

# **Evermont Renewable Hydrogen Fueling System**

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# Overview

- **Timeline**

- Start Date April 2004
- End Date September 2006
- 85% Complete

- **Budget**

- Total Project Funding
  - DOE \$937K
  - Contractors \$937
- \$757K Funding in FY05
- \$180K Funding in FY06

- **Barriers**

- G. 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

# Objectives

Overall	Develop and Test Advanced PEM Electrolysis Fueling Station Technology
2005	<ul style="list-style-type: none"><li>• Build and Test Advanced PEM Cell Stack</li><li>• Build and Test Advanced Power Supply</li><li>• Design Extreme Cold Weather System Capability</li><li>• Devise Station Site Plan</li></ul>
2006	<ul style="list-style-type: none"><li>• Complete Integrated System Tests In-house</li><li>• Complete Site Preparation and Incorporate Renewable Wind Generated Power</li><li>• Procure a Hydrogen Fueled Vehicle</li><li>• Commission and Test Advanced PEM Fueling Station</li></ul>

# Plan and Approach

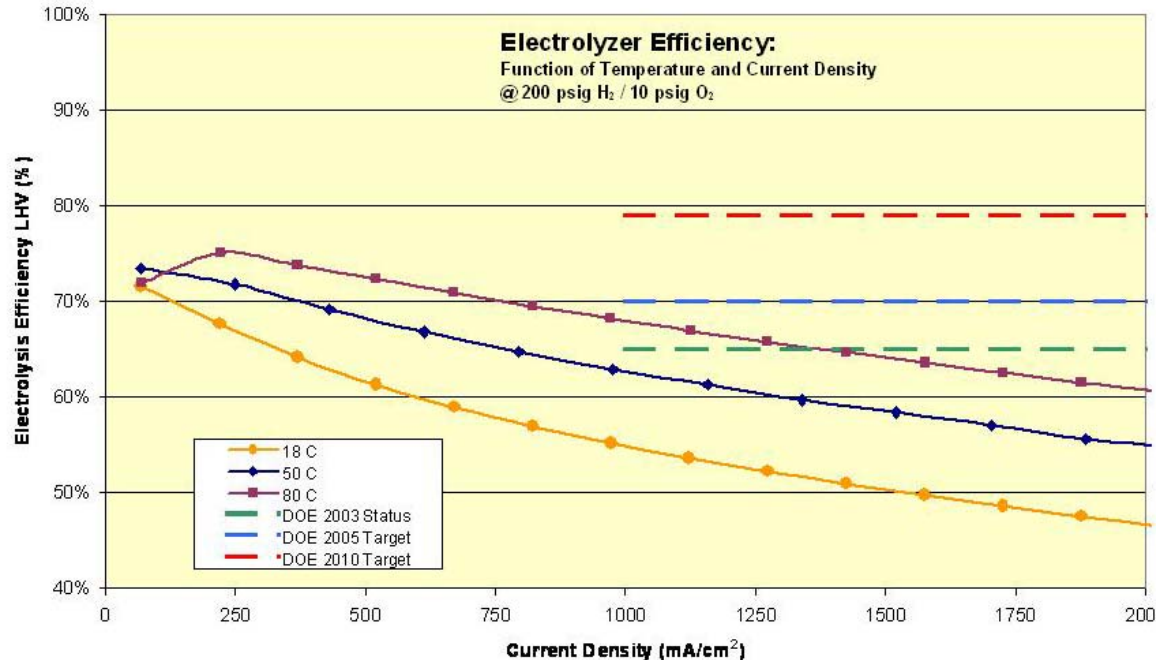
<b>R&amp;D and In-house Testing</b>	<ul style="list-style-type: none"> <li>- Build and Test <b>Advanced</b> PEM Electrolysis Cell Stack Hardware</li> <li>- Build and Test <b>Advanced</b> Power Electronics Hardware</li> <li>- Assemble and Test Full Scale 12 kg/day PEM Electrolysis System</li> <li>- In-house test of entire Fueling System</li> </ul>
<b>System Design and Engineering</b>	<ul style="list-style-type: none"> <li>- Design for High System Efficiency, Low Cost, Renewable Energy, and Extreme Cold Temperatures in Vermont</li> <li>- Final Design and Fueling Station Site Layout</li> </ul>
<b>Site Preparation, Installation, and Commissioning</b>	<ul style="list-style-type: none"> <li>- Site Plan, NEPA Documentation, Permitting</li> <li>- Training for Safety, Operation, and Maintenance</li> </ul>
<b>Procure H<sub>2</sub> Vehicle</b>	<ul style="list-style-type: none"> <li>- Devise Vehicle Requirements, Solicit Bids, Downselect, Procure</li> </ul>
<b>Testing, Monitoring, and Analysis</b>	<ul style="list-style-type: none"> <li>- Measure or calculate H<sub>2</sub> output, power consumption, efficiency, wind turbine output, seasonal/temperature related performance</li> <li>- Vehicle fill times, performance (km/kg), and maintenance requirements</li> </ul>

