The Florida Hydrogen Initiative

April 12, 2007

Project # TVP11

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The Florida Hydrogen Initiative (FHI) is a non-profit organization incorporated under the laws of the State of Florida to move Florida to the forefront of the nation's hydrogen economy. The Florida Hydrogen Initiative uses its resources to aid the development of a robust Florida-based hydrogen industry thereby establishing Florida as the cornerstone of a southeastern hydrogen hub. The nonprofit corporation is comprised of public leaders, university researchers, citizens, and industry representatives.

The Florida Hydrogen Initiative, Inc. develops Florida's Hydrogen Infrastructure by:

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

Three Projects Funded by FHI

The FHI is a grantee of the US Department of Energy Hydrogen Program and has funded three projects:

1. The HyTech 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 in Florida that would be required to support consumer demand and a hydrogen powered car rental fleet for Orlando, Florida. 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.

DOE Hydrogen Program

Hydrogen Technology (HyTech) Rest Area

Michel Fuchs

EnerFuel, Inc.

5/15/2007

TVP11 – FHI 2005-02

HyTech Rest Area
Project Overview

Timeline

- Start – Oct 2006
- Finish – Mar 2008
- 8% complete

Budget

- Total project funding
  - DOE - $550K
  - Contractor - $632K
- Funding received in FY06
  - $14.6K
- Funding for FY07
  - $413K

Barriers

- Performance
- System Thermal and Water Management
- Startup and shut-down time and Energy/Transient Operation
  - **Targets**

	2003	**2005**	**2011**
Electrical Energy Eff.	30%	32	40
Transient response time	<3ms	<3ms	<3ms

Partners

- **Anderson Consulting** – Identify citrus derived methanol source
- **Technology Research & Development Authority** – Assist in demo site preparations

Objectives

Overall	• Design, construct and demonstrate a 10kW$_{net}$ PEMFC stationary power plant operating on citrus derived methanol • Achieve an electrical energy efficiency >32% • Demonstrate transient response time <3ms
2006	• Demonstration site identification •Trade study to identify best PEM technology for project, i.e. direct methanol fuel cell or standard PEMFC (utilizing reformer)
2007	• Identification of citrus derived methanol source • Identification of fuel processor supplier • Identification of fuel cell stack supplier

Plan & Approach

- **Task 1: Citrus derived methanol**
  - Identify source
  - Test methanol for compatibility w/ reformer
  - Work out transportation and storage logistics
  - Identify/establish safety protocols for use
- **Task 2: Demo site preps**
  - Obtain permitting
  - Identify electrical interface requirements
  - Establish location for fuel cell power plant and methanol storage
- **Task 3: Fuel cell power plant design**
  - DMFC vs. standard PEMFC trade study
  - Identify fuel cell stack source
  - Identify reformer source
  - Design system through modeling
- **Task 4: Power plant construction and testing**
  - Construct power plant
  - Test and debug power plant
  - Benchmark performance
- **Task 5: Power Plant installation and demonstration**
  - Operate system for 3 months
  - Install power plant at demo site

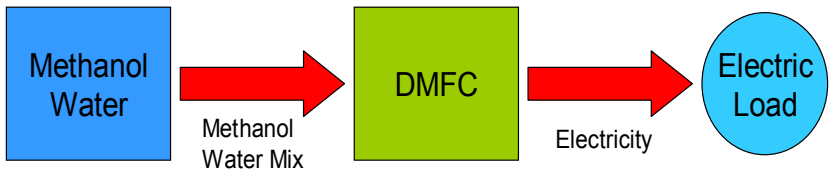
Accomplishments

- **<u>Fuel cell system demonstration site</u>**
  - Selected the Florida's Turnpike Enterprise's Turkey Lake Service Plaza as demonstration site
  - Met with Florida's Turnpike Enterprise to secure their approval and support
  - Tentatively selected location of power plant and methanol storage container
  - Began survey of electrical interface requirements to rest area facility

