

# Developments in U.S. Alternative Fuel Markets

by Mary Joyce<sup>1</sup>

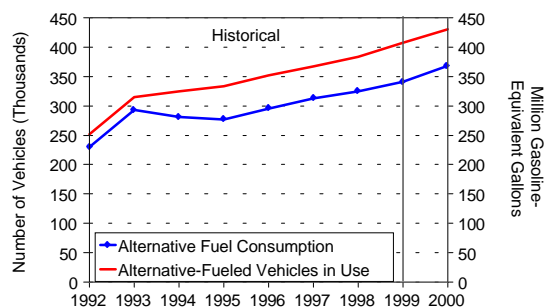
## Introduction

The alternative fueled vehicle (AFV)/alternative fuels industry experienced a number of market-related changes in the second half of the 1990s. In 1994, when the Energy Information Administration (EIA) published *Alternatives to Traditional Transportation Fuels—an Overview*, liquefied petroleum gas (LPG) was the dominant alternative transportation fuel (ATF). Most of the AFVs in use were conversions of gasoline or diesel vehicles. And the parties most interested in ATFs were governments and fuel providers. Today, the new-vehicle manufacturers supply a much larger share of AFVs. Natural gas and other fuels have begun to erode LPG's dominant position. AFVs are available in greater variety than before, with more attention to demands for different types. There's much talk about markets, with a focus on greater penetration of certain niche markets. And there is a significant increase in the number of organizations and activities established to promote AFV use, coordinate purchases, and educate the public, with the ultimate goal of increasing the numbers of AFVs operating in the Nation. The small size of a refueling and maintenance infrastructure for AFVs still hinders the growth of the market. Vehicle cost and driving range are improving, although, in most cases, they are not yet to the point necessary to compete with traditionally fueled vehicles. This article describes each of the alternative transportation fuels and the AFVs in detail. It provides information on the development to date and looks at trends likely to occur in the future.

Alternative fuels legislation of the 1980s and 1990s placed more emphasis on deploying AFVs than on using alternative fuels. Therefore, much of this discussion focuses on the development of vehicle markets. How-

ever, as Figure 1 shows, there has been growth in use of both vehicles and fuels.<sup>2</sup> It is expected that in the future there will be more emphasis on using ATFs rather than AFVs.

**Figure 1. Estimated Alternative-Fueled Vehicles in Use and Alternative Fuel Consumption, 1992-2000**



Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1998*, DOE/EIA-0585(98) (Washington, DC, December 1998), Tables 1 and 10.

Many of the data in this article were obtained from the EIA's survey of AFV suppliers and users that was conducted in 1999. The survey is conducted annually and collects data on AFVs supplied, or made available, in the previous year and AFVs planned to be made available in the survey year. The survey also collects data on AFVs operated by selected user groups in the year prior to the survey.<sup>3</sup> The remaining data, including data for AFV users as a whole, are estimates that were derived in 1999 using an established estimating methodology.<sup>4</sup> Since 1995, EIA has published estimates of AFVs in use in the most recently completed year and estimates of AFVs expected to be in use in the two following years.

<sup>1</sup> The author gratefully acknowledges the contributions to research and analysis for this article that were provided by Amy Jo Wheeler-Melvin, energy industry specialist, Decision Analysis Corporation of Virginia.

<sup>2</sup> In 1997, some vehicle manufacturers began including E85-fueling capability in whole model lines of vehicles. Figure 1 estimates of AFVs in use include only those E85 vehicles believed to be intended for use as alternative fueled vehicles. These are primarily fleet-operated vehicles. All of the E85 vehicles are included in the data for "AFV's made available," shown in Table 2.

<sup>3</sup> Survey data are collected on Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey." For more information about the survey and estimates, see EIA's website, [www.eia.doe.gov](http://www.eia.doe.gov).

<sup>4</sup> The estimating methodology is explained in "Alternatives to Traditional Transportation Fuels 1996," Appendix A, which can be found on EIA's website, [www.eia.doe.gov](http://www.eia.doe.gov).

