EVermont Renewable Hydrogen Fueling System

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PDP17

Overview

- **Timeline**
  - Start Date April 2004
  - End Date September 2007
- **Budget**
  - Total Project Funding
    - DOE $937K
    - Contractors $937
- **Barriers**
  - G. Capital Cost
  - H. System Efficiency
  - I. Grid Electricity Emissions
  - J. Renewable Integration
- **Partners (Subcontractors)**
  - Northern Power Systems
  - Proton Energy Systems
- **Suppliers/Site Owner**
  - Air Products, Quantum
  - Burlington (VT) Dept of Public Works

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Objectives

Overall	Develop and Test Advanced PEM Electrolysis Fueling Station Technology
2006	• **Complete Integrated System Tests In-house** • **Complete Site Preparation** • **Installed monitoring electrical demand & wind energy** • **Procure a Hydrogen Fueled Vehicle** • **Commission and Test Advanced PEM Fueling Station**
2007	• Performance Monitoring and Testing

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Plan and Approach

R&D and In-house Testing	– Build and Test **Advanced** PEM Electrolysis Cell Stack Hardware – Build and Test **Advanced** Power Electronics Hardware – Assemble and Test Full Scale 12 kg/day PEM Electrolysis System – In-house test of entire Fueling System
System Design and Engineering	– Design for Higher System Efficiency, Lower 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
Procure H_2 Vehicle	– Devise Vehicle Requirements, Solicit Bids, Downselect, Procure
Testing, Monitoring, and Analysis	– Calculate H_2 output, power consumption, efficiency, wind turbine output, seasonal/temperature related performance – Vehicle fill times, performance (km/kg), and maintenance requirements

Accomplishments

R&D and In-house Testing	– Built and Tested Advanced PEM Electrolysis Cell Stack Hardware – Built and Tested Advanced Power Electronics Hardware – Assembled and Initiated Testing of Full Scale 12 kg/day PEM Electrolysis System and entire Fueling System
System Design and Engineering	– Successfully Tested In-house Extreme Cold Temperature Solution – Final Design and Fueling Station Site Layout Completed
Site Preparation, Installation, and Commissioning	– **Permitting Completed** – **Site Construction Completed** – **Station Equipment Installed and Commissioned - June 2006**
Procure H_2 Vehicle	– **Quantum H_2 ICE Prius – Delivered May 2006**
Testing, Monitoring, and Analysis	– **Vehicle Performance Data Collection Underway** – **Station Hydrogen Generation Data Collection Underway** – **Station Usage And Wind Generated Electricity Monitoring**

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Accomplishments

Station Construction and Commissioning Completed

Fueling Station Site June 2006 at
Burlington (VT) Department of Public Works

- Completed Site Construction
- Completed Fueling Equipment Installation and Commissioning
- Inspections by Local Authorities
- Emergency Response Plan
- Training of Personnel

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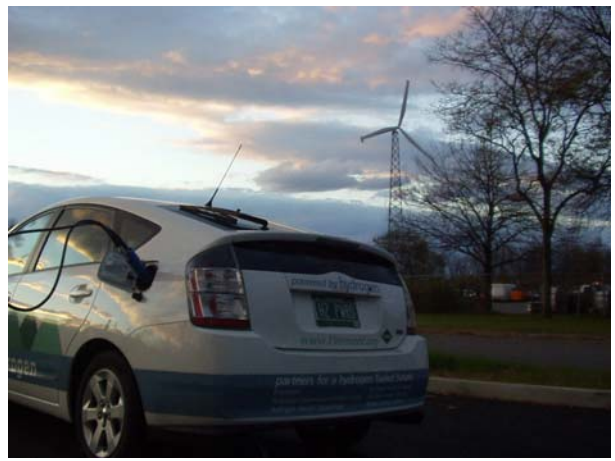
Accomplishments

Station Grand Opening Event in July 2006

Fueling Station Site Grand Opening July 2006

- Ceremony held July 3, 2006
- Good government and public attendance
- Local and national interest in site and demonstration goals



