

Texas Hydrogen Highway

Fuel Cell Hybrid Bus and Fueling Infrastructure Technology Showcase

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This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Project TV011

Overview

Timeline

- Start: Sept. 1, 2008
- End: Sept. 1, 2010
- 85% complete

Budget

- Total Project Funding:
\$382,776
 - DOE share: 100%
 - Contractor share: 0%
- Funding received:
 - FY09: \$244,069
 - FY10: \$138,707

Barriers

- Technical Barriers Addressed
 - Lack of fuel cell vehicle performance and durability data
 - Hydrogen storage
 - Lack of hydrogen refueling infrastructure performance and availability data
 - Maintenance and training facilities
 - Codes and standards
- Partners
 - Interactions/collaborations
 - University of Texas at Austin
 - Gas Technology Institute
 - Houston Advanced Research Center
 - Project Lead
 - Texas H2 Coalition



The 22-ft fuel cell hybrid bus (E-Bus) on its way to the Dallas-Ft. Worth area for demonstration
Gas Technology Institute
University of Texas at Austin

The hydrogen station is automated with on-site hydrogen generation. The reformer, gas clean-up, compression, and controls are on a skid that is fabricated prior to installation.



Relevance:

Objectives

- Objectives
 - To provide public outreach and education by showcasing the operation of a 22-foot fuel cell hybrid shuttle bus and hydrogen fueling infrastructure
 - To showcase operation of zero-emissions vehicle for potential transit applications
 - To advance commercialization of hydrogen-powered transit buses and supporting infrastructure

Relevance Milestones

| Objectives | Milestones | Progress |
|---|---|--|
| <p>To provide public outreach and education by showcasing the operation of a 22-foot fuel cell hybrid shuttle bus and hydrogen fueling infrastructure</p> | <ul style="list-style-type: none"> • Final bus prep and checkout • Route data collection, modeling and simulation • Support, start-up, and operation of fueling station • Over six months, conduct public outreach and education through bus and fueling station operation and performance evaluation • Mid-term inspection and evaluation | <ul style="list-style-type: none"> • Complete • Complete • Complete • All activities completed except one possible final event • Complete |
| <p>To showcase operation of zero-emissions vehicle for potential transit applications</p> | <ul style="list-style-type: none"> • Bus training for transit staff • Station training and follow-on activities • On-site education and outreach | <ul style="list-style-type: none"> • Complete • Complete • Complete |
| <p>To advance commercialization of hydrogen-powered transit buses and supporting infrastructure</p> | <ul style="list-style-type: none"> • Validate refueling time of 3 minutes or less for 5 kg hydrogen at 5,000 psi with advanced communications • Validate hydrogen cost of \$3.00/gge • Validate refueling site compression technology • Validate refueling site stationary storage • Validate the ability to produce 5,000 psi hydrogen from natural gas for \$2.50/gge. | <ul style="list-style-type: none"> • In progress • In progress (based on marginal cost only) • In progress • In progress (using composite storage system) • In progress (based on marginal cost only) |

Relevance

Impacts on Barriers

| Barriers | Project's Impacts |
|---|---|
| Lack of fuel cell vehicle performance and durability data | Demonstrated fuel cell performance on transit bus; route simulation for transit application as part of outreach, education and training |
| Maintenance and training facilities | Showcased operation for transit agencies and others, including state agencies and local governments. |
| Hydrogen storage | Demonstrating composite ground storage applicability for fueling stations |
| Lack of hydrogen refueling infrastructure performance and availability data | Demonstrating technical viability of utilizing natural gas distribution network to leverage hydrogen infrastructure build-out. |
| Codes and standards | Demonstrating ability to work with local codes officials to demonstrate hydrogen vehicle and infrastructure technologies. |

Approach

The Austin, Texas hydrogen fueling station and transit bus were implemented over a five-year period through support of state, federal, and private funding to show a skid-mounted, fully integrated factory-built and tested hydrogen fueling station that simplified and lowered infrastructure costs.

