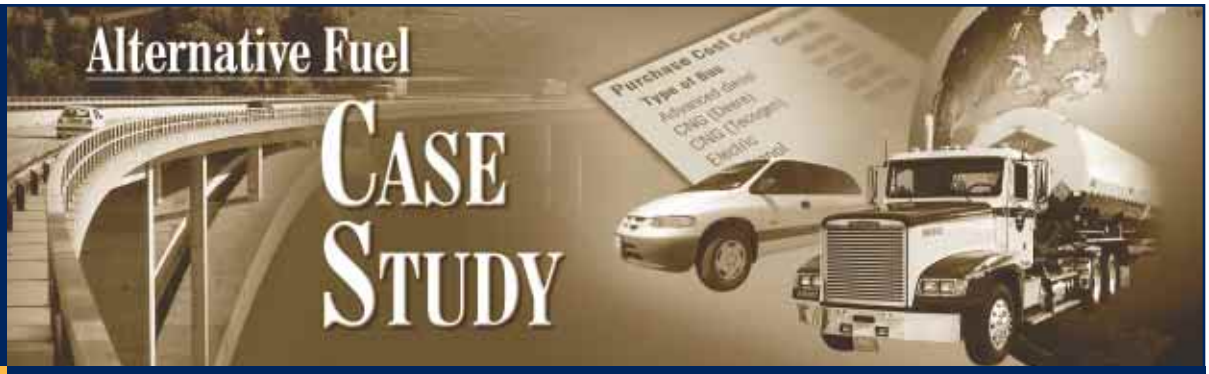
Clean Cities
Alternative Fuel Information Series



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

Ohio's First Ethanol-Fueled Light-Duty Fleet

Introduction

In 1996, the State of Ohio established a project to demonstrate the effectiveness of ethanol as an alternative to gasoline in its fleet operations. The state purchased and incorporated a number of flexible-fuel vehicles (FFVs) into its fleet. Flexible-fuel vehicles are designed to operate on all gasoline, all E85 (a blend of 85% ethanol and 15% gasoline), or any blend of both fuels as high as 85% ethanol. This project was developed and supported through grants from the Council of Great Lakes Governors and the Public Utilities Commission of Ohio's Biomass Energy Program, which received funds through the U.S. Department of Energy's (DOE) Regional Biomass Energy Program.

All vehicles in the study were 1996 model year Ford Tauruses: ten were FFVs and three were standard gasoline models. All were assigned to individuals or vehicle pools at state agencies, and were generally used for local trips around the Columbus area. The vehicle specifications for the FFV and the gasoline Tauruses were the same overall; however, Ford incorporated a number of design changes into its FFV model to ensure that the vehicles performed well on ethanol blends. These changes included alcohol-resistant materials in the fuel system and an alcohol fuel sensor linked to a control module that was calibrated to compensate for varying fuel blends. In addition, the fuel tanks were larger on the FFVs because somewhat more fuel was needed to drive the same distance on E85 as on gasoline (the energy content of E85 is lower than that of gasoline).

Fleet Facts

Fleet Type:	Sedans in state fleet service
Fleet Size:	About 8,000 light-duty vehicles, of which 624 are AFVs
Alternative Fuels:	Ethanol (E85) and compressed natural gas (CNG)
Study Vehicles:	10 E85 FFV sedans, 3 gasoline sedans
Location:	Columbus, OH
Mileage Accumulation:	~14,000 miles annually

By the Numbers: Vehicle Specifications

Specification	E85 Taurus	Gasoline Taurus
Engine Displacement	3.0L	3.0L
Engine Configuration	V6	V6
Compression Ratio	9:1	9:1
Fuel Capacity	18.4 gallons	16 gallons
Estimated mpg: city	20*	20
highway	29*	29

* EPA fuel economy on gasoline (EPA fuel economy numbers on E85 not available)

During the planning process for this project, state administrators decided to set up two E85 refueling sites in the Columbus, Ohio, area to fuel their new E85 vehicles. One was an operating 500-gallon station that was used throughout the project; the other was a new installation that included a 2,000-gallon storage tank and cost approximately $28,000. The new facility was completed and began operating about 6 months after the project started.