## A Changing Mix of Vehicle Suppliers

AFVs are any vehicles capable of operating on an alternative fuel such as natural gas, LPG, alcohol, or electricity. AFVs (except electric vehicles) may be configured as either dedicated or non-dedicated vehicles. Dedicated vehicles are designed to run exclusively on one fuel. Non-dedicated vehicles can be: (1) bi-fueled vehicles, which can operate on either an alternative fuel or a conventional fuel, but not at the same time, and have separate on-board storage systems for each fuel; (2) flexible (or variable) fueled vehicles, which can operate on either an alternative or conventional fuel or on a combination, and have a single onboard storage and combustion system; or (3) dual fuel vehicles, which can burn two fuels simultaneously. In dual fuel vehicles, the fuels are not mixed in storage but are injected into the engine combustion chamber simultaneously. Dual-fuel configurations are typically used in heavy-duty vehicles. Electric vehicles are classified as either hybrid or non-hybrid vehicles. Electric hybrids and fuel cell vehicles, which operate on electricity and another fuel, are considered non-dedicated vehicles.

AFVs are supplied by either original equipment manufacturers (OEMs) or converters. An OEM is an organization that provides the original design and materials for assembly and manufacture of vehicles. It is directly responsible for manufacturing, marketing, and providing warranties for new vehicles.<sup>5</sup> A vehicle converter modifies or alters a vehicle originally designed to operate on one fuel—usually gasoline or diesel fuel—to operate on an alternative fuel.

An OEM might authorize an independent conversion facility to take direct delivery of its vehicles and convert the vehicles' engines to use an ATF before the vehicles

are delivered to end users.<sup>6</sup> In that case, the converter is called an OEM vehicle converter, and the vehicle is considered to be an OEM vehicle. If an organization or individual converts, modifies, or repowers vehicles after the vehicle's initial delivery to an end user, it is called an aftermarket vehicle conversion facility and the AFVs are considered to be converted vehicles.

The vehicle OEMs most familiar to the general public are the light-duty vehicle (LDV) suppliers (domestic or foreign) that usually perform the final assembly of, market, and warrant automobiles, vans, pickups, and similar vehicles. OEM's also include truck, bus, nonroad, and specialized vehicle suppliers.<sup>7, 8</sup> Converters of light-duty vehicles often install purchased conversion kits. Conversions may be performed by "in-house" staff for "in-house" vehicles or they may be performed for an organization by a second party. However, in heavy-duty vehicles, conversion may be by way of repowering or rebuilding an engine.<sup>9</sup> Most aftermarket conversions today are engine conversions. Table 1 shows the incidence of different types of conversion methods for the AFVs reported on the EIA-886 survey.

**Table 1. Number of Onroad Alternative-Fueled Vehicles Converted, by Conversion Type, 1998**

Type of Conversion	Total
Engine Converted Only . . . . .	4,222
Vehicle Repowered/Engine Replaced . . .	10
Engine Modified . . . . .	199
Engine Converted and Rebuilt . . . . .	0
<b>Total Conversions . . . . .</b>	<b>4,431</b>

Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

<sup>5</sup> In some cases, one OEM assembles a final product, but that product is marketed and warranted by another OEM.

<sup>6</sup> The vehicle delivered from the OEM to the converter could be a traditional gasoline- (or diesel) fueled vehicle or a "glider" (vehicle without an engine/motor) in which the conversion facility installs an alternative fueled engine or motor.

<sup>7</sup> Medium- and heavy-duty vehicles (HDV) are often assembled somewhat differently from light-duty vehicles. Often, one OEM will manufacture an alternative fueled engine for a HDV and the engine will be installed in a cab and/or on a chassis that was manufactured by another party. The engine may be warranted by one OEM, while the truck cab or the vehicle as a whole is warranted by another OEM. Sometimes an incomplete vehicle (e.g., a chassis, a chassis with a cab, a chassis with a cutaway cab, etc.) with an alternatively fueled engine/motor installed, is transported to another party that completes the AFV by adding user-specified components (e.g., a cargo carrying container, bus body, etc.).

<sup>8</sup> Contact information for most of the OEM's and some converters can be found in "Resource Guides" available on the Alternative Fuels Data Center website, [www.afdc.doe.gov](http://www.afdc.doe.gov).

<sup>9</sup> The repowering process does not use a conversion system; the old conventionally-fueled engine is removed and replaced in its entirety by an engine designed to operate on an ATF. The same alternative fueled engine that might be installed into a new vehicle (e.g., transit bus) may also be installed as a replacement engine in an existing vehicle. Sometimes, beyond converting an engine, the engine is rebuilt to take advantage of the capabilities offered by the ATF. For example, an engine might be converted to operate on natural gas or propane and the engine might be further modified to take advantage of higher compression ratios associated with gaseous fuels.