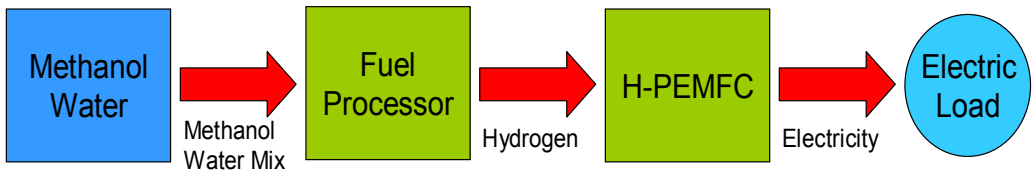
Accomplishments

- **DMFC vs. IMFC (indirect methanol fuel cell) trade study**
  - Compared the attributes of direct methanol fuel cell technology to indirect methanol fuel cell technology (standard PEMFC)
  - Determined IMFC paired with a fuel processor to be the best alternative to achieving project goals

DMFC System



IMFC System



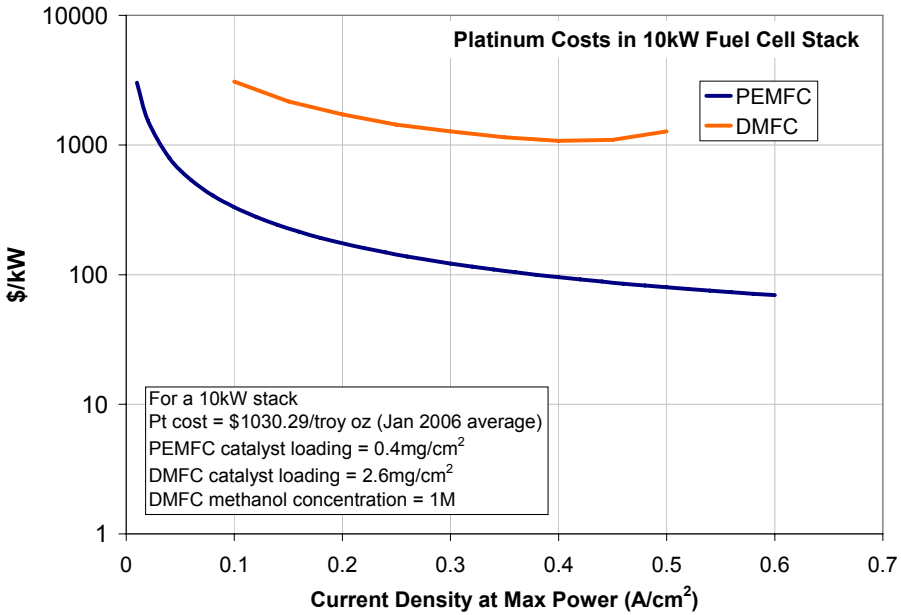
Accomplishments

- **DMFC vs. IMFC trade study results**

Performance Criteria	DMFC	IMFC	Basis
Overall System Cost		**X**	10kW 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**	10kW DMFC stack will contain ~3 times as many cells as an equivalent H-PEMFC stack
System Complexity	**X**		DMFC system has 9 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