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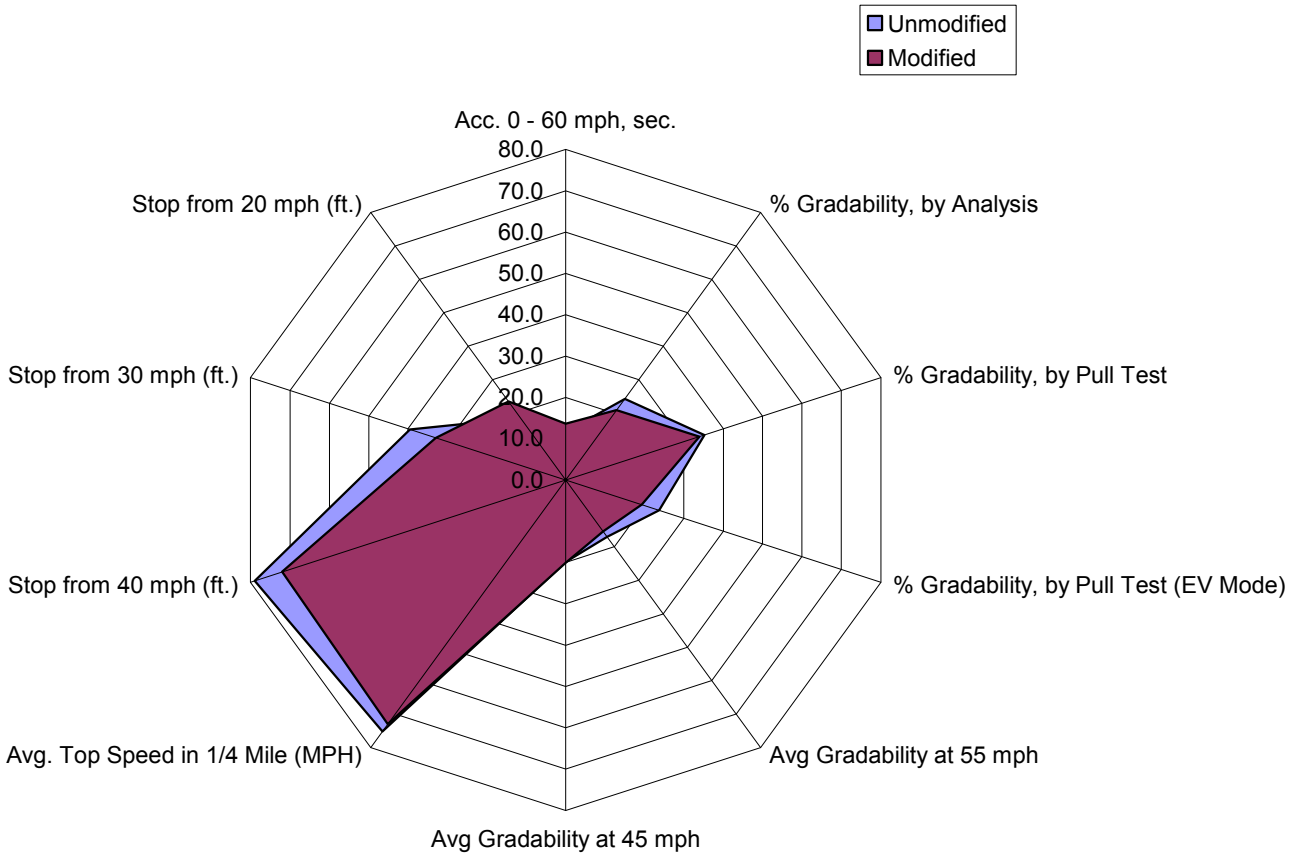
Accomplishments

Performance Comparison of Unmodified to Modified Vehicle



Accomplishments

Example of Vehicle Usage Log 4th QTR 2006

Date	Current Vehicle Mileage	Miles Traveled from Last Fueling	Kilograms of H2 Dispensed	Comments
25-Oct-06	4,969	--	--	Tank Filled
29-Oct-06	5,001	32	0.545	Note: 83% Full: Pressure Transmitter Disagreement error
2-Nov-06	5,001	-	0.272	Complted fill process from 29 Oct: Total 0.817 kg
10-Nov-06	5,020	19	0.406	Mix of Urban/suburban/interstate. At mile 10 rough engine operation
12-Nov-06	5,023	3	0.311	Rough engine operation/hesitation/backfire remains. Top off tank, as previous fill w
16-Nov-06	5,043	20	0.556	Replaced spark plugs: runs/idles smoothly.
17-Nov-06	5,074	31	0.723	Two connections required to fill tank. One at 0.409 kg, and 2nd at 0.314 kg.
14-Dec-06	5,099	25	0.873	Two connections required to fill tank. One at 0.405 kg, and 2nd at 0.468 kg.
17-Dec-06	5,142	43	1.045	Interstate driving/normal fill.
19-Dec-06	5,185	43	0.860	Interstate driving/90% fill.
27-Dec-06	5,219	34	0.684	Mix of interstate and secondary roads/85% fill.
29-Dec-06	5,245	26	0.755	90% fill
3-Jan-07	5,298	53	1.414	100% fill

Accomplishments

Advanced Cell Stack and Power Supply performance monitoring

- Monitoring ~10% increase in power efficiency
- Monitoring ~7% decrease in thermal energy
- No reliability issues to date

- ~5-10% increase in power efficiency
- No reliability issues to date

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Accomplishments

- Incorporating many enhancements in new production fueling electrolyzer due to lessons learned
  - Cold temperature operation
  - More efficient Advanced Cell Stack
  - Power Conservation Mode
  - Easier field installation

Future Work

- Vehicle upgraded to cold weather package (Summer 2007)
- Testing, monitoring & Analysis (September 2007)

Summary

Station construction and commissioning completed
Vehicle converted and performance monitoring program underway
Advanced cell stack and power supply performance monitoring
Electrolyzer freeze protection successful through winter months