DEVELOPMENT OF A RENEWABLE HYDROGEN PRODUCITON AND FUEL CELL EDUCATION PROGRAM

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Overview

Timeline
- Start – September 2008
- Finish – August 2011
- 10% complete

Budget
- Total project funding
  - DOE – $300,150
  - Contractor – $74,966
- Funding for FY09
  - $140,503

Barriers Addressed
- A – Available, objective, technically accurate information
- B- Clear message on technology readiness and fit into National Policy

Targets – undergraduate and graduate scientists and engineers

Partners
- NREL
- EERC
- Proton Energy Systems
- ND Energy Industry

Relevance / Objectives

- The primary objective is to provide formal multi-disciplinary renewable hydrogen production and fuel cell training to undergraduate and graduate level engineers and scientists
- Training at three levels to maximize program benefits
  - Expose large number of students to basics of hydrogen technologies
  - Provide “mid-level” training to moderate number of students
  - Provide detailed training to smaller subset with interest and potential to make significant contributions to technology development
- The ultimate goal is to provide students with technically relevant and objective training in hydrogen energy necessary to support research, development, and demonstration activities in the government, industry, and academic sectors

Approach

Task Overview

- Task 1: Development of Case Studies
- Task 2: New Course Development
- Task 3: Laboratory Experiments in Hydrogen
- Task 4: MS/PhD Teaching Experience
- Task 5: Summer Internship
- Task 6: Hydrogen Seminary Series
- Task 7: Develop Modules for PowerOn!

Approach: Task 1: Development of Case Studies

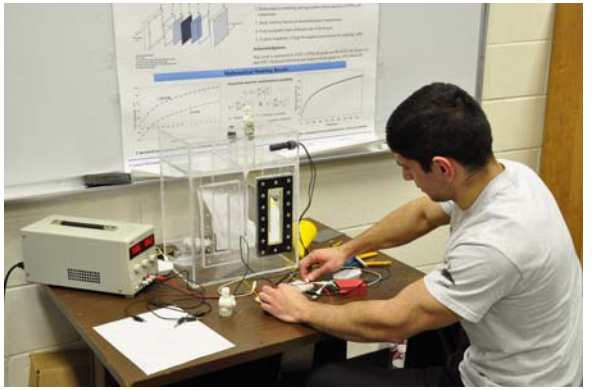
Concept: Imbed exposure to hydrogen technologies into many undergraduate courses

Delivery: Use hydrogen-based applications to support fundamental concepts of course content / introduce to freshman – add depth throughout curriculum

Target Audience: freshmen through graduate level (Intro to Engineering, Mass and Energy Balances, Unit Operations, Thermodynamics, Transport Phenomena, Process Dynamics, Power Systems, Professional Integrity)

Dissemination: UND h2Power web site, NSF sponsored Case Study Teaching in Science website, DOE

Expected Outcome: All UND ChE and EE students exposed to minimal level of training (~60 graduates/yr). Interest students into more detailed study of topic. Material will be available for adaptation by many universities.



Approach: Task 2: New Course Development

Concept: Develop new elective courses

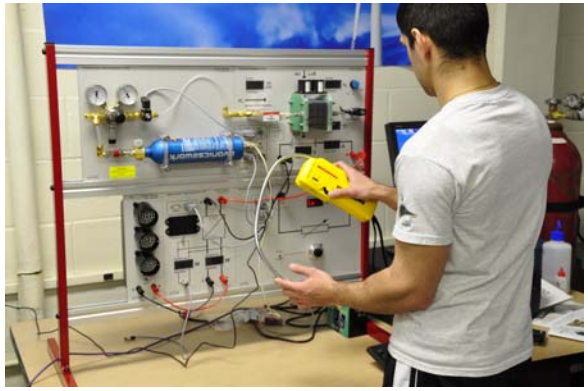
Delivery: Traditional courses: 1) Hydrogen Production, Storage, and Transport; 2) Hydrogen Utilization

Target Audience: junior/senior and graduate students

Dissemination: Traditional on-campus students, UND distance students, canned course available on-line

Expected Outcome: Provide strong foundation allowing graduates to work in hydrogen-related field. Reach relatively large number of students

Approach: Task 3: Laboratory Experiments in Hydrogen



Concept: Enhance student hands-on laboratory experience

Delivery: Present meaningful laboratory experiences at all levels

Target Audience: All ChE and EE majors

Dissemination: Distribute experiments throughout lab sequence. Copies available through UND's h2Power web site and DOE

Expected Outcome: All UND ChE and EE students will have hands-on exposure to electrolysis and fuel cell operations. Labs available for adaptation by other universities

Approach: Task 4: MS/PhD Teaching Experience

Concept: Provide graduate students with experience in teaching hydrogen-related material

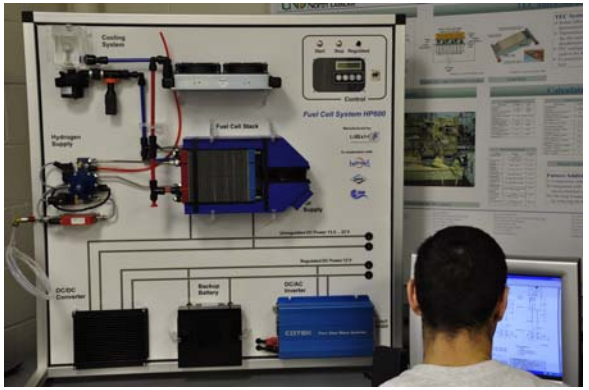
Delivery: MS/PhD students help develop and deliver material from Tasks 1-3

