IX.12 Hydrogen and Fuel Cell Technology Education Program (HFCT)

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Fiscal Year (FY) 2011 Objectives

- Develop and implement an accredited engineering technology baccalaureate program in hydrogen and fuel cell technologies (HFCT) at the University of North Carolina at Charlotte (UNCC).
- Prepare students to work as hydrogen and fuel cell technology professionals in government, industry, and academia.
- Prepare program graduates with a mastery of the knowledge, techniques, skills and modern tools related to hydrogen and fuel cell technologies.
- Prepare program graduates with the ability to apply current knowledge and to adapt to emerging applications in the area of hydrogen and fuel cell technologies.
- Disseminate program information and HFCT activities to community colleges, high schools, industrial partners, governmental agencies, other universities, and the public.

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

(F) Mixed messages

Contribution to Achievement of DOE Education Milestones

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

- Milestone 21 – Facilitate development and expansion of college and university hydrogen technology education offerings.

FY 2011 Accomplishments

The HFCT project was successful and accomplished all its goals and objectives as follows:

- All hydrogen and fuel cell courses have been developed and offered at UNCC.
- All laboratories were equipped and experiments were developed and offered.
- A HFCT program concentration was implemented as an option in the UNCC engineering programs.
- Industry collaborations are established.
- The program continues as part of national HFCT educational work, is positioned for continuation, and future activities are planned.

The website for HFCT is part of the UNCC engineering programs as follows: http://et.uncc.edu/about-us/facilities-a-labs/178.html. The UNCC website is http://www.uncc.edu/.

Introduction and Approach

The objective of the Hydrogen and Fuel Cell Technology education program is to develop and deliver an accredited baccalaureate level HFCT educational program at the UNCC. This objective has been successfully accomplished by developing HFCT courses and associated laboratories, teaching the new courses and labs and integrating the HFCT option into the UNCC mechanical engineering technology and mechanical engineering programs. The program has also established ongoing collaborations with the UNCC energy related centers. The HFCT courses have been offered successfully and student enrollments are good. HFCT results have been disseminated and published and the program has cooperative efforts with industries representatives. The HFCT program has addressed DOE goals by supplying readily available, objective and technically accurate information that is available to students, industry and the public. In addition, the program has supplied

educated trainers and training opportunities for the next generation workforce needed for research, development, and demonstration activities in government, industry, and academia.

The UNCC is an urban university that has a student body of 24,700 and offers 92 bachelors, 59 masters, and 18 doctoral programs. The HFCT courses are part of the UNCC College of Engineering. The engineering college has 4,000 students with 950 students in the Mechanical Engineering Department and 850 students in the Engineering Technology Department.

Results

The HFCT project was comprised of the completion of five project tasks and the results of the project activities can be presented as two major areas – course and laboratory development and offerings and program recruitment, promotions and collaborations.

I. Course and Laboratory Development and Offerings

Over the project period, the primary activity has been the development and offering of the HFCT courses and accompanying laboratories. This process has taken three years with the courses first being developed and then offered each year over the timeframe. The 11 courses that were developed and offered are presented in Table 1.

These courses are described as follows.

1. **Applied Energy Systems – ETM 4220.** The Applied Energy Systems course is an introduction course to topics of energy, work and thermal systems and processes. The course presents fundamentals of thermodynamics, electricity and nuclear technologies and the process of obtaining electricity from solar, wind, biomass and geothermal energy sources. The course also includes the efficiency of the different energy sources and effects on the environment. A one semester-long group project is assigned to students.
2. **Analysis of Renewable Energy – ETGR 3000-01 & ETME 4250.** The Renewable Energy course is an upper level course that looks at analysis of renewable energy systems. Topics include well-to-wheels analysis, lifecycle energy and emissions and total cost. Students learn skill sets, methodologies and tools needed to analyze various technologies on a consistent basis for a given application.
3. **Combined Hydrogen Production & Storage with Labs – ETGR 3000-02, MEGR 3090-020 & ETME 4260.** The Combined Hydrogen Production & Storage with Labs course presents basic concepts and principles of hydrogen technologies to include properties, usage, safety and a fundamental understanding of hydrogen storage and production technologies. The three laboratories are:
4. **Laboratory 1: Hydrogen and Fuel Cell Experiment.** Purpose: To calculate well-to-wheel values.
5. **Laboratory 2: Hydrogen as an Energy Carrier.** Purpose: To calculate power output from photovoltaics input to electrolyzer and the power outputs from fuel cell. Find photovoltaics max current and max power point locations on a voltage-current (V-I) curve.
6. **Laboratory 3: Methanol Fuel Cell.** Purpose: To draw V-I curve, interpret characteristic curve, enter operating voltage and current of the motor in V-I characteristic curve, draw power-current diagram, and calculate motor's power consumption and enter the values in power vs. current diagram.

