EVermont Renewable Hydrogen Fueling System

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PDP28

Overview

Timeline

- Start Date April 2004
- End Date December 2006
- 30% Complete

Barriers

- Q. Cost
- R. System Efficiency
- S. Grid Electricity Emissions
- T. Renewable Integration

Budget

- Total Project $937K
  - 50% Cost Share
- $ 0K Funding in FY04
- $932K Funding in FY05
- $ 35K Funding in FY06

Partners (Subcontractors)

- Northern Power Systems
- Proton Energy Systems

Suppliers/Site Owner

Air Products, Quantum

Burlington (VT) Dept. of Public Works

Objectives

Develop Advanced PEM Electrolysis Fueling Station Technology

- Implementation of Advanced PEM Cell Stack Technology
- Implementation of Advanced Power Conversion Technology
- Emphasis on Efficiency and Low Cost
- Incorporate Renewable Wind Generated Power
- Procure a Hydrogen Fueled Vehicle for Testing up to 350 bar onboard H_2 Storage and to Validate the Station

Hydrogen Prius

Advanced PEM Cell Stack Advanced Power Supply
Extreme Cold Weather Capable

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Approach

R&D and In-house Testing

- Build and Test Full Scale **Advanced** PEM Electrolysis Cell Stack Hardware
- Build and Test Full Scale **Advanced** Power Electronics Hardware
- Assemble and Test Full Scale 12 kg/day PEM Electrolysis System with the Advanced Hardware
- In-house test of entire Fueling System

System Design and Engineering

- Preliminary Design for High System Efficiency, Low Cost, Renewable Energy, and Extreme Cold Temperatures in Vermont
- Final Design and Fueling Station Site Layout

Site Preparation, Installation, and Commissioning

- Site Plan, NEPA Documentation, Permitting
- Training for Safety, Operation, and Maintenance

Testing, Monitoring, and Analysis

- Measure or calculate H_2 output, power consumption, efficiency, wind turbine output, fueling characteristics, seasonal/temperature related performance
- Vehicle fill times, performance (km/kg), and maintenance requirements

Accomplishments

R&D and In-house Testing of Advanced PEM Electrolysis Cell Stack Barriers Q (Cost) and R (Efficiency) addressed

Table 3.1.8a. Technical Targets: Water Electrolysis[1]

Characteristics		Units	250 kg/day Refueling Station[2]			Small-Scale Refueling[3]: 2 kg/day		
			Calendar Year			Calendar Year		
			2003 Status	2005 Target	2010 Target	2003 Status	2005 Target	2010 Target
Power Conversion	Cost[8]	$/kg	0.38	0.28	0.08	0.32	0.21	0.12
	Energy Efficiency	% (LHV)	95	96	98	95	96	98
Cell Stack	Cost	$/kg	0.64	0.48	0.25	1.37	0.79	0.30
	Energy Efficiency	% (LHV)	72	76	81	65	70	79
Balance of Plant[4]	Cost	$/kg	0.13	0.13	0.07	0.21	0.14	0.10
	Energy Efficiency	% (LHV)	98	98	98	97	97	98
Compression[5]	Cost	$/kg	0.47	0.32	0.16	0.34	0.21	0.09
	Energy Efficiency	% (LHV)	90	92	95	83	90	93
Storage and Dispensing	Cost[8]	$/kg	0.19	0.14	0.06	0.21	0.16	0.12
	Energy Efficiency	% (LHV)	99	99	99	99	99	99
Electricity[7]	Cost	$/kg	1.90	1.80	1.60	4.10	3.30	2.80
Total	Cost[8]	$/kg	4.70	3.80	2.50	7.40	5.30	3.80
	Energy Efficiency	% (LHV)	60	65	73	49	58	70

