

IX.9 Hydrogen and Fuel Cell Education at California State University, Los Angeles

David Blekhman (Primary Contact), Trinh Pham,
Chivey Wu

California State University, Los Angeles (CSULA)
5151 State University Drive
Los Angeles, CA 90032
Phone: (343) 323-4569
E-mail: blekhman@calstatela.edu

DOE Manager

GO: Greg Kleen
Phone: (720) 356-1672
E-mail: Greg.Kleen@go.doe.gov

Contract Number: DE-FG36-08GO18106

Project Start Date: October 15, 2008

Project End Date: June 30, 2011

Fiscal Year (FY) 2011 Objectives

California State University, Los Angeles, has partnered with the DOE in addressing the workforce preparation and public education needs of the fuel cell industry and the U.S. economy through a comprehensive set of curriculum development and training activities:

- Developing and offering several courses in fuel cell technologies, hydrogen and alternative fuels production, alternative and renewable energy technologies as means of zero emissions hydrogen economy, and sustainable environment.
- Establishing a zero emissions proton exchange membrane (PEM) fuel cell and hydrogen laboratory supporting curriculum and graduate students' teaching and research experiences.
- Providing engaging capstone projects for multi-disciplinary teams of senior undergraduate students.
- Fostering partnerships with automotive manufacturers and energy providers.

Technical Barriers

This project addresses the following technical barriers from the Education section (3.9.5) of the 2009 Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

- (A) Lack of Readily Available, Objective, and Technically Accurate Information
- (B) Mixed Messages
- (D) Lack of Educated Trainers and Training Opportunities

Contribution to Achievement of DOE Education Milestones

This project will contribute to achievement of the following DOE milestones from the Education section of the 2009 Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

- Milestone 11: Develop set of introductory materials suitable for a non-technical audience. (4Q, 2006)
- Milestone 21: Launch new university hydrogen education program. (4Q, 2009)
- Milestone 27: Launch high school teacher professional development. (4Q, 2008 through 3Q, 2011)

FY 2011 Accomplishments

- In the 2010-2011 academic year, we continued to offer course modules and hydrogen and fuel cell technology (HFCT) dedicated courses; TECH 470-Electric and Hybrid Vehicles (enrollment 10 technology, eight mechanical); TECH 250-The Impact of Technology on the Individual and Society (detailed in the next section). Milestone 21 (**M:21**).
- TECH 250-The Impact of Technology on the Individual and Society course is a general education required course, which contains one week module on fuel cells and hydrogen economy. It is open to all majors in the university and is selected to deliver our message to the university-wide student body. Multi-section course enrollment exceeded 200 students. **M:21**.
- CSULA students built a fuel cell vehicle and participated in 2011 Shell-Eco competition, Houston, TX. CSULA built fuel cell vehicle Hydrogen Super Eagle was on display at AltCar Expo, Santa Monica 2010, October 2010, Los Angeles Auto Show, in November 2010 and the Metropolitan Water District of Southern California Sustainable Expo, May 2011. The vehicle participated in filming the Mercedes-Benz F-Cell World Drive video EcoTrek 7 (at 3rd minute): <http://www.youtube.com/watch?v=qDPhJsMUBR4>. **M:21**, Milestone 11 (**M:11**).
- CSULA students participated in 2010 and 2011 Hydrogen Design Contests organized by the National Hydrogen Association. **M:21**.
- CSULA has been selected for EcoCAR 2 *Plugging into the Future* competition 2011-2014. **M:21**, **M:11**.
- The College of Engineering, Computer Science and Technology (ECST) is completing the 10 kW solar photovoltaic installation. The system consists of 56 Sharp and 23 Solec modules and three SMA inverters. The funds were provided by Southern California Edison, ECST and this funding. **M:21**.
- There has been an appreciable number of public outreach and educational activities through which fuel cell and hydrogen technologies and the new curriculum

at CSULA were promoted. CSULA participated in numerous meetings and discussions of future projects and collaborations with fuel cell vehicle manufacturers, federal and state government officials. Significant collaboration has been developed with California Fuel Cell Partnership. **M:11.**

- CSULA is completing the construction of a hydrogen station with 60 kg/day generation capacity. That will enable further development of educational program and research into hydrogen technologies. **M:21.**
- Multidisciplinary team of CSULA faculty, including Dr. Blekhman, received National Science Foundation (NSF) funding to establish Center for Energy and Sustainability. The same group has secured American Recovery and Reinvestment Act funding to renovate laboratory spaces including the Zero Emissions Fuel Cell and Hydrogen Laboratory (ZEFC). Dr. Blekhman has been awarded NSF Major Research Instrumentation funding to conduct research into hydrogen purity. These will contribute to the longevity of the research program. **M:21.**



Introduction

Our interest in developing hydrogen and fuel cell education stems from the recognition of the urgent need for workforce development and public education in the entire spectrum of alternative and renewable energy technologies (ARET). ECST is taking steps to graduate more students fluent in ARET as well as to raise campus and state-wide awareness of green technologies. This includes the ongoing construction of a hydrogen fueling station on campus. The comprehensive nature of the university, its strategic location in the hydrogen and fuel cell abundant industrial region and a historically minority-serving charter has made CSULA an ideal candidate to carry out the tasks listed in the objectives.

