

### VII.3 Washington State Fuel Cell Education and Demonstration Program (New Project)\*

*Mira Vowles, PE (Primary Contact)*

*Bonneville Power Administration*

*905 NE 11th Street, PNG-1*

*Portland, OR 97232*

*Phone: (503) 230-4796; Fax: (503) 230-5147; E-mail: mkvowles@bpa.gov*

*DOE Technology Development Manager: Christy Cooper*

*Phone: (202) 586-1885; Fax: (202) 586-9811; E-mail: Christy.Cooper@ee.doe.gov*

*\*Congressionally directed project*

#### Objectives

- Develop fuel cell curriculum for use in high schools.
- Train 200 middle and high school teachers on hydrogen and fuel cells.
- Educate 18,000 high school students in the state of Washington on hydrogen and fuel cells.
- Measure impact through online quiz.
- Demonstrate proton exchange membrane (PEM) fuel cell at Central Washington University.
- Provide opportunities for college students to receive internships to learn about fuel cells.

#### Technical Barriers

This project addresses the following technical barriers from the Education section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- A. Lack of Awareness
- B. Lack of Demonstrations or Examples of Real World Use
- C. Institutional Barriers and Access to Audiences
- D. Regional Differences

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#### Approach

The Washington State Fuel Cell Education and Demonstration Project was made possible through a \$100,000 State Energy Program (SEP) grant from the U.S. Department of Energy Hydrogen Program. The Washington State Department of Community, Trade and Economic Development received the SEP grant and contracted with Bonneville Power Administration to manage the work.

The Washington State Fuel Cell Education and Demonstration Project includes the development of an eight-day module using a fuel cell car and curriculum kit. This kit was given to 200 teachers in exchange for their teaching the module to three

classes by September 30, 2004, reaching an estimated 18,000 students. In addition, several public events were coordinated to address the lack of awareness of hydrogen and fuel cells. The lack of demonstration projects was addressed by installing a demonstration fuel cell at Central Washington University as part of this grant.

Over \$125,000 of in-kind funding and support was received from the U.S. Army Engineer Research and Development Center Construction Engineering Research Laboratory (ERDC-CERL), the Washington State Office of Superintendent of Public Instruction (OSPI), Central Washington University, the Combined Heat and Power Consortium, Washington science teachers, Sargent-Welch,

Heliocentris, ReliOn (formerly Avista Labs) and the Northwest Energy Technology Collaborative.

Ross McCurdy, a teacher at Ponaganset High School in Rhode Island, was consulted as part of this grant because he used fuel cell car kits in his classroom. The Hyco fuel cell car kit that Ross recommended for use in classrooms is manufactured by Heliocentris and comes with a photovoltaic module, reversible PEM fuel cell, model car base, stopwatch, load box and a hydrogen reference book. The Heliocentris kit was chosen because of its ease of use and potential for use in real science experiments. The next step was developing a straightforward, easy-to-demonstrate curriculum tied to state standards.

With Ross's help, two Washington teachers, Gary Thayer and Trevor Macduff, customized the curriculum. Several experiments from Heliocentris were combined with additional activities into a multimedia, easy-to-use curriculum kit targeted to ninth through 12th grade science classes. Each experiment was designed for a small group of students to perform and report their findings to the class at the end of the period. The experiments built on each other, requiring students to pay attention to the results from previous experiments. Since only one car kit was given to each teacher, a matrix of other activities was developed for students to do when they weren't using the kit. The experiments start with a discovery learning investigation where students observe, predict and question what is going on with the fuel cell car kit; this activity engages the students and gets them excited about the next experiments. Other experiments investigate the effect of the angle and distance between the photovoltaic module and the light source, measure the current produced, and time the production of hydrogen. Then students use the hydrogen in the fuel cell model car and calculate the efficiencies of the electrolyzer and the fuel cell. The final activity is to write a research paper on "how fuel cells can save the world."

Ten hands-on workshops reached 200 Washington teachers. The workshops were three hours long and free to the teachers. The teachers received a fuel cell car and curriculum kit after signing an obligation form that specified that they

would use the kit in three classes by September 30, 2004. Teachers could receive clock-hours or professional development credits for the training, and the grant paid for their substitutes. Even with these incentives, barriers prevented some teachers from attending the workshops.

Institutional barriers and regional differences were noted in setting up these workshops. In urban areas, workshops scheduled after school hours were better attended. In rural areas, it was difficult for some teachers to attend because of the travel required. Where principals didn't support workshop attendance, a local champion, such as a Science Coordinator, helped ensure attendance.

