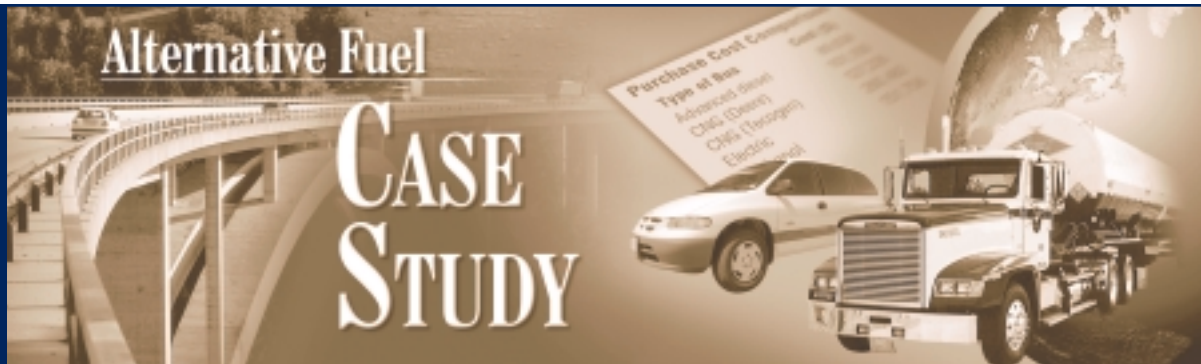




Alternative Fuel Information Series



March 2001

U.S. DEPARTMENT of ENERGY,
OFFICE of ENERGY EFFICIENCY and RENEWABLE ENERGY

SuperShuttle CNG Fleet Study Summary

Introduction

In March 1999, the Office of Technology Utilization's Field Operations Program began a fleet evaluation of CNG vans in the SuperShuttle fleet in Boulder, Colorado. The results for the evaluation were positive, and the fleet is considering adding more alternative fuel vehicles (AFVs) in the future. This fact sheet summarizes the details of the study.

Background

SuperShuttle, which was started in Los Angeles in 1983, is a shuttle service providing a shared-ride, door-to-door airport passenger service. It now serves 23 airports, with 1,000 vehicles transporting more than 20,000 passengers each day. The company began using AFVs in 1990 when it added several propane-powered vehicles to the fleet. The first compressed natural gas (CNG) vehicles were added in 1994. SuperShuttle operates approximately 290 CNG vehicles in seven locations including Washington, D.C.; Phoenix, Ariz.; Boulder/Denver, Colo.; and Sacramento, San Francisco, Los Angeles, and Orange County, Calif.

SuperShuttle began operating in Colorado in mid-1996, serving the local community and Denver International Airport (DIA). Its fleet of 85 vehicles includes 18 AFVs fueled by both liquefied petroleum gas (LPG) and CNG. SuperShuttle managers decided to add CNG vans to the Boulder fleet after hearing a presentation spelling out the potential cost savings of using natural gas vehicles.

The vans are operated for two types of service: in-town shuttle service around Boulder, which is mostly stop-and-go driving, and inter-city highway service between



Boulder and DIA. Boulder is approximately 45 miles from DIA, and the vans typically accumulate about 60,000 miles per year.

SuperShuttle operates a service shop at its Boulder facility for all scheduled maintenance and some unscheduled maintenance. Scheduled maintenance includes oil and air filter changes and tire rotations, as well as preventative maintenance checks. The local dealership provides any necessary warranty work.

The managers of SuperShuttle in Colorado were open to providing records and other information for an evaluation of the AFVs in their fleet. SuperShuttle Boulder was an excellent study fleet because it provided the chance to evaluate different CNG technologies side-by-side with gasoline models in a high mileage application.

Fleet Facts

Fleet Type:	Vans in airport shuttle service
Fleet Size:	85 vans and shuttle buses, of which 18 are AFVs
Alternative Fuel:	CNG and LPG
Study Vehicles:	15-passenger vans: 5 dedicated CNG, 5 bi-fuel CNG, and 3 gasoline
Service Area:	Boulder, Colo. to DIA
Mileage Accumulation:	60,000 miles annually

For this project, data were collected from 13 passenger vans for 12 months. Data on operations, maintenance, and costs were gathered along with the results of three rounds of emissions tests.

