



Hydrogen Energy in Engineering Education (H₂E³)

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Overview



Timeline

- Project start date: 09/15/2008
- Project end date: 09/15/2011
- Percent complete:
 - 20% as of 3/19/09
 - ~35% completion projected by 5/21/2009

Budget

- Total project funding
 - DOE share: \$395,532
 - Contractor share: \$114,876
- Funding received in FY09: \$239,399
- Funding for FY10: \$111,867

Barriers

- As identified in HFCIT MYPP, Section 3.9.5:
- Lack of educated trainers
 - Regional differences

Partners

- Project lead: Schatz Energy Research Center (PI: Peter Lehman)
- UC Berkeley/Institute of Transportation Studies
- Industry partners:
 - Jadoo Power Systems, Inc.
 - Protonex Technology Corp.
 - UTC Power
 - IdaTech LLC



Relevance:

Objectives over 3-year project (2008-2011)

- Deliver effective, hands-on hydrogen energy and fuel cell learning experiences to a large number of undergraduate engineering students at multiple campuses in the California State University (CSU) and University of California (UC)
- Provide follow-on internship opportunities for students at hydrogen and fuel cell companies
- Develop commercializable hydrogen teaching tools including a basic fuel cell test station and a fuel cell/electrolyzer experiment kit suitable for use in university engineering laboratory classes



Relevance

Objectives over project period to date (9/15/2008-present)

- Establish working relationships with interested engineering faculty at University of California, Berkeley (UCB) and Humboldt State University (HSU)
- Begin development of curricula for specific engineering courses at UCB and HSU, including
 - introductory courses (E10 at UCB, ENGR 115 at HSU)
 - engineering thermodynamics at both campuses
 - upper division engineering labs (107B at UCB, ENGR 475 at HSU)
- Design and begin fabrication of two fuel cell test stations for use at UC and CSU campuses
- Design and fabricate 24 benchtop electrolyzer/fuel cell kits for use in engineering laboratories



Relevance

Relevance to DOE Hydrogen Program

National Hydrogen Energy Roadmap (2002)

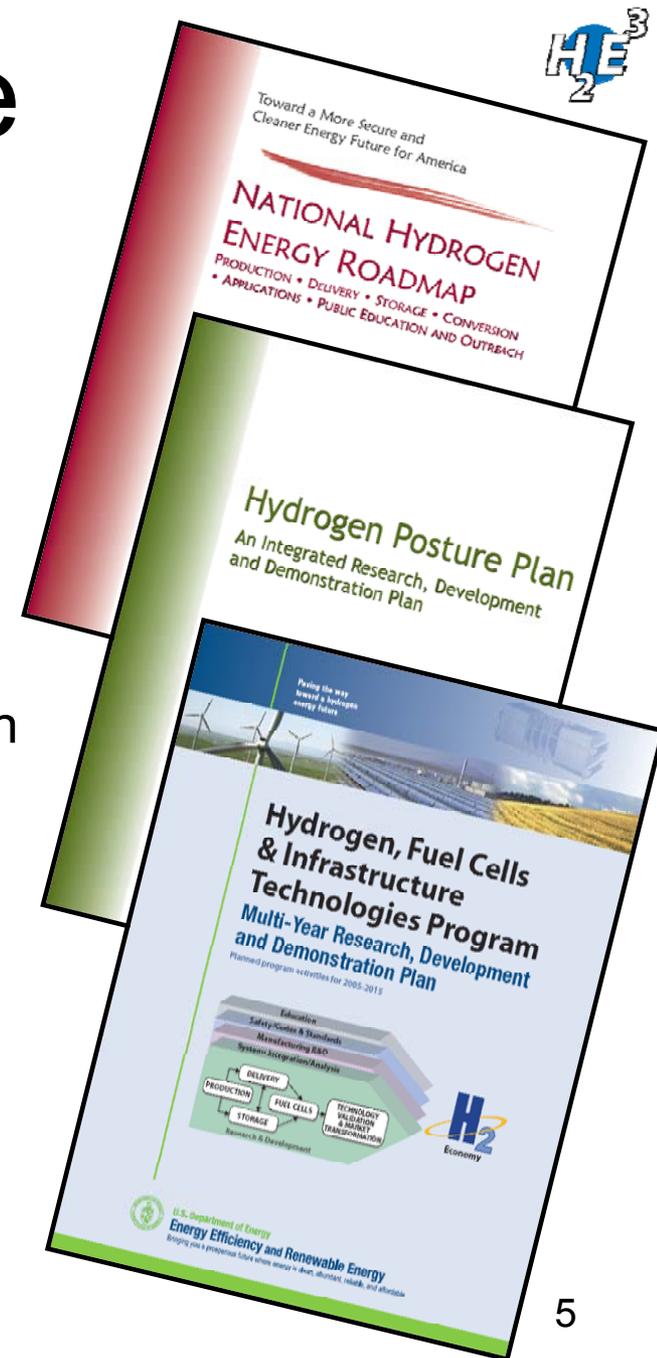
Notes that “hydrogen education programs are minimal” (still the case) and identifies college students and science teachers as target outreach audiences

