Project # 2: Renewable Energy System

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Project Summary:

Energy production in a friendly to the environment 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.

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 UC CoE has integrated these realities into the current teaching and research programs giving more emphasis to Renewable Energy Systems. The major goal 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.

Figure 1 Proton Exchange Membrane (PEM) Hydrogen Fuel Cell

First Hydrogen Fuel Cell will be introduced. The equipment is shown in Figure 1. The participants will learn about the principles of a Proton Exchange Membrane (PEM) hydrogen fuel cell and to provide them with an experimental opportunity to practice this knowledge. In addition, they will be required to measure, calculate and plot the current, voltage and energy efficiency of a PEM fuel cell. They also will prove experimentally the high efficiency of the PEM fuel cell, and will discover the advantages of the hydrogen technology for power generation that is pollution-free. The students will be also introduced to the challenges of hydrogen storage, and to some safety

Figure 2. Direct Methanol Fuel Cell

The second experiment is called Direct Methanol Fuel Cell (DMFS): SFC A 50, as shown in Figure 2. It is also a PEM device, but instead of hydrogen methanol is used as a fuel, which produces protons and electrons in the presence of water and catalysts. The DMFC has lower efficiency than the previously described hydrogen fuel cell, but is expected in the very near future to find application in portable electronic devices such as cell phones and laptops. The DMFC supports a 12-volt car battery and starts charging it automatically when the battery

voltage goes below a certain level.

The third experiment (Hydro-Genius Professional System) will illustrate how the solar energy can be converted into hydrogen by electrolysis of water (Figure 3). 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 produced oxygen and hydrogen 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.

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 4.

Figure 3. Hydro-Genius Professional System

Figure 4. Silicon Cell

Possible Ideas for Classroom Implementation

We plan to donate to each teacher successfully completing the lab course a working model of a hydrogen fuel cell powered car that 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 be a rewarding experience for the high school students. They will learn through this exercise 3 major topics: a) silicon solar cell; b) hydrogen production; and c) hydrogen fuel cells. The second item considered for donation to the teachers attending the Emerging Energy Systems class is a kit consisted of the carbon nanotube and Buckyball models shown in Figure 5.

Figure 5, Buckyballs

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 a especially dedicated teaching session.