Target Audience: MS/PhD students

Dissemination: Requirement for all students doing hydrogen-related research

Expected Outcome: Teaching combined with research provided through other funding will provide six experts trained at a high level

Approach: Task 5: Summer Internship



Concept: Provide experiential learning to undergraduate students

Delivery: Work with partners to provide internship opportunities

Target Audience: Sophomore and junior level engineering students

Dissemination: Optional for students – will recruit students that have taken UND developed courses and/or involved in UND hydrogen research

Expected Outcome: Five to ten students completing high quality internships preparing them to make meaningful contributions to workforce after graduation

Approach: Task 6: Hydrogen and Fuel Cell Seminary Series

Concept: Utilize experts in field to expose students to latest developments and career opportunities

Delivery: Establish a Hydrogen Energy Seminar Series / fall and spring seminar

Target Audience: All levels

Dissemination: Available to all on-campus students (not just majors). Recorded lectures made available through h2Power web site

Expected Outcome: Exposure of many students to relevant topics / Informal review of UND program for relevance to industry and government goals

Approach: Task 7: Develop Modules for PowerOn!

Concept: Use undergraduate students to develop training modules for middle school

Delivery: Provide guidance to students developing modules for middle school mobile lab – focus two modules on hydrogen (delivery to middle schoolers not funded under this program).

Target Audience: Undergraduate students

Dissemination: Learning experience limited to those involved in program. Middle schoolers will benefit from the projects developed by these students

Expected Outcome: Up to 10 undergraduate students will obtain additional training. At least two learning modules will be developed.

Approach – FY09 Milestones

Task Number	Project Milestones	Task Completion Date				Progress Notes
		Original Planned	Revised Planned	Actual	Percent Complete	
1	Develop and implement six new case studies	05/15/09			10%	Behind Schedule
1	Post six case studies on NSF sponsored web site	08/15/09			0%	Not started.
2	Develop and teach new undergraduate course	05/15/09			10%	Ongoing
2	Develop and teach new graduate level course	05/15/10			25%	Ongoing.
3	Develop and teach 5 new undergraduate laboratory experiments	05/15/09			15%	Ongoing
5	Identify and place two interns	05/15/09			25%	Ongoing
6	Presentation for hydrogen seminar	3/15/09			50%	Ongoing
7	Develop hydrogen related modules for PowerOn	05/15/09			50%	Ongoing

Status as of March 15, 2009

Approach - Evaluation

- ABET assessment tools
  - Student satisfaction with content and delivery
  - Extent exposure prepared for career in hydrogen energy
- Number of students directly impacted
- Number of students pursuing hydrogen related research projects
- Number of students hired to hydrogen related jobs
- Number of web hits for educational content ??

Technical Accomplishments

Task 1 – Case study development

- Work initiated on three case studies:
  - freshman introductory engineering courses
  - chemical engineering mass and energy balances
  - chemical engineering thermodynamics

Task 2 – Development of new courses

- Course content of EE 522-Renewable Energy Systems, Fall 2008, modified to highlight fuel cells and electrolysis
- Two new courses under development
  - Fall 2009: Hydrogen production and storage.
  - Spring 2010: Hydrogen utilization
  - Taught simultaneously at undergraduate/graduate and DEDP

Technical Accomplishments

Task 3 – Laboratory Experiments in Hydrogen

- Hydro-geniuses lab
  - solar cell, single cell PEM electrolyzer, two single cell PEM fuel cells, small resistive load.
  - I-V curves of fuel cell and the electrolyzer, system efficiencies. Fuel cells operated in series and in parallel.
  - EE 522 lecture course / ChE 322 junior lab
- HP 600 – currently developing lab experiments
  - 600 watt PEM fuel cell stack, DC/DC and DC/AC converter, metal hydride storage, electric load, integrated control system
  - in-class demonstrations and new laboratory experiments
- Off-grid instructor
  - 40 watt fuel cell with integrated microprocessor, electronic load, metal hydride storage, and constructor kit.
  - in-class demonstrations and new laboratory experiments

Technical Accomplishments

Task 4: MS/PhD Teaching Experience

- Nilesh Dale, PhD candidate developed new case studies / input into hydrogen production, storage and transportation course

Task 5: Summer Internship

- Two students placed at EERC

Task 6: Hydrogen Seminary Series

- “Characterization of PEM Electrolyzer and PEM Fuel Cell Stacks using Electrochemical Impedance Spectroscopy”
- UND Energy & Environmental Research Center Hydrogen Summit

Task 7: Develop Modules for PowerOn!

- Electrolysis and fuel cell car modules developed

Collaborations

- Partners
  - NREL: technical review of course content
  - Proton Energy Systems: technical input
  - EERC: internships
- Technical Transfer
  - Development of case studies in progress

Future Work – FY09/10

- Implement and publish six case studies
- Teach two new lecture courses
- Implement five new laboratory experiments
- Integrate two new graduate students
- Place two interns
- Sponsor two hydrogen seminars
- Deliver two PowerOn! modules

Summary

Program designed to maximize student exposure

- Case studies and lab experiments expose every ChE and EE student in UND program
- New lecture courses provide in-depth technical training
- Sharing material makes impact world wide
- Involvement of NREL and Proton Energy provide added focus to program