Hydrogen Posture Plan (2006)

Education efforts need to “facilitate the expansion of hydrogen and fuel cell programs and learning modules at educational institutions, including... universities, for use in training a workforce of...engineers”

HFCIT Multi-Year RD&D Plan (2007)

“Work with university partners to develop and expand hydrogen technology course offerings and facilitate networking among schools with similar programs”





Relevance



Addressing Barriers

- **Lack of educated trainers.** Only a small number of universities in California offer hydrogen and fuel cell-specific learning opportunities for undergraduate engineering students. Even at these campuses, the number of engineering faculty with direct experience using fuel cells remains small, and fuel cell course content is underdeveloped.
- **Regional differences.** California has the advantages of being home to many hydrogen and fuel cell developers and on the leading edge of hydrogen energy infrastructure development. These features call for a special hydrogen energy education effort in California universities that makes use of these existing resources available in close proximity to many campuses.



Approach

- Curriculum
 - Aimed specifically at undergraduate engineering students
 - Modules designed to replace portions of existing course curricula, not adding to total instructional burden for faculty
 - Initial use at UCB and HSU, later replication at other campuses
- Fuel Cell/Electrolyzer Kits
 - Alkaline electrolyzer and PEM fuel cell
 - More robust and higher power capacity than existing kits
- Fuel Cell Test Stations
 - Designed to work with any ~500W internally humidified stack
 - Emphasis on component visibility and pedagogical use in a research grade instrument
- Fueling Station Analysis
 - Study performance & efficiency of Hydrogen Highway fueling facilities
- Industry Internships
 - Follows directly on classroom experience, extends learning for students while grooming engineers for fuel cell industry partners



Technical Accomplishments and Progress: *Curriculum Modules*

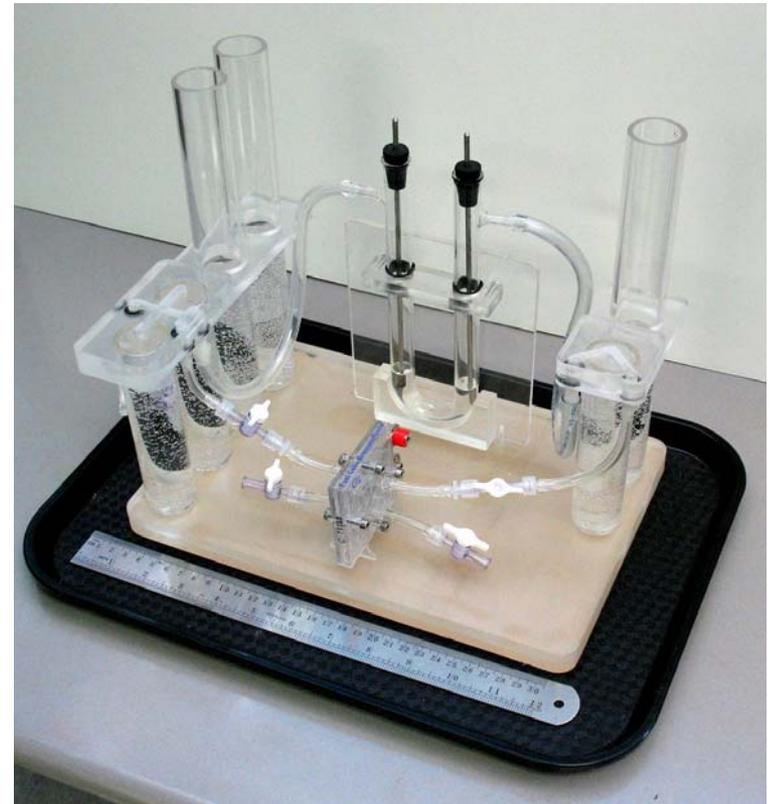
- Identified two introductory engineering classes for initial use of curriculum: E10 at UCB and ENGR 115 at HSU. These courses already include some fuel cell content.
- Recruited interested faculty to review and pilot the curriculum modules in these courses, including:
 - Prof. Robert Dibble, UCB Mechanical Engineering
 - Prof. David Dornfeld, UCB Mechanical Engineering
 - Asst. Prof. Dustin Poppendieck, HSU Environmental Resources Engineering
- Met with faculty to introduce H₂E³ project and solicit their input on module content and lab hardware needs
- Developed draft module outlines, worked with instructors to refine
- Currently working on detailed modules for these two courses