The study vehicles were all 1999 Ford E-350 passenger vans based at SuperShuttle’s Boulder location. Five of the vans were dedicated CNG, five were bi-fuel CNG/gasoline, and three were standard gasoline vans used for comparison. Because the CNG tanks on the AFVs were located under the body of the van, there were no differences in passenger/luggage space.

By the Numbers: **Vehicle Specifications**

Specification	Dedicated CNG	Bi-fuel CNG	Gasoline
Model Year	1999	1999	1999
Make, Model	Ford, E350	Ford, E350	Ford, E350
Engine Displacement	5.4L	5.4L	5.4L
Engine Configuration	V8	V8	V8
Compression Ratio	9.1	9.1	9.1
Engine Horsepower	200	200 CNG/ 235 gas	235
Fuel Capacity	14 gge ¹	8.5 gge CNG/ 35 gal gasoline	35 gal

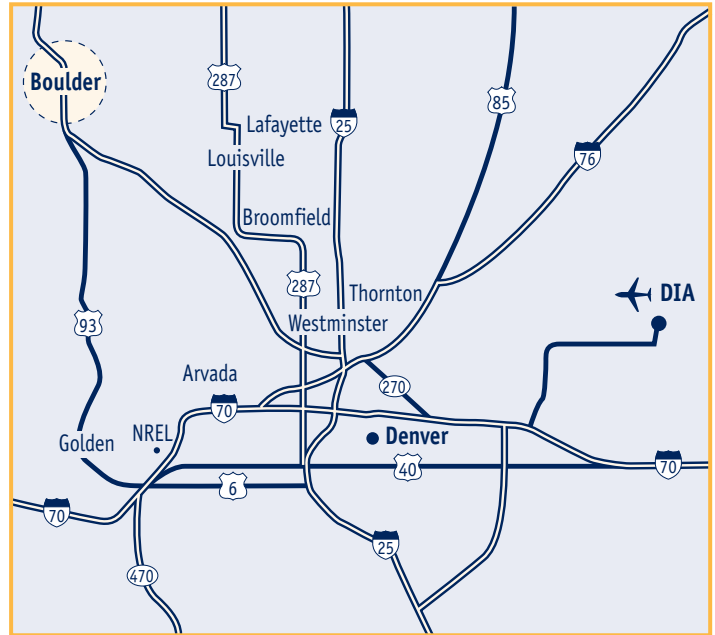
¹ gallon gasoline equivalent

The Fleet’s CNG Experience

By the end of the study, the vans had accumulated between 41,000 and 70,000 miles. The gasoline vans accumulated the most miles, partly because they arrived several weeks before the first AFVs and were immediately put into service. On a monthly basis, both the gasoline and the bi-fuel vans accumulated more miles than the dedicated CNG vans. The gasoline vans averaged 5,493 miles per month and the bi-fuel vans averaged 5,161 miles per month, while the dedicated CNG vans averaged only 3,692 miles per month. The gasoline and bi-fuel CNG vans were used in the same way with respect to percentage of highway versus city driving. However, mainly because of the fleet’s concern with vehicle range, the dedicated CNG vans were used mostly in local service around Boulder, resulting in shorter trips and lower overall mileage accumulation.

What is a gge?

Natural gas is sold in gallon gasoline equivalent, or gge. A gge is the amount of CNG that has the same energy content as a gallon of gasoline.



Service area for SuperShuttle Boulder



Warren Gretz, NREL/PIX 07351

Fuel Economy and Cost

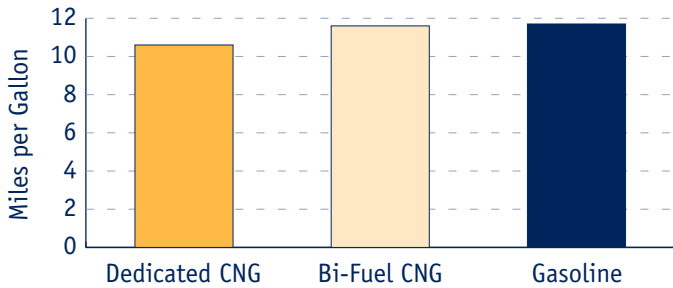
SuperShuttle tracks fueling records on the vehicles using credit cards issued to each vehicle. Drivers use these cards in an electronic reader each time they fuel. Date and time of fueling as well as the amount and price of the fuel are automatically recorded for each transaction. The driver enters the odometer reading into the electronic card reader at each fueling.

