Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

TEAM:
Chevron Technology Ventures
Hyundai-Kia Motor Company
UTC Power

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May 2007
Overview

Timeline
- January 15, 2004
- September 30, 2009
- 45 % complete

Budget
- Total project funding - $93.9 mil
  - DOE share - $37.8 mil
  - Contractor share - $56.1 mil
- Prior Funding - $16.1 mil
- Funding FY07 - $ 0.5 mil

Barriers
- Vehicles
- H2 Refueling Infrastructure
- Codes & Standards

Team Members
- Hyundai-Kia Motor Companies
- UTC Power
- Hyundai Kia America Technical Center
- Alameda Contra Costa Transit
- Southern California Edison
- Tank Automotive Research, Development and Engineering Center (DOD)
- Gas Technology Institute
## Objectives

<table>
<thead>
<tr>
<th>Overall</th>
<th><strong>Obtain data to validate 2009 performance targets</strong></th>
</tr>
</thead>
</table>
| FC Stack Durability: >2000 hr | • Collect:  
| Vehicle Range: >250 miles |   – FC vehicle operating data  
| Hydrogen Cost: <$3.00/gge | • Demonstrate:  
| |   – Different methods of on-site hydrogen generation |
| **2006** | • Hydrogen safe chassis dyno and Maintenance facility  
| | • Test different climatic conditions on FC vehicles  
| | • Three On-site Generators  
| |   – Rosemead  
| |   – Oakland  
| |   – Orlando (not funded by DOE) |
| **2007** | • Increase Vehicle availability and reliability  
| | • Improve Vehicle Performance with 2nd Gen. vehicles  
| | • Operate and report from 5 on-site generation stations  
| | • Construct and Operate Partial Oxidation Gas Turbine (POGT) |
### Approach

<table>
<thead>
<tr>
<th>H₂ Milestone 2</th>
<th>Demonstrate 50% higher fuel economy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conduct Dyno testing – initial testing complete</td>
</tr>
<tr>
<td></td>
<td>Conduct on road testing – data reported to NREL monthly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H₂ Milestone 3</th>
<th>Demonstrate 2005 energy and mass density targets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>350 bar vehicles on the road</td>
</tr>
<tr>
<td></td>
<td>700 bar vehicle to be tested</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H₂ Milestone 5</th>
<th>Validate vehicle range of ~200 miles and 1000 hours</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>On road testing data being reported to NREL monthly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H₂ Milestone 6</th>
<th>Validate refueling less than 5 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Work complete</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H₂ Milestone 11</th>
<th>Validate $3/gge production cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On-site hydrogen generation stations in operation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H₂ Milestone 12</th>
<th>Five station and two maintenance facilities constructed.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data reported to NREL from 2 stations</td>
</tr>
<tr>
<td></td>
<td>Three additional stations on line 1Q 2007</td>
</tr>
<tr>
<td></td>
<td>Maintenance facility operational in Chino</td>
</tr>
</tbody>
</table>
### Approach – Vehicle Deployment

<table>
<thead>
<tr>
<th>Operation Area</th>
<th>Service Facility</th>
<th>Site Host Location</th>
<th>Operator</th>
<th>Total</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern California</td>
<td>Chino</td>
<td>Chino</td>
<td>HATCI</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rosemead</td>
<td>SC Edison</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Northern California</td>
<td>Sacramento</td>
<td>Sacramento</td>
<td>CARB</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oakland</td>
<td>AC Transit</td>
<td>11</td>
<td>1</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Michigan</td>
<td>Ann Arbor</td>
<td>Selfridge</td>
<td>TARDEC</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>3 Regional Areas</td>
<td></td>
<td>5 Organizations</td>
<td></td>
<td>32</td>
<td>4</td>
<td>8</td>
<td>20</td>
</tr>
</tbody>
</table>

### Map

The map illustrates the deployment locations across the United States, with key service facilities marked. The map shows the locations of each operator: SCE, CARB, HATCI, ACT, and TARDEC.
## Status – GTI Program POGT

### Design
- Process Flow Diagram, Equipment Layout, and Piping & Instrumentation Drawings Completed
- HazOp Review Completed
- PSA System and Gas Analysis Available

