

Final Report

Detroit Commuter Hydrogen Project

Cooperative Agreement DE-FG36-06GO-86051.A001
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SEMCOG

Team members:

- Southeast Michigan Congress of Governments (SEMCOG)
- Ford Motor Company
- BP America
- Wayne County Airport Authority
- Metro Cars Inc.
- ASG Renaissance



METRO CARS®



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SEMCOG

This program was undertaken as a part of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan, resulting in a cooperative agreement between Southeast Michigan Congress of Governments (SEMCOG) and the DOE to evaluate the viability of hydrogen power internal combustion engine vehicles in a mass transit application.

Ford Motor Company had developed a hydrogen fueled internal combustion engine applied in a bus chassis suitable for parking shuttle applications. SEMCOG worked with the Wayne County Airport Authority (WCAA) to develop a plan to use two of these vehicles for evaluation.

The deliverables of this project are to be used to provide critical input to the hydrogen economy commercialization decisions by 2015.

Principle 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.

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Executive Summary

This project was undertaken to demonstrate the viability of using hydrogen as a fuel in an internal combustion engine vehicle for use as a part of a mass transit system. The advantages of hydrogen as a fuel include renew-ability, minimal environmental impact on air quality and the environment, and potential to reduce dependence on foreign energy sources for the transportation sector.

Recognizing the potential for the hydrogen fuel concept, the Southeast Michigan Congress of Governments (SEMCOG) determined to consider it in the study of a proposed regional mass transit rail system for southeast Michigan. SEMCOG wanted to evaluate the feasibility of using hydrogen fueled internal combustion engine (H2ICE) vehicles in shuttle buses to connect the Detroit Metro Airport to a proposed, nearby rail station.

Shuttle buses are in current use on the airport for passenger parking and inter-terminal transport. This duty cycle is well suited to the application of hydrogen fuel at this time because of the ability to re-fuel vehicles at a single nearby facility, overcoming the challenge of restricted fuel availability in the undeveloped hydrogen fuel infrastructure. A cooperative agreement between SEMCOG and the DOE was initiated and two H2ICE buses were placed in regular passenger service on March 29, 2009 and operated for six months in regular passenger service. The buses were developed and built by the Ford Motor Company. Wayne County Airport Authority provided the location for the demonstration with the airport transportation contractor, Metro Cars Inc. operating the buses.

The buses were built on Ford E450 chassis and incorporated a modified a 6.8L V-10 engine with specially designed supercharger, fuel rails and injectors among other sophisticated control systems. Up to 30 kg of on-board gaseous hydrogen were stored in a modular six tank, 350 bar (5000 psi) system to provide a 150 mile driving range. The bus chassis and body were configured to carry nine passengers with luggage.

By collecting fuel use data for the two H2ICE buses, with both written driver logs and on-board telemetry devices, and for two conventional propane-gasoline powered buses in the same service, comparisons of operating efficiency and maintenance requirements were completed. Public opinion about the concept of hydrogen fuel was sampled with a rider survey throughout the demonstration.

The demonstration was very effective in adding to the understanding of the application of hydrogen as a transportation fuel. The two 9 passenger H2ICE buses accumulated nearly 50,000 miles and carried 14,285 passengers. Data indicated the H2ICE bus fuel economy to be 9.4 miles/ gallon of gasoline equivalent (m/GGE) compared to the 10 passenger propane-gasoline bus average of 9.8 m/GGE over 32,400 miles. The 23-passenger bus averaged 7.4 m/GGE over 40,700 miles.

Rider feedback from 1050 on-board survey cards was overwhelmingly positive with 99.6% indicating they would ride again on a hydrogen powered vehicle.

Minimal maintenance was required for these buses during the demonstration project, but a longer duration demonstration would be required to more adequately assess this aspect of the concept.

Objectives and Background

The objective of this project was to evaluate clean, hydrogen powered internal combustion engine (H2ICE) technology for use in mass transit applications. The Southeast Michigan Council of Governments (SEMCOG) was the sponsor of this program. SEMCOG is working with local and federal agencies to determine whether a mass transit rail system can be created to link Ann Arbor to Detroit. If the public rail system is implemented, hydrogen ICE vehicles could be used to link Detroit Metropolitan Airport and the rail line at a proposed stop approximately four miles from the airport, at Michigan Avenue and Merriman road.

Two H2ICE buses were prepared by Ford Motor Company, as part of a larger evaluation project, and provided to the Wayne County Airport Authority (WCAA) for use at the Detroit Metropolitan Airport in the airport's regular shuttle bus operations, which are managed by Metro Cars Inc. through a contract with WCAA.

The H2ICE shuttle buses were used to evaluate the feasibility of using clean domestically produced renewable fuels as part of a sustainable transportation infrastructure. The two hydrogen powered ICE shuttle buses and two propane-gasoline powered ICE shuttle buses were included as part of the demonstration project to permit comparison of vehicle attributes such as reliability, acceptability and cost of operation.

Hydrogen fuel was available at a station located on the grounds of the nearby City of Taylor Department of Public Works facility. The fueling station had been placed in service as a part of another hydrogen fuel demonstration program and was operated by BP America.

The program, as conceived, was to encompass 20 months of operation. However, at the outset, there was some question about hydrogen fuel availability beyond December of 2009. This was related to BP's uncertain commitment to the operation of the City of Taylor hydrogen station. Recognizing this, it was judged that even a contracted project would provide useful information about the technologies and their application in a mass-transit system, and the decision was made to pursue the objectives of the demonstration. The operation of the buses began at the end of March, 2009.

Subsequently, BP made a decision to cease operation of the fuel station at the end of September 2009. Alternative fueling options were pursued and evaluated but none were feasible within the economic constraints of the participants. As a consequence, the operation of the buses ended on September 30th after six months of customer use.

In spite of the truncated project, significant data was gathered that permits a comparison of the fuel economy, maintenance requirements, and acceptability to shuttle bus passengers.

