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## X.3 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; Fax: (323) 343-4571  
E-mail: blekhman@calstatela.edu

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

DOE Project Officer: Gregory Kleen  
Phone: (303) 275-4875; Fax: (303) 275-4788  
E-mail: Greg.Kleen@go.doe.gov

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### Objectives

California State University, Los Angeles, has partnered with the Department of Energy 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 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 original equipment manufacturers (OEMs) and energy providers.

### Technical Barriers

This project addresses the following technical barriers from the Education section (3.9.5) of the Hydrogen, Fuel Cells and Infrastructure 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 Hydrogen, Fuel Cells and Infrastructure 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)

### Accomplishments

- In the 2008-2009 academic year, we developed course modules or completely new offerings in four courses: ME 454-Renewable Energy and Sustainability (enrollment 26); ME 554-Fuel Cell Systems (graduate course; enrollment 16); TECH 478-Fuel Cell Applications (enrollment 10 technology, 11 mechanical and 1 electrical engineering); TECH 250-The Impact of Technology on the Individual and Society. **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 the hydrogen economy. It is open to all majors in the university and is selected to deliver our message to the university-wide student body. Enrollment was as following: Fall 2008 – 31, 33, 30, 32 (4 sections were offered), Winter 2009 – 35, Spring 2009 – 25. **M:21.**
- Six faculty who are usually assigned to teaching TECH 250 were trained on the topic and provided teaching materials on fuel cells and the hydrogen station to be built on campus. See published materials section. **M:21.**

- Work has begun on the Zero Emissions Fuel Cell and Hydrogen Laboratory. Major equipment has been acquired: Heliocentris -- Dr. Fuel Cell, Nexa Training System Complete, Nexa Integration Kit; and Proton-Hogen GC600 Electrolyzer. Two graduate students were selected for educational and research projects in the laboratory. **M:21.**
- The College of Engineering, Computer Science and Technology (ECST) assembled a multidisciplinary senior design team which installed 21 solar panels (1.8 kW total power) donated by Southern California Edison and valued at \$5,000. The team consisted of four electrical engineering (EE) and one technology (TECH) student. The work will be continued to complete wiring and connection to the Zero Emissions Lab. CSULA published an article describing the project [1].
- ECST assembled a multidisciplinary senior design team to design and build a Hydrogen Safety demonstrator. The team consisted of two mechanical engineering (ME) and two EE students. The enabled experiments produced spectacular performance. For safety, the explosions are activated with a wireless remote. **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. **M:11.**
- CSULA has continued to build its relationship with OEMs and the industry through its Hydrogen Station efforts, hosting the National Renewable Energy Laboratory's hydrogen station permitting workshops and other industry contacts.
- The technology student, who participated on the solar installation, completed courses in Advanced Engine Design, Hybrid and Electric Vehicles, and Fuel Cell Applications. He was hired as the automotive instructor at a local high school. **M:27.**



## 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 our bid for 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 make it 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. Concurrently, ECST established a Zero Emissions Fuel Cell and Hydrogen Laboratory to support curriculum and graduate students' teaching and research experiences. Further, enrichment of student experiences is accomplished through projects and fostering partnerships with automotive OEMs and energy providers.

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

## Results

Four courses either with integrated modules or fully dedicated were introduced into the interdisciplinary curriculum at ECST: ME 454-Renewable Energy and Sustainability, ME 554-Fuel Cell Systems, TECH 478-Fuel Cell Applications, TECH 250-The Impact of Technology on the Individual and Society. Significant developments were introduced in TECH 478. The Honda Clarity FCX team gave a lecture and a demonstration on Honda fuel cell vehicles, see Figure 1. As part of the final exam, students attended the 2009 American Society of Mechanical Engineers (ASME) Fuel Cell conference which was available locally. ASME sponsored student registration. At other occasions, General Motors fuel cell vehicle center in Burbank, CA,

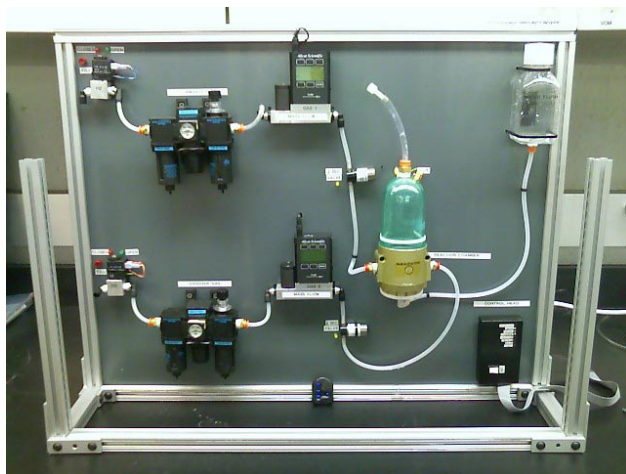


**FIGURE 1.** CSULA students are studying Honda Clarity FCX fuel cell vehicle during Honda's visit.

as well as the Southern California Edison Electrical Vehicle Center in Pomona, CA, hosted CSULA students for tours. Attending the ASME conference and OEM participation greatly contributed to our objective of fostering partnerships with the industry.