Technical Accomplishments and Progress: *Electrolyzer/Fuel Cell Kits*



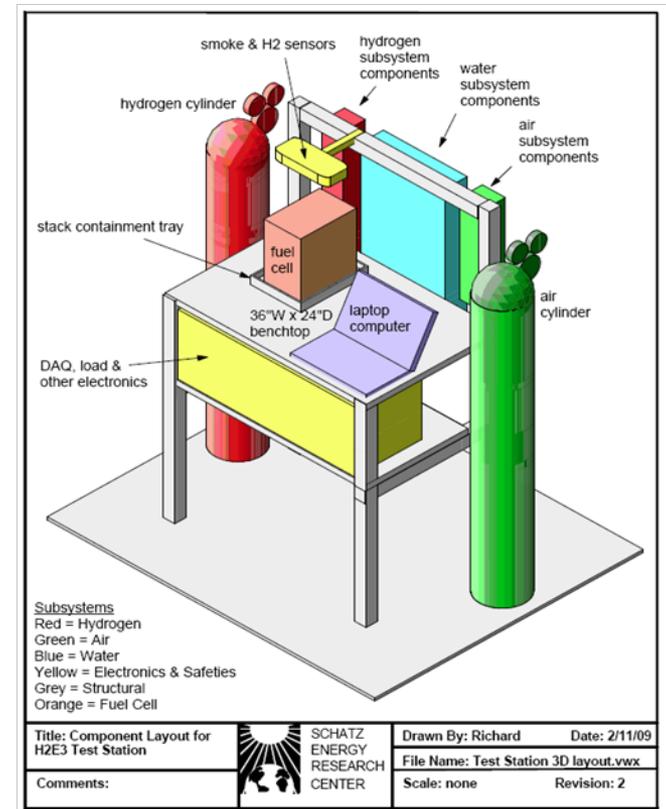
- Basing design on kits developed by SERC for HyTEC project (DOE-funded project in collaboration with Lawrence Hall of Science, UC Berkeley)
- H₂E³ kit design has higher gas generation rate and gas storage capacity, physically more robust
- Prototype design complete; currently fabricating 24 kits with April 30, 2009 completion date.





