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Overview

**Timeline**
- Project start: October 2004
- Project end: September 2006
- Percent complete: 75%

**Budget**
- Total Funding: $380K
- FY 2005 Funding: $200K
- FY 2006 Funding: $180K

**Barriers**
- Hydrogen Storage A
  Lack of a hydrogen/carrier and infrastructure options analysis
- Tech Validation C
  Hydrogen refueling infrastructure
- Systems Analysis E
  Lack of understanding of the transition to a hydrogen-based economy

**Collaborators**
- UC Davis, ORNL, Arizona State University
Objectives

FY 2006
• Quantify hydrogen demand in the U.S.
• Estimate costs to support infrastructure to meet emerging hydrogen demand.

FY 2005
• Quantify and location a minimal interstate based hydrogen infrastructure
Approach

- Identify key demographic attributes affecting hydrogen vehicle adoption
- Prioritize attributes
- Evaluate scenarios
- Define infrastructure scenarios at various penetration rates
- Identify costs and potential for stranded assets
Hydrogen Analysis Diagram
Identify Key Demographic Attributes Affecting Hydrogen Vehicle Adoption by Consumers

- 2+ vehicle households
- Education
- Commuting distance
- Employment
Identify Key Demographic Attributes Affecting Hydrogen Vehicle Adoption by Consumers

- Household income
- Air quality
- State incentives
- Clean Cities coalitions
- Hybrid registrations
Identify Key Demographic Attributes Affecting Hydrogen Vehicle Adoption by Fleets

- Private fleet vehicles
- Public fleet vehicles
## Prioritize Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Consumer Impacts</th>
<th>Fleet Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households with 2+ Vehicles</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Household Income</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Education</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Commute Distance</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Employment</td>
<td>L</td>
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<td>State Incentives</td>
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<td>Air Quality</td>
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<tr>
<td>Clean Cities Coalition</td>
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<td>H</td>
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<tr>
<td>Hybrid Registrations</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Private Fleets</td>
<td></td>
<td>H</td>
</tr>
<tr>
<td>Public Fleets</td>
<td></td>
<td>H</td>
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</tbody>
</table>
Consumer Results

Hydrogen Infrastructure Demand
Consumer Strategy

Hydrogen Demand
- Very High
- High
- Very Good
- Good
- Fair
- Low

Preliminary Results
Do Not Distribute

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Consumer Demographic Emphasis

Hydrogen Infrastructure Demand
Consumer Strategy - Demographic Emphasis

Very High
High
Very Good
Good
Fair
Low

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April 2008
Consumer Policy Emphasis

Hydrogen Infrastructure Demand
Consumer Strategy - Policy Emphasis

Map of the United States with color-coded regions indicating different levels of demand.
Fleet Results

Hydrogen Infrastructure Demand
Fleet Strategy

Hydrogen Demand
- Very High
- High
- Very Good
- Good
- Fair
- Low

Preliminary Results
Do Not Distribute

April 2006
NREL

National Renewable Energy Laboratory
Estimating Hydrogen Quantities

Estimated Hydrogen Demand at Selected Penetration Rates

Preliminary Results
Do Not Distribute

Hydrogen Demand and Penetration Rates (Billion kg/year)

<table>
<thead>
<tr>
<th>Demand</th>
<th>1%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>3.8</td>
<td>19.3</td>
<td>38.7</td>
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<tr>
<td>High</td>
<td>3.2</td>
<td>16.1</td>
<td>32.3</td>
</tr>
<tr>
<td>Very Good</td>
<td>2.5</td>
<td>12.9</td>
<td>25.8</td>
</tr>
<tr>
<td>Good</td>
<td>1.9</td>
<td>9.7</td>
<td>19.3</td>
</tr>
<tr>
<td>Fair</td>
<td>1.2</td>
<td>6.4</td>
<td>12.9</td>
</tr>
<tr>
<td>Low</td>
<td>0.646</td>
<td>3.2</td>
<td>6.4</td>
</tr>
</tbody>
</table>

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Local Demand Analysis

Can be applied to local areas with more detailed analysis and data.
Local Hot Spot Analysis

Los Angeles Basin Urbanized Area

Estimated Hydrogen Demand at Existing Gasoline Stations
- Very High
- High
Future Work

• Define infrastructure scenarios at various penetration rates
  – Match demand to hydrogen needs within each area

• Identify costs and potential for stranded assets
  – Use population trends to predict where hydrogen demand will grow rapidly

• Draft technical report to DOE July 2006
Project Summary

- U.S. demand results indicate that government policies can influence geographic areas surrounding major metropolitan areas
- Different areas have different demographic and geographic constraints that affect hydrogen demand dispersion
- Geographic demand is critical to infrastructure analysis
  - Provide a spatial component to other transition analyses (HyTrans, HYDS, MSM)
  - Provide a spatial component to non-transition analyses (HOPE, H2A)
## Responses to Previous Year Comments

<table>
<thead>
<tr>
<th>Comment</th>
<th>How Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Give more emphasis to lessons learned from alternative fuels</td>
<td>Attributes were based on alternative fuels lessons learned research and experience</td>
</tr>
<tr>
<td>Focus is only on interstates</td>
<td>Expanded to identify demand nationwide and will use that demand to identify infrastructure needs</td>
</tr>
<tr>
<td>Assumes government-driven rather than industry/economics</td>
<td>Attributes selected balance general consumer demographics with government stimulation</td>
</tr>
</tbody>
</table>
Publications and Presentations

Publications
Melendez, Margo, *Transitioning to a Hydrogen Future: Learning from the Alternative Fuels Experience*, February 2006

Presentations
• 2005 DOE Hydrogen Program Review poster
• 2006 American Association of Geographers Conference presentation
Critical Assumptions and Issues

• Consumers will be satisfied refueling near their homes
• Attributes and weightings selected are appropriate; need to get better industry feedback