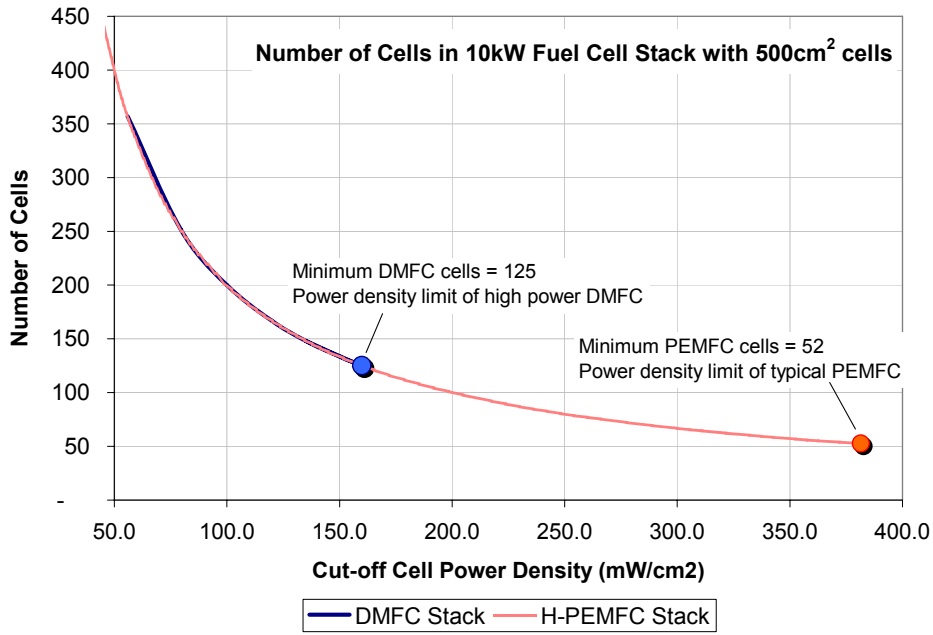
Accomplishments

- **DMFC vs. IMFC trade study results**



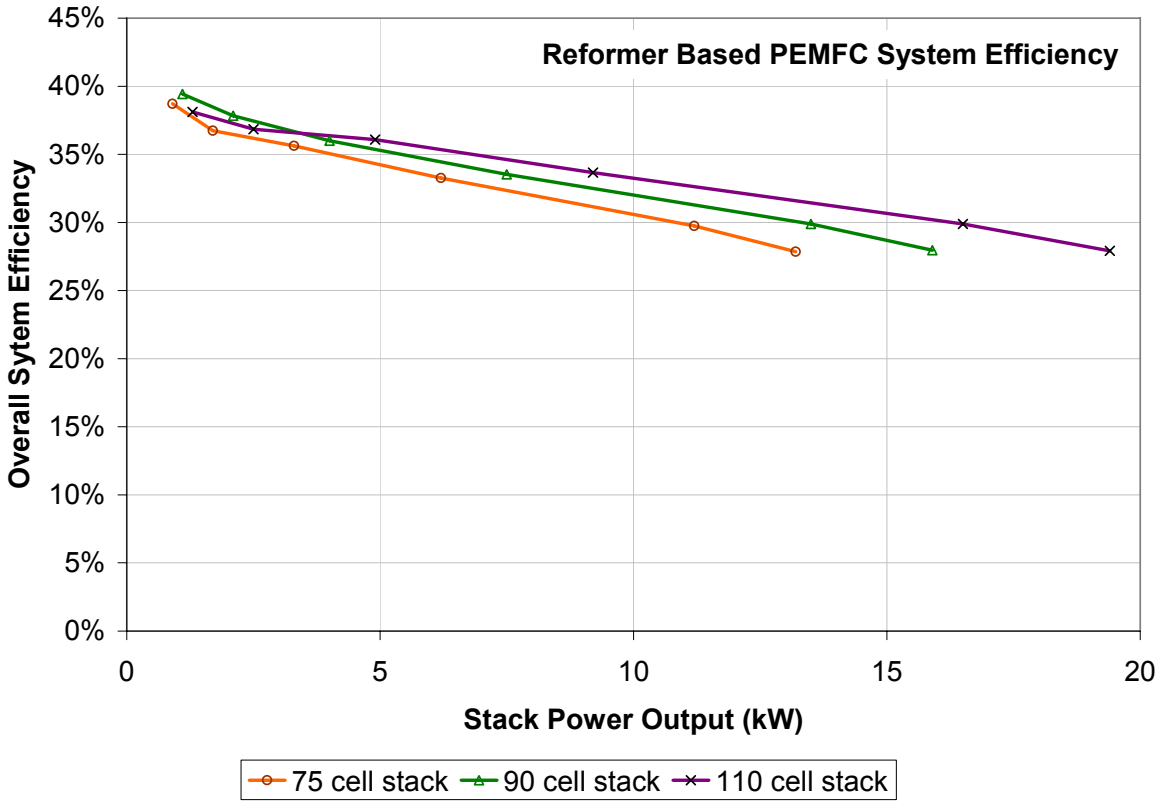
Cost of platinum in DMFC and PEMFC stacks. DMFC performance based on best single cell data reported by Los Alamos National Laboratory. PEMFC performance as reported by Ballard Power Systems

Number of cells required for a 10kW DMFC and PEMFC stack. The cell active area is 500cm2



