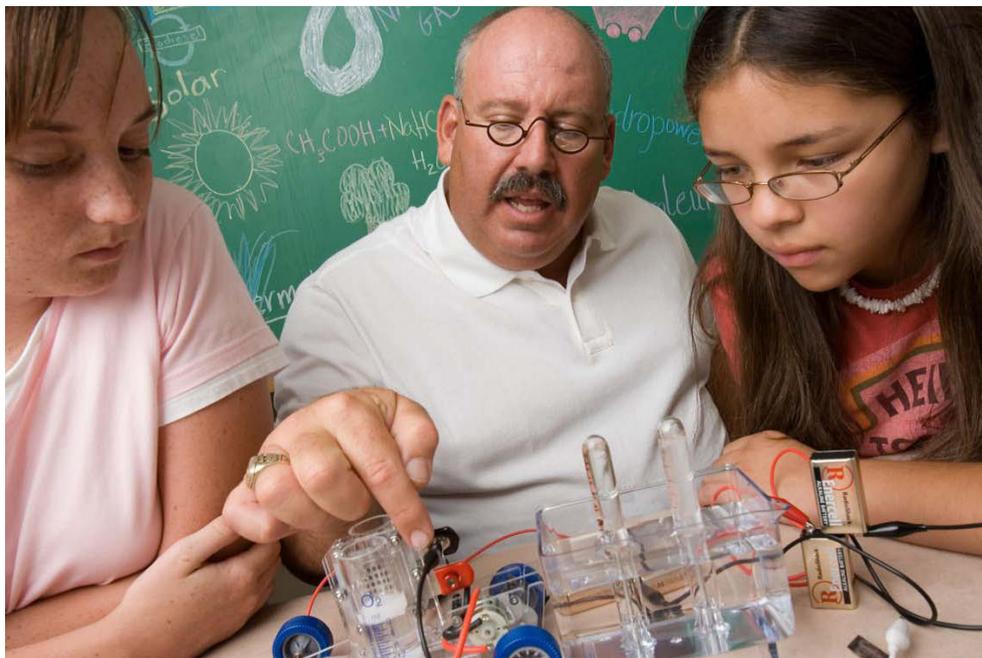


Education and Outreach

The Fuel Cell Technologies Office creates learning opportunities and encourages students to continue their energy education by expanding the availability of curricula, establishing a database of hydrogen and fuel cell related educational materials, and providing teacher training tools and workshops.

Building the next generation workforce is a critical component of ensuring that hydrogen and fuel cells remain an integral part of the nation's clean energy portfolio. Educational materials and programs designed specifically for future scientists, engineers, technicians, and technology users provide students with the tools they need to continue market and technology development. By increasing awareness and hands-on experiences with hydrogen and fuel cell technologies, the Office creates learning opportunities and prepares students to work as energy professionals.



Hydrogen Technology and Energy Curricula, University of California-Berkeley Lawrence Hall of Science (HyTEC)

The University of California-Berkeley Lawrence Hall of Science's Hydrogen Technology and Energy Curricula (HyTEC) project targeted a diverse audience of high school students and teachers. The HyTEC program has expanded the reach of hydrogen and fuel cell curricula and experimental plans developed for high school students and teachers. The team developed and field tested an instructional module for high school students focused on the science and applications of hydrogen and fuel cells within the context of broader energy issues. The complete module, *Investigating Alternative Energy: Hydrogen and Fuel Cells*, with supporting materials and an equipment kit was published in Spring 2011. This two-week

module for high school chemistry, environmental science, or physical science classes includes laboratory, simulation, data analysis, and discussion activities. It also incorporates online videos of applications and simulations of fuel cell reactions.

As of February 2012, over 500 teachers have attended HyTEC awareness workshops at state and national science teacher conferences and received sample curriculum activities to try in their classrooms. Teacher evaluations of the curriculum show that it is practical and can be implemented in a wide variety of high schools and science courses. Evaluations of professional development sessions resulted in ratings of 4.5 to 5 on a 5-point scale. New teacher participants taught the curriculum to over 860 students in five different states. Presentations at science teacher conferences reached over 240 teachers during 2010.