This project addresses the following technical barriers 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
- (D) Public Acceptance

The tasks defined for this project were:

- 1.0 Research & Development for Ford H2ICE Shuttle Buses
- 2.0 Hydrogen Shuttle Vehicle Build & Delivery
- 3.0 Hydrogen Shuttle Operator Training
- 4.0 Hydrogen Shuttle Operation
- 5.0 Project Management and Reporting

This report summarizes the learning from the project. The order of reporting is:

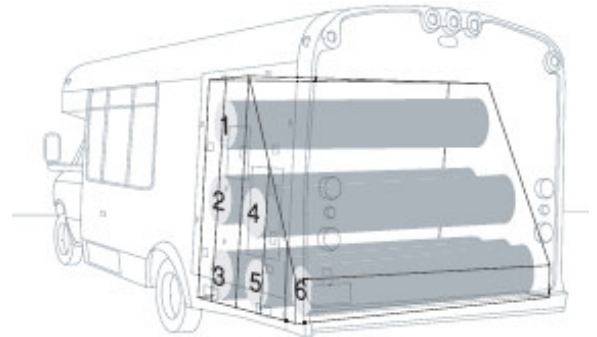
- 1. Overview of H2ICE Bus
- 2. Discussion of Bus Operations
- 3. Comparative Fuel Economy Review
- 4. Summary and Discussion of Rider Survey Inputs
- 5. Summary & Conclusions

Overview of the H2ICE Bus

Ford Motor Company began preparing the hydrogen powered internal combustion engine (H2ICE) concept engine in 2004. At that time the emphasis by the DOE and commercial interests across the country was to determine how an alternative, clean fuel such as hydrogen could be used in commercial applications. The DOE had undertaken the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan. Ford Motor was already involved in the evaluation of fuel cell car technology, and viewed an H2ICE as a possible bridge from current fuel technologies to hydrogen fuel cell vehicles, and as a backup to the fuel cell as a logical approach toward a sustainable transportation sector. The concept also supported the interest in energy security and fossil fuel independence.

Because of the lack of a hydrogen distribution system, it was envisioned that fleet operations, such as shuttle buses that are operated in a localized service area and able to be fueled at a single central location, would be ideal places to perform real-world evaluation of the H2ICE. For this reason, a development effort was instituted to focus on these applications and to serve the interest of the hydrogen programs of the DOE.

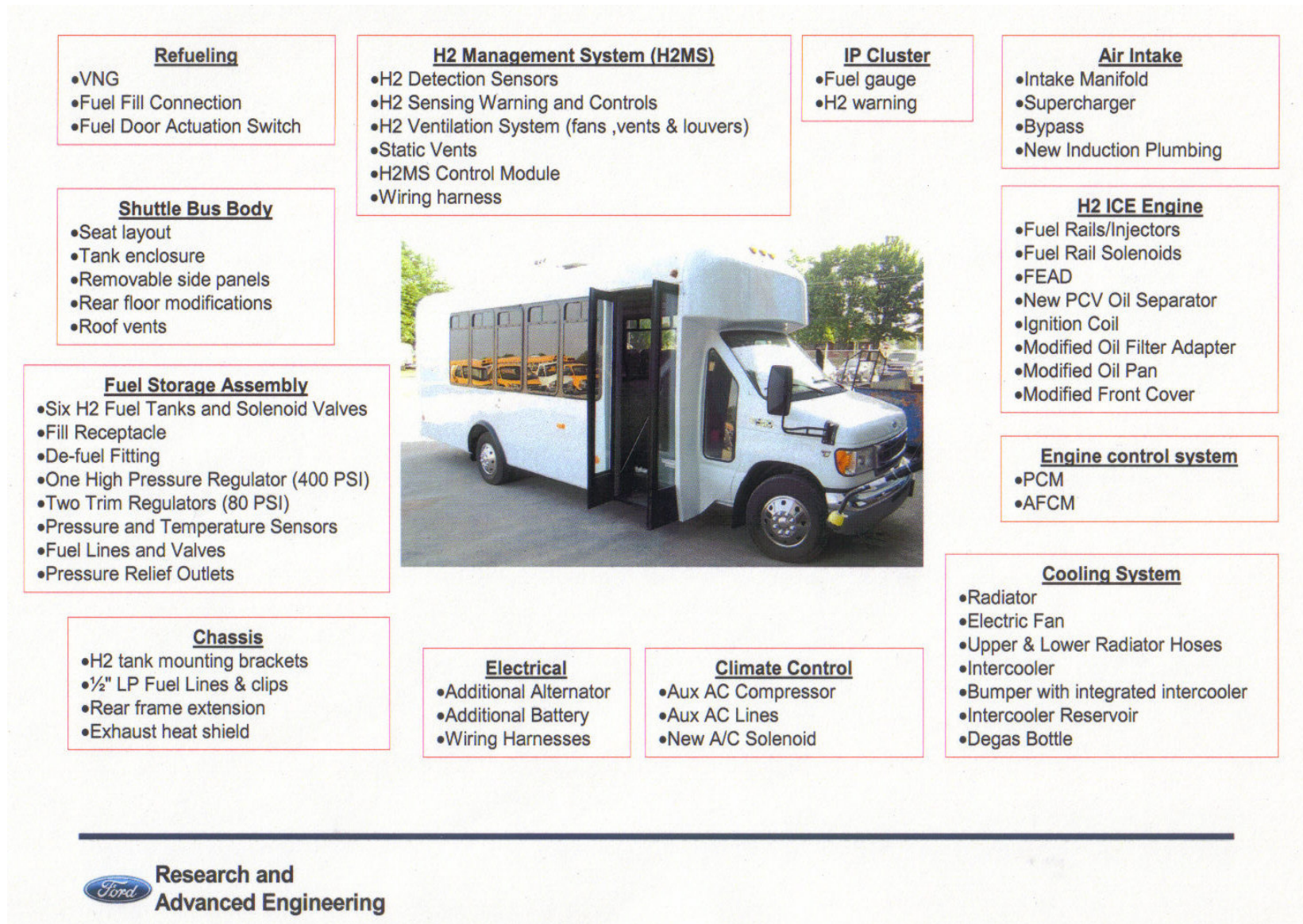
The shuttle bus is equipped with a hydrogen storage system capable of 150 mile range and has operating characteristics comparable to existing compressed natural gas (CNG) vehicles. The fuel storage system was designed to store 29.1 kg (27.5 kg usable) of compressed hydrogen gas at 350 bar (5000 psi) at 20° C. The fuel system was also designed to permit fast refueling by use of data connections with the fueling station. In addition, the fuel tank system was designed as a modular package to facilitate leak checks as a unit prior to installation in the bus chassis. Finally, the high-pressure hydrogen package was isolated in one space, which is monitored with hydrogen sensors. A 6.8L V-10 engine was extensively modified with a supercharger, fuel rails and injectors, along with many changes to adapt and control the hydrogen fuel.