Work has begun on establishing the Zero Emissions Fuel Cell and Hydrogen Laboratory. The laboratory is designed to provide hands-on activities supporting fuel cell courses offered in the program. Major equipment has been acquired: Heliocentris -- Dr. Fuel Cell, Nexa Training System Complete, Nexa Integration Kit; and Proton-Hogen GC600 Electrolyzer. The solar installation on the roof will provide the renewable generation of power for hydrogen electrolysis. A multidisciplinary senior design team designed and built a custom hydrogen safety demonstrator that allows to experiment with the comparative explosivity limits of hydrogen and other explosive gases, see Figure 2.

CSULA has actively pursued public outreach and educational activities through which the DOE-sponsored Fuel Cell and Hydrogen curriculum at CSULA is promoted. During the summer of 2008, a team of six summer undergraduate researchers representing four different states built a 25-cm<sup>2</sup> fuel cell test stand, see Figure 3. The test stand was taken to the Hydrogen Road Tour Day at the California Science Center in Los Angeles in August 2008. It was displayed at the Santa Monica Alternative Car Show in September 2008. During the fall of 2008, ECST hosted two open house events for middle and high-school students, about two hundred of whom toured the Zero-Emissions Fuel Cell laboratory. In February, the stand was a part of the Southern California Edison Black History Month event. On April 18, 2009, CSULA participated in the first annual "Green Valley Expo" organized by Lookin' Green Magazine, Pasadena, CA. The magazine also published our material explaining operation of a fuel cell



**FIGURE 2.** Hydrogen Safety Experiment Built by a Senior Design Team



**FIGURE 3.** Fuel cell test stand and a CSULA team of two faculty and a student representing innovative curriculum during Hydrogen Road Tour Day.

[2] online and in the hardbound copy. The magazine also placed an online article describing the CSULA Hydrogen and Fuel Cell program [3].

CSULA has partnered with East Los Angeles College to provide summer workshops to 15 college students. At the end of the program, a LEGO Mindstorm robot powered by a Horizon 20 W fuel cell was built. ECST is also executing its Research Experience for Undergraduates National Science Foundation program through which four students are working on various projects in the Zero Emissions Fuel Cell and Hydrogen Laboratory.

The principal investigator (PI) attended the 2009 Annual Merit Review in Washington DC, 2009, Hydrogen + Fuel Cells conference in Vancouver, Canada, and, 2009 ASME Fuel Cell conference, Newport Beach, CA. One research student and the PI attended the Short Fuel Cell Course at Los Alamos National Laboratory in August 2009.

## Conclusions and Future Directions

CSULA has methodically pursued its objectives in executing the grant. The team has offered a comprehensive suite of courses addressing fuel cell and hydrogen technologies. The Zero Emissions Fuel Cell and Hydrogen Laboratory was established and actively utilized for course support, student projects, outreach activities and research. Significant effort has been extended for community education on all levels and establishing effective partnerships with the industry.

Next year, efforts will focus on further refinement of course offerings and laboratory experiences for students. Most of the development will take place in the laboratory, where work is planned for completing the solar installation and student manuals for the equipment. It will also be important to engage in activities which will assure the long-term viability of the Hydrogen and Fuel Cell program at CSULA.



## FY 2009 Publications/Presentations

1. Title: Prof.\_Blekhman-Fuel Cells, Duration: 00:34:08  
Link: <http://ess-msite.calstatela.edu/Mediasite/Viewer/?peid=10b36466-a786-43a7-9bfc-142ebc51f5fb>
2. Title: Prof.\_Blekhman-Hydrogen Economy, Duration: 00:35:24  
Link: <http://ess-msite.calstatela.edu/Mediasite/Viewer/?peid=c39fd43a-c9c8-4e95-b799-48ebbf51116f>

## References

1. The online summer issue of Cal State L.A. TODAY magazine published an article titled 'The Next 'Solar' Generation'. The article discusses the solar installation by our engineering students including the solar panels for the Zero Emissions Fuel Cell laboratory. The link to the article is <http://www.calstatela.edu/univ/ppa/publicat/today/>
2. Poster explaining the operation of a fuel cell, page 31 of the Lookin' Green Magazine, April 2009. Last retrieved August, 2009. [http://www.lookinggreen.com/images/stories/special\\_edition/LookingGreen200903\\_31.pdf](http://www.lookinggreen.com/images/stories/special_edition/LookingGreen200903_31.pdf)
3. Cal State LA Advanced Fuel Cell, Lookin' Green Magazine online edition, April 2009. Last retrieved August, 2009. [http://www.lookinggreen.com/index.php?option=com\\_content&view=article&id=343:cal-state-la-advanced-fuel-cell-pg-31&catid=86:special-edition&Itemid=174](http://www.lookinggreen.com/index.php?option=com_content&view=article&id=343:cal-state-la-advanced-fuel-cell-pg-31&catid=86:special-edition&Itemid=174)