Technology Validation: Fuel Cell Bus Evaluations

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This presentation does not contain any proprietary or confidential information
Overview

Timeline

• Evaluations typically cover 2 years of data
• Start date determined by bus delivery
• International collaboration ongoing

Technology Validation Barriers

• A. Vehicles
• B. Storage
• C. Hydrogen Fueling Infrastructure
• D. Maintenance & Training
• E. Codes & Standards

Budget

• Current FY05 funding: $338 K ($80 K to Battelle for data collection & analysis support)
• FY04 funding $238 K
## Overview: Partners

### Operating Fleets
- AC Transit
- Santa Clara VTA
- SunLine
- Hickam AFB

### Manufacturers/Systems Integrators
- Enova Systems
- Gillig
- ISE Research
- Van Hool

### Fuel Cell Suppliers
- Ballard
- Hydrogenics
- UTC Fuel Cells

### H₂ Infrastructure
- APCI
- ChevronTexaco

### Collaborations

<table>
<thead>
<tr>
<th>U.S.</th>
<th>International</th>
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<tbody>
<tr>
<td>FTA</td>
<td>CaFCP</td>
</tr>
<tr>
<td>NAVC</td>
<td>University of Hawaii</td>
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<tr>
<td>HCATT</td>
<td>UC Davis</td>
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<td>EC</td>
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<td>PREMIA</td>
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<td>ECTOS</td>
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<td></td>
<td>CUTE</td>
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<td>STEP</td>
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<td>NRCan</td>
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<tr>
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<td>UNDP-GEF</td>
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Objectives

• Validate fuel cell and hydrogen technologies in transit applications
  – Determine status of fuel cell systems for buses and corresponding hydrogen infrastructure
  – Provide feedback for HFCIT Program R&D
  – Provide “lessons learned” on implementing next generation fuel cell systems into transit operations

• Harmonize data collection efforts with other fuel cell bus demonstrations worldwide (in coordination with FTA and other U.S. and international partners)
  – Leverage resources by gathering data and comparing a larger statistical set of vehicles (8 - U.S., 30 - Europe)
  – Establish a common template for collecting and sharing data between programs
Approach

• Evaluations
  – Collect and analyze operational data on fuel cell buses in service (using conventional diesel or CNG as baseline):
    • Vehicle specifications, use, and duty-cycle
    • Fluid consumption (fuel, oil, water, etc.)
    • Maintenance records (scheduled and unscheduled)
    • Facility descriptions and costs
    • Fleet experience with buses and infrastructure
    • Detailed data similar to light-duty demonstrations (when possible)

• International Collaboration
  – International Fuel Cell Bus Working Group
    • Define common data set to collect and share
    • Proposal for Workshop to be an IPHE event
Overview of Technical Accomplishments/Progress

• Evaluations: Working with transit fleets to evaluate fuel cell buses in service
  – Developed FCB Data Collection Plan
  – Completed evaluation of ThunderPower bus
  – Santa Clara VTA - Data collection in progress
  – Hickam AFB - Data collection in progress
  – AC Transit & SunLine - Planning stage, expected delivery of buses in Sept/Oct 2005

• International Collaboration
  – Actively participated in 2nd International Fuel Cell Bus Workshop
  – Coordinating committee for Working Group
California FCB Demonstration Sites
Progress: FCB Evaluations

SunLine Transit Agency
Thousand Palms, CA

ThunderPower Fuel Cell Bus - Hybrid fuel cell system integrated by ISE Research

### Bus Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus Manufacturer/Model</td>
<td>ElDorado National/EZ Rider 2</td>
</tr>
<tr>
<td>Bus Model Year</td>
<td>2002</td>
</tr>
<tr>
<td>Gross Vehicle Weight Rating</td>
<td>34,000 lbs.</td>
</tr>
<tr>
<td>Curb Weight</td>
<td>25,180 lbs.</td>
</tr>
<tr>
<td>Seats/Wheelchair Positions</td>
<td>26/two</td>
</tr>
<tr>
<td>Hybrid Type</td>
<td>Series/Charge Sustaining</td>
</tr>
<tr>
<td>Regenerative Braking</td>
<td>Yes</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>Panasonic/Lead Acid/48 12-volt Batteries in Two Modules</td>
</tr>
<tr>
<td>Electric Motor</td>
<td>Siemens 2 X 85 kW @ 650 VDC</td>
</tr>
<tr>
<td>Power Plant</td>
<td>UTC Fuel Cells/PEM</td>
</tr>
<tr>
<td>Power Plant Power Rating</td>
<td>60 kW Continuous</td>
</tr>
<tr>
<td>Fuel Storage</td>
<td>Nine Quantum Cylinders with Compressed Hydrogen</td>
</tr>
<tr>
<td>Fuel Storage Capacity</td>
<td>25 kg Hydrogen at 3,600 psi</td>
</tr>
</tbody>
</table>
Progress: FCB Evaluations

SunLine Transit Agency
Thousand Palms, CA

Bus Use:
• 6-month in-service evaluation
• Line 50
  – 12.8-mile loop
  – 43 minutes per loop
  – 17-mph average speed
# Progress: FCB Evaluations

