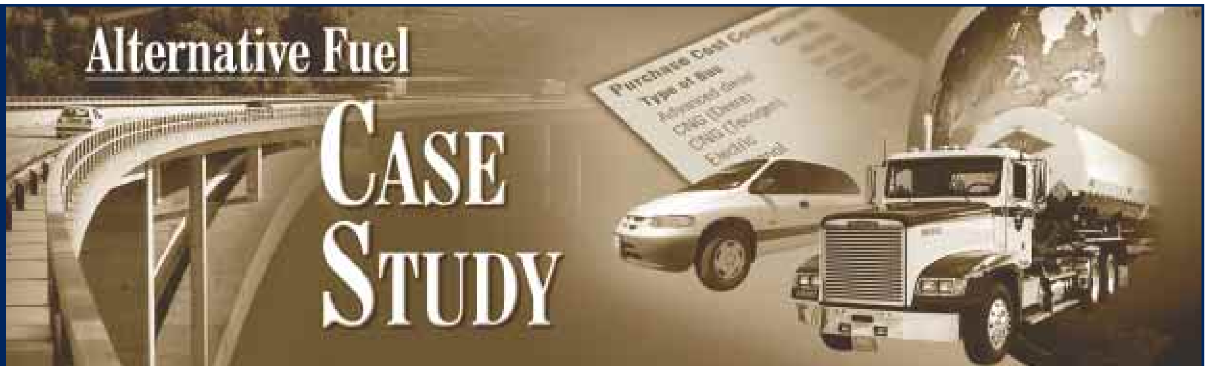
Clean Cities

Alternative Fuel
Information Series



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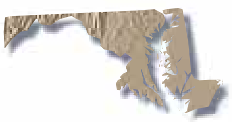


Barwood Cab Fleet Study Summary

Introduction

In 1996, Barwood, Inc., a cab company based in Kensington, Maryland, committed to incorporating a limited number of dedicated compressed natural gas (CNG) vehicles into its fleet. Incentives available from the local gas utility made it possible for Barwood to gain some experience with CNG vehicles without additional capital expenditures.

Barwood is a privately held, family-owned company that has been in business for more than 30 years. The company operates a fleet of about 400 vehicles, serving some 5,000 customers daily. The cabs are assigned to individual drivers, who work as independent contractors and pay daily rent to use their vehicles. The driver is responsible for keeping the vehicle clean, bringing it in for regular servicing, and paying for the vehicle's fuel. Drivers typically work 6 days each week, averaging 5 to 12 short trips and 5 to 15 longer trips daily. About two-thirds of their trips are city-type driving and one-third are highway driving.

Because Barwood owns and operates its own maintenance and repair facility, and its own 24-hour towing and emergency road service, the company does nearly all the maintenance and repair servicing on its cab fleet, including the new CNG vehicles. CNG was available and obtained at several local stations operated by Washington Gas Company in the metropolitan Washington, D.C., area.

Operating these vehicles in Barwood's fleet provided a unique opportunity to evaluate alternative fuel vehicles (AFVs) in a high-mileage application. In addition, Barwood representatives were willing to share information on their fleet, as well as data related to operating their vehicles. Operations, maintenance, and cost data for the dedicated CNG and selected gasoline vehicles were collected throughout 12 months of vehicle operation. In addition, a series of emissions tests was conducted on the study vehicles at selected mileage intervals. We then evaluated and compared the performance and cost of operating CNG AFVs and gasoline vehicles in this fleet application.

Fleet Facts

Fleet Type:	Taxi cabs (sedans)
Fleet Size:	400 vehicles, of which 10 are AFVs
Alternative Fuel:	CNG
Study Vehicles:	10 dedicated CNG sedans and 10 gasoline sedans
Location:	Kensington, MD
Mileage Accumulation:	5,000 to 6,000 miles per month

All vehicles in the study were Ford Crown Victoria sedans (as are approximately 90% of the cabs in the Barwood fleet): 10 were dedicated CNG models and 10 were standard gasoline models. The CNG vehicle uses a slightly higher compression ratio, which takes advantage of the higher octane rating of CNG to improve efficiency. Other differences of note include the increased curb weight and reduced trunk space because of the CNG fuel tanks, and the lower fuel capacity of the CNG vehicle.

