VI.E.1 Florida Hydrogen Initiative*

Edwin A. Levine (Primary Contact),
Stephen C. Adams
Florida Hydrogen Initiative, Inc.
422 Rehwinkel Road
Crawfordville, FL 32327
Phone: (850) 559-2606
E-mail: executivedirector@h2florida.org

DOE Technology Development Manager:
John Garbak
Phone: (202) 586-1723; Fax: (202) 586-9811
E-mail: John.Garbak@ee.doe.gov

DOE Project Officer: David Peterson
Phone: (303) 275-4956; Fax: (303) 275-4788
E-mail: David.Peterson@go.doe.gov

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*Congressionally directed project

Background

The Florida Hydrogen Initiative, Inc. (FHI) is a nonprofit corporation that uses its resources to aid the development of a robust Florida-based hydrogen industry. The FHI seeks to develop Florida's hydrogen infrastructure by:

- Brokering partnerships for applied technology demonstration projects throughout Florida;
- Sponsoring research in the production, storage, and use of hydrogen fuels; and
- Facilitating technology transfers between the public and private sectors to create, build, and strengthen high-growth potential, high technology companies.

The FHI is a grantee of the U.S. Department of Energy Hydrogen Program and in the past year has funded and administered three projects:

1. The Hy-Tech Rest Area Project is being conducted by EnerFuel, Inc, which will demonstrate the use of hydrogen derived from citrus waste in a fuel cell located at a Florida Turnpike rest area;
2. The development of location strategies for the initial hydrogen refueling infrastructure that would be required to support consumer demand and a hydrogen-powered car rental fleet for Orlando, FL. This project is being conducted by Rollins College;
3. Designing and building a museum exhibit to tour 18 Florida science museums to inform and educate the public about hydrogen's potential and use as an energy carrying medium and the future role of hydrogen in energy distribution. This project is being conducted by the Orlando Science Center.

Each of the three projects' annual reports is provided in the following.

I. Hydrogen Technology (Hy-Tech) Rest Area Project

Michael Fuchs
EnerFuel, Inc.
1501 Northpoint Parkway, Suite 101
West Palm Beach, FL 33407
Phone: (561) 868-6720, Ex. 239

Start Date: October 1, 2006
Projected End Date: September 30, 2008

Objectives

- Design, construct, and demonstrate a 10 kW_{net} proton exchange membrane fuel cell (PEMFC) stationary power plant operating on citrus derived methanol.
- Achieve and electrical energy efficiency >32%.
- Demonstrate and transient response time <3 ms.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan

(C) Performance
(D) System Thermal and Water Management
(G) Start-Up and Shut-Down Time and Energy/ Transient Operation

Contribution to Achievement of DOE Technology Validation Milestones

This project will contribute to the achievement of the following DOE Technology Validation milestones from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 35: Validate $1.60/gge hydrogen cost from biomass and $3.10/kg for renewable/electrolysis at the plant gate.** The project will assess the sources and economics of bio-derived methanol in Florida.

Accomplishments

- Completed direct methanol fuel cell (DMFC) vs. indirect methanol fuel cell (IMFC) trade study.
- Selected fuel cell system demonstration site.

Introduction

One of Florida's most important agricultural-based industries is citrus and using citrus waste as a source of fuel for the generation of electrical power would be a significant benefit to the environment and provide an additional feedstock for fuel cell H_2. The EnerFuel project will determine the effects of citrus derived methanol on long-term fuel cell power plant performance and assess requirements for future projects and commercialization. By designing, constructing, and operating a 10 kW_{net} stationary fuel cell power plant at the Florida Turnpike's Turkey Lake Service Plaza to provide electrical power to the rest facilities, the project will demonstrate the value of the citrus waste as a viable source of fuel for the generation of electrical power.

Approach

EnerFuel is identifying sources of citrus derived methanol, designing and demonstrating its transportation and storage, and the safety protocols required for the use of citrus derived methanol. They will obtain all of the required permits and prepare the demonstration site for power plant installation, including the electrical interface and methanol storage. They will design, construct, test and benchmark the fuel cell power plant and install and operate it at the Florida Turnpike Turkey Lake Service Plaza. The analysis of the fuel cell power plant under operation will determine the overall electrical efficiency, document system transient response to load changes, determine the effects of citrus derived methanol on long-term power plant performance, and assess requirements for future commercialization.

