

## X.6 Bachelor of Science Engineering Technology Hydrogen and Fuel Cell Program Concentration

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### Objectives

- Develop and implement an accredited baccalaureate level hydrogen and fuel cell technologies (HFCT) university program.
- Prepare students to work as hydrogen and fuel cell technology professionals in government, industry, and academia.
- Prepare program graduates to demonstrate an appropriate mastery of the knowledge, techniques, skills and modern tools related to hydrogen and fuel cell technologies.
- Prepare program graduates to demonstrate an ability to apply current knowledge and adapt to emerging applications of hydrogen and fuel cell technologies.
- Disseminate program information and activities to community colleges, high schools, industrial partners, governmental agencies and universities.

### Technical Barriers

This project addresses the following technical barriers from the Education section (3.9.5) of the

Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

- (A) Lack of Readily Available, Objective, and Technically Accurate Information
- (B) Mixed Messages

### Contribution to Achievement of DOE Education Milestones

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

- Milestone 21 – Launch new university hydrogen education program. (4Q, 2009)

### Accomplishments

- Hydrogen and fuel cell courses have been developed and offered at University of Central Florida (UCF) and at University of North Carolina at Charlotte (UNCC).
- During 2009, program course development and offering was transferred to the UNCC because of academic program reductions at UCF. Administration of program remains at UCF.
- Courses that have been developed and offered are:
  - ETM 4220 Applied Energy Systems – offered in Spring 2009 at UCF.
  - ETGR 3000 Analysis of Renewable Energy Systems – offered in Spring 2012 at UNCC.
  - ETGR 3000-002 and MEGR 3090-020 Combined Hydrogen and Production Storage – offered in Summer 2010 at UNCC.
  - Three laboratory experiments (Hydrogen Fuel Cells, Hydrogen as an Energy Carrier and Methanol Fuel Cells) were developed and offered as part of the Combined Hydrogen Production and Storage course.
  - Thermodynamics, Energy Management and Fluid Dynamics Lab courses have been offered at UNCC to complement the HFCT courses.
- Students from all engineering majors and from engineering technology can register for the above courses.



## Introduction

The objective of the HFCT program is to develop and implement a baccalaureate level educational program that will supply the need for educating students that will comprise the next generation workforce needed for HFCT research, development, and demonstration activities within government, industry, and academia. The project includes the development and delivery of undergraduate courses at the Engineering Technology Department within an accredited Bachelor of Science in Engineering Technology (BSET). Courses will be offered at UNCC and the laboratory facilities that are developed will be located at UNCC.

Current public knowledge and awareness levels of hydrogen and fuel cells need improvements and have prevalent misunderstandings of hydrogen properties giving negative opinions about the safe use of hydrogen as an energy carrier. The Fuel Cell Technologies Education subprogram seeks to facilitate near-term market transformation and future commercialization by providing technically accurate and objective information to key target audiences, including: state and local government representatives, potential end users, safety and code officials, and local communities. Undergraduate and graduate students, university faculty, and middle and high school teachers and students comprise another important audience, as they are our nation's future researchers, scientists, engineers, technicians, and technology users.

## Approach

The approach for achieving the objectives of the project is to develop, offer, and sustain a BSET or BSE program that contains courses for an HFCT concentration. The course offerings were started in Spring 2009 and have continued through the present time. The original courses were offered at UCF and the courses and laboratories are now being offered at UNCC. Efforts to promote the program include advertisement, recruiting students and outreach plans, visits to community colleges and other institutions, publications and presentations in professional meetings

Future efforts will include the evaluation of the HFCT program offerings using a wide range of qualitative and quantitative methods and triangulation procedures to assess and interpret a multiplicity of information. Data will be gathered during all phases of the program to provide timely formative feedback to/from project stakeholders on implementation, participants' perspectives about the activities and what they may have learned, and how goals and objectives are being met. Formative evaluation will provide recommendations and allow for design modifications to improve course impact answering questions like: Is the program providing high-quality experiences? What

impact is the program having on participating students' attitude, interest, confidence and knowledge related to hydrogen and fuel cell technologies? Is faculty using project-developed content to replace some of their standard lessons?

## Results

This project is comprised of completing three major tasks – developing courses, offering the developed courses, and promoting the program through advertisement, recruiting students and outreach plans. The results for these tasks follow.

### Developing Courses

The courses that have been developed are:

Hydrogen Production and Handling	3 Credit Hours
System Analysis of Renewable Energy Systems	3 Credit Hours
Analysis of Renewable Energy Systems	3 Credit Hours
Combined Hydrogen Production and Storage	3 Credit Hours

Other course development activities that will be offered in the Fall 2010 semester are:

Fuel Cell Technologies I	3 Credit Hours
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Work has also begun on development of two one credit hour courses called hydrogen lab and fuel cell lab. These will be offered at a time to be determined in the future. The course outlines for the two labs are:

#### Hydrogen Laboratory Schedule

Introduction and Hydrogen Laboratory Safety  
Gas Cylinder and Safety Handling  
Instrumentation I  
Instrumentation II  
Material Balance  
Characterization of Chemical Hydride Materials  
Hydrogen Liquefaction Experiments  
Student Project

#### Fuel Cell Laboratory Schedule

Introduction and Laboratory Safety  
Fuel Cell Chemistry and Efficiency  
Electrochemistry  
Fuel Cell Components and Assembly  
Operating Conditions I  
Operating Conditions II  
Fuel Cell Diagnostics  
Student Project

In addition, development has begun on a new senior design course.

### Offering the Developed Courses

The course ETM 4220 Applied Energy Systems was offered in Spring 2009 at UCF. The course was taught by Dr. Sleiti as part of the HFCT program. Thirty-seven students took the course.