Although U.S. automakers were producing AFVs for Federal and demonstration fleets in the early 1990s, uncertainty about the future of AFVs made many OEMs reluctant to begin market production. However, from 1995 to 1998, OEMs increased the number of AFVs they supplied by more than 40 times. The reason for such a dramatic increase was the decision by Chrysler Corporation and Ford Motor Co. to include flexible fuel capability (for use with E85 or gasoline) as standard on several models of vehicles (see p. 8). During the same period, conversions declined, dropping by 40 percent between 1996 and 1997 and by almost 50 percent between 1997 and 1998 (Table 2). The two major reasons for the decline were the implementation by the Environmental Protection Agency of an Addendum to Memorandum 1A,<sup>10</sup> which limited the number of conversion kits certified for use, and the availability of more OEM AFVs, which are usually more efficient than conversions.

**Table 2. Number of Onroad Alternative-Fueled Vehicles Made Available, by Supplier Type, 1995-1998**

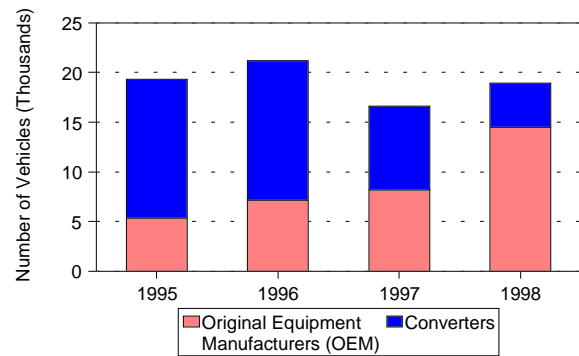
	1995	1996	1997	1998
Original Equipment Manufacturers (OEM) . . . . .	5,766	10,420	87,985	230,675
Converters . . . . .	13,976	14,045	8,397	4,431
<b>Total . . . . .</b>	<b>19,742</b>	<b>24,465</b>	<b>96,382</b>	<b>235,106</b>

Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

In 1995, 29 percent of all AFVs were supplied by OEMs. By 1998, 98 percent of AFVs were OEM vehicles. Even if E85 vehicles are excluded, the percentage of OEM-supplied AFVs had risen to 78 percent by 1998 (Figure 2).

Conversion is often a way for users to get the specific type of AFV that fits their needs. As the range of alternative fuel vehicle types provided by OEMs expanded, conversions also declined. In 1998, according to data reported on Form EI-886, OEM AFVs were made available in 25 of 40 major vehicle categories (although many vehicle types are only available in one or two alternative fuel types).

**Figure 2. AFVs Made Available by Supplier Type, Excluding E85 Vehicles, 1995-1998**



Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

In October 1998, the Alternative Fuels Data Center listed 34 alternative-fuel, light-duty vehicle models that were offered by OEMs to U.S. markets for model year 1999. The available AFVs consisted of a range of vehicle types including sedans, vans, pickups, and sport utility vehicles.<sup>11</sup> The OEMs expected to offer a few more AFV models in 2000. Also in Model Year 2000, the Honda Insight and Toyota Prius were the first gasoline/electric hybrid vehicles sold in the United States. Although technically not AFVs, because they aren't included in the Energy Policy Act of 1992 (EPACT) definition of AFVs, gasoline/electric hybrids are grouped often with other electric vehicles in marketing and analysis work.

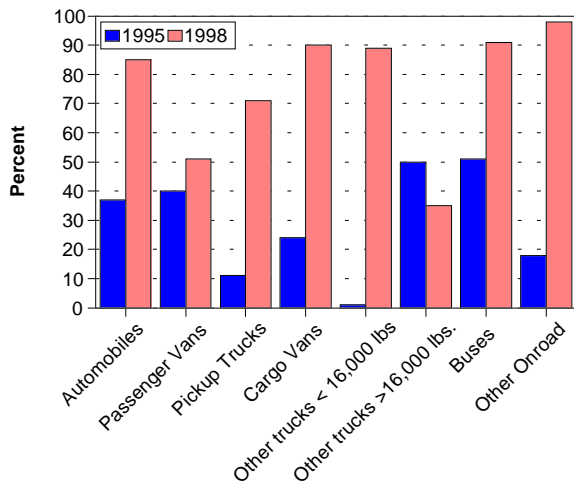
Between 1995 and 1998, the portion of alternative fuel autos, buses, pickup trucks, and cargo vans supplied by OEMs each climbed over the 70 percent mark (Figure 3). Conversion, however, still appears to be an important means of supplying some types of medium and heavy-duty AFVs, particularly trucks. In 1998, according to data reported in the EIA-886 survey, the only categories having more conversions than OEMs were trucks with gross vehicle weight greater than 16,000 pounds.