Approach

Design of a comprehensive engineering and technology curriculum addressing fuel cells and hydrogen technologies is the foundation for our contribution toward green workforce training. This is accomplished through a mix of new courses or special modules in existing courses to introduce the concepts of fuel cell technologies, hydrogen and alternative fuels, alternative and renewable energy technologies as means of zero emissions hydrogen economy, and sustainable environment. ECST has established the ZEFC to support curriculum, undergraduate and graduate students' teaching and research experiences. Further, enrichment of student experiences is accomplished through projects and fostering partnerships with automotive manufacturers and industry.

Community education and public outreach goals are met through a series of on campus and off-campus public events and demonstrations.

Results

The initial grant period was extended by nine months which allowed supporting students that led team efforts in creating a fuel cell vehicle and participating in 2011 Hydrogen Design Contests organized by the National Hydrogen Association. The contest was to design a home hydrogen refueling facility. The twelve-student team included two students from East Los Angeles College. CSULA took 7th place among 17 teams that submitted and 54 registered, third place among the U.S. teams.

An ECST team of six students built a fuel cell vehicle. The team participated in 2011 Shell-Eco competition, Houston, TX. The fuel cell vehicle called Hydrogen Super Eagle was also on display at AltCar Expo, Santa Monica 2010, October 2010, Los Angeles Auto Show, November 2010 and the Metropolitan Water District of Southern California Sustainable Expo, May 2011. The vehicle participated in filming the Mercedes-Benz F-Cell World Drive, see Figure 1. The multi-episode documentary is called Eco Trek and is available on YouTube. CSULA is featured in EcoTrek 7 (at third minute): <http://www.youtube.com/watch?v=qDPHjsMUBR4>.

Two courses with integrated fuel cell/hydrogen modules were offered: TECH 470-Electric and Hybrid Vehicles and TECH 250-The Impact of Technology on the Individual and Society. The latter had multiple sessions throughout the year.

CSULA has actively pursued public outreach and educational activities through which the DOE-sponsored Fuel Cell and Hydrogen curriculum at CSULA was promoted. During the fall of 2010, ECST hosted a Boeing open house for middle and high-school students. More than



FIGURE 1. CSULA-Built Fuel Cell Vehicle Driving along Mercedes-Benz F-Cell World Drive Car

a hundred of them toured the ZEFC. There were multiple additional events with K12 students being introduced to fuel cells, see Figure 2.

CSULA is nearing the completion of a \$4.5 M hydrogen station on campus, see Figure 3. It will deploy the latest technologies with the capacity of 60 kg/day, sufficient to fuel 15+ vehicles or a bus and five more vehicles. The station is utilizing a Hydrogenics electrolyzer, first and second stage compressors capable of fast-filling at 5,000 psi and 10,000 psi, and 60 kg of hydrogen storage. The station will be grid-tied and powered by 100% renewable power.

Dr. Blekhman attended the 2011 Annual Merit Review and 2011 NHA conference both in Washington, D.C., and the 2011 ASEE conference in Vancouver, BC.

Conclusions and Future Directions

CSULA has been very successful in meeting the objectives proposed in the grant. In this extended period of funding, the team has continued to offer courses with modules addressing fuel cell and hydrogen technologies. The work in ZEFC laboratory progressed with the solar installation that will be powering the lab electrolyzer and the rest of the engineering building. Students continued to be challenged through industry and competition projects far beyond those proposed initially.

CSULA is well poised to continue fuel cell and hydrogen educational and research efforts beyond current funding, which provided the foundation for many other activities. Among future activities are operating the hydrogen station, participating in EcoCAR 2 competition and operating a high-quality gas chromatograph-mass spectroscopy for testing hydrogen purity in Southern California. We will also continue our educational program, outreach and collaborations with the industry.



FIGURE 2. Marengo Elementary School Science Night; a Fuel Cell Display is Demonstrated, in January 2011



FIGURE 3. CSULA Hydrogen Station Construction on June 22, 2011