This project was aimed at showcasing this equipment to advance commercialization through outreach and education with transit and other audiences in Texas as well as providing information and data on DOE identified technical barriers.

| Technology | Outreach and Education | Commercialization and Technical Barriers Addressed |
|--|---|--|
| <ul style="list-style-type: none">• Bus: 22-ft. fuel cell plug-in hybrid electric transit bus• Fueling infrastructure: Integrated fueling station with steam reformer, gas processing, compression, storage and dispensing. | <ul style="list-style-type: none">• Presentation of vehicle performance data and experience to target audiences• Demonstration of hydrogen storage and refueling for target audiences• Use of facilities, vehicle, and staff experience for training of transit staff• Information dissemination on experience with vehicle infrastructure in applying codes and standards | <ul style="list-style-type: none">• Vehicle performance data and experience• Hydrogen storage• Refueling infrastructure performance and availability data• Training• Codes and standards |

Technical Accomplishments 1

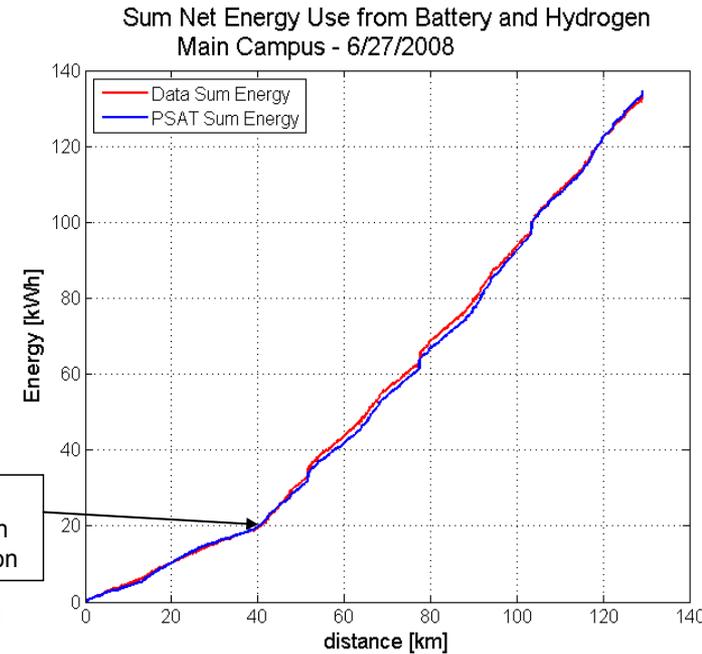
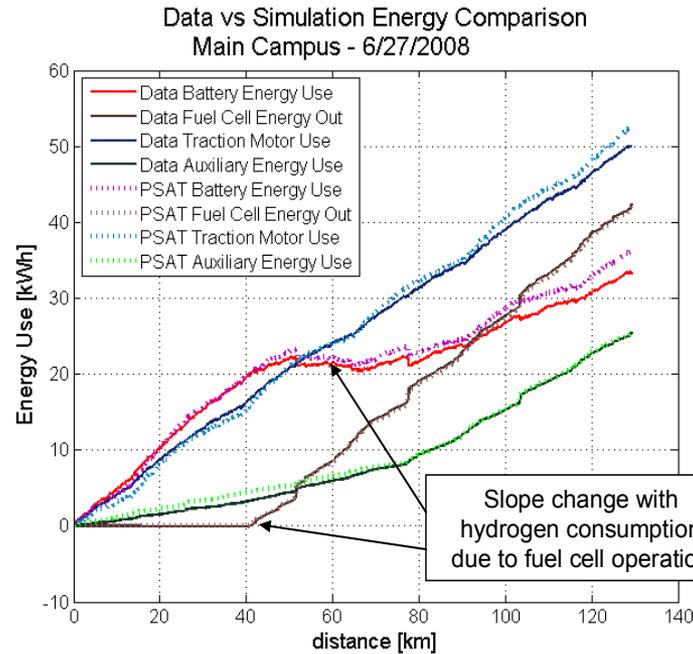
- Objective: outreach on fuel cell bus and fueling infrastructure
 - Transported fuel cell bus to the Dallas/Ft. Worth area for demonstration to transit staff and other target audiences in the area.
 - Houston presentations on bus and infrastructure as part of hydrogen workshop at clean air conference.
 - San Antonio presentations on bus and infrastructure including transit fleet staff.
 - Showcase event in Austin at the UT Pickle Research Center including a vehicle demonstration and demonstration of fueling infrastructure. Event included participation by transit staff.
 - Briefing of Texas legislative staff on fuel cell vehicle and fueling infrastructure, including vehicle demonstration.
 - Showcase event at engineering conference using fuel cell bus including staff of the Texas Department of Transportation and the Federal Highway Administration.
 - Showcase event with vehicle at alternative fuel conference in Austin.
- Milestone
 - Completion of major showcase events
- Conclusions
 - Level of interest driven somewhat by hands-on experience with vehicle (riding), infrastructure (touring and fueling), and staff experience (question and answer)
 - Combined vehicle and fueling experience important as a package experience, rather than the vehicle by itself or fueling by itself.