Natural Fuels Corporation is the local CNG fuel provider for the area. It currently operates 37 open-access CNG fueling stations in Colorado, Wyoming, and Nebraska. Eighty-eight percent of the time, SuperShuttle used the Boulder fueling site, which is about two miles from its facility. The fueling facility at DIA was used the remainder of the time.

Bi-fuel vehicles can be operated on either CNG or gasoline. Because of this, our calculation of fuel economy was a combined CNG/gasoline value based on monthly

odometer readings and total fuel used for each month. The average use of CNG in the bi-fuel vehicles was 28.3% by volume. The fuel economy for the dedicated CNG and gasoline vehicles was based on calculations from individual fueling records.

Average Fuel Economy



The fuel economies for the three types of van were not drastically different. The average fuel economies for the gasoline and bi-fuel vans were nearly the same, at 11.7 and 11.6 mpg respectively. The dedicated CNG vans had a slightly lower average fuel economy at 10.6 mpg. This lower fuel economy is expected, considering the higher percentage of in-town driving experienced by the dedicated CNG vans.

The real difference between fuels shows up in the cost comparison. During the data collection period, the price of CNG was very stable. Based on the fueling records collected, CNG prices ranged from a low of \$0.85 to a high of \$0.91 per gge with an average of \$0.86. Although gasoline prices were low when the study began, there was a steady increase over the 12-month data collection period. Gasoline prices ranged from a low of \$0.91 to a high of \$1.48 per gallon, with an average of \$1.21 per gallon. On a per-mile basis, the dedicated vans cost 8.16 cents to fuel. This was 28.6% lower than the per-mile cost of the gasoline vans and approximately 19% lower than the bi-fuel vans. The bi-fuel vans cost 10.06 cents per mile to fuel, approximately 12% lower than the cost of the gasoline vans (11.43 cents per mile).

Maintenance and Reliability

Records for scheduled and unscheduled maintenance for each van were collected throughout the evaluation period. The average number of maintenance visits per vehicle was similar for the bi-fuel and gasoline control vans, and slightly less for the dedicated CNG vans: 14.2 for the bi-fuel, 14.6 for the gasoline, and 12.8 for the dedicated CNG vans. The three gasoline vans were serviced an average of every 20 days, while the dedicated CNG and bi-fuel vans were serviced every 40 days. This was due, in part, to the faster mileage accumulation of

the gasoline vans. However, SuperShuttle maintenance personnel also noticed that used oil from the dedicated CNG vans appeared clean. For this reason, they lengthened the mileage between services for those vans.

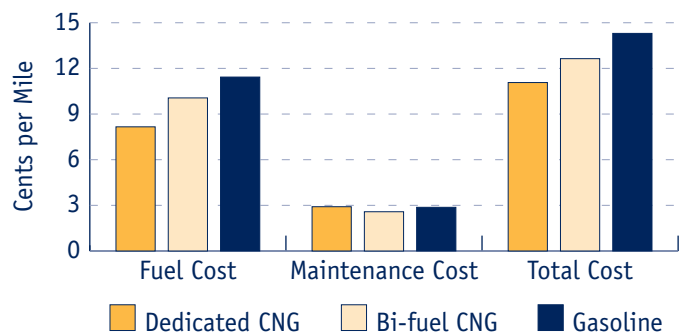
Comparison of scheduled maintenance shows that both the dedicated CNG and bi-fuel vans cost SuperShuttle less to maintain than the gasoline vans. Unscheduled maintenance was similar for the bi-fuel and the gasoline vans but was higher for the dedicated CNG vans. This was because midway through the data collection, the “check engine light” came on in several of the dedicated CNG vans. When the local dealer was unable to diagnose the problem, Ford sent out two engineers from its alternative fuels division in Michigan to help with the problem. Examination of the vehicles showed that there was a contaminate build-up in the fuel injectors that was causing the “check engine light” to come on. Natural Fuels and Ford took steps to clean the contaminate and prevent further occurrences. Because of required injector flushes, the unscheduled maintenance for dedicated CNG vans was greater.