By the Numbers: Vehicle Specifications

Specification	CNG Crown Victoria	Gasoline Crown Victoria
Engine	4.6L V8	4.6L V8
Engine Family Code	TFM4.6V8C7EK	TFM4.6V8GFEL
Fuel Capacity	10 gal (gasoline equivalent)	20 gal
Compression Ratio	10:1	9:1
Estimated mpg:* city	17	17
highway	25	25
Curb Weight	3,814 lb	3,780 lb
Trunk Volume	14 ft^3	20.6 ft^3

*miles per gasoline gallon equivalent for CNG

The Fleet's CNG Experience

The CNG vehicles were used essentially the same as the gasoline vehicles in Barwood's fleet. At the end of the study, the CNG vehicles had accumulated from 80,000 to 155,000 miles, averaging nearly 108,000 miles per vehicle. The gasoline vehicles accumulated from 112,000 to 143,000 miles, averaging more than 127,000 miles per vehicle. The gasoline vehicles were in service about 3 months longer, on average, than the CNG vehicles. The gasoline vehicles were put in service between September and November of 1996; the CNG vehicles were put in service in December 1996 and January 1997. On a monthly basis, the CNG vehicles accumulated slightly less mileage (about 3% less) than the gasoline vehicles—5,737 miles compared to 5,885 miles, on average, for the gasoline vehicles. Differences in monthly mileage accumulation rates—vehicle to vehicle—generally resulted from the work patterns of the individual drivers.

Limited availability of CNG (compared to gasoline) throughout the D.C. metro area did have some effect on where the CNG drivers were willing to go to pick up or drop off fares. In addition, drivers and fleet managers expressed concerns about losing fares as a result of the trunk space reduction in the CNG Crown Victoria. Based on Barwood's experience, we estimate that the typical driver would have to pass up less than 0.5% of fares, over the course of a year, because of trunk space limitations.

Fuel Economy and Cost

Fuel usage data were also collected. For 3 months during the study, all available fueling records were compiled to enable evaluation of fuel economy and fuel costs. Barwood supplied the CNG vehicle fueling records, which were copies of the fuel use records Washington Gas Company provided to Barwood. These monthly records included accumulated mileage, fuel used, and fuel costs by vehicle. Fuel usage data on the gasoline vehicles were collected directly by the drivers of the study vehicles. Because their drivers operate as independent contractors, and purchase their own fuel, Barwood does not normally collect fuel use data. The drivers of the gasoline vehicles kept logs of fueling data for the 3-month period.

The fuel economy of the CNG and gasoline versions of the Crown Victoria were basically identical—rounding to 17.3 miles per gallon (gasoline gallon equivalent for CNG) of fuel for each vehicle type. This was not surprising because the vehicles are being operated in the same types of service, and they have the same EPA-estimated fuel economy numbers.

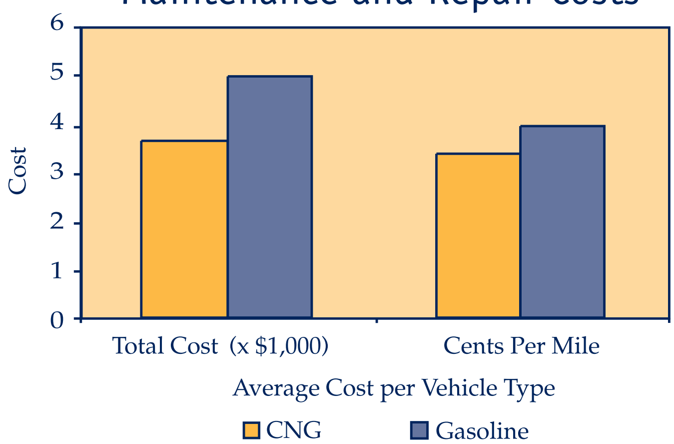
Some real differences between CNG and gasoline appear in the area of cost. On a cents per mile basis, fuel costs for the CNG vehicles were more than 30% lower than those of the gasoline vehicles: 4.35 cents per mile compared to 6.39 cents per mile for gasoline. During the portion of the study period evaluated, fuel averaged about $0.75 per gasoline gallon equivalent for CNG and $1.10 per gallon for gasoline. This can prove to be a big advantage to a fleet.

Maintenance Comparison and Cost

All maintenance and repair records and cost data were collected for the study vehicles, including scheduled and unscheduled maintenance and repairs. Barwood provided these records in two forms, spreadsheet summaries by vehicle and copies of vehicle servicing work orders. These records included a description of the service or repair, service date, odometer at time of the work, and a list of the costs associated with the required servicing.