By fuel type, OEM percentage growth was largest for natural gas vehicles (Figure 4). Although the total number of natural gas vehicles made available annually has hardly changed since 1995, the percentage of natural gas vehicles supplied by OEMs increased from 20

<sup>10</sup> Memorandum 1A explained how the Environmental Protection Agency would enforce vehicle tampering prohibitions of the Clean Air Act with respect to vehicle maintenance and the use of aftermarket parts. The addendum revised the enforcement policy for vehicles which are converted to alternative fuels.

<sup>11</sup> The website, [www.afdc.doe.gov](http://www.afdc.doe.gov), includes a search system to locate information about specific OEM vehicles.

**Figure 3. Percent of Original Equipment Manufacturer (OEM) Supplied AFVs (excluding E85), by Vehicle Type, 1995 and 1998**



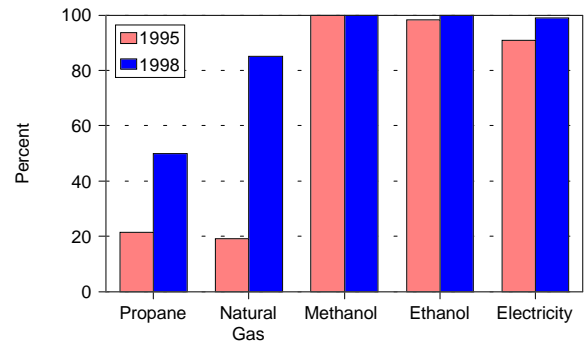
Source: Energy Information Administration, Form EIA-886, “Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey.”

percent to 85 percent by 1998. The number of different types of natural gas vehicles supplied by the OEMs, however, has not changed significantly since 1995. There are still no OEM-supplied natural gas mid-size autos, small pickups or special purpose vehicles, all of which had notable conversions.

About half of the LPG vehicles made available in 1998 were conversions. The total number of LPG vehicles made available has decreased since 1995, when 22 percent of LPG vehicles were supplied by OEM’s. The OEMs offer many fewer vehicle types for LPG than for natural gas. Absent are autos, 16,000-26,000 pound trucks, large pickups, and school buses, all of which have notable numbers of conversions.

The OEM percentage for electric vehicles has always been relatively high. The total number of electric vehicles made available has increased substantially since 1995, led mostly by OEM-supplied vehicles. The OEM percentage increased from 91 percent to almost 100 percent between 1995 and 1998. The number of different electric vehicle types made available has stayed nearly the same.

**Figure 4. Percentage of OEM Supplied AFVs, by Fuel Type, 1995 and 1998**



Source: Energy Information Administration, Form EIA-886, *Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey*.

## Market Trends by Fuel Type

The EPACT specified that liquefied petroleum gas (LPG), natural gas, alcohols in blends containing at least 85 percent alcohol, hydrogen, and electricity were to be considered alternative transportation fuels. Since EPACT’s enactment, two more fuels—100-percent biodiesel and P-Series fuel—have been designated as alternative fuels by the U.S. Department of Energy. The EIA estimates that almost 90 percent of the 430,000+ alternative fueled vehicles expected to be in use in the United States at the end of 2000 will be vehicles designed for LPG or natural gas. But, the shares of AFVs designed for LPG and methanol are on the decline, while the shares of natural gas, ethanol, and electric vehicles have increased since 1992 (Figure 5).

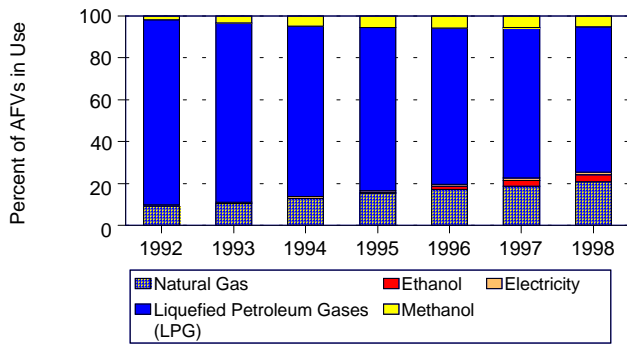
### Liquefied Petroleum Gas (LPG) or Propane

When speaking of alternative fuels, the terms LPG and propane are often used interchangeably. LPG for vehicular use is a mixture containing at least 90 percent propane, 2.5 percent butane and higher hydrocarbons, and a balance of ethane and propylene.<sup>12</sup> Henceforth in this article, LPG used as a vehicle fuel will be referred to as propane.