Other classroom resources were offered through the project. These resources included an online "Chalkboard," where students and teachers could post questions, answers and resources related to the program. Students and teachers could ask Ross McCurdy, his students or Heliocentris questions about fuel cells. Several teachers posted resources they found useful and their lesson plans. Other resources included fuel cell field trip information, an essay contest, a poster contest and summer internships. More information on the program, including these online resources, is available at: [http://www.bpa.gov/Energy/N/projects/fuel\\_cell/education/](http://www.bpa.gov/Energy/N/projects/fuel_cell/education/)

## **Results**

As of June 28, 2004, the Washington State Fuel Cell Education and Demonstration Project trained 200 teachers, providing them with fuel cell car and curriculum kits. The teachers that responded to an e-mail survey reported that they have taught the eight-day fuel cell module to 6,566 students. In addition, eight students demonstrated the kits to elementary school classes.

The teacher survey asked if the kits engaged students, and some of their responses were:

- "students were fighting over who got to work with the cars first";
- "everyone has been captivated with this piece of technology";
- "the kids loved the kit";

- "there was a very high level of focus";
- "students want to sign the kit out on the weekend";
- "the kids loved this cutting edge technology";
- "definitely liked the hands on experiments";
- "my students loved working with the hydrogen cars, even some of my disinterested students were engaged";
- "Yes! Such a thrill for them as well as an ongoing learning opportunity";
- "lots of questions and critical thinking!";
- "The kits were the best part. Students were fascinated with the fuel cell and the car. A good deal of curiosity was generated concerning how the fuel cell created electricity. Students were also very interested in the performance of the car; how far it would travel, how fast and so on.";
- "I had students doing research until the end of class, and they would come in all excited about what they heard or saw on the news or read about hydrogen.";
- "fuel cells fit in well with our new science and sustainability curriculum"; and
- "the students were engaged with the kit and appeared to be having fun learning".

This level of engagement demonstrates the success of the program.

Another survey will be sent to the teachers in October to determine the total number of students reached by September 30, 2004. The program estimated 18,000 students would be taught; however, science classes did not average 30 students as was assumed in the estimate. The impact of the eight-day fuel cell module was tracked through an online fuel cell quiz. While this quiz was not intended to be a scientific survey, students showed a 30 percent improvement after participating in the program.

The quiz could be improved in several ways. The quiz should be tied more directly to the curriculum, and several of the questions should be reworded to avoid misinterpretation. Several teachers reported technical difficulties with the online quiz, and some teachers requested a summary of student scores. The quiz was set up to protect the

anonymity of the students, so student scores weren't available for teachers.

The program received very good publicity. Press conferences at the delivery and ribbon-cutting ceremony of the fuel cell at Central Washington University (CWU) received positive coverage. A video documenting the installation is being developed by CWU and will be shown during tours; the television and video player will be powered by the fuel cell. The team of engineering students who designed the CWU fuel cell installation also provide tours, and their excitement and passion make the tours an excellent learning experience. Over 200 people toured the Central Washington University fuel cell during the first month, and they expect over 1,000 to tour it over the summer of 2004. The fuel cell poster contest awards ceremony was also well attended on Earth Day.

The fuel cell poster resulting from the contest successfully addresses fuel cell advantages and challenges, as demonstrated by some of the student quotes that are included in the poster:

- "The fuel cell is going to work because it does not make any pollution or mess up the world";
- "I think it would be good if we used these (fuel cell) cars because it would give off less pollution and would be better for our environment instead of harming it. One problem that we are having with fuel cell cars is that we need more room to hold the fuel";
- "You could make it so all of the cars got to tow trailers of hydrogen"; and
- "Have a couple of tanks on your car".

Students' pictures of the sun and a windmill address making hydrogen with renewable resources. Copies of this fuel cell poster will be displayed in Washington and Oregon. While the fuel cell poster contest was a success, there were no entries for the fuel cell essay contest. To encourage entries in future contests, an incentive should be offered to teachers who encourage students to write fuel cell essays.

As part of this project, one student and one teacher will benefit from summer internships at Pacific Northwest National Laboratories. While three student internships were offered at ReliOn, a

Washington fuel cell manufacturer, no students have applied for these internships. These internships are relatively inexpensive, but the results are immeasurable.

This project successfully addressed all of the identified barriers.

- The posters, publicity and public events help raise awareness of hydrogen and fuel cells.
- The fuel cell at CWU will be demonstrated to thousands and incorporated into the engineering curriculum.
- The institutional barriers and regional differences of Washington high schools were addressed with

a creative and flexible approach to the curriculum and teacher workshops.

This project was successful because of the fuel cell education champions who participated. Their passion and support was invaluable. This project helped make Washington state a fuel cell education leader, and all of the teachers responded that they will continue to use the fuel cell car and curriculum kits. Another measure of success is that teachers have purchased 35 additional kits for their classrooms, demonstrating the ease of use and effectiveness of the kits developed for this project.