Alternative Fuels for Vehicles Fleet Demonstration Program

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ALTERNATIVE FUELS FOR VEHICLES FLEET DEMONSTRATION PROGRAM

Final Report

Volume 3: Technical Reports

Prepared for

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ABSTRACT

The Alternative Fuels for Vehicles Fleet Demonstration Program (AFV-FDP) was a multiyear effort to collect technical data for use in determining the costs and benefits of alternative-fuel vehicles in typical applications in New York State. Volume 1 of this report provides in summary format: (1) information about the purpose and scope of the AFV-FDP; (2) a summary of AFV-FDP findings organized on the basis of vehicle type and fuel type; (3) a short review of the status of AFV technology development, including examples of companies in the State that are active in developing AFVs and AFV components; and (4) a brief overview of the status of AFV deployment in the State. Volume 2 contains appendices that provide supplemental information on key topics surrounding AFVs. This volume (No. 3) provides expanded reporting of AFV-FDP technical details, including the complete texts of the brochure *Garage Guidelines for Alternative Fuels* and the technical report *Fleet Experience Survey Report*, plus an extensive glossary of AFV terminology. Information is presented by fuel within broad categories of light-duty and heavy-duty vehicles. Topics covered for each vehicle and fuel type include: fuel description and properties; emissions reactivity; greenhouse gases; vehicle technology; refueling infrastructure; fuel economy; reliability and durability; acceleration; emissions; fuel costs; safety; facility modifications; other demonstrations; and lessons learned. The report encompasses the results of AFV use in 21 fleets in New York State operating a mix of 257 AFVs that logged 7.3 million miles of operation using the equivalent of 862,000 gallons of conventional fuels.

Keywords: Alternative fuel vehicles, compressed natural gas, ethanol, methanol, LPG/propane, electric vehicles

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Section 1
INTRODUCTION

This report (Volume 3) provides extensive technical details from the Alternative Fuels for Vehicles Fleet Demonstration Program (AFV-FDP), a multi-year effort sponsored by the New York Energy Research and Development Authority to collect technical data and field experience for use in determining the costs and benefits of alternative fuels used in typical applications in New York State. Volume 1 of this report provides in summary format: (1) information about the purpose and scope of the AFV-FDP; (2) a summary of AFV-FDP findings organized on the basis of vehicle type and fuel type; (3) a short review of the status of AFV technology development, including examples of companies in the State that are active in developing AFVs and AFV components; and (4) a brief overview of AFV deployment status in the State. **Volume 2 contains the appendices referenced in this volume.**

Alternative vehicle fuels such as natural gas, methanol, ethanol, propane, and electricity have long been proposed as a way to provide significant air quality benefits over petroleum fuels, including reformulated gasoline and "clean diesel fuel."[1] (See Appendix G for information about production and basic characteristics of these alternative fuels.) By the late 1980s, these alternative fuels had been demonstrated in several states, at the federal level, and by other countries, but the results were not conclusive.[2] Questions remained as to whether alternative-fuel vehicles (AFVs) could consistently and reliably achieve emission reductions, especially since many different types of engine technologies were being used, with apparently varying levels of success. It also remained unclear what potential cost, operational, or other disadvantages alternative fuels might produce that could offset air-quality benefits.

Alternative fuels also have been proposed as a means to increase U.S. energy security. The oil supply and price shocks of the 1970s highlighted the dangers of the nation's dependence on imported petroleum. Since that time, most energy-consuming sectors of our economy have successfully diversified their sources of energy to make them less vulnerable to future oil shocks. The transportation sector has been singularly unsuccessful in this regard. As in 1973, when the Arab oil embargo disrupted the fuel market in the U.S., the cars, trucks, and buses we drive today are still almost totally dependent on petroleum. As our current dependence on imported

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[1] Clean diesel fuel is diesel fuel that has reduced sulfur and aromatic content. This results in reduced emission of particulates and nitrogen oxides.

