

# Technology Validation: Fuel Cell Bus Evaluations



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May 25, 2005

This presentation does not contain any proprietary or confidential information

Project ID #  
TVP5

# 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<sub>2</sub> Infrastructure

APCI  
ChevronTexaco

## Collaborations

### U.S.

FTA                      CaFCP  
NAVC                  University of Hawaii  
HCATT                  UC Davis

### International

EC                      CUTE  
PREMIA                  STEP  
ECTOS                  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	EIDorado 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



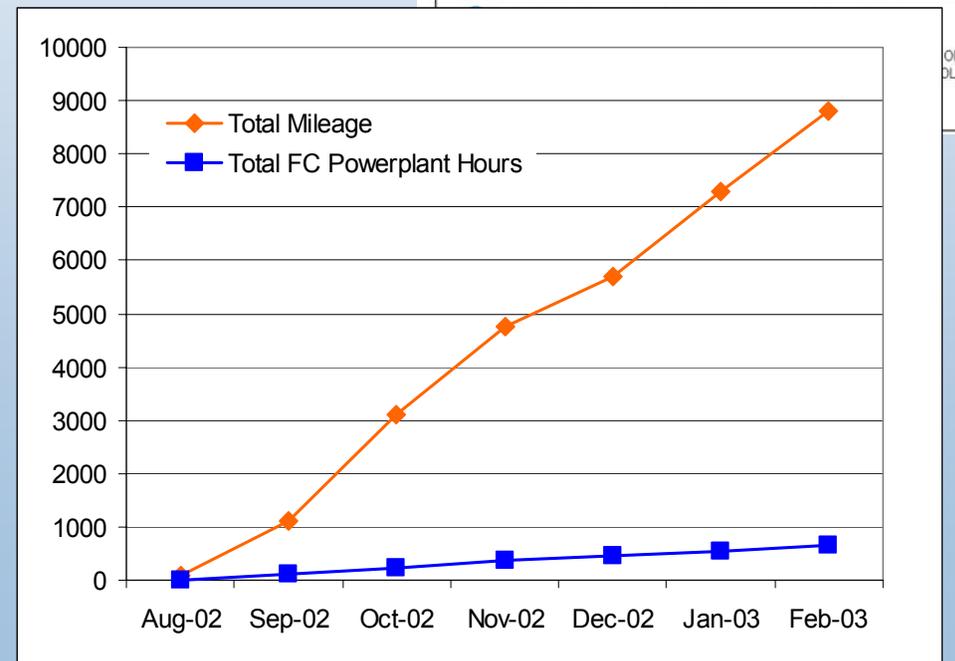
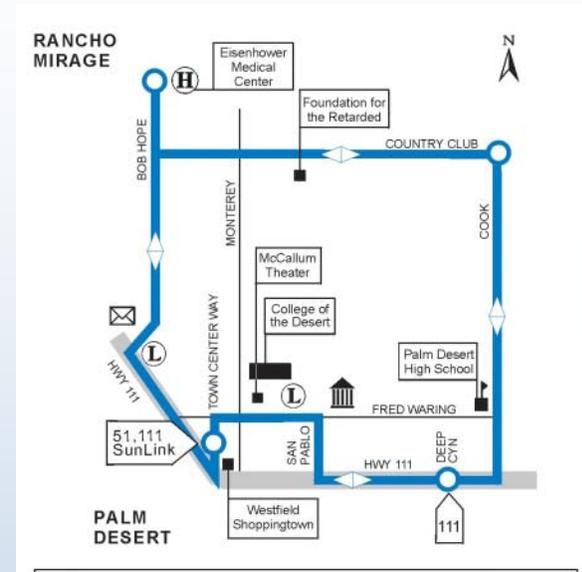
# Progress: FCB Evaluations

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



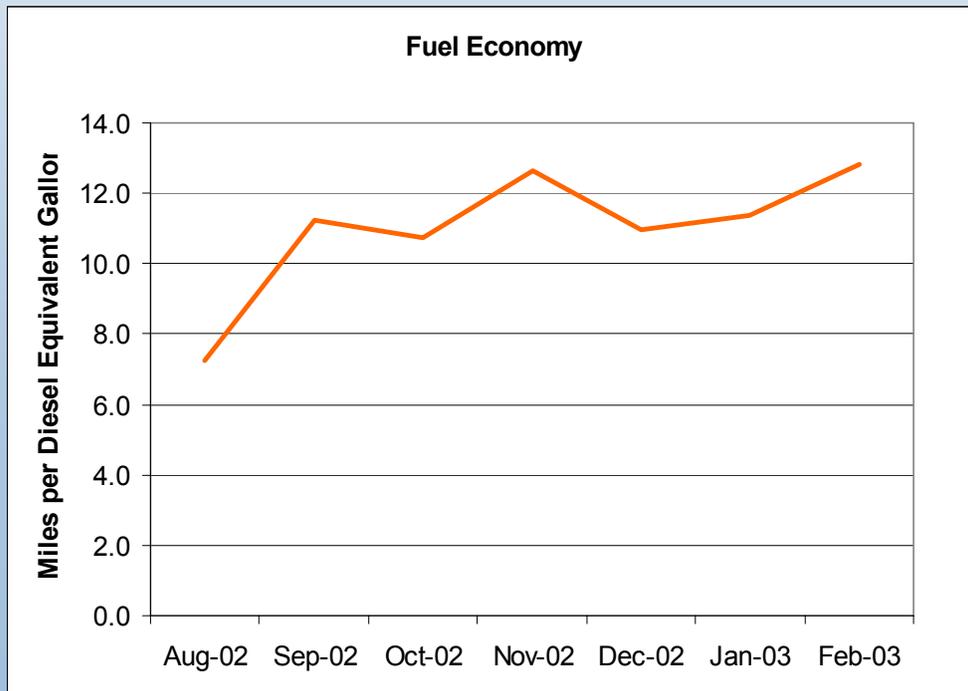
# Progress: FCB Evaluations

## SunLine Transit Agency

Thousand Palms, CA

### Hydrogen Fuel Use:

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



# Progress: FCB Evaluations

## SunLine Transit Agency

Thousand Palms, CA

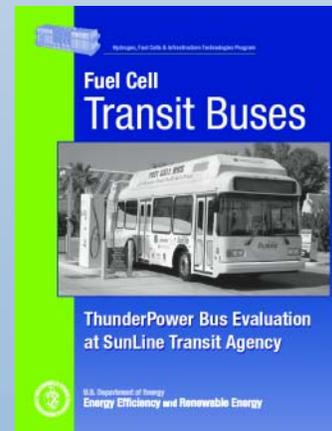
## Reports available on the web:

### Fact Sheet

[www.eere.energy.gov/hydrogenandfuelcells/tech\\_validation/pdfs/33639.pdf](http://www.eere.energy.gov/hydrogenandfuelcells/tech_validation/pdfs/33639.pdf)

### Final Evaluation Report

[www.eere.energy.gov/hydrogenandfuelcells/tech\\_validation/pdfs/sunline\\_report.pdf](http://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<sub>2</sub> 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

## 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 VanHool 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 3<sup>rd</sup> 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 3<sup>rd</sup> 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.