# Accomplishments

<b>R&amp;D and In-house Testing</b>	<ul style="list-style-type: none"> <li>- Built and Tested <b>Advanced</b> PEM Electrolysis Cell Stack Hardware</li> <li>- Built and Tested <b>Advanced</b> Power Electronics Hardware</li> <li>- Assembled and Initiated Testing of Full Scale 12 kg/day PEM Electrolysis System and entire Fueling System</li> </ul>
<b>System Design and Engineering</b>	<ul style="list-style-type: none"> <li>- Successfully Tested In-house Extreme Cold Temperature Solution</li> <li>- Final Design and Fueling Station Site Layout Completed</li> </ul>
<b>Site Preparation, Installation, and Commissioning</b>	<ul style="list-style-type: none"> <li>- Permitting Completed</li> <li>- Site Construction Initiated; To Be Completed May 2006</li> </ul>
<b>Procure H<sub>2</sub> Vehicle</b>	<ul style="list-style-type: none"> <li>- Quantum Selected to Provide H<sub>2</sub> ICE Prius – Delivery in May 2006</li> </ul>
<b>Testing, Monitoring, and Analysis</b>	<ul style="list-style-type: none"> <li>- To be initiated in June 2006</li> </ul>

# Accomplishments

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



(Ref. Everett Anderson, Dave Henderson, Proton Energy Systems, 2005)

**Advanced Stack to be Tested in Fueling System in 2006**

- 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<sub>2</sub> Fueling Costs by up to \$0.50/kg from present costs

# Accomplishments

## R&D and In-house Testing of Advanced Power Supply

### Advanced Power Supply Built and Installed in Electrolyzer System Testing to be Completed in 2006

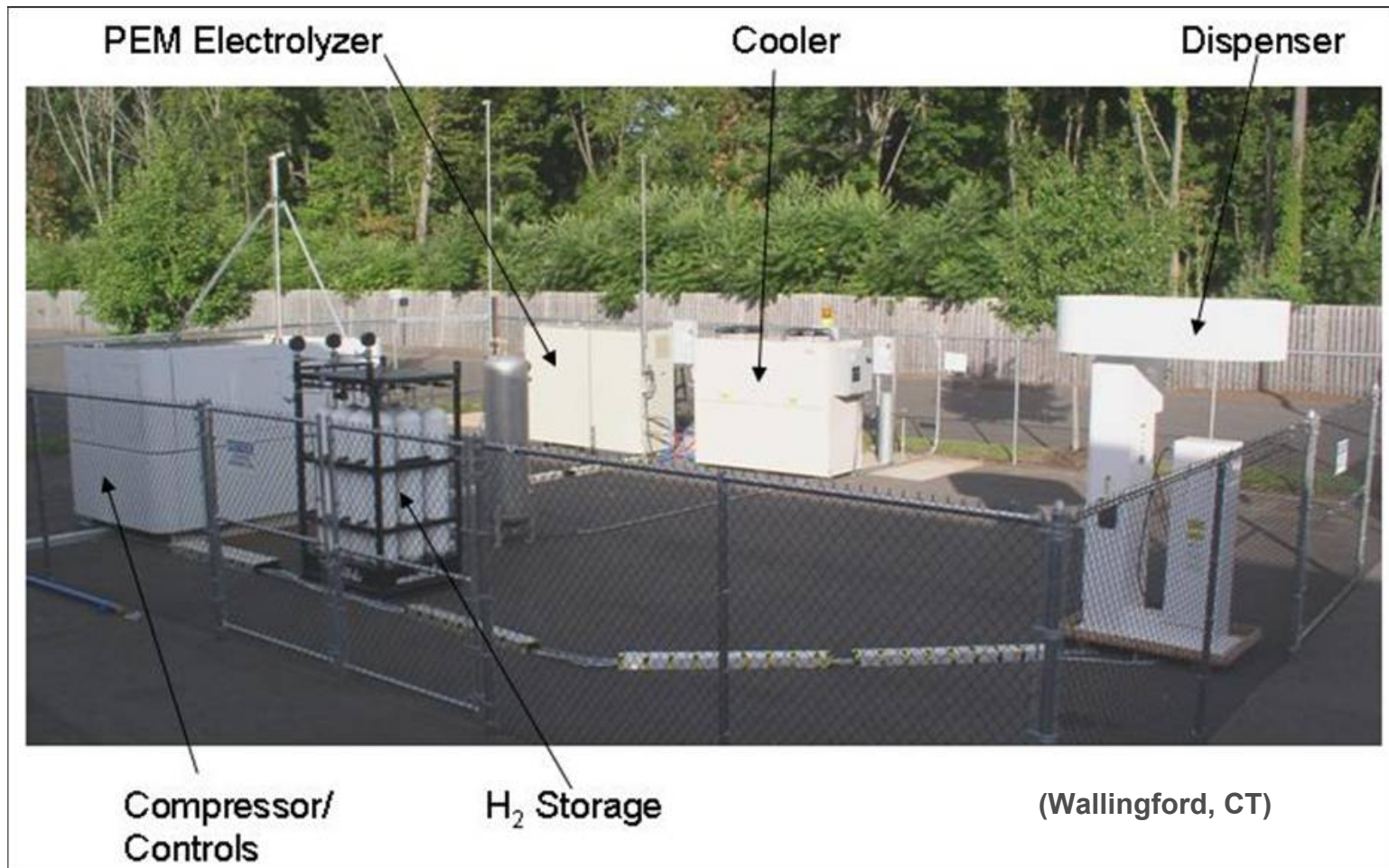
**Table 3.1.4. Technol Targets: Water Electrolysis<sup>a</sup>**