The bus body was adapted to specific customer requirements. In airport applications such as in this project, seating was reduced from a maximum of 12 passengers to 9 to permit the installation of luggage storage racks.

The following page provides an overview of the many changes required to make the bus ready to carry airport passengers.

All of the work performed to prepare and deliver the buses to WCAA represents the completion of **Tasks 1.0 and 2.0** in the original statement of work.



Overview of Changes to Conventional ICE Shuttle Bus

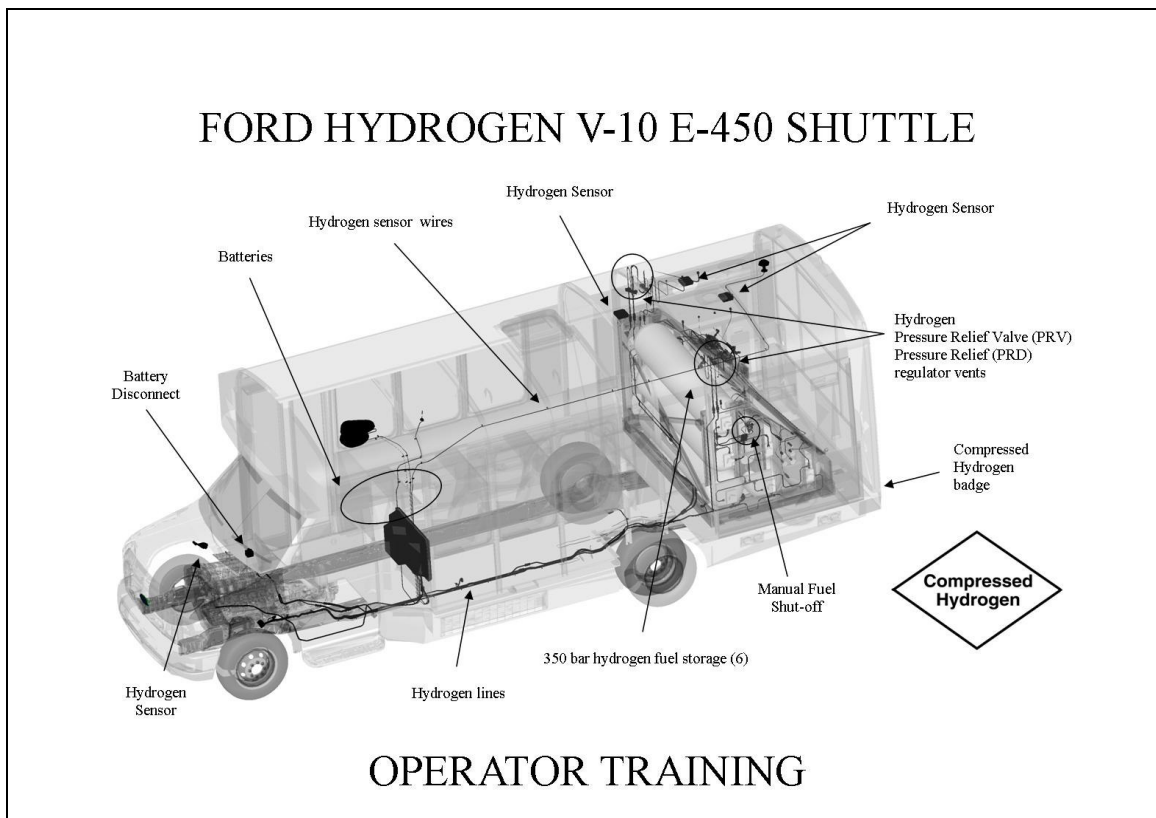
Operator Training: Task 3

In preparation for the deployment of the hydrogen powered vehicle, special training was planned for operators, and selected training was prepared for technician support at the Metro Cars facility. It should be noted however that any repair of the hydrogen systems of the vehicles was to be performed by Ford technician while the Metro Cars personnel were to perform the routine checks and maintenance required to keep the vehicles serviceable on a daily basis.

Operator training consisted of:

- Hydrogen Safety
- Vehicle Operation
- Fueling Procedures

Ford Motor Co engineering personnel conducted training classes on hydrogen safety and vehicle operation. For this fleet, the training was conducted at the Metro Cars Facility for six operators and several support people. The following illustration is a sample of the material used for this training that shows the bus configuration:



Training covered the following topics:

- Hydrogen
- Vehicle Specifications
- Safety Features
- Hydrogen Management Systems
- Vehicle Operations
- Fueling

BP and Linde conducted fueling Training on March 24th, just prior to bus deployment. Topics covered in this training included:

- Hydrogen
- City of Taylor Fuel Station Equipment
- Safety considerations
- Safety Implementation
- Dispenser Operations
- Emergency Procedures
- City of Taylor DPW Emergency Response Plan

In addition, Ford personnel contact local emergency response teams to determine the need for additional training specific to the H2ICE shuttle bus. The local teams were already trained in hydrogen safety as a part of other ongoing hydrogen demonstration programs. Training material was delivered to these teams in the airport area. Ford presented awareness training for the buses to the Romulus Fire Department and to the airport training office.