The Fleet's E85 Experience

Vehicle use during the study period was about the same for the two vehicle types. The FFVs accumulated an average of a little more than 1,100 miles per month compared to almost 1,200 miles for the gasoline vehicles. Overall, the study vehicles accumulated approximately 14,000 miles annually (typical of light-duty fleet vehicles). Vehicle operations, maintenance, and cost data were collected for 24 months.

The E85 use in the FFVs averaged 63% (by volume). Delays in opening the new station affected the E85 use in four of the FFVs during the early part of this study. The fleet minimized its use of these four vehicles to limit the number of miles operated on gasoline only.

During the final 12 months of the study, E85 use increased to 72% (by volume) after the new fueling station opened. None of the FFVs operated exclusively on E85. During the last 12 months of the study, all the FFVs used E85 at least 50% of the time, and five averaged 75% or higher E85 use. E85 use was limited because, even with two stations available, refueling at an E85 station was not always convenient.

Fuel Economy and Vehicle Range

Each participating state agency agreed to keep and submit fuel use logs and fuel receipts. The state also provided monthly fuel use and cost data, which were used to evaluate fuel economy and cost, from its database records. There are a couple of ways to look at fuel economy when comparing alternative fuel and gasoline vehicles. Of most interest to drivers is actual volumetric fuel economy, which is calculated directly from the number of miles driven divided by the number of gallons of fuel used. The average fuel economy for the FFVs was a little more than 23 miles per gallon (mpg), lower than the average of 24.6 mpg for the gasoline vehicles. We expected this because the energy content of E85 is lower than that of gasoline, and the fleet operated its FFVs on E85 a significant part of the time.

The vehicle range (the number of miles that can be traveled on a tank of fuel) is also important to the fleet and its drivers. Although the fuel economies of the E85 and gasoline vehicles were somewhat different, the drivers saw little difference in vehicle range. Ford opted to ensure that its FFVs and gasoline Tauruses had a similar range by installing a slightly larger fuel tank in the FFVs (to account for the difference in energy content of E85).

Maintenance and Repairs

All maintenance and repair records and cost data, including all scheduled and unscheduled maintenance and repairs, were collected for the study vehicles. The Department of Administrative Services provided access to centralized state vehicle and service records, which included paper and electronic data collection systems.

State vehicles are generally maintained or repaired by local auto repair facilities or the local Ford dealer, depending on the service. The Department of Agriculture performed maintenance on its own vehicles, except for warranty repairs, which were done at the local Ford dealership. The FFVs and gasoline-only vehicles followed the maintenance schedule recommended by the manufacturer.
The only major difference in service between the FFVs and gasoline vehicles was that, during the first part of the study, the FFVs were required to use a special oil. During the last 6 to 12 months, Ford eliminated that requirement and the state began to use standard oil in its FFVs. This caused no performance or maintenance problems.

Very little unscheduled maintenance and few unscheduled repairs were required for either the FFVs or the gasoline study vehicles: only 12 instances for the FFVs and 7 for the gasoline vehicles. These repairs were covered under warranty, and only one FFV repair (a spark plug coil problem that affected power) may have been fuel-related.

Operating Costs

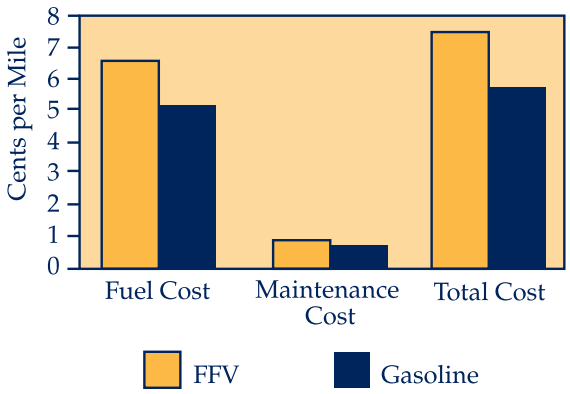
The operating costs considered in this study included the fuel use and maintenance costs. The fuel use costs are the cost of the fuel used per mile. Maintenance costs included parts, labor, and other (recycling, parts disposal, engine oil, and so forth).