Characteristic		Units	1500 kg/day refueling station			Central Renewable <sup>b</sup>
			2008 Status	2005 Target	2010 Target	2015 Target
Power Conversion, Cell Stack, Balance of Plant <sup>c</sup>	Cost	\$/gge H <sub>2</sub>	0.95	0.80	0.39	0.24
	Total Cell Efficiency	%	66	68	76	77
Compression, Storage, Dispensing <sup>d</sup>	Cost	\$/gge H <sub>2</sub>	0.33	0.77	0.19	0.08
	Efficiency	%	94	94	99	99.5
Electricity <sup>e</sup>	Cost	\$/gge H <sub>2</sub>	2.57	2.47	1.89	1.32
O&M	Cost	\$/gge H <sub>2</sub>	0.80	0.71	0.38	0.11
Total <sup>f</sup>	Cost	\$/gge H <sub>2</sub>	5.15	4.75	2.85	2.75 <sup>g</sup>
	Efficiency	%	62	64	75	76

- Explicitly Addresses DOE Efficiency and Cost Targets for Power Conversion
- 5-10% Power Supply Efficiency Improvements Anticipated
- 25-50% Power Supply Cost Reduction Anticipated
- Potentially decrease H<sub>2</sub> Fueling Costs by up to \$0.50/kg from present costs