These activities, all conducted prior to the deployment of the buses, constituted the completion of **Task 3.0** of this project.

Discussion of Bus Operations: Task 4.0

Days and Shifts of Operation

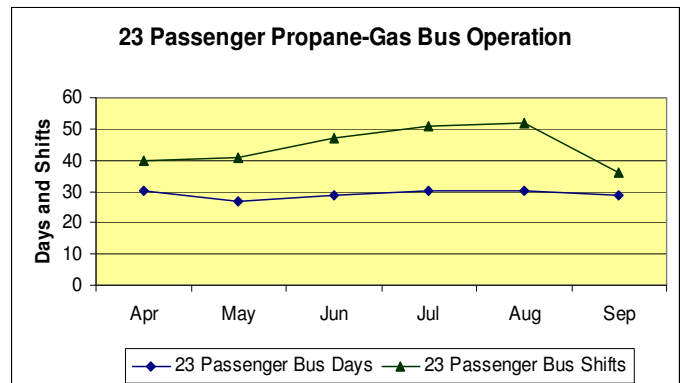
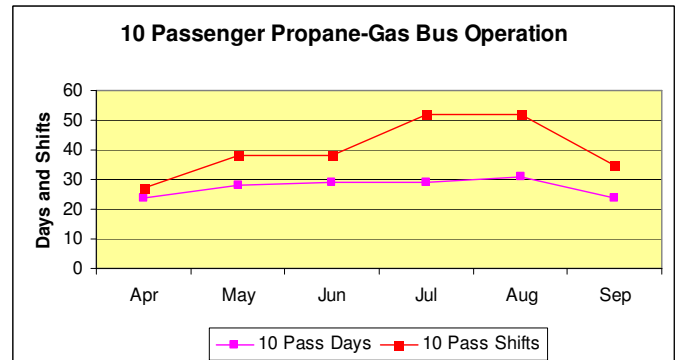
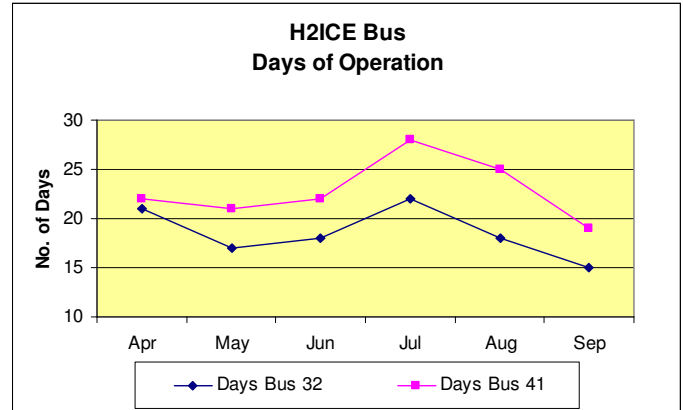
The plots at the right and on the following page provide summary data by month that captures the relative use of each of the three types of vehicles used in this program. Inter-terminal usage varies by airline volume and seasonal demand while parking service runs on regular schedules.

The 9-passenger hydrogen powered buses operated for a combined 248 days. Labeled No 32 and No 41 on the first plot, their operation had a grand average of 20.67 days per month.

In comparison, over 165 days of operation, the similar 10-passenger Propane/Gas bus average 27.5 days/mo. However, unlike the Hydrogen buses, the propane-gas bus frequently worked more than one shift per workday. The second line in the plot shows the number of shifts worked, a total of 265. This will be used later to calculate the average number of passengers carried per trip. The average was 40.3 shifts/month.

Finally, the large 23-passenger propane-gas bus operated 175 days and 267 shifts, and averaged 29.2 days of use per month, and 44.5 shifts.

The 9 and 10 passenger buses were used in inter-terminal routes while the 23 passenger units served the parking areas.



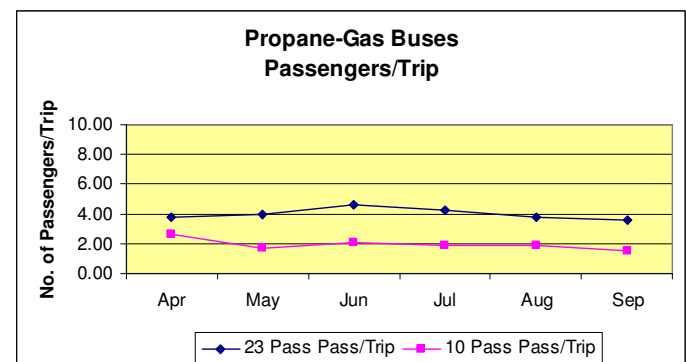
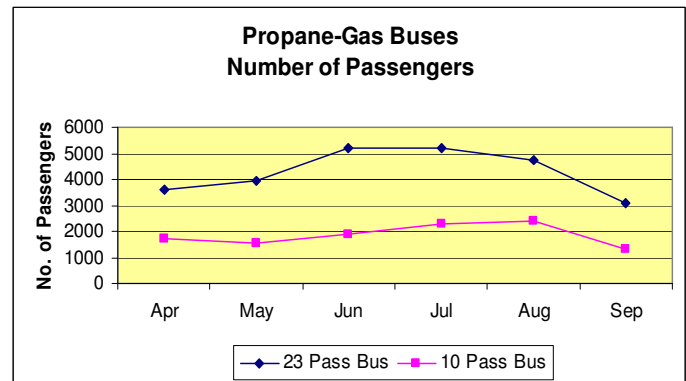
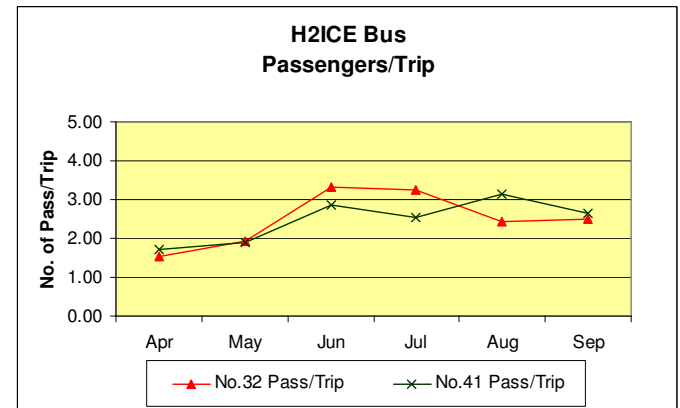
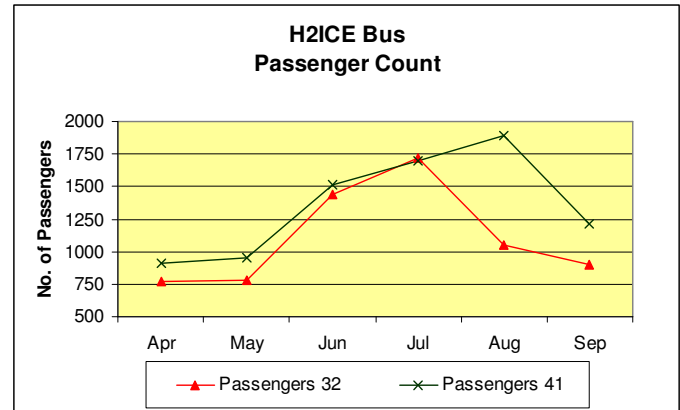
Comparative Number of Passengers