Propane is a by-product of natural gas processing or petroleum refining. It is a gas at room temperature but

<sup>12</sup> U.S. Department of Energy, U.S. Hemispheric Clean Cities Initiative, *Fast Fuel Facts*. Online. <http://www.hemisphericities.doe.gov/altfuels/propane.html> (extracted August 18, 1999).

**Figure 5. Estimated Alternative-Fueled Vehicles in Use, by Fuel Type, 1992-1998**



Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1998*, DOE/EIA-0585(98) (Washington, DC, December 1998), Table 1.

turns to liquid when compressed. Liquid propane is stored in special tanks that keep it under pressure (about 200 psi).<sup>13</sup> Although stored onboard vehicles as a liquid, propane is returned to a gaseous form before being burned in the engine.<sup>14</sup>

Experiments using propane as a motor fuel were first conducted around 1910. During the 1950's, the conversion of conventional vehicles to AFVs became popular. A taxi fleet in Milwaukee boasted a fleet of nearly 300 taxis running on propane at that time, and the Chicago Transit system operated more than 500 propane-fueled buses.<sup>15</sup> For onroad use, propane is currently used in both light- and medium-duty vehicles as well as heavy-duty trucks and buses. Propane is also a popular choice for nonroad vehicles, such as forklifts and agricultural and construction vehicles.

Vehicle and fuel costs remain barriers to propane's widespread use as an ATF. Many propane vehicles are conversions, with conversion costs typically ranging between \$1,000-\$2,000. Propane retail prices were consistent with unleaded gasoline prices during the 1990s, and future propane prices are expected to be less than gasoline. Since propane prices tend to move along with oil prices, however, propane prices can greatly fluctuate.<sup>16</sup>

<sup>13</sup> California Energy Commission, "Alternative Fuel Vehicles ... They're in Your Future." Online. <http://www.energy.ca.gov/education/AFVs/LNG.html> (extracted August 20, 1999).

<sup>14</sup> California Energy Commission, "Liquid Petroleum Gas/Propane-Powered Vehicles." Online. <http://www.energy.ca.gov/afvs/lpg/propane.html> (extracted August 20, 1999).

<sup>15</sup> *Butane-Propane News*, Vol. 31, No. 6 (Arcadia, CA: Butane-Propane News, Inc., June 1999), pp. 27-29.

<sup>16</sup> California Energy Commission, "Liquid Petroleum Gas/Propane-Powered Vehicles." Online. <http://www.energy.ca.gov/afvs/lpg/propane.html> (extracted August 20, 1999).

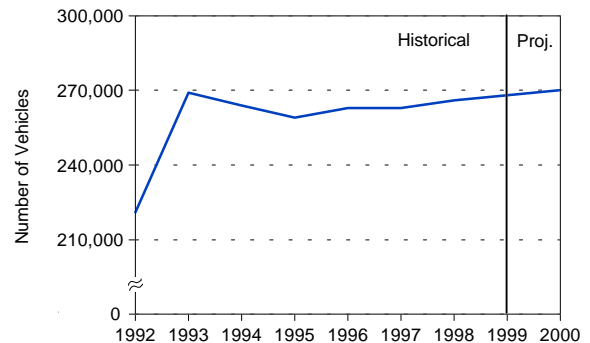
<sup>17</sup> *Ibid.*

<sup>18</sup> *Butane-Propane News*, "Fleet Manager Says Propane is the Best Alternative Fuel for DeKalb County, Ga." Online. <http://www.bpnews.com/htmlfile/otherhtm/April/apr98005.html> (extracted August 20, 1999).

One frequent complaint about dual-fuel propane passenger vehicles is the loss of trunk space due to the installation of the propane tank. An advantage, however, is that propane vehicle engines are reported to last two to three times longer than gasoline or diesel engines.<sup>17</sup> After conducting a study of alternative fuel vehicles, DeKalb County, Georgia, noted that although initial acquisition costs were steep, the long-term savings on fuel costs and maintenance outweighed the short-term costs.<sup>18</sup>

In 1998, there were an estimated 266,000 onroad propane vehicles in use in the United States. Although that is the largest number among all alternative fuel types, propane vehicles experienced the slowest growth between 1992 and 1998 (Figure 6). As a result, propane has lost some of its market share. The greatest concentration of propane vehicles is in the South, where large numbers are operated in the oil-producing States of Oklahoma and Texas.

**Figure 6. Estimated Number of Propane Vehicles in Use, 1992-2000**



Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1998*, DOE/EIA-0585(98) (Washington, DC, December 1998), Table 1.