FFV Purchase Price

FFV Taurus:	$14,196
Gasoline Taurus	$14,434
Net Cost Difference:	- $238

Note: The state bids a vehicle contract with no incentives included in the bid price (and sees no rebates).
The state would not normally purchase sedans the size of the Taurus, so grant funding was used to offset the higher price for these vehicles.

Operating Costs



The price of gasoline fluctuated significantly during the study period, ranging from $1.03 per gallon to $1.33 per gallon. The average price of gasoline throughout the study period was $1.23 per gallon. During the last 12 months of the study, gasoline averaged $1.18 per gallon. The price of E85 was stable during the study, but depended on the purchase site. The site with the smaller storage facility had an average fuel price of $1.88 per gallon. At the larger fueling station, E85 averaged $1.33 per gallon. This study clearly indicated that E85 fuel prices could be lower if fuel were purchased in larger (bulk) quantities.

In evaluating the fuel use cost for the FFVs, gasoline and E85 costs had to be taken into account, because the vehicles used both fuels. The fuel costs per gallon for the FFV, based on the monthly fuel use and cost data, ranged from $1.20 to $1.63 per gallon of fuel used. The average fuel cost for the FFVs was $1.50 per gallon during the whole study period and $1.52 for the last 12 months. On a cents per mile basis, fuel cost for the FFVs was about 15% higher than for gasoline, at 6.55 cents per mile compared to 5.01 cents per mile for the gasoline vehicles.

Overall, maintenance costs for this fleet of study vehicles were low. However, for the FFVs they were nearly 13% higher than for the gasoline vehicles. This was due almost entirely to the cost of the special oil used in the FFVs. Once this need was eliminated by Ford, the maintenance costs (over similar mileage intervals) were very similar for the FFVs and the gasoline vehicles. We expect that other fleets that choose to operate these FFVs will see little difference in the maintenance and repair costs between the FFVs and similar gasoline vehicles.

The total operating cost was 7.44 cents per mile for the FFVs compared to 5.78 cents per mile for the gasoline vehicles. This cost difference was driven almost entirely by the higher cost of the E85 fuel.

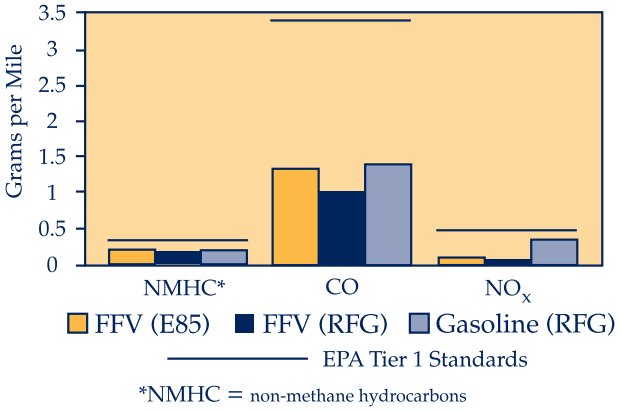
This fleet's experience indicates that purchases of larger quantities of E85 fuel can reduce costs per gallon of fuel (in this case, by about 28%). This can help to bring the total costs of operating these FFVs closer to those of operating the gasoline vehicles. And at least in the near term, E85 will likely continue to cost more than gasoline because of limited production. Fuel cost will continue to dominate the operating cost differences between FFVs and gasoline vehicles, with the total difference depending on actual per-gallon fuel price and amount of E85 use. Based on this fleet's experience, fuel cost differences could be as low as about 8%.

Emissions Results

Emissions testing was conducted on two FFVs and two gasoline vehicles according to the Federal Test Procedure (FTP). California Phase 2 Certification gasoline (designated "RFG") was used as the baseline gasoline fuel. This clean-burning gasoline provides the best modern gasoline for comparing the FFVs and gasoline vehicles. The E85 used in the testing consisted of 85% ethanol blended with the base RFG fuel. The FFVs were tested on both RFG and E85. Although the emissions testing was limited in this project, the results followed some trends seen in more extensive test programs, including decreased carbon monoxide (CO) and oxides of nitrogen (NO_x) for the FFVs compared to the gasoline vehicles (Kelly et al. 1996a, b). The differences between emissions results of the FFV and gasoline-only vehicles are by-products of calibration compromises required to enable the FFVs to operate on E85, gasoline, and blends of the two fuels. Differences between E85 and gasoline can be expected to decrease as the automobile manufacturers continue to improve control technologies.

