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

Budget

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

Technology Validation Barriers

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

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

H_2 Infrastructure

APCI

ChevronTexaco

Collaborations

U.S.

FTA

NAVC

HCATT

CaFCP

University of Hawaii

UC Davis

International

EC

PREMIA

ECTOS

CUTE

STEP

NRCan

UNDP-GEF

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

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

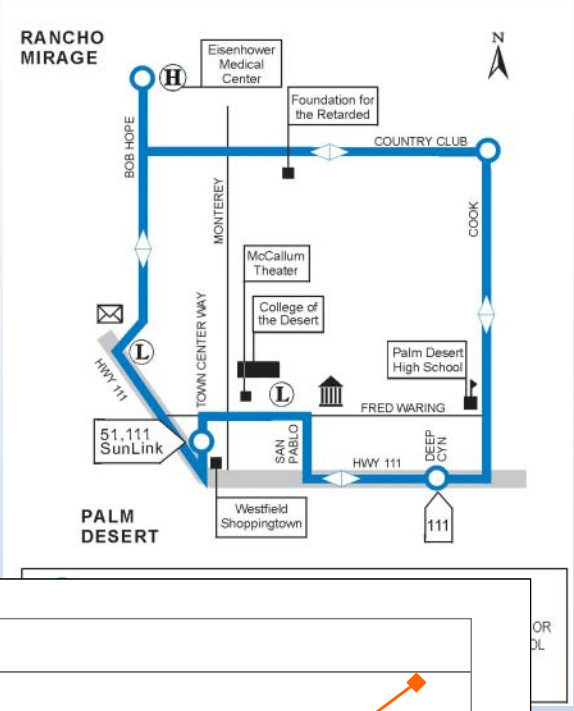
Progress: FCB Evaluations

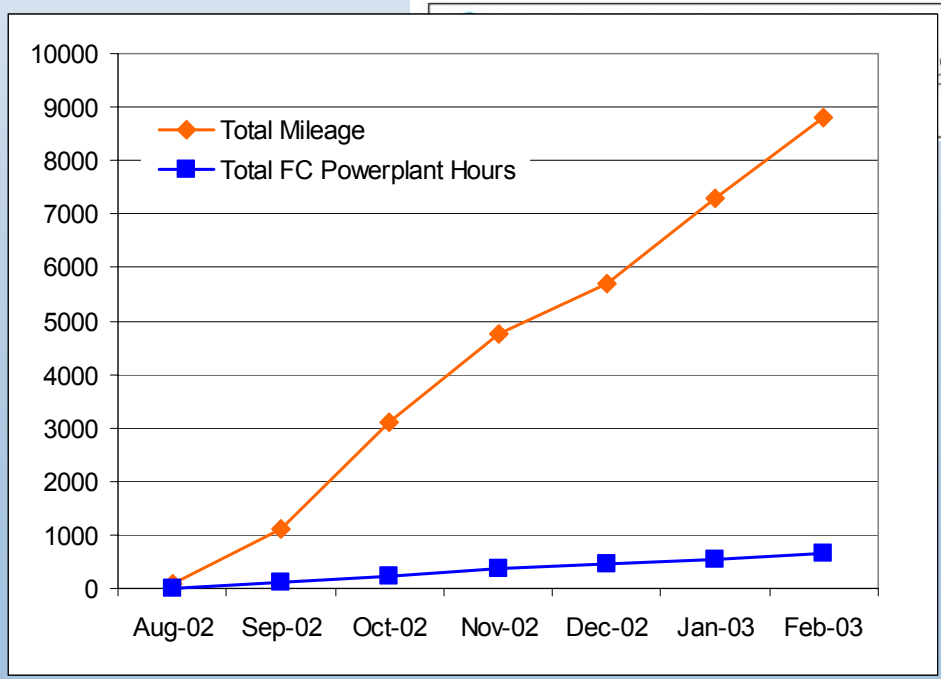
SunLine Transit Agency

Thousand Palms, CA

Bus Use:

- 6-month in-service evaluation
- Line 50
  - 12.8-mile loop
  - 43 minutes per loop
  - 17-mph average speed