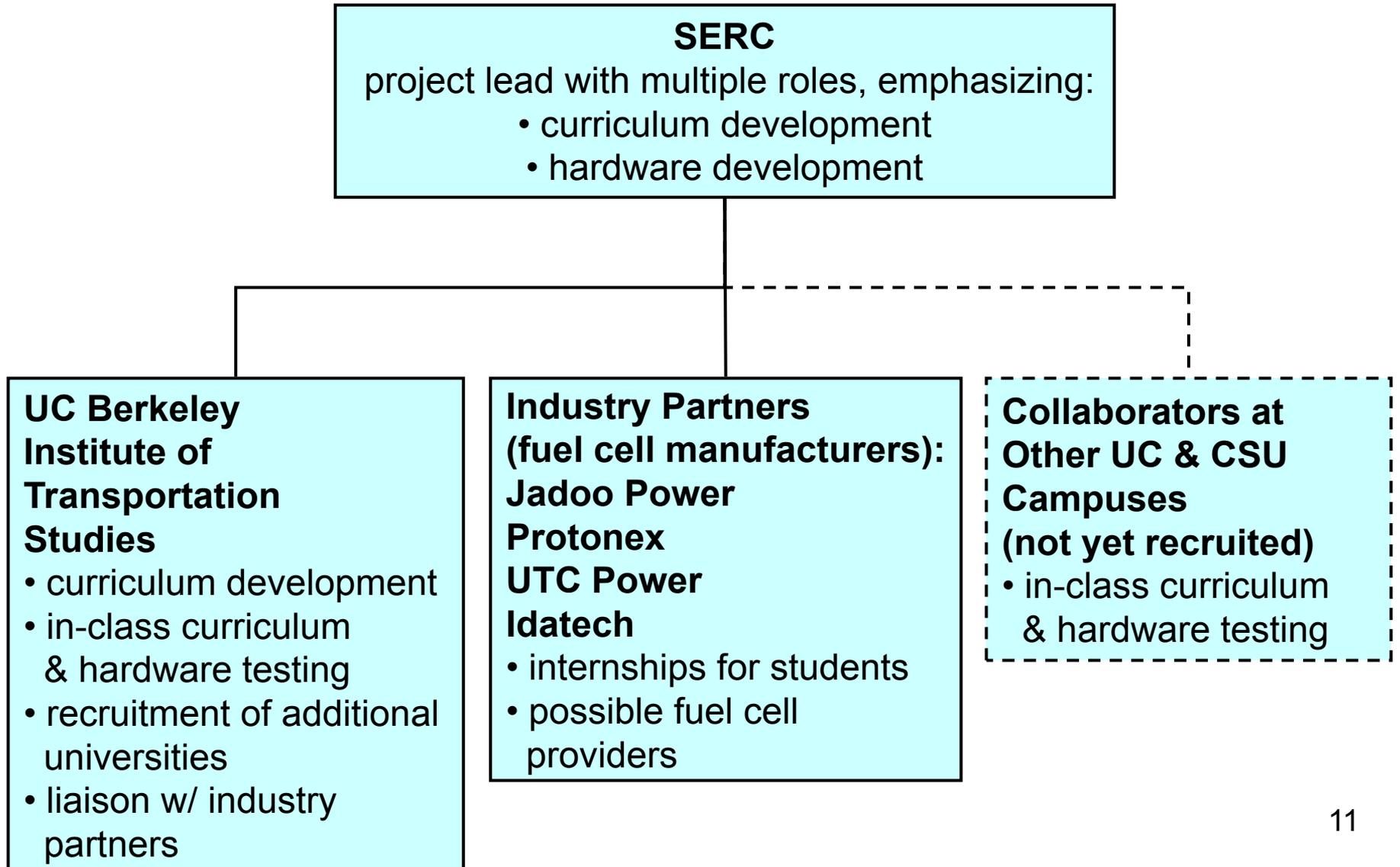
Technical Accomplishments and Progress: *Fuel Cell Test Station*

- Performed market scan of available PEM stacks in ~500W range
- Solicited quotes from all appropriate manufacturers
- Receiving no acceptable bids, decided to build stacks in-house – stacks currently undergoing assembly & testing
- Designed test station based in part on past SERC stations, adjusting design to emphasize component visibility, pedagogical use, and portability
- Have procured components; stations currently under assembly
- Target completion date: August 31, 2009





Collaborations





Proposed Future Work



Remainder of FY 2009:

- Complete all curriculum drafts and distribute for review
- Complete and deliver electrolyzer/fuel cell kits
- Complete, deliver, and install fuel cell test stations
- Train faculty in test station operation and monitor test station performance

FY 2010:

- Conduct pilot testing of curriculum modules in classrooms and labs at UCB and HSU
- Recruit faculty at other UC and CSU campuses
- Develop learning opportunities for participating campuses tied to Hydrogen Highway fueling stations
- Initiate student internships with industry partners



Summary



- Relevance
 - SERC's near-term and long-term project objectives are closely tied to DOE's Hydrogen Program objectives
- Approach
 - Curriculum modules
 - Fuel cell/electrolyzer kits
 - Fueling facility analysis
 - Fuel cell test stations
 - Industry internships
- Technical Accomplishments and Progress
 - Curriculum modules being developed for introductory engineering courses: UCB E10 and HSU ENGR 115
 - Fuel cell/electrolyzer kits and test stations in production
- Collaborations
 - Partners: UCB, industry partners, other UC/CSU campuses, possibly other DOE hydrogen education awardees
- Proposed Future Work
 - FY 2009: Complete all curriculum modules and lab hardware
 - FY 2010: Test modules, recruit faculty at other campuses, launch internships, incorporate H₂ fueling station analysis