Accomplishments

- **DMFC vs. IMFC trade study results**



Efficiency of an IMFC system for various stack sizes operating at 60oC

Future Work (FY07 – FY08)

- **FY07**
  - Design fuel cell power plant
  - Select citrus Methanol source
  - Test methanol for suitability with fuel processor
  - Implement safety procedures for methanol handling, transportation and storage
  - Prepare demo site for power plant installation, i.e. permitting, electrical interface, methanol storage
- **FY08**
  - Construct, test and bench mark power plant
  - Power plant ready for delivery by end of December 2007
  - Install power plant at Turkey Lake Service Plaza demo site
  - Power portion of service plaza for period of 3 months

Future Work (FY07 – FY08)

- **<u>FY08 – Analysis of fuel cell power plant under operation</u>**
  - Determine overall electrical efficiency
  - Document system transient response to load changes
  - Determine effects of citrus derived methanol on long term power plant performance
  - Assess requirements for future projects and for future commercialization

HyTech Rest Area
Project Summary

- **Relevance**
  - Demonstrate the value of citrus waste as a viable source of fuel for generation of electrical power
- **Approach**
  - Construct and demonstrate a stationary fuel cell power plant operating off citrus derived methanol
- **Technology collaboration**
  - Participation with Florida citrus ethanol producers and the state or Florida
- **Proposed future projects**
  - Develop commercial stationary fuel cell power plant design for use with citrus and food waste derived methanol

Location Strategies for the Initial Hydrogen Refueling Infrastructure in Florida

May 15, 2007

Dr. Lee Lines, Department of Environmental Studies, Rollins College
Dr. Michael Kuby, Department of Geography,Arizona State University

TVP11 – FHI 2005-01

Overview

Timeline

- Start: August 1, 2005
- End: June 30, 2007
- 80 percent complete

Budget

- Total project funding
  - DOE share: $160K
  - University share: $40K
- $33K received in FY06
- $80K received in FY07

Barriers

- Barriers addressed
  - Infrastructure barriers
  - Analysis barriers
  - Market barriers
  - Financial/cost barriers

Partners

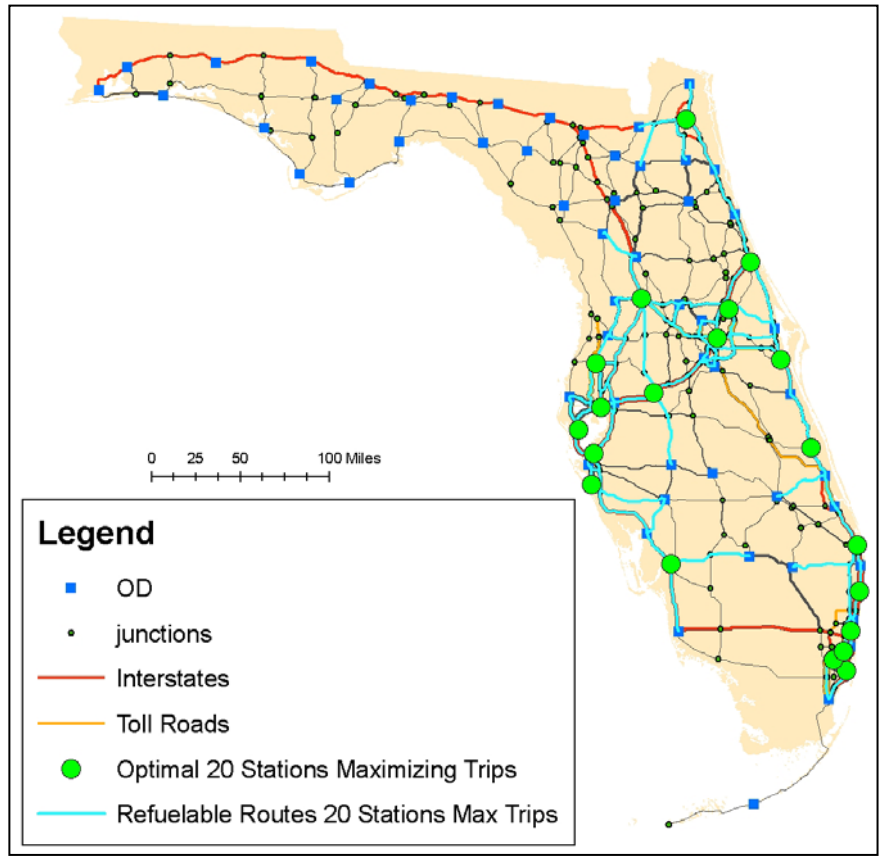
- Rollins College (Winter Park, FL), Arizona State University, Florida Atlantic University
- Data from Florida DOT, Michigan DOT