[2] The majority of AFV demonstrations in the U.S. at that time had been conducted in California. California's climate and air pollution problems are distinctly different than those of New York State; moreover, the demonstrations in California did not collect emissions data and other information important to decision makers in other states.

sources of petroleum heads towards an all-time high, the vulnerability of the transportation sector grows. Recognizing this situation, the U.S. Congress passed the Energy Policy Act of 1992, known as EPACT (see Appendix H for a detailed explanation of EPACT). The objectives of EPACT are to promote, to the maximum extent practicable, the replacement of petroleum fuels in the transportation sector with fuels that reduce oil imports, improve the health of the nation's economy, and reduce greenhouse gas emissions. To achieve these goals, EPACT requires federal, state, and fuel-provider fleet operators to acquire and use AFVs. EPACT also includes provisions for requiring private and municipal fleet operators to acquire AFVs if deemed necessary by the U.S. Department of Energy to meet EPACT goals.

Since the early 1980s, the New York State Energy Research and Development Authority (NYSERDA) has funded projects to evaluate the benefits of AFVs. In 1989, NYSERDA, under the guidance of the State's Alternative-Fuel Vehicle Coordinating Council,[3] greatly expanded the State's exploration of alternative fuels by initiating the AFV-FDP. The objective of the AFV-FDP was to place large numbers of AFVs in service in State, municipal, and private fleets to provide "real-world" answers to the questions about their benefits.

Data and other information derived from the AFV-FDP are intended to assist State and local policy makers in determining the contribution alternative fuels can make towards achieving three major objectives:

- Improving air quality, especially in urban areas, and meeting National Ambient Air Quality Standards;
- Diversifying the State's fuel-supply mix by reducing the transportation sector's dependence on petroleum; and
- Creating growth opportunities for New York State companies that produce AFVs, vehicle components, and related infrastructure.

The AFV-FDP was a cooperative demonstration program that relied on the public and private sectors, as well as on national-state-local government partnerships, to demonstrate and evaluate alternative fuels and technologies. Program participants included 21 fleets (see Table 1.1) across the State operating a mix of 257

[3] The AFV Coordinating Council comprised representatives from NYSERDA, the New York State Thruway Authority, the New York City Department of Environmental Protection, the Port Authority of New York and New Jersey, and the following New York State agencies: Office of General Services, Department of Environmental Conservation, and Department of Transportation.

AFVs that logged 7.3 million miles through September 1995. The AFV-FDP has generated a wide range of essential data unavailable elsewhere to characterize and compare AFV emissions, fuel consumption, performance, safety, and maintenance characteristics relative to conventional-fuel-vehicle counterparts. The vehicle emissions data may help environmental agencies and others to simulate the benefits of various alternative-fuel use scenarios. Economic and energy data enable the evaluation of alternative-fuel substitutions as one of several elements in strategies to reduce petroleum demand and the State's dependence on imported oil.

Table 1.1 Fleets Participating in the AFV-FDP

- NYS Thruway Authority (NYSTA)
- Port Authority of New York and New Jersey - John F. Kennedy (JFK) Airport
- Town of Tonawanda
- Broome County Transit
- Central New York Regional Transportation Authority (CENTRO)
- Long Island Bus (LIB)
- Niagara Frontier Transit Authority (NFTA)
- NYC Office of Fleet Administration (NYCOFA)
- Rochester-Genesee Regional Transportation Authority (RGR)
- NYSERDA
- City of White Plains
- Monroe County
- Yankee Trails Holiday Tours Bus Company
- City of Buffalo
- Erie County
- Kenmore-Tonawanda School District
- NYS Dept. of Environmental Conservation (NYSDEC)
- NYS Public Service Commission (NYSPSC)
- NYS Office of Mental Health, South Beach (NYSOMH)
- US Postal Service (USPS) - Staten Island
- NYS Office of Parks, Recreation and Historic Preservation (NYSOPR)