- 2-4 kg H_2/day per stack
- Explicitly Addresses DOE Efficiency and Cost Targets for Electrolysis Cell Stacks
- 8-10% Cell Stack Energy Efficiency Improvements Anticipated
- 20-30% Cell Stack Cost Reduction Anticipated
- Potentially decrease H_2 Fueling Costs by $0.74/kg from present costs
- Testing in Progress. Test Completion Scheduled for 5/31/05

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Accomplishments

R&D and In-house Testing of Advanced Power Electronics
Barriers Q (Cost) and R (Efficiency) addressed

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- 4-12 kW Power Converter (2-4 kg H_2/day)
- Explicitly Addresses DOE Efficiency and Cost Targets for Power Conversion
- 7-11% Power Conversion Energy Efficiency Improvements Anticipated
- 30-50% Power Conversion Cost Reduction Anticipated
- Potentially decrease H_2 Fueling Costs by $0.78/kg from present costs
- Testing in Progress. Test Completion Scheduled for 4/30/05

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Accomplishments

System Design and Engineering

Barriers Q (Cost), R (Efficiency), S (Grid Emissions), T (Renewable Integration) addressed

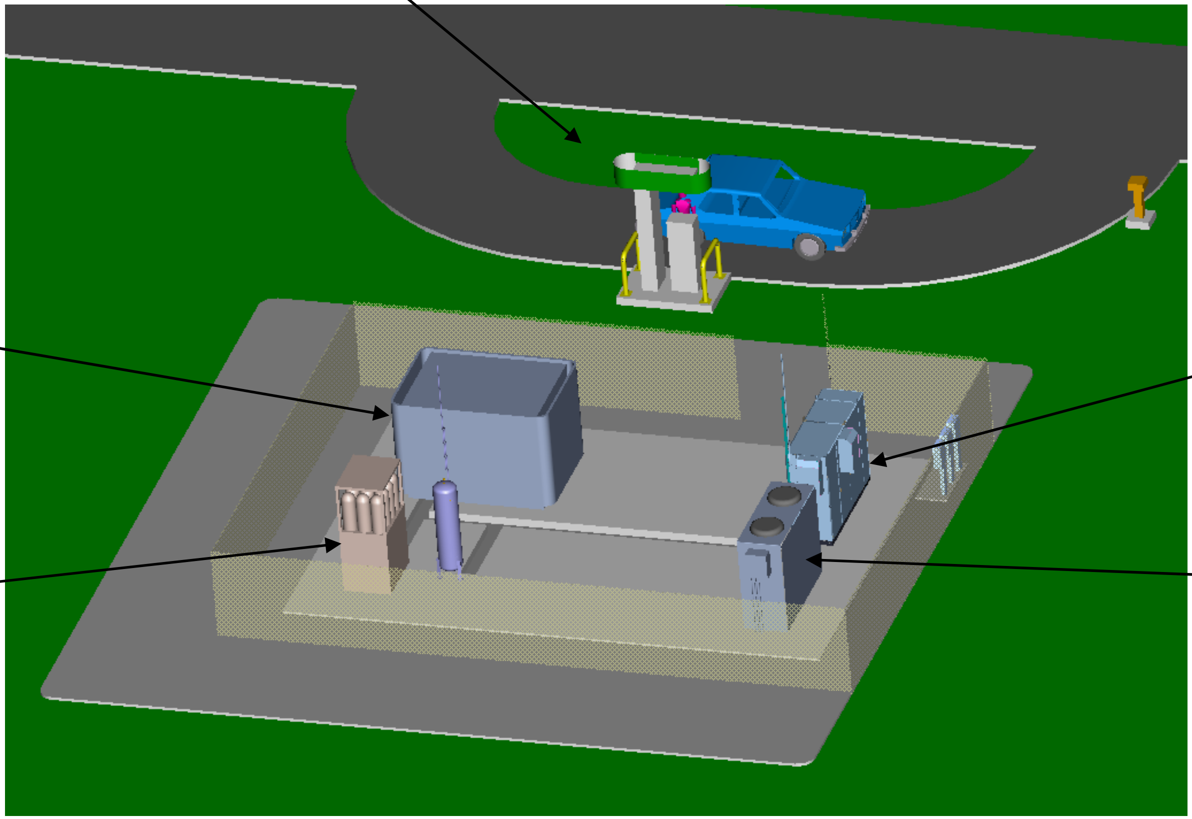
Wind Turbine (Renewable Integration)