Adding the scheduled and unscheduled maintenance gives the total cost of maintenance on the study vans. The results for this study show that the dedicated CNG vans cost only 1.4% more to maintain than the gasoline vans. The bi-fuel vans cost 11.8% less to maintain compared to the gasoline vans.

Total Operating Costs

The average fuel and maintenance costs are combined to give total operating cost per mile for each type of vehicle. When you compare the total operating costs for the three van types, the dedicated CNG vans cost 11.07 cents per mile to operate, which was 22.6% less than the gasoline vans. The bi-fuel vans cost 12.62 cents per mile, 11.6% less than gasoline. If these results remain consistent over time, a fleet accumulating 60,000 miles on a vehicle per year could see annual cost savings of nearly \$2,000 per vehicle by operating dedicated CNG vans.

Operating Costs



Capital Costs and Payback

For the 1999 model year, the incremental cost for the dedicated CNG fuel option on the E350 van was \$3,541. The incremental cost for the bi-fuel option was \$4,507. The following table shows the simple payback analysis for SuperShuttle using the results of the data collected for the project.

	Dedicated	Bi-fuel
Operational Cost (\$/mi)	\$0.11	\$0.13
Annual Mileage	60,000	60,000
Estimated Cost Savings/Year	\$2,000	\$1,000
Simple Payback (yrs)	1.83	4.47

Assuming each van travels 60,000 miles per year, the alternative fuel option on a dedicated CNG van would be paid off in under two years, while the option on the bi-fuel van would be paid off in approximately 4.5 years. This analysis does not include incentives or rebates available to the fleet for purchasing AFVs.

Emissions Results

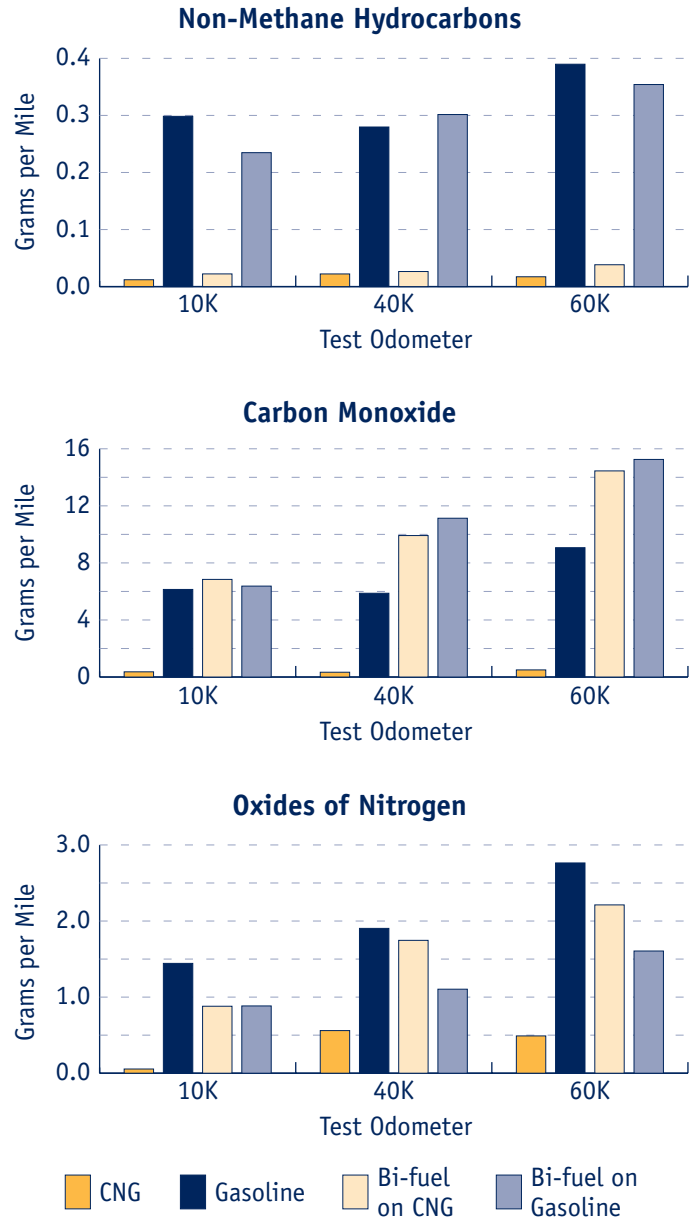
Three rounds of emissions tests were performed on the 13 study vans. These tests followed the EPA’s Federal Test Procedure (FTP-75). The tests were scheduled at odometer levels of approximately 10,000 miles, 40,000 miles, and 60,000 miles over the course of the yearlong study. During the second round of testing, three vans of each type were subjected to more detailed testing, which included an evaporative test and emissions tests under aggressive driving (US06) and cold conditions (Cold CO).