But regardless of test fuel or vehicle type, all the emissions results from this project were well below the applicable EPA certification life standards.

Regulated Emissions Levels



*NMHC = non-methane hydrocarbons

Lessons Learned from the State of Ohio's Experience

• **Fuel flexibility and availability play into alternative fuel vehicle (AFV) selection.** Availability of alternative fuel is a consideration for fleets selecting AFVs. FFVs were selected in part because of the limited availability of alternative fuels. The state administrators in Ohio decided to set up two E85 fueling sites in the metropolitan Columbus area during the process of selecting and incorporating AFVs into their fleet. As a result, this fleet achieved about 72% use of E85 in its FFVs.

• **Overall performance of the FFVs was the same as the fleet's gasoline vehicles.** The fleet experienced no difference in the overall performance of the FFVs. Except for needing special oil (a requirement eliminated by Ford during the course of the project), these Ford vehicles required no different or additional maintenance or repairs.

• **Higher operating costs are driven by the price of E85.** Although this fleet experienced slightly higher maintenance costs for its FFVs, the operating cost difference was dominated by the difference in fuel cost. Fleets adding this type of FFV should expect to see somewhat higher operating costs, which result almost exclusively from the higher cost of E85 fuel.

Overall, the State of Ohio's staff has been pleased with the Taurus FFVs. The vehicles perform well and meet the operators' needs. During the course of this study, the state added more FFVs to its fleet—more than 200 in 1997 and more than 300 in 1998, and has committed to continue including AFVs in its fleet. The state is also continuing to expand its E85 fueling infrastructure.

References

Kelly, K.; Bailey, B.K.; Coburn, T.; Clark, W.; and Lissiuk, P. (1996a). "Federal Test Procedure Emissions Test Results from Ethanol Variable-Fuel Vehicle Chevrolet Luminas." *Alternative Fuel: Composition, Performance, Engines, and Systems.* SP-1181. Warrendale, PA: Society of Automotive Engineers, Inc.; pp. 249-268; NICH Report No. 20784.

Kelly, K., Bailey, B.K.; Coburn, T.; Clark, W.; Eudy, L.; and Lissiuk, P. (1996b). *Light-Duty Vehicle Program Emissions Results (Interim Results from Alternative Fuel OEM Vehicles).* NREL/TP-425-21294. Golden, CO: National Renewable Energy Laboratory.

Additional information is also available in the detailed project report titled *Ohio's First Ethanol-Fueled Light-Duty Fleet: Final Project Report*, prepared by Battelle for the National Renewable Energy Laboratory (NREL) in October 1998 (SR-540-25237), which is available on the World Wide Web at http://www.ott.doe.gov/otu/field_ops/ohiofleet.html. For more information on alternative fuels, AFVs, 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.

Acknowledgments

This project is one of the fleet studies sponsored by DOE's Office of Technology Utilization and managed by DOE's NREL. These studies are designed to collect and provide objective information on real-world fleet experiences with AFVs and to demonstrate that AFVs can meet the vehicle needs of fleets. This AFV evaluation was a cooperative effort supported by the following organizations:

Participants	Role/Responsibility
State of Ohio, Department of Administrative Service; various state agencies	Purchased vehicles, served as host fleet, and funded emissions testing fleet
Council of Great Lakes Governors	Provided grant to support purchases of vehicles and fuel
Public Utilities Commission of Ohio, Biomass Energy Program	Provided grant to support purchases of vehicles and fuel
U.S. DOE Office of Technology Utilization	Provided funding for data collection, analysis, and reporting
Battelle (under contract to NREL and the State of Ohio)	Collected, analyzed, and reported on vehicle performance and operations data

Disclaimer

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

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