Total passenger counts and average numbers of passengers per trip are useful information for providing a more direct comparison of operational parameters that are relative to variation in load that the buses carry. Average passenger/trip numbers cannot be considered an accurate number because neither the number of trips nor the number of passengers were recorded in a fashion that would permit the calculation, but using experienced assumptions, some useful comparisons can be made.

The top plot shows monthly passengers data for the two H2 buses. The total number of passengers on the two H2ICE buses was 14,825. The data shows an average of 1235 passengers per month. These buses work one shift per day, or 8 hours. Metro Cars management agrees that buses nominally make about three trips/hour. Using the data for days of operation and total passenger counts; the number of passengers per trip can be estimated. This is shown in the second plot. The grand average for both buses is 2.5 pass/trip.

The next plot shows the same data for the Propane-Gas buses. Passenger volumes are much higher owing to number of shifts of operation, service routes and size of the vehicles. Records document 25,738 riders on the 23-passenger bus and 11,182 riders on the 10-passenger bus. (23 Pass average 4290/mo; 10 Pass average 1864/mo) However, average passenger/trip numbers are similar with 23-passenger bus at 4.0 and the 10-passenger bus at 2.0

These numbers will be used to compare overall fuel economy between the three types of buses.



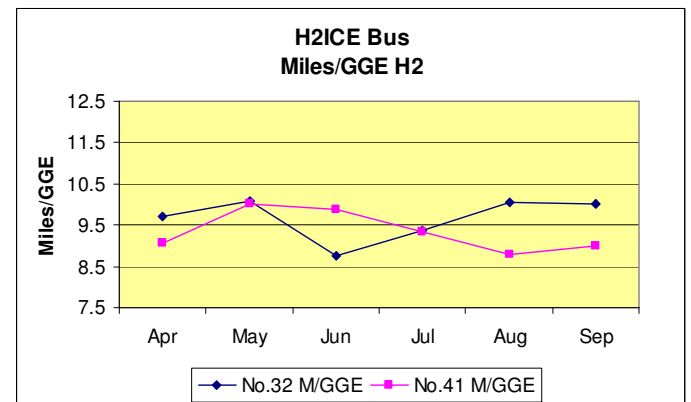
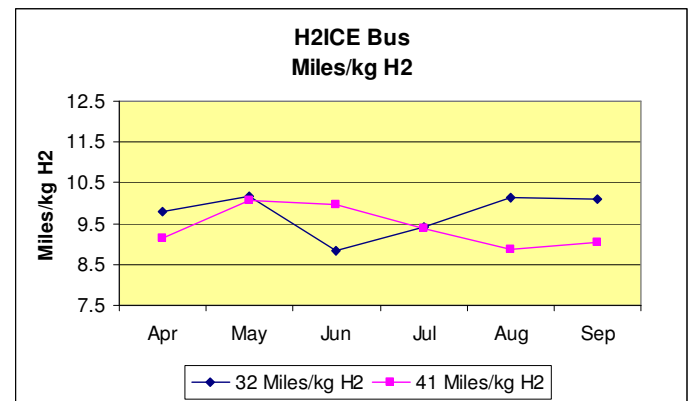
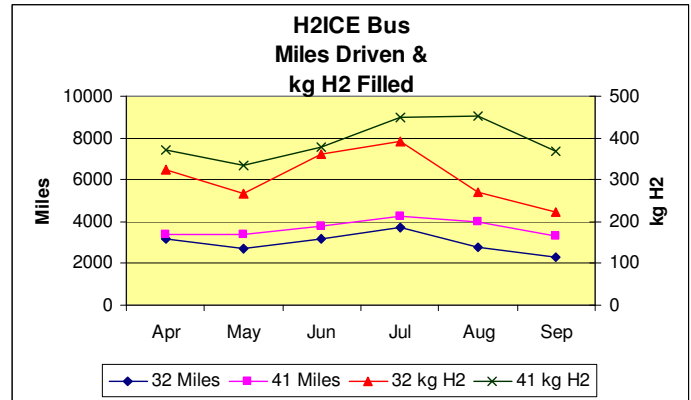
Comparative Fuel Use and Fuel Economy