### Construction
- Partial Oxidation Gas Turbine (POGT) and Partial Oxidation Reactor (POR) Integration in Progress
- Water Gas Shift (WGS) Slipstream Unit Fabricated
- Compressor and Buffer Tank Received
Alameda County Transit (ACT)
• 30 more employees have been trained in vehicle operation since last review for a total of 50
• ACT performed maintenance and light repair of 3 of their fleet vehicles
• HATCI has provided an updated Routine Maintenance Check sheet along with photos

Southern California Edison (SCE)
• 5 employees have been trained in vehicle operation at Southern California Edison
• 3 employees have been trained in vehicle maintenance at Southern California Edison

Safety and ER Training
• HATCI has participated in First Responder Training in both Northern and Southern California
• Zero Vehicle Accidents
Infrastructure – Rosemead Energy Station

- 20 kg/day generation capacity
- 60 kg storage
- Single dispenser
- 5000 psig
- Fill rate – up to 3.6 kg/min
Infrastructure – Selfridge Energy Station

- 40 kg/day generation
- 312 kg storage
- Single Dispenser
- 5000 psig
- Fill rate – up to 3.6 kg/min
Infrastructure – Orlando Energy Station

- 114 kg/day generation
- 312 kg storage
- Single Dispenser
- 5000 psig
Infrastructure – GTI POGT

Slipstream Water-Gas-Shift Reactor
(shown uninsulated)

Partial Oxidation Gas Turbine System

Partial Oxidation Reactor (POR)

Partial Oxidation Gas Turbine (POGT)
Hot test performed at Death Valley on Jul. 2006

- Test region: Death Valley & Mojave PG(HMC)
- Test modified cooling module

- Achieved improved cooling performance
  - No power degradation
  - Positive water balance at Daylight and Towne pass
Cold start up test successfully performed on Feb. 2007

- Test region: UTC Power (Hartford, CT)
- Cold climate soaking time: more than 3 days
Vehicle Service Facilities

- Hydrogen Safe Dyno Bay (Chino)

- Hydrogen Safe Work Bay (Chino)

- H2 Safety Dyno Cell:
  Chino, CA ('07. 3)

- H2 Safety Work Bay:
  - CaFCP (5 vehicle bay)
  - Chino, CA (1 vehicle bay)
  - Selfridge, MI (Under Construction)
  - Seminary, CA (1 veh. Tent)
  - Pomona, CA (1 veh. Bay)
Fleet Monitoring and Data Collection

- 5 Local servers added
- 8 Local servers installed
  - AC Transit (4)
  - SC Edison (1)
  - TARDEC (1)
  - HATCI : Chino (1), CaFCP (1)

Data Analysis

Real Time Monitoring

Verizon Wireless

CDMA

HMC

DB server

WEB server

Client

Log Book

Data Analysis S/W

Local server

Data to NREL

Vehicle Monitoring (@Chino)
Lesson Learned Storage Inventory Calculation
Use First Order Filter on Temperature Measurement

- Ambient temperature external of storage is used for mass calculation
  - Eliminates electrical equipment in C1D2GB electrical area
  - Eliminates penetration into high pressure storage vessel
- However, Peak pressure does not coincide with peak daily temperature
  - Delay is due to heat transfer from ambient to massive steel vessels
- Mismatch leads to error and variation in “constant” mass calculation
- First order filter reduces standard deviation of calculated mass by a factor of 10
Future Work

• Field 32 Vehicles
  – by the end of 2007

• Collect operating data from Stations in:
  – Rosemead, CA
  – Selfridge, MI
  – Orlando, FL*

• POGT Testing 2\textsuperscript{nd} quarter

*not in DOE program but data to be shared with DOE
Program Summary

Relevance
- FC vehicle real world operating data
- On-site hydrogen generation demonstration

Approach
- Fleet testing of 32 FC vehicles
- Operation of six on-site hydrogen generators
  - Reformers CSA 5.99 US Certified

Technical Accomplishments and Progress
- Range and Durability reported to NREL
- Two stations reported to NREL
- Third Party fuelings conducted at stations

Technology Transfer
- Lessons learned included in merit review

Proposed Future Work
- Continue testing of vehicles and data reporting to NREL
Fleet Monitoring and Data Collection

**Strategy**
1) Provide safe and delightful driving to partners
2) Provide quick maintenance
3) Monitor the route and encourage usage