VIII.10 Detroit Commuter Hydrogen Project*

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*Congressionally directed project

Objectives

- To evaluate the feasibility of using renewable fuels as a part of a sustainable transportation infrastructure, feeding a regional, public mass-transit system.
- To compare reliability, acceptability and cost effectiveness of hydrogen and propane/gasoline internal combustion engine powered buses.

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section (3.6.4) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Lack of Vehicle Performance and Durability Data

(B) Hydrogen Storage

(C) Lack of Hydrogen Fueling Infrastructure Performance and Availability Data

Contribution to Achievement of DOE Technology Validation Milestones

This project will contribute to achievement of the following DOE milestones from the Technology Validation milestone section 3.6.6 of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 5: Validate vehicle refueling time of 5 minutes or less for a 5 kg tank (1 kg/min). (4Q, 2006)**
  The buses in the Detroit Commuter Hydrogen project are hydrogen-fueled internal combustion engine buses (H2ICE). They have been able to demonstrate some fuel fill times that meet the 1 kg/min target. Filling the 30 kg tanks of the buses has been done in some cases with rates as high as 1.4 kg/min. However, average fill rates have been 0.94 kg/min for a number of reasons associated with the reliability of the fueling station. Frequent compressor and other hardware issues have caused the fill times to extend while operators wait to have a slow-fill deliver a sufficient quantity of hydrogen to provide adequate operating time for the buses. These buses use a significant quantity of hydrogen and when the station operates as designed, the fill times have been demonstrated to be acceptable to the commercial user.
- **Milestone 8: Demonstrate the ability to achieve 250-mile range without impacting passenger cargo compartment. (4Q, 2008)**
  The Detroit Commuter Hydrogen Demonstration buses are not expected to perform to the same standards as a consumer designed fuel cell vehicle, but the demonstrated range in shuttle bus operation is more than adequate for project operation. Specifically, the two buses have provided 9.8 miles/kg of hydrogen, and in these buses, this produces a useable range of around 270 miles. This performance permits a single fill for each day of fleet use and is more than acceptable to the fleet operator. The H2ICE bus configuration in this project accommodates nine passengers compared to similar propane/gas-powered shuttle buses that can carry 10 passengers.
- **Milestone 14: Validate achievement of a refueling time of 3 minutes or less for 5 kg of hydrogen at 5,000 psi using advanced communication technology. (2Q, 2012)**
  As noted in the discussion of fill times above, although communications technologies are employed, the reliability of the filling station has made it difficult to demonstrate achievement of this target. Assuming the best fill times of 1.4 kg/min as potentially viable in the process as designed, and using the communication technology that is employed at the station, the process would deliver 5 kg of hydrogen in 3.6 minutes.

Accomplishments

- Operated two H2ICE buses for 20,130 miles with high reliability.
- Demonstrated fuel economy of 9.6 to 9.8 miles/kg H_2.
- Carried over 6,560 passengers in regular airport shuttle service.
- Collected rider comment survey cards from 759 passengers with written comments from 325 passengers.
- Demonstrated overwhelming rider acceptance of the hydrogen power concept used in these H2ICE buses: 88.4% indicated this is an important environmental project and 99.6% indicated they would ride again on hydrogen-powered buses.
- Demonstrated that the H2ICE bus has comparable fuel economy, expressed in miles per gallon of gasoline equivalent energy, to the propane/gas-powered buses currently in use.

Introduction

SEMCOG is exploring the development of a mass transit rail system to link Detroit with Ann Arbor and other southeast Michigan cities. If the public rail system is implemented, the Detroit Metropolitan Airport will be a key element of the system, and there will be a need to connect it to the commuter rail system at a station not too distant from the airport terminals. H2ICE vehicles could be used to link to the rail line at a proposed stop four miles from the airport.

This project is designed to evaluate the performance of H2ICE shuttle buses that can provide this passenger linking capability. Ford Motor Co. has developed a hydrogen powered V-10 engine and installed it into a shuttle bus chassis and body with a specially designed, multi-tank hydrogen storage system capable of holding 30 kg of hydrogen at 350 bar (5,000 psi).

Approach

Ford Motor Co. has applied hydrogen fuel technology to internal combustion engines and has built and delivered two buses powered by hydrogen fuel. These buses are designed to carry nine passengers with their luggage in normal airport shuttle service. Detroit Metro Airport has provided these buses to their ground transportation sub-contractor, Metro Cars Inc. Ford and BP, the fuel station operator, provided training in unique and safe operating procedures to METRO CARS® bus operators. METRO CARS® is operating and maintaining the buses in normal passenger service in airport parking operations.

Fueling is being done at a nearby City of Taylor hydrogen fueling facility. Bus operators are providing manual data collection, and Ford has installed on-board telemetry systems to collect real-time data about the buses operation and fuel use. Both the manual and telemetry data is being analyzed to determine the fuel economy of the hydrogen-powered buses, and to compare these two buses with similar propane/gasoline-powered buses operating in the same passenger carrying fleet. At the same time, survey cards are being provided to passengers to permit them to express their impression of the buses and their reaction to this hydrogen fuel initiative.