Objectives

- **Develop a model for optimal location of a system of hydrogen refueling stations**
- **Use the model to recommend location strategies for refueling stations at two scales:**
  - **Statewide network**
  - **Orlando area network**
- **Investigate the feasibility of a hydrogen rental car business based at the Orlando Intl. Airport**
  - **Survey of car renters**
  - **Analysis of barriers and solutions**
- **These objectives are linked by the infrastructure barrier—most car renters in Orlando could be served by very few stations**

Approach

- The model integrates operations research and GIS.
- Locates a given number of stations to maximize the number of trips (or vehicle miles traveled) that can be refueled given a reasonable driving range between stations.
- Model assumes drivers "stop along their way" to refuel: thus, trips consist of the shortest paths (in minutes) through the network from every origin to every destination.
- For Orlando, trip table consists of 102x102 matrix of flows, from FDOT. For Florida, we used a 74x74 matrix.
- Clustering/connecting is not hard-wired into model, but these strategies emerge (see example).



- Can be applied at urban, state, or national scale.

Accomplishments

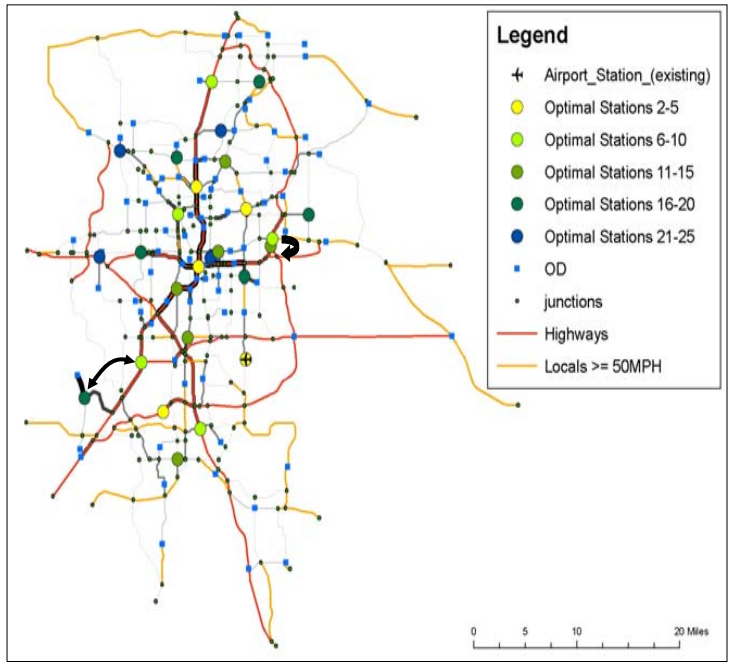
- **Developed software and databases.**
- **Ran models under several scenarios and at different scales.**
- **Surveyed car renters and interviewed key people in rental and hydrogen industries.**
- **Interim Report #1 on Optimal Refueling Infrastructure Strategies.**
- **Interim Report #2 on the Feasibility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