## SunLine Transit Agency

Thousand Palms, CA

### Hydrogen Fuel Use:

<table>
<thead>
<tr>
<th>Category</th>
<th>All DataWhile at SunLine</th>
<th>Nonrevenue Operation (Aug to Nov 02)</th>
<th>Revenue Operation (Nov 02-Feb 03)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Economy Mileage</td>
<td>8,019</td>
<td>2,985</td>
<td>5,034</td>
</tr>
<tr>
<td>Hydrogen Used (kg)</td>
<td>789</td>
<td>316</td>
<td>473</td>
</tr>
<tr>
<td>DGE</td>
<td>698</td>
<td>279</td>
<td>419</td>
</tr>
<tr>
<td>Miles per DGE</td>
<td>11.5</td>
<td>10.7</td>
<td>12</td>
</tr>
<tr>
<td>GGE</td>
<td>779</td>
<td>312</td>
<td>467</td>
</tr>
<tr>
<td>Miles per GGE</td>
<td>10.3</td>
<td>9.6</td>
<td>10.8</td>
</tr>
</tbody>
</table>

![Fuel Economy Chart](chart.png)
Progress: FCB Evaluations

SunLine Transit Agency
Thousand Palms, CA

Reports available on the web:
Fact Sheet
www.eere.energy.gov/hydrogenandfuelcells/tech_validation/pdfs/33639.pdf

Final Evaluation Report
Progress: FCB Evaluations

Santa Clara Valley Transportation Authority
San Jose, CA

• Vehicles
  – 3 Gillig 40-ft buses with Ballard FC system

• Fueling
  – APCI station
    • Liquid H₂ storage with 9,000-kg capacity
Progress: FCB Evaluations

Santa Clara Valley Transportation Authority

• Project Status
  – Infrastructure operational 2004
  – New maintenance facility completed early 2005
  – Buses placed into service Feb/Mar 2005
  – Data collection in progress
  – 2-page project description drafted
Progress: FCB Evaluations

Hickam Air Force Base
Honolulu, HI

• Vehicles
  – 1 ElDorado 30-ft bus
    • Enova battery-dominant hybrid FC system
    • Hydrogenics 20kW FC
  – 1 step van
    • Enova hybrid FC system
    • Hydrogenics 60kW FC
Progress: FCB Evaluations

Hickam Air Force Base

- **Fueling**
  - Modular unit using electrolysis

- **Status**
  - 2-page fact sheet completed
  - Bus operating on battery only because of an issue setting up temporary hydrogen fueling
  - Expect permanent fueling on-site by June 2005
  - Step van in development stage
Progress: FCB Evaluations

Alameda Contra-Costa Transit Agency
Oakland, CA

• Vehicles
  – 3 Van Hool 40-ft buses with UTC fuel cell and hybrid system by ISE Research

• Fueling (part of DOE Controlled Fleet Project)
  – ChevronTexaco station - natural gas reforming
  – Learning Center
  – Mobile fueler

• Status
  – Infrastructure complete and operational by mid-2005
  – Buses scheduled to arrive Sept/Dec 2005 and Feb 2006
Progress: FCB Evaluations

SunLine Transit Agency
Thousand Palms, CA

- Vehicles
  - 1 Van Hool 40-ft bus with UTC fuel cell and hybrid system by ISE Research
  - 1 New Flyer 40-ft bus with hybrid hydrogen internal combustion engine (HHICE) system by ISE

- Fueling
  - Stuart electrolysis unit
  - HyRadix Reformer

- Status
  - Infrastructure on-line and operational
  - FCB scheduled for Oct 2005 delivery
  - HHICE bus in service April 2005
Progress: International Collaboration

Second Workshop held in Porto, Portugal, Nov 2004:

– Agreement to share project details in a common format
  • Draft template in circulation for approval

– Agreement to share summary performance data (bus and infrastructure), safety, and lessons learned with group
  • List of data elements being drafted

– Formation of International Fuel Cell Bus Working Group

– Planning 3rd International Fuel Cell Bus Workshop
Future Work: FCB Evaluations

• Remainder of FY05
  – Publish fact sheet on VTA project
  – Begin data collection on AC Transit & SunLine buses
  – Continue data collection on VTA and Hickam buses
  – Data analysis and interim report on Hickam evaluation
  – Gain agreement to collect more technical data on FCBs and infrastructure to complement DOE Controlled Fleet Demo

• FY06
  – Publish fact sheets on AC Transit and SunLine projects
  – Feed early results back into HFCIT program R&D
  – Data analysis and interim report on VTA evaluation
  – Begin collection and analysis of technical data on buses and infrastructure for all fleets
Future Work: International Collaboration

• Remainder of FY05 - International Fuel Cell Bus Working Group tasks:
  – Finalize list of informational data elements
  – Collect informational data elements and report in a common format
  – Develop draft list of operational and performance data to be shared
  – Plan 3rd Workshop for Dec 2005

• FY06
  – 3rd International Fuel Cell Bus Workshop
  – Finalize list of operational and performance data
  – Begin collecting data
  – Plan 4th Workshop
Publications and Presentations

Publications:


Presentations:


Hydrogen Safety

• Each demonstration site is responsible for specific safety plans for fueling, operating and maintaining fuel cell buses and corresponding hydrogen infrastructure.

• NREL data collection includes reports of any safety incidents that occur with the vehicles or infrastructure.

• Reports from incidents will be fed back to DOE and the 4 other demonstration sites to share lessons learned and help avoid similar occurrences.