Every effort was made to keep accurate records of the amount of fuel used in each bus application. In the hydrogen-powered buses, this was done in two ways. First, an on-board telemetry data collection system (Telematics) provided a continual data stream that was automatically collected in a host computer. In this data, calculations of the amount of *hydrogen used* were made whenever there was a fueling event. An algorithm calculated the mass (kg) of H₂ gas used since the last fuel event using the known pressure, temperature and volume recorded at each fueling event. At the same time mileage numbers were recorded so it made it feasible to make a reasonably accurate calculation of miles/kg of H₂ for that period, and for the overall life of the program. Second, drivers kept logs of the amount of fuel they added to the tanks during fill operations. This is a straight forward recording, unadjusted for environmental variables. Small errors in recording occurred in both systems because of technical problems and use of alternative fuel sites on a few occasions. Over the complete 6-month driving program, the fuel used data and the fuel filled data was very close, and for purposes of this study, either could be used for comparative analysis (A table of fuel data from telemetry and driver logs is in Appendix 1 of this report).

The top plot summarizes the monthly data for the two H₂ powered buses, both kg used and miles driven. No. 32 drove 17,796 miles and averaged 2966 miles/mo. No. 41 drove 22,097 miles and averaged 3683 miles/mo. Combined miles were 39,893 for an average 3324 miles/mo/bus. Average H₂ use was 307 kg for No. 32, and 392 kg for No. 41, for a grand average of 349 kg/mo/bus.

The next two plots combine the data and show the average fuel economy, first in miles/kg H₂ and second in miles/GGE (gallon of gasoline equivalent). The following table presents the averages of the data:

Bus	Miles/kg H ₂	Miles/GGE
32	9.7	9.6
41	9.4	9.3
Combined	9.5	9.4



The Propane-Gas buses are a bit more complex when calculating fuel economy because both fuels are used. In normal operation, propane supplies most of the operating energy, but for starting, acceleration and heavy loads, gasoline is burned. In addition, if there are problems with propane supply, gasoline may be used exclusively. In addition, although this data is primarily from one 10-passenger bus and one 23-passenger bus, there were times when similar buses were substituted because of vehicle maintenance or other operational problems.

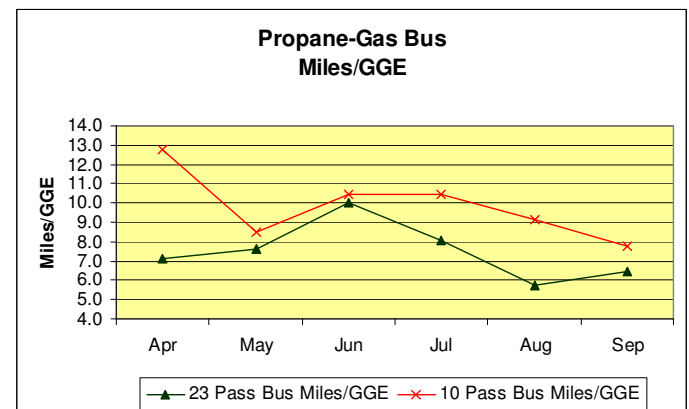
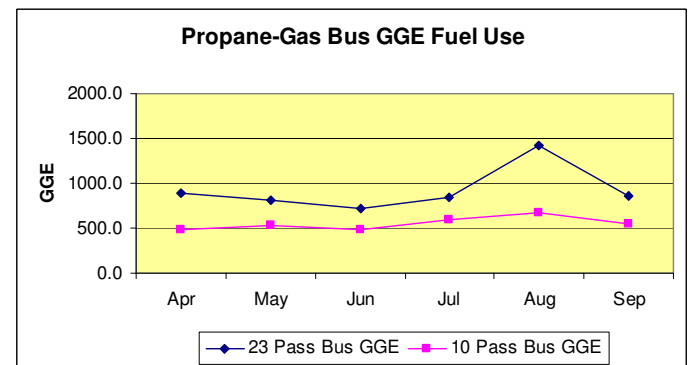
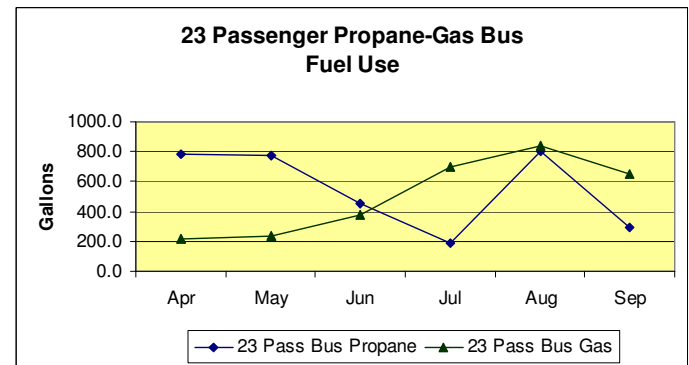
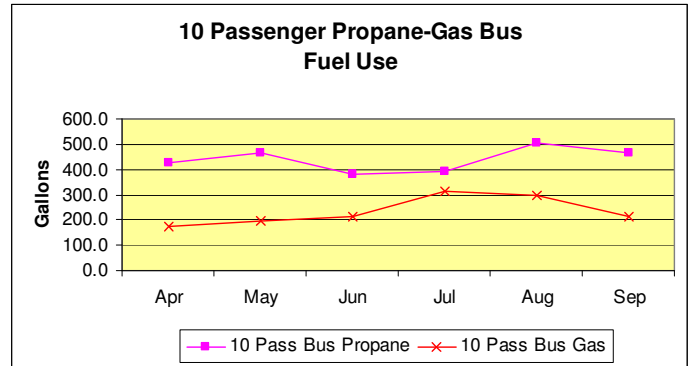
The first plot on this page shows the gallons of propane and of gasoline used each month in the 10-passenger bus. The second shows the same data for the 23-passenger bus.