Statewide Analysis

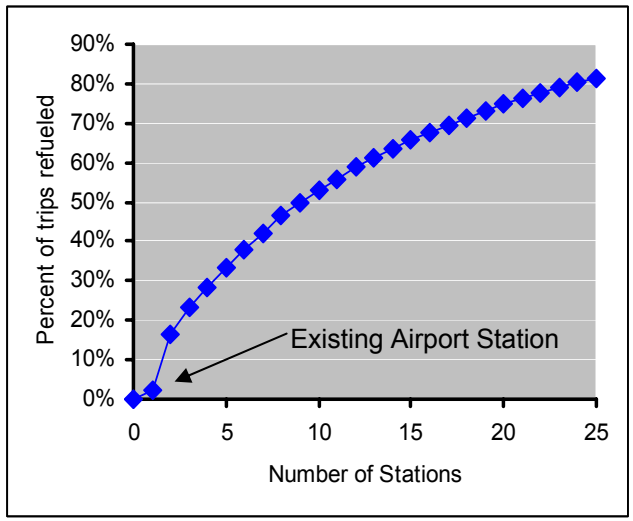
- **Preliminary statewide analysis suggests a strategy somewhat similar to that being developed in California, beginning with clusters in the major cities, followed by bridging stations between them to facilitate longer inter-city trips.**
- **Cluster 1: Miami-West Palm Beach**
- **Cluster 2: rapidly-urbanizing I-4 corridor from Tampa to Orlando**
- **When to build bridging stations depends on characteristics of each unique network**

Orlando Analysis

- **Locate stations at funnel points on road network, capturing trips from many origins to many destinations while not stranding assets at other stations.**
- **Locate early stations mainly on freeways.**
- **Beyond the first 10-15 stations, put stations at smaller funnel points in suburban areas.**
- **Spreading stations evenly across region is not cost-effective for capturing trips.**
- **Ten stations could intercept 53% of Orlando trips (see graph).**

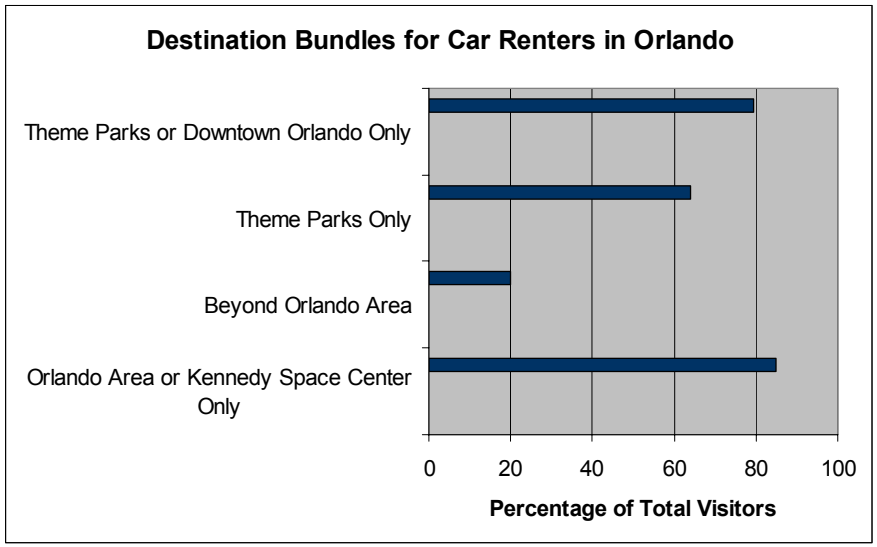


Optimal 25 stations in the Orlando area, maximizing trips with 100-mile range. Substitutions shown by arrows.



Survey of Car Renters

- **Surveyed 435 car renters.**
- **Four stations could serve 85% of trips:**
  - **Airport (existing)**
  - **Disney**
  - **Downtown**
  - **Kennedy Space Ctr**
- **Almost half are willing to pay more for H2 car and detour up to 5 miles for refueling.**
- **Other concerns identified.**



Barriers (Solutions) for Rental-Car Business

- **Target markets (greens, tech, HOV use)**
- **Consumer concerns (safety, insurance, maintenance, refueling)**
- **Supply of cars (stepped approach ICE-to-FCV, publicity benefits)**
- **Resale of used vehicles (environmental and health groups, state, car clubs, past customers)**
- **Synergies abound (with Disney, NASA, State of Florida, car companies, refueling infrastructure)**

Future Work

- **Run more model scenarios.**
- **Combine and integrate recommendations for Orlando, statewide, and tourist networks.**
- **Discuss partnering with Disney, NASA, EV Rentals, and others.**
- **Submit two journal articles and Final Report.**