Results

The project selected the demonstration site and secured the approval and support of the Florida Turnpike Authority for the fuel cell power plant to provide the electrical power for the rest area facility. The locations of the power plant and the methanol storage container were tentatively selected and the survey of the electrical interface requirements was begun. EnerFuel completed the trade study to compare the attributes of DMFC or IMFC approaches and determined that an indirect methanol fuel cell is the best alternative for achieving the project's goals (Table 1).

TABLE 1. DMFC vs. IMFC Trade Study Results

Performance Criteria	DMFC	IMFC	Basis
Overall System Cost		X	10 kW DMFC system is ~579% more expensive than IMFC system
Stack Cost		X	DMFC stack is an order of magnitude more expensive than an equivalent H-PEMFC stack
Stack Size		X	10 kW DMFC stack will contain ~3 times as many cells as an equivalent H-PEMFC stack
System Complexity	X		DMFC system has nine major components. IMFC has at least 13
Overall System Efficiency		X	IMFC overall system efficiency is ~30%. DMFC is ~20%
Energy Density		X	Methanol/water tank is major contributor to lower DMFC power density. DMFC fuel tank is ~20 times larger than for an IMFC system with same energy storage
Emissions		X	Both systems are susceptible to emitting trace methanol amounts. Nonetheless, lower DMFC overall system efficiency means greater CO_2 emissions will be released from the DMFC system. Therefore, in this category IMFCs performed better

Conclusions and Future Directions

- The project has selected the technical approach for using citrus waste derived methanol for the fuel cell power plant and has selected a function and location for the power plant.
- In the coming year EnerFuel will design, build, deliver and install the fuel cell power plant and analyze it under operation at the Turkey Lake Service Plaza.

II. Location Strategies for the Initial Hydrogen Refueling Infrastructure in Florida

Lee Lines (Primary Contact), Rollins College;
Michael Kuby, Arizona State University
Department of Environmental Studies, Rollins College

1000 Holt Avenue
Winter Park, FL 32789
Phone: (407) 628-6377
E-mail: llines@Rollins.edu

Start Date: January 1, 2006
Projected End date: June 30, 2007

Objectives

- Develop a model for optimal location of a system for hydrogen refueling stations.
- Use the model to recommend location strategies for refueling stations at two scales: statewide network and Orlando network.
- Investigate the feasibility of a hydrogen rental car business based at the Orlando International Airport.

Technical Barriers

This project addresses the following technical barrier from the Hydrogen Delivery section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Lack of Hydrogen/Carrier and Infrastructure Options Analysis

Contribution to the Achievement of DOE Hydrogen Delivery Milestones

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

- **Milestone 2: Identify cost-effective options for hydrogen delivery infrastructure to support the introduction and long-term use of hydrogen for transportation and stationary power. (4Q 2007)** The development and use of the model will support the cost-effective and timely location of hydrogen refueling stations in the Orlando area and the development of the entire statewide refueling systems network.

Accomplishments

- Developed software and databases.
- Ran models under several scenarios and at different scales.
- Surveyed car renters and interviewed key people in rental and hydrogen industries.
- Wrote and submitted Report #1 on Optimal Refueling Infrastructure Strategies.
- Wrote and submitted Report #2 on Feasibility of Hydrogen Rental Car Business.

Introduction

The location of hydrogen refueling stations is a non-trivial problem as the costs of each station are significant and the number of hydrogen-fueled internal combustion engines (ICE) and fuel cell vehicles (FCV) is currently small. A barrier to consumer purchases of hydrogen fuel cell vehicles is the availability of refueling stations and the limited range of current FCVs. Determining where the refueling stations should be located to maximize the number of trips that can be refueled given a reasonable driving range will greatly assist the adoption of FCVs by reducing consumer concerns about the availability of H_2 and increase the probability that investors will be willing to provide and operate refueling stations. The project developed models for the optimal location of a system of hydrogen refueling stations for the Orlando area and for a statewide network. Orlando, Florida, is the hub of a major tourist industry and a FCV car rental business, located at the Orlando International Airport, could be supported by a small number of refueling stations. A 2006 NREL study of barriers found that the fleet market is "not sufficient to generate sufficient sales for vehicle manufacturers," and concluded that "finding a way to transition from fleets to consumers is equally critical." A hydrogen rental car fleet could be ideal for this purpose.