The third plot sums the equivalent energy of propane and gasoline used to show a total equivalent number of gallons of gasoline used for each bus configuration. The data indicates an average GGE for the 10-passenger bus of 555 gallons and the 23-passenger bus of 922 gallons.

The last plot combines the mileage information and the GGE used data to show the miles/GGE fuel economy for the propane-gas buses. Fuel economy is reduced in the warmer months when air conditioning may be operating more frequently. Total distance driven by the 10-passenger bus was 32,468 miles and for the 23-passenger bus was 40,712 miles. The average fuel economy was:

Bus	Miles/GGE
10 Passenger	9.8
23 Passenger	7.4

The standard deviation of fuel economy distribution for the 10-passenger bus was 1.8miles/GGE and for the 23-passenger bus it was 1.5 miles/GGE.



This table summarizes the Fuel Data for each of the buses for the total six month drive program:

Bus No.	820	830	32	41
Passenger Capacity	23	10	9	9
Miles Driven	40712	32468	17796	22097
Hydrogen Used (kg)	0	0	1840	2352
Propane used (gal)	3403	2631	0	0
Propane GGE Used	2486	1922	0	0
Gas Used (gal)	3044	1406	0	0
Total GGE Used	5530	3328	1855	2371
M/GGE	7.4	9.8	9.6	9.3
Telematix kg H2 Used thru 9/30/09			1867	2364
Telematix GGE Used thru 9/30/09			1882	2383
Telematix m/gge 9/30/09			9.5	9.3

The summary data indicates that the hydrogen powered buses have fuel economy that is very similar to the 10 passenger bus. To compare all three bus configurations (i.e. 9, 10 and 23 passenger), the average number of passengers/trip data is used.

An accurate direct comparison of fuel economy cannot be made, but an estimate can. It is understood that the fuel required to move an empty bus is greater than that required to move the passengers. This is because the bus chassis and body weigh far more than the passenger load. Adding a passenger adds a relatively small weight and reduces fuel economy only slightly, proportionate to the percent change of total vehicle and passenger weight.

The data provides information to make this estimate. There were some propane/gas vehicle availability issues that occurred through the program, and alternative buses were, at times, substituted for the program buses. However the substituted buses were of the same configuration and fuel/passenger data was merged to provide a picture of the propane/gasoline bus performance.

The 23-passenger bus (Ref No. 820) is the standard of comparison. The 23-passenger bus carries an estimated average of 4 passengers per trip*. The following table shows how the fuel economy would reduce if the 10-passenger propane/gasoline bus (Ref No. 830) and the 9 passenger H2 Buses were also carrying a 4-passenger average load:

Bus (passengers capacity)	Reported Average Fuel Economy	Average # passenger*	% Weight increase/ FE Reduction at 4 passengers	Est. FE (miles/GGE) at 4 Passenger Load
23	7.4	4	0%	7.4
10	9.8	2	5%	9.3
H2 Buses (9)	9.4	2.5	3%	9.1

* Assumes the buses run 8-hour shifts, and an average of three trips per hour. This permits the estimation of the total number of trips for each bus. Allows 200 lbs. per passenger and luggage.

This table shows that, if each of the three configurations were carrying the average 4 passengers per trip, the hydrogen buses would be nearly identical in operating characteristics to the 10 passenger propane/gasoline, and either of the smaller buses would have better fuel economy than the larger bus.

Since the intent of this demonstration was, to a large extent, to determine if a hydrogen fueled bus with optimal emissions characteristics would be a viable means for transporting passengers to and from a nearby rail terminal, then the data suggests that, in terms of fuel energy, the hydrogen powered bus would be effective. Because there was no significant maintenance or downtime on the buses, this demonstration indicates that the buses overall would be an acceptable and desirable alternative to propane-gasoline powered buses. However, because the demonstration was terminated prematurely, it would be necessary to operate the buses for a longer period to determine the relative cost of maintenance over the normal life of a shuttle bus in Metro Cars' operations.

Rider Survey Analysis

Through August 7th, 1050 riders completed the Rider Survey Cards that were designed for the Metro Cars buses (Card form contained in Appendix 2 of this report). No survey cards were completed after that date. 7% of the 14825 people who have ridden the buses completed some or all of the survey questions. The following is the summary of their input:

Comments About Buses							
	Seats	Temp	Clean		Smooth	Noise	Ride
Very Good	790	659	816	Better	628	806	765
Good	205	250	131	Same	395	216	255
OK	26	50	11	Worse	2	3	2
Not Good	5	8	0				
total	1026	967	958		1025	1025	1022

	Seats	Temp	Clean		Smooth	Noise	Ride
Very Good	77.00%	68.15%	85.18%	Better	61.27%	78.63%	74.85%
Good	19.98%	25.85%	13.67%	Same	38.54%	21.07%	24.95%
OK	2.53%	5.17%	1.15%	Worse	0.20%	0.29%	0.20%
Not Good	0.49%	0.83%	0.00%		0.00%	0.00%	0.00%

Comments about the Concept			
Environmental Importance?		Ride Again?	
Very Important	821	Yes	966
No Opinion	115	No	4
Not Important	38		
	974		970

Environmental Importance?		Ride Again?	
Very Important	84.29%	Yes	99.59%
No Opinion	11.81%	No	0.41%
Not Important	3.90%		

451 riders have taken the time to provide written comments about the buses, the technology and the service provided. Their comments have been overwhelmingly positive and were reported in the quarterly data submission for this project.

The following table summarizes the nature of their comments. The total number (631) is larger than the 451 because respondents may have commented on more than one aspect of the project.