DOE-funded Education and Outreach efforts have:

- Reached > 26,000 first responders/code officials
- Educated > 9,600 teachers
- Produced seven video segments for teacher professional development
- Developed a two-week curriculum module for high school students
- Reached an estimated 65,000 classrooms due to a strong relationship with the National Association of State Energy Officialsⁱ

K-12 Project Objectives

- Provide education and training for the next generation workforce in hydrogen and fuel cells
- Develop and field test hydrogen and fuel cell technologies curriculum modules to be implemented into existing K-12 school materials
- Introduce hydrogen science and technology into middle school and elementary school classrooms
- Conduct a professional development plan for high school and elementary school teachers who will use the curricula
- Assess and evaluate the quality and effectiveness of the curriculum materials
- Expand outreach network with new partners
- Disseminate the curricula and laboratory tools to a broad national audience through teacher training and other professional development activities

National Energy Education Development Project (NEED)

The H₂Educate program of the NEED Project was designed to target middle school teachers and students with educational materials, training programs, and curricula evaluation. NEED materials and training conferences provide comprehensive, objective information about major energy sources including production and consumption and their impact on the environment, economy, and society. The program emphasizes the development of critical thinking and problem solving skills using inquiry activities that encourage students to consider the trade-offs inherent in energy decisions. The H₂Educate curriculum was created by

a team of educators and subject matter experts to provide a dynamic classroom curriculum for middle schools. The curriculum is correlated to national and state science standards and NEED continues to update annually to provide the most up to date information in the classroom. All NEED materials are available for educators to download free of charge.

The NEED Project provides professional development sessions for educators interested in learning more about hydrogen's role in our energy future. Ranging from one hour to one day, NEED has provided training to over 9,600 teachers in 35 states across the United States since H₂Educate's inception in 2004. Data from participating schools and workshops show a 60% increase in student and teacher knowledge. Teacher training programs have been completed in 35 states. www.need.org

Michigan Technological University (MTU)

Dozens of course modules and accompanying problem sets using a theme of hydrogen and fuel cells were created for existing core engineering

courses in chemical, mechanical, and electrical engineering, which increases student awareness of hydrogen and fuel cells without adding additional coursework. The modules contain background, example problem statements and solutions, and homework problems. The project work courses include freshman to senior students from various disciplines working on energy related projects. These courses are also offered as electives to the Graduate Certificate in Hybrid Electric Vehicle Engineering. In addition, MTU added an Interdisciplinary Minor in Hydrogen Technology.

Humboldt State University

The Schatz Energy Research Center (SERC), part of the Humboldt State University's Hydrogen Energy in Engineering Education (H₂E³) project, included the development of hydrogen and fuel cell curriculum material and teaching tools for a hands-on experience in classrooms and labs for undergraduate engineering students in California's public universities. SERC developed hydrogen and fuel cell curricula and distributed more than 50 experimental bench top fuel cell/electrolyzer test stations for student laboratories. SERC



Humboldt State students in a renewable energy class perform fuel cell experiments using an H₂E³ test station, December 2010

University Project Objectives

- Provide education and training for the next generation workforce in hydrogen and fuel cells
- Develop and refine courses and accredited university level programs in hydrogen, fuel cells, and renewable energy technologies
- Develop curriculum programs, modules, and supplements to commonly used textbooks and core courses
- Distribute project materials for expanded utilization
- Foster partnerships with universities and members of the hydrogen and fuel cell industry
- Encourage university laboratories to support hydrogen and fuel cell research and development
- Develop widely available hydrogen teaching tools

also developed two full-featured portable fuel cell test stations for use with SERC-built fuel cell stacks of up to 500 Watts. The curriculum has been incorporated into thirteen different courses at five University of California and California State University campuses, including Humboldt State University, UC-Berkeley, Sonoma State University, San Francisco State University, and UC Riverside. The project team monitored and evaluated the curriculum implementation process, including pre- and post-participation assessment of student knowledge and faculty surveys. Finally, SERC produced several instructional videos focused on using the kits and test stations. www.hydrogencurriculum.org



CSULA built fuel cell electric vehicle and a Mercedes-Benz F-Cell World Drive car.