In many ways, State and local fleets represent an ideal laboratory for testing the implementation of AFVs. In these fleets, AFVs are both operated under controlled conditions that facilitate data collection and exposed to the entire range of driving conditions experienced by the public. State fleets also are among the first to come under the EPACT mandates to purchase AFVs, beginning in the 1997 vehicle model year (see Appendix H). These purchases of AFVs also may satisfy these fleets' obligations under the Clean Air Act Amendments of

1990 (CAAA) Clean Fuel Fleet mandate to purchase Clean Fuel Vehicles.[4] (See Appendix I for a detailed explanation of the requirements of the CAAA Clean Fuel Fleet program.) An additional benefit of using government fleets is that the data collected can be disseminated widely for the benefit of all fleet operators, unlike private fleets, where competitive factors may limit publication of experimental findings.

The operators had full control over the AFVs in their fleets, including the options to stop using a vehicle or to switch back to conventional fuel. During the data-collection period (from 1992 through 1995), these options were used temporarily in several situations. In each case, NYSERDA worked with the fleet operators to resolve problems encountered with their AFVs, refueling facilities and garages, and operating staff. For example, some vehicles converted to compressed natural gas (CNG) bifuel (vehicles that can run on either CNG or gasoline) operation were found to have limited range when using CNG, and the operators found frequent switching back and forth between fuels troublesome. This deficiency was corrected by the installation of one additional CNG storage cylinder per vehicle. In another situation, one vehicle that had been converted from gasoline to dedicated CNG operation was believed to have inherent drivability problems caused by the CNG fuel system. A thorough analysis found a problem with the engine control computer unrelated in any way to the CNG fuel system, and the problem was corrected.

Table 1.2 shows the type of vehicles and fuels used in the AFV-FDP. Detailed data were collected from 209 of the 257 vehicles in the program. These 209 AFVs collectively traveled 7.3 million miles during the three-year data collection period, consuming the equivalent of 114,000 gallons of gasoline, and 748,000 gallons of diesel fuel. Of the original 257 vehicles in the AFV-FDP, 227 are still in operation.[5]

Data regarding vehicle specifications, miles traveled, fuel use and costs, emissions, performance, and maintenance histories were collected and stored in a computer database. In all, 5,900 vehicle-months of data are included in the AFV-FDP database and are accessible to the public through NYSERDA.

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[4] Clean Fuel Vehicles must use alternative fuels, reformulated gasoline, or clean diesel fuel. EPA determines what fuels are acceptable for use in Clean Fuel Vehicles.

[5] Five of the AFVs were operated to the ends of their useful lives. Twenty more had to be converted from methanol to gasoline operation because of an agreement with the vehicle manufacturer that supplied them (these were pre-production vehicles that could not be supported indefinitely in alternative fuel configuration). Three methanol transit buses were converted back to diesel fuel after their demonstrations. One propane vehicle was converted back to gasoline because it had insufficient range on propane. One CNG automobile was taken out of service due to a traffic accident unrelated to alternative fuel use.

Table 1.2 AFVs by Vehicle and Fuel Type

	CNG	Electric	Ethanol	Methanol	Propane	Totals	Percent
Light-Duty Trucks	46				5	51	19.8
Passenger Cars/Vans	29	1	1	89		120	46.7
Postal Vans	50					50	19.5
School Buses	2					2	0.8
Transit Buses	31			3		34	13.2
Totals	158	1	1	92	5	257	100
Percent	61.5	0.4	0.4	35.8	1.9	100	

Over the course of the AFV-FDP, 1,003 emissions tests were performed. The tests were performed on a chassis (treadmill-type) dynamometer, and tailpipe emissions were measured over a variety of simulated driving conditions such as congested stop-and-go driving and constant-speed highway driving. The objective of the emissions testing was not to determine how clean AFVs could be; rather, it was to find out how clean AFVs *would be* compared to conventional vehicles in regular use and maintained by conventional-fuel vehicle mechanics. The emissions test results were among the more revealing data sets collected by the AFV-FDP.[6]

The widespread adoption of alternative fuels has been stymied by a "chicken-and-egg" syndrome, with the vehicle manufacturers reluctant to build AFVs without a refueling infrastructure in place, and the fuel providers unwilling to invest in fuel production, distribution, storage, and dispensing infrastructure without a ready market of AFVs. Because of the general lack of AFV refueling infrastructure at the start of the AFV-FDP in 1990, the project scope included assistance in establishing refueling stations to support field operations.