The propane industry has been criticized by some for not promoting the fuel's use as an alternative transportation fuel, particularly compared to the natural gas industry, which aggressively advertises its fuel for vehicular use. Propane industry officials have stated that

the industry lacks the internal cohesion necessary to promote the use of propane as a transportation fuel. Officials have also noted that, traditionally, the propane industry has been made up of small-scale suppliers who primarily serve residential customers. Some of these suppliers fear that growth in the use of propane as a transportation fuel would cause the deterioration of the suppliers' smaller businesses. And some propane consumers have expressed concern that increasing demand for propane as a vehicle fuel would increase prices.<sup>19</sup> In response, the General Accounting Office concluded in 1998, that there will only be a small increase in propane's use as an alternative transportation fuel over the next 10 years and that propane consumption by non-transportation sectors will not be affected by this increased demand.<sup>20</sup>

Of all the alternative fuel types, propane has the largest percentage of converted vehicles. In 1997, propane vehicle converters were significantly impacted by EPA's addendum to Memorandum 1A, which limited the number of conversion kits certified for use, and led to a sharp decrease in the number of vehicle conversions. However, after a period of adjustment to the new regulations, it appears that conversions will continue. In addition, vehicle manufacturers are committed to producing some new propane vehicles. These factors point to steady, but slow, growth in the use of propane vehicles.

## Natural Gas

Natural gas is a mixture of hydrocarbons (mainly methane) that is extracted from underground reserves. Natural gas can also be produced as a by-product of landfill operations. It is transported to end users through a gas pipeline system that reaches every State in the continental United States. For storage and use as an alternative fuel in vehicles, natural gas is either compressed (CNG) or liquefied (LNG). Compression usually occurs at a refueling station, where natural gas from the distribution pipeline is compressed to about

3,000 psi for vehicular purposes. Natural gas is liquefied by cooling it to minus 260 degrees Fahrenheit at atmospheric pressure. Liquefaction sometimes occurs offsite and LNG is delivered by truck to the refueling station. LNG is primarily used as an alternative to diesel to operate heavy-duty vehicles, while CNG is primarily used in light- and medium-duty vehicles as an alternative to gasoline.

Natural gas vehicles (NGVs) have been in use since the 1930s.<sup>21</sup> Currently, there are far more NGVs in use throughout the rest of the world than in the United States. The largest numbers are found in Argentina, Italy, and Russia, where a total of about 900,000 NGVs are operated.<sup>22</sup> U.S. automakers began producing natural gas versions of some vehicles in the late 1980s and the United States' first public natural gas refueling station opened in Denver in 1990.

Dedicated light-duty NGVs cost about \$3,500 to \$7,000 more than their gasoline counterparts.<sup>23</sup> Some of the expense is due to the need for specialized storage tanks. As demand increases and more NGVs are sold, prices will likely decrease. NGVs have significantly fewer exhaust emissions than gasoline vehicles. Evaporative emissions are also reduced when refueling an NGV.<sup>24</sup> If any natural gas escapes from the refueling nozzle, the gas will not lie along the ground or enter sewage systems because the natural gas is lighter than air.<sup>25</sup> Because CNG is a gas, and less dense than liquid fuels, most CNG vehicles have a shorter operating range than gasoline vehicles. LNG has a much higher energy content, and therefore LNG vehicles can travel further on the same volume of natural gas. LNG also allows for quicker refueling, but the cost of liquefaction and of well-insulated, pressurized, tanks for onboard storage adds to the cost of using LNG.

NGV use is increasing annually in the United States (Figure 7). It is estimated that CNG vehicles experienced an average annual growth rate of 22.6 percent from 1992 to 1998. The use of LNG vehicles has increased at an

<sup>19</sup> U.S. General Accounting Office, "Including Propane as an Alternative Motor Fuel Will Have Little Impact on Propane Market," GAO/RCED-98-260 (Washington, DC, September 1998), pp. 1-7.

<sup>20</sup> *Ibid.*

<sup>21</sup> Natural Fuels Company, LLC, Q & As. Online. <http://www.Naturalfuels.com/4.htm> (extracted March 29, 2000).

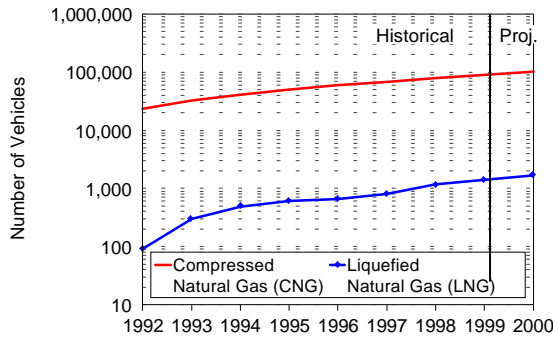
<sup>22</sup> International Association for Natural Gas Vehicles, *NGV Statistics*. Online. <http://www.iangv.org/ngv/stats.html> (extracted March 29, 2000).