TABLE 1. HFCT Courses and Course Offerings

Course	Prefix	Credit Hours	Offered	Future Offering
Applied Energy Systems	ETM 4220	4	Spring 2009	
Analysis of Renewable Energy Systems	ETGR 3000-01 and ETME 4250	3	Spring 2010	Spring 2011
Combined Hydrogen Production & Storage with Labs	ETGR 3000-02, MEGR 3090-020 and ETME 4260	3	Summer 2010	Summer 2012
Lab 1: Hydrogen and Fuel Cell Experiment	Part of ETGR 3000	-	Summer 2010	Summer 2012
Lab 2: Hydrogen as a Energy Carrier	Part of ETGR 3000	-	Summer 2010	Summer 2012
Lab 3: Methanol Fuel Cell	Part of ETGR 3000	-	Summer 2010	Summer 2012
Fuel Cell Tech 1	ETGR 3000-M01 MEGR 3090-M03 and ETME 4270	3	Fall 2010	Fall 2011
Lab 1: Assembly MEA FC	Part of ETGR 3000	-	Fall 2010	Fall 2011
Lab 2: Fuel Cell Performance Testing	Part of ETGR 3000	-	Fall 2010	Fall 2011
Lab 3: FC Performance as function of temp. & humidity	Part of ETGR 3000	-	Fall 2010	Fall 2011
Senior Design Course	MEGR 3255-001 ETGR 4100-EC1	4	Spring 2010, Fall 2010, Spring 2011.	Fall 2011

7. **Fuel Cell Tech I with Labs– ETGR 3000-M01 & MEGR 3090-M03 & ETME 4270.** The Fuel Cell Tech I with Labs course presents basic concepts and principles of fuel cell technologies to include chemistry, thermodynamics, electrochemistry, cell components, operating conditions and fuel cell systems. The three laboratories are:
8. **Laboratory 1: Assembling a 3-layer Membrane Electrode Assembly (MEA) Fuel Cell.** Purpose: To learn and practice the assembly of a proton exchange membrane (PEM) fuel cell.
9. **Laboratory 2: Fuel Cell Performance Testing.** Purpose: To acquire understanding and experience in employing electrochemical test methods to determine the performance characteristics of a hydrogen PEM fuel cell, to become acquainted with the concepts of fuel cell reactant consumption rates and utilization and the associated calculations and to evaluate the performance of PEM fuel cell as a function of O_2 concentration and stoichiometry with an emphasis on their effects on electrode kinematics, mass transport limitations and cell resistance.
10. **Laboratory 3: Performance of a hydrogen PEM fuel cell as a function of temperature and humidity.** Purpose: To implement basic experimental and analysis techniques that demonstrates and characterizes the performance of a hydrogen PEM fuel cell as a function of temperature and reactant gas humidity levels.
11. **Senior Design Course – MEGR 3255-001 & ETGR 4100-EC1.** The Senior Design course is a two semester for four hours "capstone" or final year experience intended to integrate a students' academic training with real-world engineering projects and community partners.

II. Promoting the Program through Advertisement, Recruiting Students and Outreach Plans

The objectives of this task are to recruit students, to promote the HFCT program and to disseminate information on the program and its activities in order to form collaborations with industrial partners, governmental agencies and other universities. Details follow.

Recruit Students: In an effort to recruit as many students as possible, the team has hosted seminars and visited community colleges and high schools. These efforts have concentrated on community colleges that currently have technology programs with potential to transfer students directly into the HFCT option of the Bachelor of Science in Engineering Technology program.

Program Promotion and Collaborations: Closely tied with recruiting students is the promotion of the HFCT program with various organizations and groups in order to receive external recognition and support. Industry collaborations are also closely tied with these promotion efforts. Industry, national laboratories and technical organizations were visited under this sub task.

Conclusions and Future Directions

The HFCT education project has successfully developed courses and associated laboratories, taught the new courses and labs and integrated the HFCT option into the accredited mechanical engineering technology and mechanical engineering programs at the UNCC. The HFCT courses have been offered successfully and student enrollments are good.

Future plans include the continued offering and evaluation of the developed courses and labs at UNCC, continued project promotion and collaborations with industry, university and other organizations, the development of web-based HFCT courses, the extension to a Master of Science program and the development of a research component.

FY 2011 Publications/Presentations

1. Sleiti, A. (2011, February). Hydrogen and Fuel Cell Education for Engineering and Engineering Technology Disciplines, 2011 Conference for Industry and Education Collaboration (CIEC*), San Antonio, TX.

2. Blekhman, D., Keith, J., **Sleiti, A.**, Cashman, E., Lehman, P., Engel, R., Mann, M., & Salehfar, H. (2010). National Hydrogen and Fuel Cell Education Program Part I: Curriculum, ASEE Annual Conference & Exposition, Louisville, KY.

3. Blekhman, D., Keith, J., **Sleiti, A.**, Cashman, E., Lehman, P., Engel, R., Mann, M., & Salehfar, H. (2010). National Hydrogen and Fuel Cell Education Program Part II: Laboratory Practicum, ASEE Annual Conference & Exposition, Louisville, KY.