Classification of Rider Comments									
	Bus	Metro Cars	Environment	Ford	Project	Neutral	Negative	Improvement	Total Comments
Specific	205	163	82	21	87	18	9	46	631
Improvement Comments Offered	43	7	2		2				54
Negative Comment		1	1		3				5

Classification of Rider Comments									
	Bus	Metro Cars	Environment	Ford	Project	Neutral	Negative	Improvement	Total Comments
Specific	32.49%	25.83%	13.00%	3.33%	13.79%	2.85%	1.43%	7.29%	100.00%
Improvement Comments Offered	79.63%	12.96%	3.70%	0.00%	3.70%	0.00%	0.00%	0.00%	100.00%
Negative Comment	0.00%	20.00%	20.00%	0.00%	60.00%	0.00%	0.00%	0.00%	100.00%

This chart indicates, for example, that 205 (32.49%) of the 631 comments were made about some aspect of the buses. 43 of those made some suggestion for improvement, (79.6% of the 54 improvement comments), but none made comments that were wholly critical of the buses or program.

The comments about the buses were very favorable and riders were pleased to have had the opportunity to experience the clean, alternatively fueled bus. Improvement comments were generally focused on need for increased room for both number of

passengers and luggage space. Negative comments focused on the cost of the project, the cost and production of hydrogen and use of taxpayer money.

Comments identified as neutral generally contained questions about the viability, cost or environmental value of the project.

Maintenance

Only 5 total repairs were made to the hydrogen systems of the H2ICE buses and have been reported in quarterly data submissions to the DOE.

On bus No. 32, four issues were addressed:

- A fuel tank temperature sensor was corrected by selecting an alternative tank to monitor.
- Fuel injector problems were corrected with the installation of new injectors with an improved design. Subsequently, two of these new injectors were replaced.
- A faulty hydrogen sensor in the vehicle was replaced.

Bus No. 41 experienced only one issue, the replacement of the injectors with the new design.

Of the issues experienced, only the injector durability has been identified as an element requiring further development to ensure commercial viability of the concept. Ford Motor continues work toward that objective.

The above data and discussion represent the completion of **Task 4.0** of this project

Project Management and Reporting

Prior to bus deployment and throughout the project, all required reporting and coordination with the DOE was maintained by the project management team and coordinated through ASG. A safety Plan was completed, quarterly reports were prepared and submitted, an Annual Program Milestone Update report was submitted and a poster presentation for the 2009 Annual Hydrogen Program Merit Review and Peer Evaluation Meeting was made in May.

All activities for this project were completed within the approved budget.

All requirements being met with the completion of this report, **Task 5.0** for this project is complete.

Summary & Conclusions

The operation of the two H2ICE buses by Metro Cars at Detroit Metro Airport has provided meaningful data and helpful customer/rider input that supports the viability of using hydrogen powered vehicles as apart of a regional mass-transit system.

Nearly 15,000 people rode the H2ICE buses between the end of March and the end of September. Their opinions of the buses and the concept of hydrogen as a fuel were overwhelmingly positive, indicating that previous concerns about hydrogen from much publicized tragedies in which hydrogen was involved no longer affect the viability of using hydrogen in vehicles today. The lack of operational odors and cleanliness of exhaust gases make it preferred by riders.

The hydrogen bus has comparable fuel economy to the propane-gas powered buses in common use. In this demonstration, there were minimal maintenance requirements, and none that kept the buses out of service. Fuel availability problems, caused by increasingly frequent station problems, were the cause of some loss of availability.

The technology has been developed to use hydrogen in internal combustions engines which holds the potential to serve both the immediate needs of shuttle bus operations and provide a bridge to the development of other hydrogen powered vehicle applications. Local operations, such as the shuttle bus, provide the potential for relatively high volume hydrogen use, making it potentially commercially viable for the implementation of hydrogen generation and distribution stations.

Appendix 1 Total Hydrogen Use Comparison

Bus 032 Hydrogen Use			Bus 041 Hydrogen Use		
	Telematics kg. fuel used	Metro Cars Kg Fuel Filled		Telematics kg. fuel used	Metro Cars Kg Fuel Filled
April	329.20	322.805		342.5	373.023
May	254.9	267.82		316.3	333.99
June	322.10	362.39		405	376.78
July	383.80	392.05		408.1	449.57
August	299.30	271.08		390.3	451.91
September	225.3	224.223		375.5	367.138
Total	1814.60	1840.37		2237.70	2352.41
Difference		-25.77			-114.71

Total Difference			-140.48	
Total Used/Filled			4052.30	4192.78
% Difference Used/Filled			-3.47%	-3.35%

Total Hydrogen Use Comparison between Telemetry data and Driver Log data

Appendix 2 Rider Survey Card

Rider Survey Card (Front & Back)

Please take a moment to complete a brief survey about this shuttle ride.
Your opinion matters to us!

Date of shuttle ride _____
Time of shuttle ride _____ a.m. / p.m.

How was the overall comfort of this shuttle (circle one)? (circle one for each line)

SEATS	Very Good	Good	Ok	Not Good
TEMPERATURE	Very Good	Good	Ok	Not Good
CLEANLINESS	Very Good	Good	Ok	Not Good

Compared to other types of shuttles rides that you have taken would you say that this shuttle ride was (circle one)

Smoother About the same Rougher





Compared to other types of shuttle rides that you have taken would you say that the noise level of this shuttle was (circle one)


Quieter About the same Noisier

In general, Compared to other types of shuttles you have used overall would you say that this type of shuttle provided a ride that was (circle one)

Better About the same Worse

You are riding in a low-emissions vehicle.




Drive green.

You are riding in one of two hydrogen-powered shuttles built by Ford Motor Company currently operating at Detroit Metropolitan Wayne County Airport.

Hydrogen-powered internal combustion engine (ICE) vehicles can be a bridge between today's engine technology and tomorrow's fuel cell technology.

Hydrogen ICE vehicles significantly increase fuel economy compared to gasoline-powered ICE engines and produce virtually no CO₂ emissions.



How important is it to you to ride in a shuttle that is *cleaner for the environment*? (circle one)

Very important No opinion Not important

Would you ride in a hydrogen shuttle again if given the opportunity?

Yes No

Additional comments about this shuttle ride:

Thank you for taking the time to complete our survey!
Please return this card to the shuttle driver.

