a) silicon solar cell; (b) hydrogen production; and (c) hydrogen fuel cells. We will also consider a kit consisting of a carbon nanotube and Buckyball models, shown in Figure 6, as good examples to demonstrate the materials used in renewable energy system.

Alternatively, we will discuss with the teachers many other options that are offered by vendors and are related to the science and technology of Renewable Energy. During the summer stay in the lab the teachers will be asked to select a few experiments from the hundreds shown in the websites of Fuelcellstore, Fisher Science Education, and Fuelcellmaterials. These experiments will be discussed during an especially dedicated teaching session.

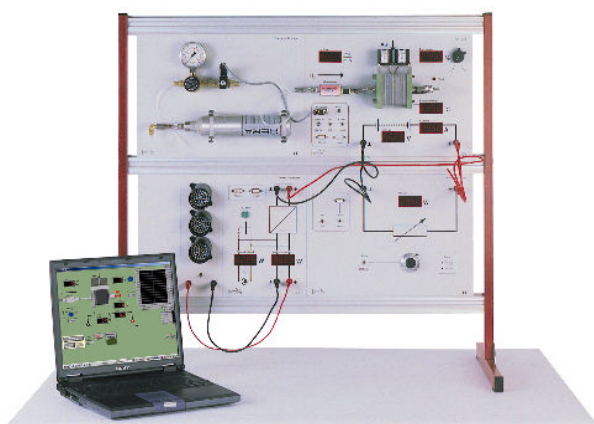


Figure 1. Proton Exchange Membrane (PEM) Hydrogen Fuel Cell

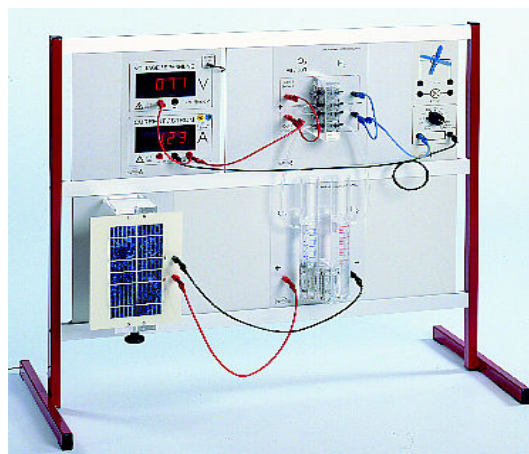


Figure 2. Hydro-Genius Professional System



Figure 3. Dye Sensitized Solar Cell



Figure 4. Performance Testing of the Solar Cell

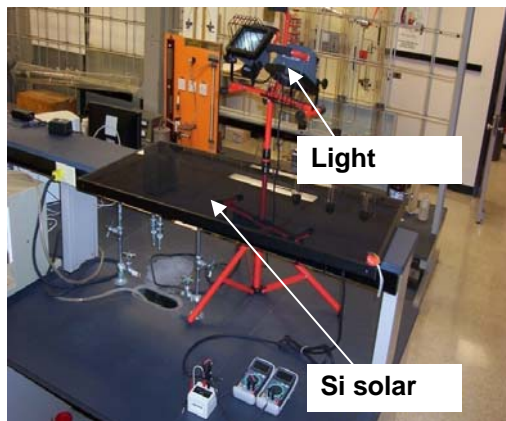


Figure 5. Silicon Solar Cell



Figure 6. Buckyballs