The dedicated vans (CNG and gasoline) were tested on their respective fuels and the bi-fuel vans were tested on both CNG and gasoline. The CNG fuel used for emissions tests was taken from the fueling site at DIA. The fuel at that location is typical of the industry average. The gasoline, referred to as RFA, was specially blended to represent industry-average gasoline composition.

FTP Emissions Results

Regulated emissions include non-methane hydrocarbons (NMHC), carbon monoxide (CO), and oxides of nitrogen (NO_x). FTP-75 emissions results show an obvious benefit of the dedicated CNG vans compared to the conventional gasoline vans. For all three regulated compounds, the dedicated CNG vans had significantly lower emissions than either the gasoline vans or the bi-fuel vans operated on either CNG or gasoline. Results from the bi-fuel van were mixed. When the bi-fuel vans were tested on

Comparison of FTP-75 Emissions Results



CNG, NMHC emissions were lower, CO emissions were nearly the same, and NO_x emissions were significantly higher than when the vans were tested on gasoline.

Emissions for all three vehicle types increased with increasing mileage. Emissions of the three regulated compounds increased in each round for both dedicated CNG and gasoline vans. The dedicated CNG vans showed the smallest increase. There also appeared to be a deterioration of emissions over time for the bi-fuel vehicles.

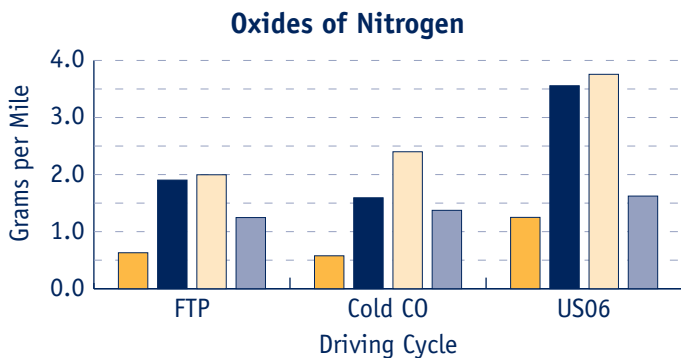
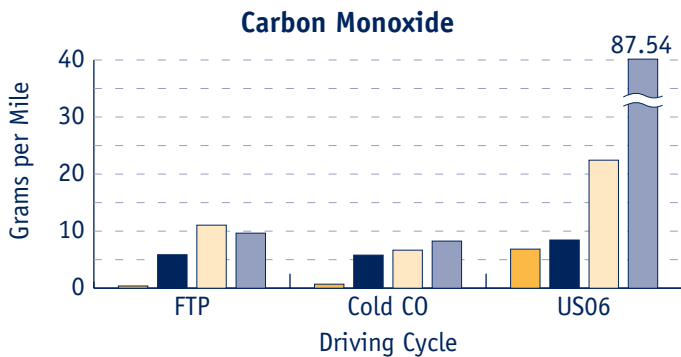
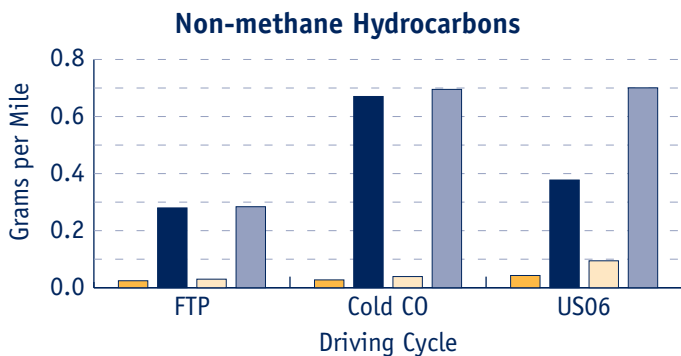
Off-Cycle Emissions Results

During the 40,000-mile emissions tests, three of each type of van were selected for two additional emissions

tests: one to measure emissions under aggressive driving (US06) and another to measure emissions during cold conditions (Cold CO). These procedures are often referred to as “off-cycle” tests.