Approach

The project team built models using operations research and geographic information system (GIS) data. The model did not assume or hard wire clustering/connecting, but those strategies did emerge from the models. The model assumes that drivers "stop along their way" to refuel, thus trips consist of the shortest path, in minutes, through the network from every origin to every destination. For Orlando this resulted in a 102x102 matrix of flows. The project team surveyed 435 car renters at the Orlando International Airport to determine where they were going and to identify any concerns they might have about renting a FCV, including safety, willingness to detour for refueling, and how much more they would be willing to pay to rent a FCV. Interviews were also conducted with key people in the car rental and hydrogen industries to determine their perceived barriers and solutions to the timely adoption of FCVs.

Results

The survey data determined that four refueling stations could serve 85% of the visiting car renters' trips: Orlando International Airport, Disney World,

Downtown Orlando, and the Kennedy Space Center. The Orlando model and analysis showed that locating refueling stations at funnel points on the road network, will capture trips from many origins to many destinations while not stranding assets at other locations. Locating the first 10–15 refueling stations on freeways would be followed by locating stations at smaller funnel points in suburban areas. The results also showed that spreading stations evenly across the region is not cost-effective for capturing trips. Ten stations, located in accordance with the model, could intercept 53% of Orlando trips (Figure 1). The statewide analysis suggests a strategy similar to that being developed in California, beginning with clusters of refueling stations in the major cities, followed by bridging stations between them to facilitate inter-city trips. The first two clusters should be in the I-4 corridor from Tampa to Orlando (including stations for rental car customers) and the Miami-West Palm Beach corridor.

Conclusions and Future Directions

- The modeling showed that the key assumption for locating refueling stations is to maximize trips or vehicle miles traveled with the given number of stations and the range for the fuel cell vehicle.
- To build the Florida infrastructure's network of stations, clusters should be built in Miami–Palm Beach and Tampa–Orlando before connecting clusters.
- For the Orlando infrastructure, key freeway and arterial junctions should be the sites for the first 10–15 stations.
- The renter survey found that a refueling station at the Orlando International Airport, and three other stations, could serve 85% of the renters.
- Orlando is an ideal location for the first hydrogen fuel cell rental car business.

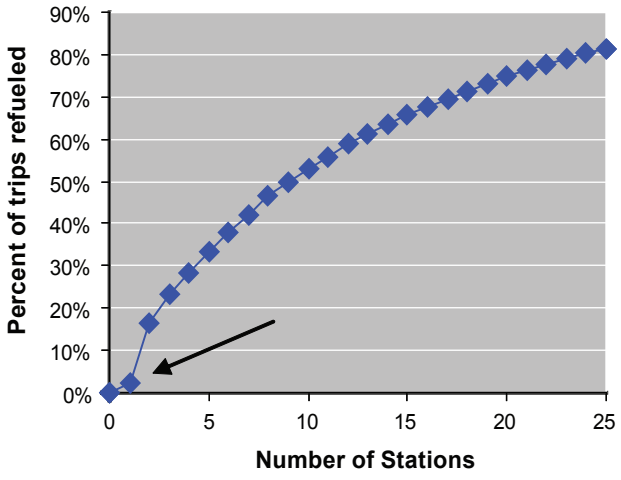

FIGURE 1. Tradeoff Between the Number of Refueling Stations and Percentage of Trips Intercepted for the Orlando Region

- Benefits would be felt nationally as tourists renting FCVs could generate publicity and attention.
- The rental of a FCV would allow interested members of the public to "test drive" the vehicle with low financial risks while the car rental agency assumes the responsibility for maintenance, initial training, and capital costs.
- A hydrogen rental car fleet would be an ideal way to transition from fleets to consumers, as recommended by NREL [1].
- Based on positive attitudes expressed in car renters' survey data, planning for a FCV car rental business could begin now.

FY 2007 Publications/Presentations

1. Location Strategies for the Initial Hydrogen Refueling Infrastructure in Florida, Michael Kuby, Lee Lines, Ron Schultz, Zhixiao Xie, Seow Lim, Jong-Guen Kim, and James Clancy. 2007 NHA Conference, San Antonio, Texas. Submitted to *Proceedings of the National Hydrogen Association* (April 11, 2007).