Through the AFV-FDP, nine methanol refueling facilities were established at convenient intervals along the length of the New York State Thruway to support vehicles operated by the Thruway Authority. This enabled

[6] All the emissions tests were chassis dynamometer tests. The light-duty vehicles were tested using the City and Highway portions of the Federal Test Procedure, and the New York City Cycle. The heavy-duty vehicles were tested using the "A" and "B" New York City Cycles and the Central Business District Cycle.

the Thruway Authority's methanol vehicles to travel from New York City to Buffalo without having to travel a carefully planned route to avoid running out of fuel. In addition, a public methanol refueling facility was established in New York City, a methanol refueling facility was built to serve fleet vehicles in Monroe County, and both a methanol and an ethanol refueling facility were set up to serve municipal vehicles in White Plains. In cooperation with participating municipalities, gasoline service station operators, and gas utility companies, three CNG refueling facilities were established to serve municipal and commercial fleets and the general public. Also, a propane distributor supplied two refueling stations to support AFV-FDP vehicles operated at two State Parks.

One of the major challenges faced by the AFV-FDP was the rapid evolution of AFV technology. The program's approach generally was to use commercially available AFV equipment, so as to replicate the experience of typical AFV users, and to use a mix of standard-design and advanced-design components to gain an understanding of the costs and benefits of innovations that have become available in the marketplace. Also, in some cases, experimental or limited-edition prototype equipment was used to provide insight into the future direction of AFV technology.

The AFV-FDP has itself been a source of technical innovations, especially in the area of refueling equipment and garage safety. Work done to establish refueling facilities and to resolve apparent fuel-quality problems and other field problems has helped improve equipment design, benefitting companies that build, install, and operate AFV refueling stations. Also, the AFV-FDP's work to assess the safety requirements of garages and maintenance facilities for AFVs has resulted in the development of guidelines to assist fleet operators and facility managers (see Appendix J).

The AFV-FDP has included efforts to educate fleet operators and the public about AFV costs, benefits, and operating characteristics. Presentations have been made directly to groups of fleet operators, as well as to numerous technical meetings and conferences. AFVs have been exhibited at auto shows around the State, and taken to schools and various community events. Findings from the AFV-FDP also have contributed to a growing national awareness of the need for vehicle storage and maintenance facility modifications tailored to AFV requirements, and has helped prompt the National Fire Protection Association to review its existing building codes and standards for garages to include AFV requirements.

The AFV-FDP's efforts have helped assist follow-on programs. For example, some of the same fleets that participated in the AFV-FDP also are participating in the U.S. Department of Energy Clean Cities program.[7] Their efforts range from simple public information campaigns to vehicle conversions and purchases to alternative-fuel infrastructure development, including establishment of alternative-fuel corridors linking cities. The country's leading automakers and fuel providers have approached these community programs with initiatives to provide them with AFVs and alternative-fuel infrastructure. Currently, there are four Clean Cities in New York State: White Plains, Western New York (Buffalo and surrounding communities), Central New York (Syracuse and surrounding communities), and Greater Long Island. Other Clean Cities groups are organizing in New York City, Rochester, Albany, and elsewhere.

[7] Clean Cities is a locally based government/industry partnership program coordinated by the U.S. Department of Energy to expand the use of alternatives to gasoline and diesel fuel. Clean Cities builds on local initiative, provides options for local problems, and creates partnerships as the mechanism to develop solutions to establish a sustainable, nationwide alternative fuels market.