<sup>23</sup> Natural Gas Vehicle Coalition, *Questions and Answers About Natural Gas Vehicles*. Online. <http://www.ngvc.org/qa.html> (extracted August 12, 1999), p. 5.

<sup>24</sup> Pacific Northwest Pollution Prevention Resource Center, *Topical Reports: Alternative Fuels for Fleet Vehicles*. Online. <http://www.pprc.org/pprc/pubs/topics/altfuels.html> (extracted August 11, 1999) p. 6.

<sup>25</sup> U.S. Department of Energy, *Alternatives to Traditional Transportation Fuels: An Overview*, DOE/EIA-0585/O (Washington, DC, June 1994), p. 53.

**Figure 7. Estimated Number of Natural Gas Vehicles in Use, 1992-2000**



Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1998*, DOE/EIA-0585(98) (Washington, DC, December 1998), Table 1.

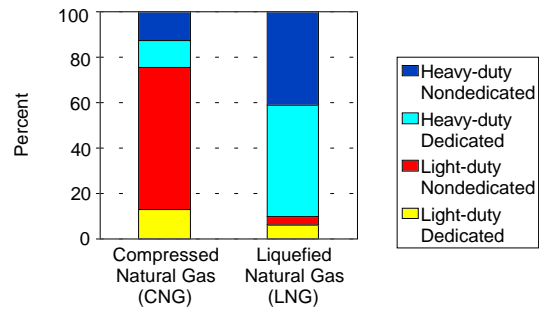
even faster pace, about 50 percent annually during that period, but LNG vehicles still comprise less than 2 percent of the natural gas vehicles in operation today. While NGV use has traditionally lagged behind propane vehicle use, NGVs are expected to comprise 24 percent of all AFVs in 2000, having risen from 9 percent in 1992.

The majority of NGVs in use in the United States are non-dedicated, light-duty, CNG vehicles. Using Form EIA-886 “Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey,” the EIA collected data on nearly 35,000 CNG vehicles in use in 1998 (almost one-half of the total CNG vehicles estimated to be in use in 1998). Of the vehicles reported on Form EIA-886, 63 percent were light-duty, non-dedicated vehicles (Figure 8). The CNG vehicles included automobiles (ranging from compact automobiles to large sedans), passenger vans, cargo vans, pickup trucks (small to large), buses (transit and school), and trucks (weighing anywhere from 6,000 to more than 33,000 pounds).

Many LNG vehicles are dedicated, heavy-duty vehicles. Approximately 700 LNG vehicles (about 60 percent of the estimated total LNG vehicles) were reported on the 1998 Form EIA-886 survey. One-half of those were dedicated, heavy-duty vehicles (Figure 8). Although they accounted for only 1.5 percent of NGVs in 1998, LNG vehicles consumed an estimated 7 percent of all natural gas consumed by vehicles.

Although heavy-duty vehicles are a much smaller percentage of NGVs than light-duty vehicles, they are

**Figure 8. Percent of Reported Natural Gas Vehicles in Use, by Weight Class and Configuration, 1998**



Source: Energy Information Administration, Form EIA-886, “Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey.”

responsible for more natural gas consumption. In 1998, one-fifth of the estimated NGVs in use were heavy-duty vehicles. Yet, heavy-duty vehicles used about 60 percent of the natural gas estimated to be consumed by vehicles.

The greatest concentration of NGVs is in the West. The largest number of NGVs are being operated in California. Following California are Texas, New York, Oklahoma, and Arizona. The most recent fuel consumption estimates show the West consuming 44 percent of the natural gas used as a transportation fuel in the United States.

Although the United States has an abundant supply of natural gas, there are currently only about 1,300 natural gas refueling stations as compared with more than 200,000 refueling stations serving gasoline and diesel.<sup>26</sup> In 1999, a new Natural Gas Vehicle Industry Strategy was developed jointly by the Gas Research Institute, the Natural Gas Vehicle Coalition, and three divisions of the DOE to create a working plan for the industry to increase demand for NGVs and for natural gas as a transportation fuel. Expanding the fueling infrastructure and increasing the use of NGVs by fleets are two prime focuses of the plan. The Strategy lists several stakeholders as key to the financial success of the NGV industry. Those stakeholders include: local distribution companies, OEMs, fuel retailers, government, and other sources. Their activities range from investing time and money into research and development to providing capital to expand the fueling infrastructure.<sup>27</sup>

<sup>26</sup> U.S. Department of Energy, Energy Information Administration, *Natural Gas 1998: Issues and Trends*, DOE/EIA-0560(98) (Washington, DC, April 1999), p. 60.