Results

The hydrogen-powered buses have been operating effectively since March 29th, 2009. They have accumulated over 20,000 miles in 126 operating shifts, and have carried over 6,500 passengers. This has permitted the collection of fuel use data and passenger comments to directly assess the viability of this technology in a regional transportation system.

Table 1 illustrates the fuel economy of the buses and compares the hydrogen-powered buses to two propane/gasoline-powered buses in the fleet. The data, both operator log and telemetry data, indicates that, on a gasoline gallon equivalent (gge) basis, the hydrogen buses are comparable to the propane buses.

TABLE 1. Comparative Fuel Economy Data
(Data from March 29 thru June 30, 2009)

Bus No.	820	830	32	41
Passenger Capacity	**23**	**10**	**9**	**9**
Fuel Type	Propane/ Gasoline	Propane/ Gasoline	Hydrogen	Hydrogen
Miles Driven	20,432	15,973	9,473	10,735
Hydrogen Used (kg)	0	0	978	1,111
Propane used (gal)	2,164	1,284	0	0
Propane GGE Used	1,581	938	0	0
Gas Used (gal)	899	597	0	0
Total GGE Used	2,480	1,535	986	1,120
MI/GGE	**8.2**	**10.4**	**9.6**	**9.6**
Telematics Fuel Used thru 7/05/09 kg			1,007.2	1,138.6
Telematics m/gge 7/05/09			9.7	9.9

The data can also be normalized for estimating the fuel economy under the assumption that all the buses in the study carried the same average number of passengers,

providing a somewhat more direct comparison. The largest (23-passenger) bus carries the highest average number of people (six) and is used as the standard for comparison. The reduction in the calculated fuel economy, for the hydrogen buses and for the 10-passenger propane/gas bus, is estimated by the percentage of weight change due to added passengers to estimate six passengers loading. Table 2 illustrates this calculation.

Passengers have reacted overwhelmingly positively to the hydrogen-powered bus concept. Their comments have been collected on survey cards provided to them by the bus drivers. 759 of 6,566 people who have ridden the buses through June 30th (11%) completed some or all of the survey questions. Tabel 3 is the summary of their input.

Conclusions and Future Directions

Conclusions

- The H2ICE concept is proving to be adaptable to shuttle bus operations.
- Fuel use and economy in shuttle buses is comparable to the current propane/gasoline-powered vehicles.
- No safety problems or concerns have arisen during this project, but continued operations will enhance the understanding of potential safety issues should they occur.
- There have been no significant maintenance issues with the hydrogen buses and continued operation will provide more learning to support this comparison with conventional buses.
- Riders overwhelmingly accept both the buses and the application of hydrogen as a fuel for use in public transportation.

Future Directions

- Continue passenger service to enhance the data with operations in summer weather conditions.
- Explore alternative fueling options to overcome a potential early termination if the Taylor hydrogen facility does not remain open for the duration of this project.

FY 2009 Publications/Presentations

A poster presentation was made at the 2009 Annual Hydrogen Program Merit Review and Peer Evaluation Meeting in May. The SEMCOG team was represented and reported that there was attendee interest in the project and this application of hydrogen in the internal combustion engine-powered buses.

TABLE 2. Fuel Economy Estimate at Standard Passenger Load

Bus (passengers capacity)	Fuel	Reported Average Fuel Economy (FE)	Average number of passengers	% Weight increase/ FE Reduction at 6 passengers	Est. FE (mi/gge) at 6 Passenger Load
No. 820 (23)	Propane/Gas	8.2	6	0%	8.2
No. 830 (10)	Propane/Gas	10.4	3	7%	9.7
H_2 Buses (9)	Hydrogen	9.8	2	6%	9.2

TABLE 3. Rider Survey Summary

Thru 7/5/09	Seats	Temperature	Clean	Smooth	Noise	Ride	Environmental Importance?		Ride Again?	
Very Good	567	470	574	459	587	560	Very Important	609	Yes	699
Good	147	177	97	275	148	173	No Opinion	74	No	3
OK	19	34	9	1	2	0	Not Important	22		
Not Good	4	5	0							
total	737	686	680	735	737	733		705		702

Thru 7/5/09	Seats	Temperature	Clean	Smooth	Noise	Ride	Environmental Importance?		Ride Again?	
Very Good	76.93%	68.51%	84.41%	62.45%	79.65%	76.40%	Very Important	86.38%	Yes	99.57%
Good	19.95%	25.80%	14.26%	37.41%	20.08%	23.60%	No Opinion	10.50%	No	0.43%
OK	2.58%	4.96%	1.32%	0.14%	0.27%	0.00%	Not Important	3.12%		
Not Good	0.54%	0.73%	0.00%	0.00%	0.00%	0.00%				