# Accomplishments

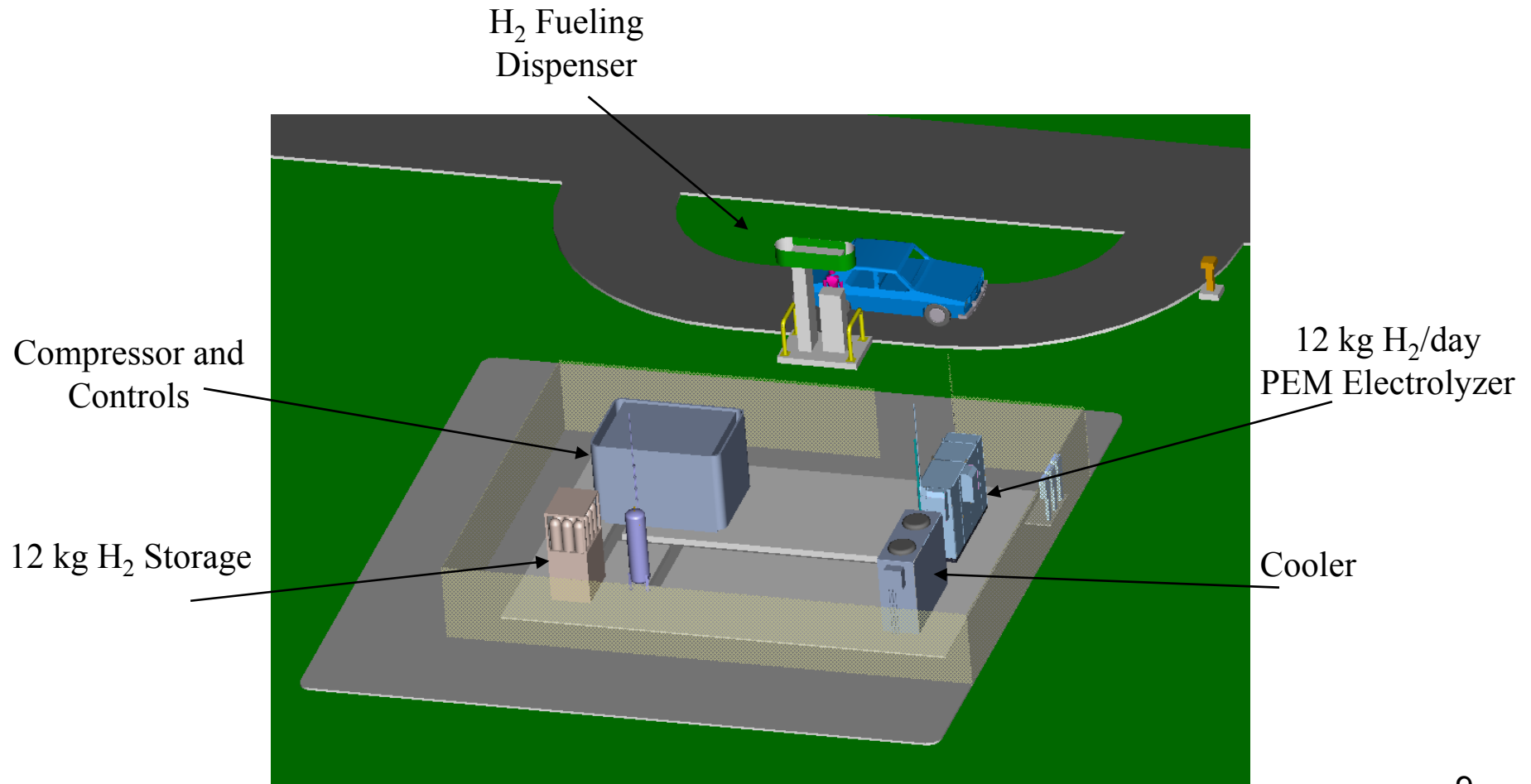
**In-house Test Installation Completed; In-house Testing 90% Completed**





# Accomplishments

Site Selected and Fueling Station Layout for Vermont Completed



# Accomplishments

## Permitting Complete, Site Construction Initiated



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

- Completed Site Plan; Initiated Site Work; Installation Scheduled May 2006
- 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<sub>2</sub> electrolysis
- Began estimation of renewable energy credits for the Wind-electrolysis H<sub>2</sub> Fueling System

# Future Work

## FY 2006

- Complete In-house Testing (May 2006)
- Complete Site Work in Burlington, VT (May 2006)
- Receive H<sub>2</sub> Vehicle (May 2006)
- Install and Commission System (June 2006)
- Testing, Monitoring, and Analysis (Jun-Sep 2006)

# Summary

An advanced PEM Electrolysis Cell Stack and an advanced AC-DC Power Converter were successfully built and will be field tested for the first time in a full scale fueling system

An outdoor heated purge operating configuration for efficient freeze-protection in extreme cold weather was tested successfully

Site Plan Completed, Site Permits Obtained, Site Construction Initiated

# Responses to Previous Year Reviewers' Comments

**“This Project should focus more on the improvements of the electrolyzers and not demonstrating the technology until ready”**

- Focus has been placed on the two key electrolysis subsystems:  
Cell Stack and Power Supply
- Testing in a controlled environment has been completed
- Field testing will provide vital feedback for actual operating efficiency, durability, and actual progress towards DOE goals.

**“Should further develop a strong public relations and education component”**

- Public Meetings were held in Burlington, VT to discuss this project
- Objectives and Lessons Learned for this Project were presented at the PowerGen Renewable Energy and Fuels Conference in April 2006
- A Grand Opening Event in Burlington, VT will be planned in Summer 2006
- Performance Data will be presented in public forum, as appropriate

# Publications and Presentations

1. A. Khan, N. Borland, K. Dreier, H. Garabedian, R. Boehm, et al., "REAL WORLD EXPERIENCE WITH RENEWABLE HYDROGEN FUELING STATIONS" presented at the 2006 Power-Gen Renewable Energy and Fuels Conference, Las Vegas, NV April 11, 2006

# Critical Assumptions and Issues

- No Established Funding for Long Term System or Vehicle Maintenance or for Data Analysis/Reporting after GFY06