Future Fueling Station Site
Burlington (VT) Department of Public Works

- Completed analysis of low cost system performance using electricity rates from grid-coupled wind turbine for time-of-day pricing
- Devised high efficiency extreme cold temperature operating modes for H_2 electrolysis
- Began estimation of renewable energy credits for the Wind-electrolysis H_2 Fueling System

Accomplishments

Fueling Station Layout Completed



Reviewer’s Comments From 2004

No Real New Technology and Future work may be more commercial related as opposed to research

- Project now includes research and development on advanced PEM cell stacks and on advanced power electronics
- New, first-of-a-kind stand-alone test of advanced power electronics
- New, first-of-a-kind test of advanced PEM cell stacks
- Integrated testing of the advanced cell stack and power electronics hardware

Future Work

FY 2005

Complete Testing of Advanced PEM Electrolysis Cell Stack

Complete Testing of Advanced Power Converter

Assemble and Complete In-house Tests of Complete Fueling System

Site Preparation, Permitting, Installation

FY 2006

Receive H_2 Vehicle

Testing, Monitoring, and Analysis

Publications and Presentations

None

Hydrogen Safety

1. ***The most significant potential hazard is a release of hydrogen due to loss of containment as a result of component failure.***

    <u>This poses two events of about equal severity</u>

    A. Potential for injury due to exposure of a high-pressure (6250 psig) gas stream or debris

    B. Potential for fire upon release of hydrogen

2. ***This potential hazard is being mitigated by the following:***

    A. Siting per NFPA 55 requirements (incorporates NFPA 50A)

    B. Hydrogen storage vessels meet the ASME Boiler Pressure Vessel Code Section VIII, Division 1 requirements (Appendix 22)

    C. The hydrogen piping is tested per ASME B31.3 requirements

    D. The PEM electrolyzer meets NFPA 496

continued …

Hydrogen Safety

<u>This potential hazard is being mitigated by the following:</u>

E. ***No unclassified electrical components (ignition source) within 15 feet of hydrogen storage (motor starters are housed in explosion proof cabinets)***
F. ***Hydrogen venting per the guidelines of CGA 5.5 – Hydrogen vent systems***
G. ***Relief valves are appropriately sized and placed at locations where there is a potential for over pressurization. ASME approved relief valves used where mandated***
H. ***Predominant connection types are 'medium pressure cone & thread fittings' rated to 20,000 psig***
I. ***Breakaways provided for dispensing hose***
J. ***Dispensing hose has MAWP of 7,700 psig (530 barg) & burst pressure ratio is 6:1***
K. ***Emergency stops (E-stop) available for all the units along with a remote e-stop. Pressing any one e-stop shuts down the operation of entire fueling station***

Hydrogen Safety

3. ***The most likely accident scenario for this project comes about from operator/driver error.***
   - **A.** ***Driver inadvertently drives away with the fueling nozzle attached to vehicle***
   - **B.** ***Driver/Operator smokes near the dispensing area during vehicle fueling***

4. ***The risk associated with this potential accident will be reduced by:***
   - **A.** ***Training the vehicle/fueling station operators who fuel the hydrogen-powered vehicles***
   - **B.** ***Using a dispensing system with a breakaway on the fueling hose and invoking automatic shutdown should a driver inadvertently drive away with the nozzle connected to the vehicle***
   - **C.** ***Requiring a security password to operate the fueling dispenser and requiring that the fueling nozzle interconnects be electronically verified before hydrogen fueling can commence***
   - **D.** ***Installing ‘No smoking’ signs near the dispenser***