When the vans were tested using these procedures, results showed that the dedicated CNG vans maintained their emissions benefit over the gasoline vans. As with the FTP tests, the bi-fuel vans had mixed results during the detailed tests. NMHC emissions were lower when the bi-fuel vans were tested on CNG, but the NO_x emissions were higher. Emissions of CO during the US06 test were expected to be high, but the results for the bi-fuel vans were extremely high for both fuels.

Comparison of Off-cycle Emissions Results



■ CNG
 ■ Gasoline
 ■ Bi-fuel on CNG
 ■ Bi-fuel on Gasoline

Survey of Fleet Personnel and Customers

In order to get a complete picture of this fleet’s experience with integrating AFVs into their operations, more subjective data were also collected. We documented the steps SuperShuttle took to obtain and put the vehicles into service, as well as perceptions and opinions about AFVs from both fleet personnel and customers. Interviews were conducted with fleet managers before the project started and at its conclusion. We also conducted a customer survey to determine the level of knowledge and acceptance of AFVs by the general public.

The fleet’s start-up experience with AFVs was documented in an earlier report, which is available on the Web at http://www.ott.doe.gov/otu/field_ops/supershuttle.html. Assistance from Ford and Natural Fuels was essential, not only for getting the fleet set up to use alternative fuels, but in troubleshooting problems during the project.

Although SuperShuttle’s experience with implementing AFVs into their fleet was not always smooth, the overall results were good. The company is realizing the economic and environmental benefits of using the dedicated CNG vans, and plans to add more in the near future. It still has concerns about the range of the dedicated vans, so it is looking at extended range packages. The managers of this fleet genuinely like the natural gas vans and they say they would recommend them to other fleets.



Warren Gretz, NREL/PIX 07345

Customer Survey

During the first four months of the data collection, customers riding in the AFVs were asked to participate in a brief survey. A total of 68 surveys were completed. The most important findings were that:

- 70% of respondents were not aware that they were riding in an AFV;
- 85% knew that CNG is a domestic product;
- 74% felt that development of alternatives to petroleum was important;
- 63% felt that use of CNG for a transportation fuel was acceptable; and
- 59% would be influenced to use the services of a company based on their use of environmentally friendly products.

When asked to explain their answers, most respondents stated that air quality was important to them. Numerous other respondents cited the need to reduce petroleum imports. The results from this survey show that acceptance of CNG as a vehicle fuel, at least in the Boulder area, is fairly high. Advertising the environmental benefits of their fleet in the area could increase SuperShuttle ridership.

Lessons Learned

The following lessons learned from SuperShuttle's start-up experience with AFVs held true throughout the study.

- Communication between project partners is essential. Communication among manufacturers, fleets, and fuel providers will help get the needed information to those making decisions about implementing AFVs to their operations.
- Training of vehicle operators is necessary. Operators and maintenance personnel need to understand new technology in order to become comfortable with it.
- Plan ahead. Implementing a new technology can take time. Research your options, anticipate possible problems, and formulate a "back-up plan."
- Support from the fuel industry and partners is important. Expect to experience some challenges when you integrate new technology into your fleet. These issues will be solved through cooperative teamwork between the fleet, vehicle manufacturer, and fuel provider.

A fleet should also investigate incentives. A fleet adding AFVs may be entitled to several rebates or tax incentives. These could offset the incremental cost of the alternative fuel option. To find the incentives for your area, go to DOE's Fleet Buyers Guide at <http://www.fleets.doe.gov>.

Additional information on this project is available in the detailed project report titled SuperShuttle CNG Fleet Evaluation—Final Report, on the World Wide Web at http://www.ott.doe.gov/otu/field_ops/supershuttle.html. For more information on alternative fuels and related topics, contact the National Alternative Fuels Hotline at 1-800-423-1363 or the Alternative Fuels Data Center at <http://www.afdc.doe.gov>.

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