The course ETGR 3000-Analysis of Renewable Energy Systems was offered to UNCC students in the Spring Semester 2010. This course was taught by Dr. Sleiti. The course included lectures, field visits to energy related sites and power plants and a semester-long student project. Examples of the student projects are: Fuel Cell Applications in Transportation, Applying Geothermal to Recreation Facility, Solar Panels for UNC Charlotte, and Wind Generation Plant Feasibility Study. The course was offered to all students in the College of Engineering with 22 students originally registered for the class – 20 are seniors and two are juniors. Two students withdrew from the course and 20 students successfully completed the course.

The syllabus and course analysis forms for Analysis of Renewable Energy Systems course are available, but not presented here. The syllabus includes the course title, name of the instructor, textbook used for the class, prerequisites and co-requisites, goals/objectives, course outcomes, term project description, course grading policy, course website, course policies, and a 16-week schedule of topics that are covered. The Course Analysis Form includes course assessment, program outcome assessment, recommendations and overall course observations and comments and student grades.

The course ETGR3000-002 and MEGR3090-020 – Combined Hydrogen Production and Storage was offered in the Summer Semester of 2010 to both Engineering Technology Students and Mechanical Engineering students. Five students completed the course. The syllabus and course analysis forms for the course are available. The experimental labs that were taken by the students as part of the courses are:

- Experiment 1 – Hydrogen Fuel Cells
- Experiment 2 – Hydrogen as an Energy Carrier
- Experiment 3 – Methanol Fuel Cells

Each experiment was designed to be completed within 2.5 hours and the students are required to submit a report including description, procedure, results, discussion and conclusion.

Other existing courses in the engineering technology program that complement the HFCT courses and that are being offered at UNCC are Thermodynamics, Energy Management and Fluid Dynamics Lab. Outlines for those three courses are available. Note is made that these courses are taught jointly by several instructors and they have more than one section. These courses and instructors are as follows:

Course	Section	Instructor	Semester
ETME 3143-002 Thermodynamics	002	Patty Tolly	SP 2010
ETME 3143-002 Thermodynamics	002	Dan Hoch	SP 2010
ETGR 4245: Energy Management	001	Nan Byars	SP 2010
ETGR 4245: Energy Management	001	Dan Hoch	SP 2010
ETME3151: Fluid Mechanics Lab	L01	A. Sleiti	SP 2010
ETME3151: Fluid Mechanics Lab	L02	R. Priebe	SP 2010
ETME3151: Fluid Mechanics Lab	L03	T. Jarrell	SP 2010
ETME3151: Fluid Mechanics Lab	L04	Dan Hoch	SP 2010

These courses will be repeated during subsequent semesters and will be available to students from all engineering and engineering technology majors.

### Promoting the Program through Advertisement, Recruiting Students and Outreach Plans

During the past year, the following activities have been completed:

#### A. Visits to community colleges:

The team has been following up with and scheduling meetings with community colleges that currently have technology programs with potential to transfer students from those community colleges with associate of science degrees to the HFCT program. Visits to Central Piedmont Community College and participation in the Wake Tech Spring Fling have been done.

#### B. Visits to local industry:

The team established collaboration with Savannah River National Laboratory (SRNL) during a SRNL visit to UNCC on February 18, 2010 and have had collaborations with the following companies/organizations:

- North Carolina Hydrogen Economy and Advancement Team
- North Carolina Fuel Cell Alliance
- The Advanced Vehicle Research Center of North Carolina
- Duke Energy
- AREVA
- Electric Power Research Institute
- Shaw Group
- Siemens

#### C. Contacting Universities:

The team is continuing to contact universities around the country through e-mails to make the academic community aware of the HFCT program.

**D. Other Activities:**

The UNCC team is participating in high school competition and coordinating program information sessions each semester.

**Project Management and Reporting**

The major activity in the project management area was the termination, because of financial problems, of the Bachelor of Engineering Technology program at UCF and the changing of employment of the project Co-PI, Dr. Ahmad Sleiti, to the BET program at University of North Carolina at Charlotte. Following this change, the decision was made for UCF to retain project management and to subcontract project implementation to UNCC. A subcontract was issued to UNCC to be the provider for the HFCT courses beginning on January 4, 2010 and ending on March 30, 2011.

**Conclusions and Future Directions**

At the present time, course development and offering are 65% complete, and promotion is 80% complete. The overall project is estimated at 75% complete and there are no problems or issues that will delay completion.

The plans for finishing the program activities are:

- Continue offering the developed courses at UNCC for the HFCT concentration.
- Continue evaluation of courses offered.
- Continue development of HFCT courses and labs.
- Continue working on promoting the program and recruiting students.
- Attend seminars and meetings to disseminate program results.

**FY 2010 Publications/Presentations**

1. Blekhman, D., J. Keith, **A. Sleiti**, E. Cashman, P. Lehman, R. Engel, M. Mann, and H. Salehfar, 2010, "National Hydrogen and Fuel Cell Education Program Part I: Curriculum," ASEE Annual Conference & Exposition, Louisville, KY.
2. Blekhman, D., J. Keith, **A. Sleiti**, E. Cashman, P. Lehman, R. Engel, M. Mann, and H. Salehfar, 2010, "National Hydrogen and Fuel Cell Education Program Part II: Laboratory Practicum," ASEE Annual Conference & Exposition, Louisville, KY.
3. Sleiti, A., "Bachelor of Science – Engineering Technology Hydrogen and Fuel Cell Education Program Concentration", ASME 2009 International Mechanical Congress and Exposition (IMECE) IMECE2009-12314, November 13–19, 2009, Lake Buena Vista, FL.

**Special Recognitions & Awards/Patents Issued**

It is noted that paper #1 was recognized by the American Society for Engineering Education Energy Conversion and Conservation Division as recipients of "Best Paper Award".