Barwood takes a proactive approach to maintaining its vehicles. The company focuses on preventing problems so the cabs can be kept on the road as much as possible. Barwood requires its drivers to bring their vehicles in for "regular scheduled maintenance" every 4,000 miles. Barwood's scheduled maintenance includes the standard oil changes and fluid checks, but many major vehicle systems are also inspected. The number of miles and days between service was nearly the same for the two vehicle types. Each vehicle type logged 4,300 to 4,400 miles, with just over 31 days between service visits.

Maintenance and Repair Costs



On a per-mile basis, the rate of unscheduled repairs was slightly higher for the gasoline vehicles than for the CNG vehicles. No differences in the types or frequency of fuel system or engine-related repairs were noted. Over similar mileage ranges, the gasoline vehicles had slightly higher occurrences of brake and tire-related repairs. The cause of this difference is not entirely clear, but the drivers of the CNG cabs reported that their vehicles do not accelerate as quickly as the gasoline vehicles. The drivers said that the difference in responsiveness forced them to modify how they drive the CNG vehicles.

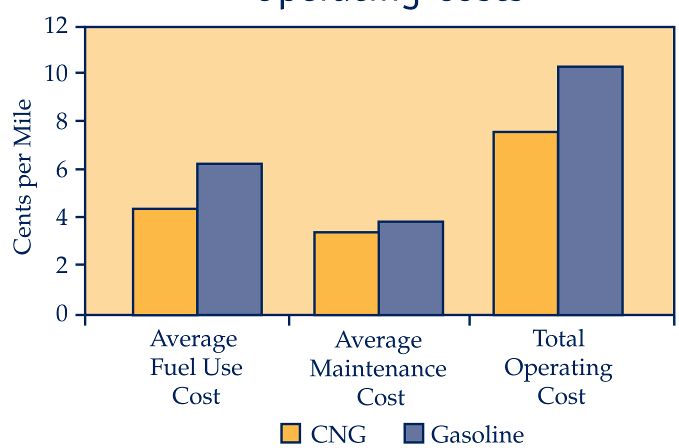
It is possible that the differences in driving style affected brake and tire wear in the CNG vehicles. Overall, Barwood experienced similar performance and reliability for the two vehicle types.

The bar chart in the left-hand column summarizes the maintenance and repair costs (excluding accident repair costs). Overall total maintenance costs were slightly lower for the CNG vehicles, at 3.39 cents per mile compared to 3.95 cents per mile for the gasoline vehicles.

Total Operating Costs

The CNG vehicles in Barwood's fleet cost about 25% less to operate than their gasoline vehicles on a per-mile basis (see bar chart below). Based on these operating costs, a fleet could expect to save about $1,300 a year operating a CNG vehicle in an application like Barwood's where vehicles accumulate 50,000 miles or more annually. In more typical light-duty vehicle service, where vehicles accumulate about 15,000 miles annually, a fleet could expect to save about $390 with a CNG vehicle.

Operating Costs



It is important to note that Barwood does not realize all the possible savings for operating the CNG vehicles. Because their drivers pay for their own fuel, much of the total operating cost savings goes to the drivers. In this scenario, it is not likely that the fleet operator will break even on the incremental cost difference of the vehicles. However, in Barwood's case, the CNG vehicles cost essentially the same as the gasoline vehicles, because the Washington Gas Company provided funds to pay the incremental cost difference between the CNG and gasoline versions of the Crown Victoria.

Payback Analysis Dedicated CNG Vehicles

Assume CNG Vehicle Premium = $2,080 (note: this accounts for manufacturer price and rebate, but does not include other incentives)
Operating Cost Difference (from this study) = $0.103/mile - $0.077/mile = $0.026/mile
Breakeven = ($2,080) / ($0.026 per mile) / (5,000 miles per month) = 16 months

Barwood's NGV Purchase Cost

Dedicated CNG Vehicle Price:	$21,930
Standard Gasoline Model Price:	$19,850
Cost Difference:	$2,080
Incentives (Local Gas Company):	$2,080
Net Cost Difference:	$0

Emissions Results

Three rounds of emissions testing were performed on seven CNG and seven gasoline vehicles. The testing followed the EPA's Federal Test Procedure (FTP-75), which uses the urban dynamometer driving schedule for exhaust emissions, and includes two 1-hour evaporative emission tests (for additional information on these test procedures, see Kelly 1996). The tests were scheduled at odometer levels of 60,000 miles, 90,000 miles, and 120,000 miles.