Technical Accomplishments 2

- Objective: Showcase for transit applications
 - Briefing and demonstration of vehicle and fueling with Austin Capital Metro staff
 - Review of transit facility to determine how fuel cell vehicle and fueling would work with existing transit operation
 - Presentations to Dallas-Ft. Worth area transit staff on vehicle and fueling infrastructure
- Milestones
 - Completed showcasing of transit route analysis conducted under previous Federal Transit Administration grant for transit staff and others as part of outreach
 - Conducted training for local transit staff on vehicle and infrastructure operations
 - Developed new fuel cell transit project for 2011 using existing fueling infrastructure for transit operation in Austin
- Conclusions
 - Transit interest is higher with the presence of vehicle and fueling infrastructure.
 - Demonstrating operational feasibility on transit routes through simulation and demonstration help confirm interest.

Vehicle Simulation for Transit Route

- Information used in outreach and training for transit staff
- Analysis conducted under FTA grant
- Simulation software used to determine if it could adequately project the energy use of the fuel cell hybrid electric bus on existing transit routes.
- Matched vehicle's net energy consumption within 5%
- Approach helps others make better choices on emerging vehicle technologies
- Avoids a “build and test” approach



Technical Accomplishments 3

- Objective: Advancing commercialization
- Milestones
 - Completed the commissioning of the first hydrogen fueling station in Texas; station is operational and being used to fuel Hydrogen Fuel Cell Plug-in Hybrid Shuttle Bus
 - Rides provided as part of events including conference with UT-Ferguson Structural Engineering Lab, the Texas Department of Transportation and the Federal Highway Administration; Austin AltCar and Climate conferences; Dallas/Ft. Worth hydrogen workshop; and for Texas legislative staff.
 - Spurred interest in Texas for additional fuel cell vehicle demonstrations
- Summary
 - Technology showcase projects are critical for early pre-commercialization of “game-changing” technologies. They help both the public and the technology provider in determining how a technology can best be utilized in a working environment.

Collaborations

- Texas H2 Coalition
 - Prime, grant recipient, 501 (c)(6) non-profit organization
- University of Texas at Austin Center for Electromechanics
 - Subcontractor
 - Site of fueling infrastructure and fuel cell bus
 - Technical support for showcasing hydrogen fueling and shuttle bus
- Gas Technology Institute
 - Subcontractor
 - Technical support for showcasing the hydrogen vehicle fueling infrastructure
- Houston Advanced Research Center
 - Subcontractor
 - Project administration and coordination

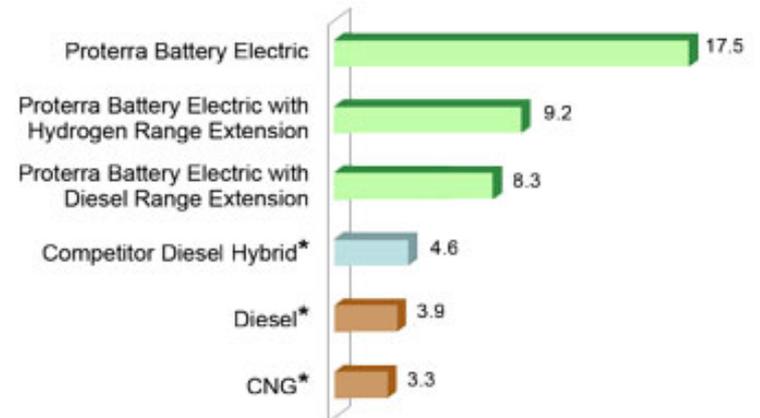
Future Work

- Final outreach event with state air quality and energy officials
- Development of continuation project as outcome of DOE project
 - New transit bus using existing fueling infrastructure (2011)
 - Local transit authority and state environmental agency implementing
- State's air quality problems are driving force for clean transportation fuels



Diesel Miles Per Gallon Equivalent

Based on March 2009 Proterra Altoona Performance Validation



Summary

- Fuel cell bus and fueling infrastructure funded by non-DOE sources served as basis for this project.
 - Provided operation and data collection with fuel cell bus and fueling infrastructure for Texas
 - Aimed at transit applications and fleets with outreach to others in the state
 - Multi-partner expertise for on-site project operations, fueling infrastructure, technical guidance, and management
- Project is providing basis for continuing fuel cell bus transit project in Texas.