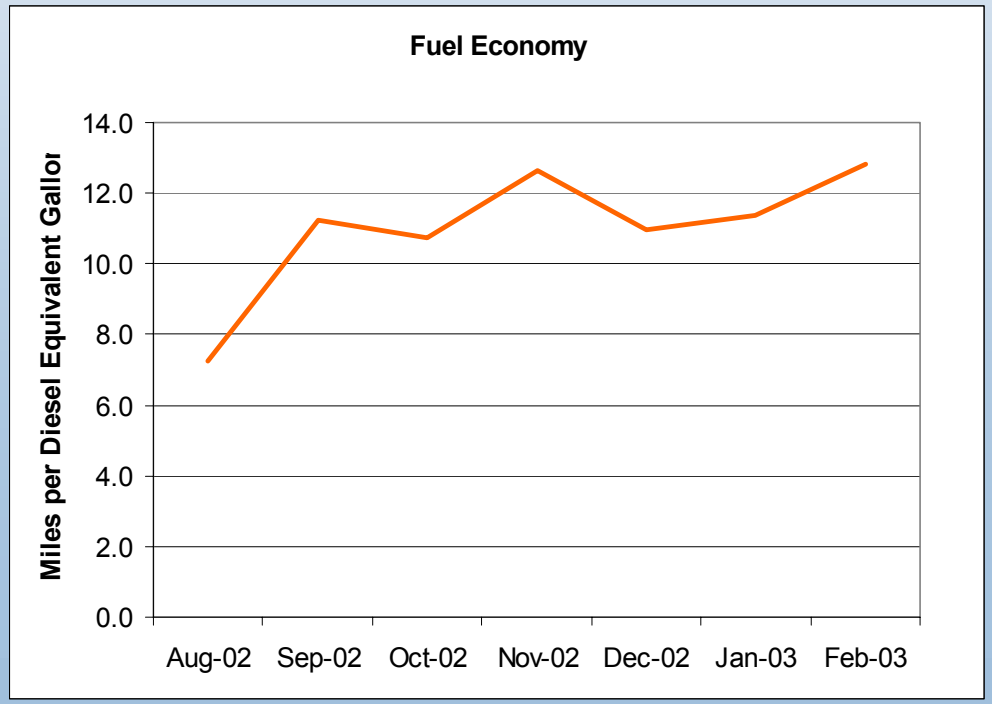
Progress: FCB Evaluations

SunLine Transit Agency

Thousand Palms, CA

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

Hydrogen Fuel Use:



Progress: FCB Evaluations

SunLine Transit Agency

Thousand Palms, CA

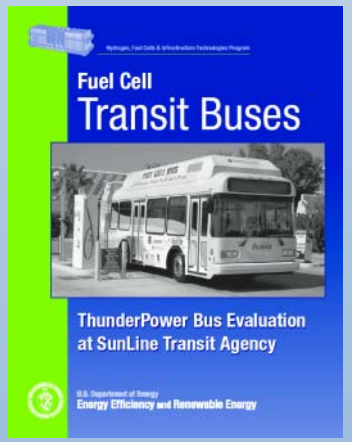
Reports available on the web:

Fact Sheet

www.eere.energy.gov/hydrogenandfuelcells/tech_validation/pdfs/33639.pdf

Final Evaluation Report

www.eere.energy.gov/hydrogenandfuelcells/tech_validation/pdfs/sunline_report.pdf



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 H_2 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


HICKAM AFB BUS FACTS

FUEL CELL BUS DEMONSTRATION PROJECTS

Fuel Cell Hybrid Bus Lands at Hickam AFB

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:

L. Eudy, K. Chandler, “Fuel Cell Hybrid Bus Lands at Hickam AFB”, DOE/GO-102004-1968, September, 2004.

K. Chandler, L. Eudy, “ThunderPower Bus Evaluation at SunLine Transit Agency”, DOE/GO-102003-1786, November, 2003.

K. Chandler, L. Eudy, J. Zuboy, “SunLine Test Drives Hydrogen Bus”, DOE/GO-102003-1768, August, 2003.

Presentations:

L. Eudy, “DOE/NREL Fuel Cell Bus Evaluation Plan”, International Fuel Cell Bus Workshop, Porto, Portugal (Nov 2004).

L. Eudy, “DOE/NREL Fuel Cell Bus Evaluation Projects”, Electric Drive Transportation Association Conference, Orlando, FL (Sep 2004).

L. Eudy, “Testing & Analysis of Advanced Propulsion Systems”, 2004 American Public Transportation Association Bus & Paratransit Conference, Denver, CO (May 2004)

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.