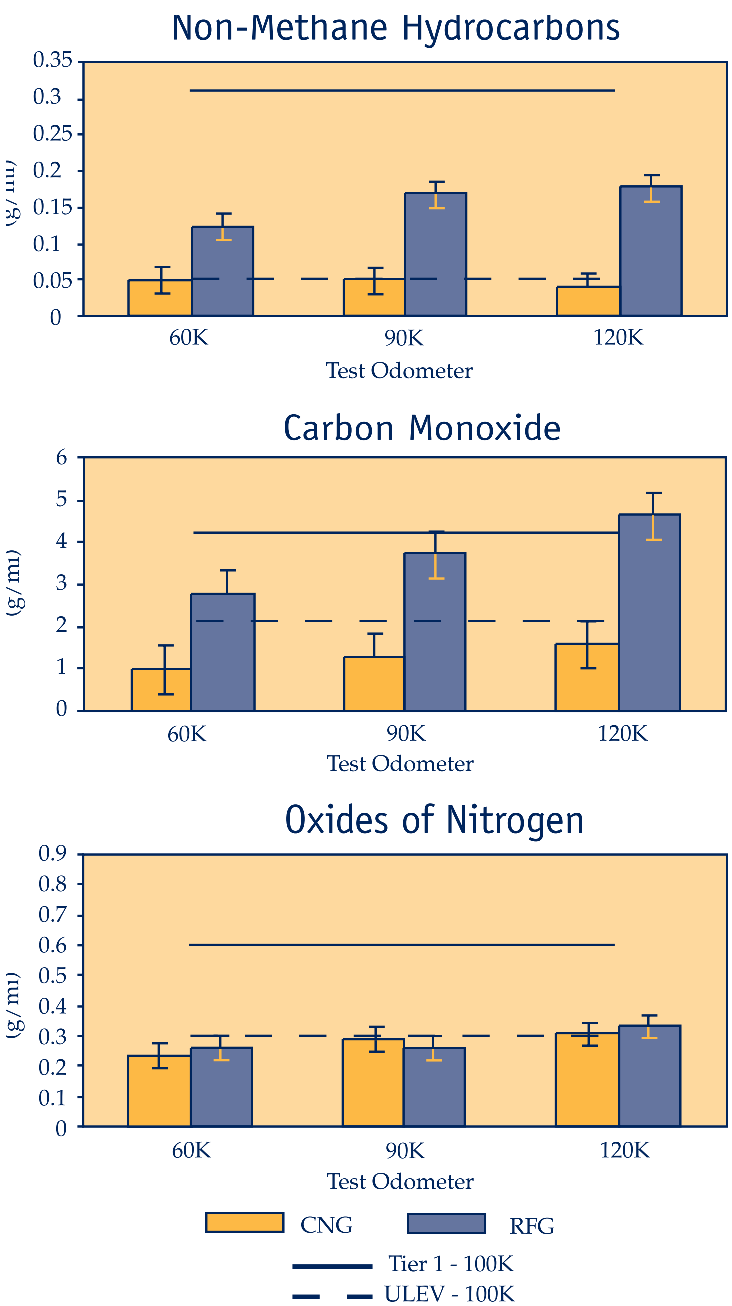
Both CNG and gasoline vehicles were tested on fuels specially blended for this testing. The CNG was blended to represent an industry-average fuel composition. The gasoline used was California Phase II reformulated gasoline (RFG), which was selected to represent the "best case" gasoline fuel.

The CNG exhaust emissions were significantly lower than their gasoline counterparts, even when a very clean RFG was used as the baseline fuel. The average regulated emissions from both the CNG and gasoline vehicles fell within the applicable EPA standards (see charts to the right), but the CNG vehicles had significantly lower levels of non-methane hydrocarbons (NMHC) and carbon monoxide (CO), and similar levels of oxides of nitrogen (NO_X).

This study is believed to be one of the first to provide an independent confirmation that these benefits can be maintained in real-world service throughout the useful life (100,000 miles) of the vehicle and beyond. The results suggest that emissions from CNG vehicles may, in fact, deteriorate less quickly than from similar gasoline vehicles.