References

1. M.Melendez. "Transitioning to a Hydrogen Future: Learning from the Alternative Fuels Experience," National Renewable Energy Laboratory. Technical Report No. NREL/TP-540-39423 (2206).

III. Assessment of Public Understanding of the Hydrogen Economy Through Science

Brian Tonner
Orlando Science Museum
777 East Princeton Street
Orlando, FL 32803
Phone: (407) 514-2011
E-mail: Btonner@osc.org

Start Date: July 31, 2006
Projected End Date: September 30, 2008

Objectives

- Design, build, and tour a museum quality interactive hydrogen exhibit and "HydroPedia" based on survey assessments of current public and key target audiences' understanding of hydrogen science and engineering.
- Increase public understanding of hydrogen science and engineering.

Technical Barriers

This project addresses the following technical barriers from the Education section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Lack of Readily Available, Objective, and Technically Accurate Information

(B) Mixed Messages

(C) Disconnect Between Hydrogen Information and Dissemination Networks

(E) Regional Differences

Contribution to Achievement of DOE Education Milestones

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

- **Milestone 11: Develop set of introductory materials suitable for a non-technical audience. (4Q 2006)** The interactive exhibit, "HydroPedia", and "H2NOW" website are designed for non-technical audiences and will be exhibited in Orlando and at 16 regional and national science museums and centers.
- **Milestone 32: Evaluate knowledge and opinion of key target audiences and progress toward meeting objectives. (4Q 2009)** The project has completed preliminary survey of Florida teachers, school children, and home-school families to determine content knowledge and attitudes towards alternative energy with embedded questions related to hydrogen as a fuel and will conduct additional surveys throughout the project lifetime.

Accomplishments

- Assessed public understanding of energy issues in general and hydrogen in particular.
- Determined affective and objective learning goals of the exhibition.
- Completed first stage selection of interactive and display elements of the exhibition.
- Completed two design charettes to determine story content of the exhibit and down-select from three story concepts to a single best concept.
- Completed first stage selection of technology, displays, and interactives.
- Designed data gathering interactives and tested two prototypes of electronic survey tools in actual audience response settings.

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Introduction

Increasing knowledge and awareness levels of hydrogen and fuel cells and correcting common misunderstandings of hydrogen's properties in order to create positive opinions about the safe use of hydrogen as an energy carrier are essential to the wide-spread adoption and commercialization of hydrogen. Translating scientific and engineering concepts into a publicly accessible format that can be viewed and accessed in an interesting and interactive manner is a challenging and import task.

Approach

Working with I.d.e.a.s. at Disney MGM Studios, the Orlando Science Museum (OSM) is designing, building, and preparing a touring exposition that will be installed initially at the OSM and then tour at 16 regional and national museums. In addition to the touring expo, a "wiki" style web resource for hydrogen education, "H2NOW" a web portal that will be a clearinghouse for the exhibit and events, and a "Hydropedia" that will be an on-line forum for information and dialog will be established. The "curriculum" of the expo and the on-line resources will be based on the results of surveys of key target audiences, including teachers, school-aged children, and home-schooling families.

Results

Completed first stage design of the touring hydrogen exposition, working with I.d.e.a.s. at Disney MGM Studios and the web site design for the "Hydropedia". Completed the first set of surveys of target audiences - teachers, school children, and home-schooling families - to determine their baseline knowledge. Determined the affective and objective learning goals of the exhibit. Potential interactives were identified, based on consultation with Florida Solar Energy Center personnel, Orlando Science Center staff, and the science center industry. The first stage selection of interactives display elements of the exhibition was completed. Prototyped exhibit elements and determined the state of the art for interactive hydrogen and alternative energy exhibits in order to develop a list of potential off-the-shelf components that that can be purchased or adapted from existing designs. Designed data gathering interactives and tested two prototypes of electronic survey tools in actual audience response settings.

Conclusions and Future Directions

- The Orlando Science Museum will fabricate the exhibit and following its installation in Orlando, will manage its touring at 16 regional and national museums.
- The content and presentation of the exhibition and the web resources will be reviewed by science and museum experts, such as the Florida Solar Energy Center.
- As an on-going activity, additional surveys of target audiences will be refined and expanded throughout the project lifetime.