Project Summary

- ***Modeling:*** **maximize trips or VMT served with given number of stations and range.**
- ***Florida Infrastructure:*** **Cluster in Miami-Palm Beach and Tampa-Orlando before connecting clusters.**
- ***Orlando Infrastructure:*** **Key freeway and arterial junctions for first 10-15 stations.**
- ***Renter Survey:*** **Three added stations could serve 85% of renters.**
- ***Rental-Car Feasibility:*** **Orlando is an ideal location for the first H2 rental business. Benefits will be felt nationally as H2 rental cars generate publicity and word-of-mouth. First experience with hydrogen could be a positive one, with customer support, centralized maintenance, and conveniently located refueling stations. Supply of reasonably priced cars will determine *when* it is feasible, but start planning now.**

Assessment of Public Understanding of the Hydrogen Economy Through Science

May 15, 2007

The Orlando Science Museum

TVP11 – FHI 2005-03

Overview

- Timeline
  - July 1, 2006 – December 30, 2007
- Barriers
  - Assessing current public understanding of hydrogen as an energy carrying medium
  - Increasing public understanding of the future role of hydrogen in energy distribution
  - Translating scientific and engineering concepts into a publicly accessible format
- Partners
  - US Department of Energy
  - Florida Hydrogen Initiative
  - US Department of Education
  - Florida Solar Energy Center
  - University of Central Florida
  - I.d.e.a.s. at Disney MGM Studios
- Budget
  - Total: $255,020.
  - DOE: $199,500.
  - OSC: $55,520.

H2NOW!
A touring exposition for public education

Objectives

Outcome objectives

- Regional and nationally touring hydrogen "expo"
- Assess current public understanding about hydrogen science and engineering
- Increase public understanding of hydrogen science and engineering

Sample learning outcomes

- Hydrogen is not a source of energy. It stores energy that is produced by other means, such as solar, geothermal, hydroelectric, coal, gas or nuclear energy.
- Experts believe that our energy budget for the future will be met by a combination of energy sources, including nuclear, coal, petroleum, hydrogen, and gas.
- One major benefit of using hydrogen to fuel transportation vehicles is that hydrogen produces no carbon dioxide when it is burned.

Approach

Deliverable objectives

- Touring exposition (hands-on exhibits; hydrogen powered competitions)
- Web site portal as clearinghouse for exhibit and events
- The “Hydropedia”, an online forum for information and dialog

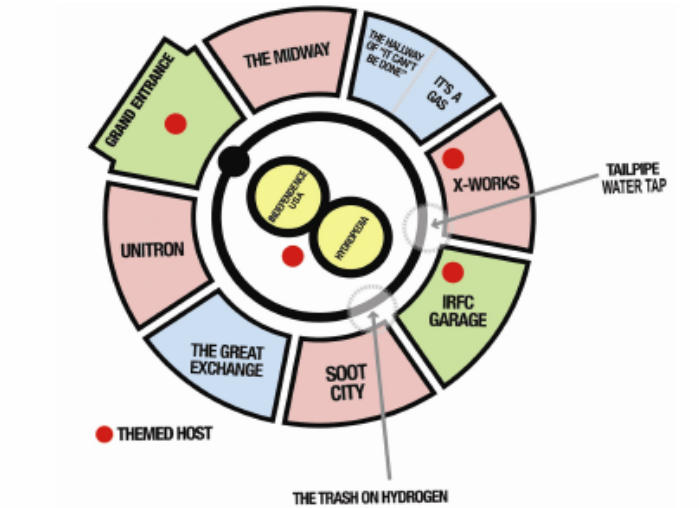
Accomplishments

STATUS: First stage design complete. Fact checking underway.

Web site design for “H2NOW”

Plan for the “HydroPedia”: an online “wiki” resource for hydrogen education.

Baseline event and exhibition design.



Future work

- Complete scientific review by outside experts
- Implement web site and “hydropedia”
- Fabricate exhibit
- Initiate tour

Hydrostick

Summary

- An exciting event of national scale—the "H2NOW" hydrogen exposition
- Acclaimed design team
- Touring through science centers, museums, and outreach organizations

H2NOW
THE 2007 HYDROGEN X-CHANGE