Evaporative emissions testing measured the hydrocarbons emanating from the vehicle with the engine off. Low levels of hydrocarbons (less than 0.4 grams per test) were measured from the CNG vehicles. Evaporative hydrocarbons from the gasoline vehicles were significantly lower. This result is a bit surprising because it is generally accepted that CNG vehicles have zero evaporative emissions. However, the test measurement includes small quantities of gaseous fuel that may escape from the fuel and air intake system after the engine is shut off. Similar low level hydrocarbons have been measured from other dedicated CNG vehicles (Kelly 1996).

Properly designed CNG vehicles have been shown to emit significantly lower levels of regulated emissions than similar gasoline vehicles. This may be important in areas of the country that are working to improve air quality. Because the CNG Crown Victoria was certified as an ultra low emission vehicle (ULEV) and an inherently low emission vehicle (ILEV), fleets that purchase them in certain parts of the country may qualify for emissions credits under the federal Clean Fuel Fleet Program (a U.S. EPA program).



Lessons Learned from Barwood's Experience

- **Find out what incentives—federal, state, and local—exist or apply in your area.** The incentives offered by the local gas company were one key to Barwood's decision to incorporate the CNG vehicles into its fleet. The incentives eliminated the incremental cost differences between the CNG and gasoline versions. Incentives can provide some economic help to a fleet that is considering introducing AFVs.

- **Evaluate your service application; you may be able to reduce your operating costs by using AFVs.** In this study, most of the economic benefits resulted from the differences in fuel cost between CNG and gasoline. This makes it almost impossible for a fleet operating like Barwood (where drivers pay for their own fuel) to recoup the incremental cost difference. If Barwood had not received incentives to help offset the vehicle costs, it might not have been able to recoup the additional vehicle cost.

- **Learning about the fuel is an important part of the decision-making process.** You may want to consult with experts as your staff is becoming familiar with new types of vehicles. Fuel providers, as well as state energy and air quality personnel, will often work with fleets to teach general principles about CNG. Barwood worked with its staff, particularly the drivers, to familiarize them with the CNG vehicles. Because Barwood's drivers refuel their own vehicles, the director of driver services conducted an introductory session with each new CNG vehicle driver at the local CNG station. This helped to alleviate some of the drivers' concerns about these vehicles.

- **Experience alleviates concerns about new technology vehicles.** Initially Barwood's drivers and maintenance staff expressed concerns about the CNG vehicles. As they gained experience in operating and servicing the vehicles, they found performance and reliability to be comparable or better than that of their gasoline vehicles. Barwood's staff is now very comfortable with the vehicles.

In fact, Barwood and its drivers have come to consider the CNG vehicles an asset to their business and to the air quality in their community. When this study ended, Barwood had been operating the CNG vehicles for more than 18 months, and the company expects to operate the vehicles for about 5 years.

References

Kelly, K., Bailey, B., Coburn, T., Clark, W., and Lissiuk, P., 1996, *Light-Duty Vehicle Program Emissions Results – Interim Results from Alternative Fuel OEM Vehicles*, NREL/TP-425-21294, NREL: Golden, CO.

Additional information is available in the detailed project report titled *Barwood CNG Cab Focus Fleet Study: Final Study Results*, which is available on the World Wide Web at: http://www.ott.doe.gov/otu/field_ops/barwood.html

For more information on alternative fuels, AFVs, and related topics, contact the National Alternative Fuels Hotline at 1-800-423-1363 or visit the Alternative Fuels Data Center at http://www.afdc.doe.gov

Acknowledgment

This project is one of the focus fleet studies sponsored by the U.S. Department of Energy's Office of Technology Utilization and managed by DOE's National Renewable Energy Laboratory (NREL). These studies are designed to collect and disseminate objective information on real-world fleet experiences with AFVs and to demonstrate that AFVs can meet the vehicle needs of fleets. This evaluation was a cooperative effort supported by :

Participants	Role/Responsibility
Barwood Cab Company	Served as host fleet for study, provided access to vehicle maintenance and fueling records
Mardi John (subcontractor to NREL)	Worked directly with fleet to collect all operating and maintenance data and cost records
Environmental Research & Development (subcontractor to NREL)	Conducted emissions testing on study vehicles at selected mileage intervals
U.S. Department of Energy	Provided funding to conduct evaluation study
National Renewable Energy Laboratory	Managed the study and conducted data analysis and project reporting

Disclaimer

This study is intended only to illustrate approaches that organizations could use in adopting AFVs into their fleets. The data cited here, although representing real experience for the Barwood CNG cab fleet, may not be replicated for other fleets.

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