California State University- Los Angeles

California State University-Los Angeles (CSULA) developed four courses and associated modules and laboratory curricula in the College of Engineering, Computer Science and Technology (ECST): Renewable Energy and Sustainability, Fuel Cell Systems, Fuel Cell Applications, and the Impact of Technology on the Individual and Society. ECST has also established a Zero Emissions Fuel Cell and Hydrogen Laboratory (ZEFC) to support the curriculum, undergraduate and graduate students’ teaching, and research experiences. The project provided capstone projects for multi-disciplinary teams of senior undergraduate students and fosters partnerships with automotive manufacturers and energy providers.

At CSULA, over 600 students have taken the Impact of Technology on the Individual and Society that contains a module relating to hydrogen and fuel cell technologies. As an additional educational opportunity, CSULA built a \$4.5 M hydrogen station on campus that leveraged the funding provided by DOE. The station includes the latest technologies with the capacity of 60 kg/day,

sufficient to fuel more than 15 vehicles. The station is powered by 100% renewable power.

University of Central Florida and University of North Carolina-Charlotte

The University of Central Florida and the University of North Carolina-Charlotte (UNCC) developed curricula for a hydrogen and fuel cell education program concentration for UNCC’s Bachelor of Science - Engineering Technology program. The Hydrogen and Fuel Cell Technologies education program includes courses and associated laboratory activities and was integrated into UNCC’s accredited mechanical engineering technology and mechanical engineering programs. UNCC established collaborations with over 10 different organizations, companies, and labs including the UNCC energy related centers of the Energy Production & Infrastructure Center, the North Carolina Motorsports and Automotive Research Center, the Infrastructure, Design, Environment and Sustainability Center, the Savannah River National Laboratory, and the Electric Power Research Institute.

University of North Dakota

The University of North Dakota's Renewable Hydrogen Production and Fuel Cell Education Program included development of courses for both the undergraduate and graduate level, case studies to be incorporated into existing undergraduate core courses, and laboratory curricula. Example courses included Hydrogen Production and Storage, Renewable Energy, and Fuels Technology. In addition, the project included development of modules and undergraduate outreach to middle and high school students through the "PowerOn!" Program. Over 200 students were directly impacted by the UND project: over 150 chemical and electrical engineering undergraduate students used the case studies and laboratory experiments, 27 students were involved in senior design projects, 73 students took hydrogen related courses, and 21 students were involved with "PowerOn!" with demonstrations made to over 1,000 middle and high school students. <http://www.h2power.und.edu/>

DOE Outreach Efforts

DOE's hydrogen and fuel cell webinar series includes topics ranging from international fuel cell collaborations to hydrogen production from renewable resources. Free to the public, these webinars are recorded and stored on the DOE web site for future reference. Several thousand have tuned in. Register to receive the Fuel Cell Technologies Office news alerts to receive notifications about upcoming webinars.

Monthly Newsletter

The Fuel Cell Technologies Office newsletter highlights news, funding opportunities, workshops, events, and recent publications. Sent to over 10,000 FCT news and financial opportunities subscribers, this monthly newsletter



recaps past news and events and includes a preview of upcoming activities. The newsletter is free, but registration is required. <http://www1.eere.energy.gov/hydrogenandfuelcells/subscribe.html>

Technical Publications

Visit the web site to access the most recent technical information regarding hydrogen; fuel cells; safety, codes and standards; and hydrogen and fuel cell technology market analysis (http://www1.eere.energy.gov/hydrogenandfuelcells/technical_info.html). This information is provided in documents such as technical and project reports, conference proceedings and journal articles, technical presentations, and web sites. All of this information is free to the public.

Annual Merit Review

The Annual Merit Review (AMR) occurs every May or June and provides an opportunity to learn about the most recent results from the projects funded

by the DOE Hydrogen and Fuel Cells Program. An opening plenary session highlights activities in the four DOE offices (Energy Efficiency and Renewable Energy, Fossil Energy, Nuclear Energy, and Science) that comprise the program. Researchers present their work and answer questions from review panels of technical experts. Sessions focus on hydrogen production, delivery, storage, fuel cells, technology validation, basic energy sciences, safety codes and standards, analysis, market transformation, and manufacturing. Meeting proceedings are posted to the web site. The AMR is free of charge, but registration is required.

References and Notes

1. 2011 Annual Progress Report, H2 Educate! Hydrogen Education for Middle Schools, http://www.hydrogen.energy.gov/pdfs/progress11/ix_14_spruill_2011.pdf