<sup>27</sup> Natural Gas Vehicle Industry Strategy, NGV Industry (1998), p. 18.

Continued strong growth in the use of natural gas vehicles is expected. If current trends continue, heavy-duty and LNG vehicles will have larger roles in the natural gas vehicle market in the future. Average natural gas use per vehicle will likely increase as heavy-duty NGVs increase and as more fueling sites open.

## Ethanol

Generally made in the United States from corn, ethanol is a liquid alcohol fuel that can be made from many biomass feedstocks, including agricultural crops, waste from agriculture and forestry, wastepaper, and municipal solid waste. As an alternative fuel, ethanol is most typically used as a blend of 85 percent ethanol and 15 percent gasoline, known as E85, which is appropriate for light-duty vehicles. Another less common ethanol/gasoline combination is a 95/5 percent blend called E95. Ethanol is most commonly used as a blending component with gasoline in a combination of 10 percent ethanol and 90 percent gasoline, but this fuel, commonly known as gasohol or E10, is not an alternative fuel. Ethanol can be blended in even lower concentrations with gasoline to produce oxygenated gasoline, which also is not considered an alternative fuel. In the future, ethanol may have another role in transportation as a component of ethyl tertiary butyl ether (ETBE), a different type of oxygenate, but not an alternative fuel.<sup>28</sup>

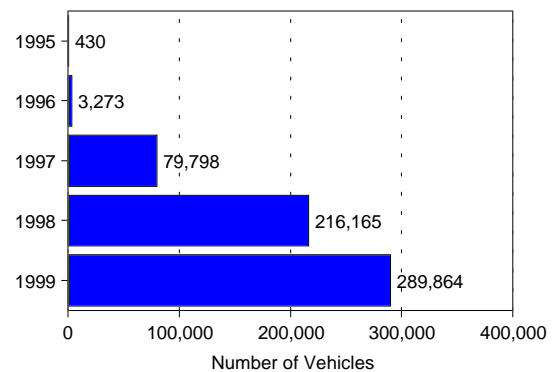
Alcohols were used as fuel in some of the earliest vehicles. Henry Ford's first car operated on alcohol fuel. Ethanol saw a resurgence as a gasoline extender during the oil crisis of the 1970s.

The most common type of vehicle using ethanol is the flexible-fueled vehicle (FFV), which operates on either ethanol or gasoline or any combination of the two fuels. Ethanol FFVs do not cost more than gasoline vehicles. However, ethanol is generally not economical as a transportation fuel. Ethanol has received special tax incentives since the late 1970s. The original incentive reduced the Federal excise tax on ethanol used as a motor fuel by 54 cents per gallon. The incentive will be reduced incrementally starting in 2001 to 51 cents per gallon in 2005. Currently, the subsidy is effective through 2007.

The lack of an adequate fuel supply system is a significant barrier for ethanol and, so far, the use of E85 and E95 has been mostly limited to the Midwest. However, ethanol has been a focus for corn-producing States interested in alternative fuels. As the largest corn-producing State in the nation, Iowa is working to promote ethanol nationwide for use in AFVs by working with surrounding States to develop refueling infrastructure and to form a purchasing network.<sup>29</sup>

Since 1997, vehicle suppliers have produced increasingly more flexible-fueled E85 vehicles. In June 1997, Ford Motor Company announced it would make E85 flexible-fuel capability a standard on its 3.0 liter Ford Ranger pickup trucks, starting in Fall 1998. At the same time, Ford also announced plans to "offer other high-volume FFV car and truck lines, including Windstar" in later years.<sup>30</sup> Shortly after Ford's announcement, Chrysler Corporation announced it would provide E85 flexible fuel systems as standard equipment on all of its 3.3 liter engine minivans, also beginning in 1998. As a result, E85 vehicles made available as reported on EIA-886, grew from about 400 in 1995 to more than 200,000 in 1998 (Figure 9). In 1999, it was announced that Ford would begin producing the Taurus EX as an E85 flexible-fueled vehicle and General Motors would offer a line of flexible-fueled E85 pickup trucks in model year 2000.<sup>31</sup>

**Figure 9. E85 Vehicles Made Available, 1995-1998 and Planned to be Made Available, 1999**



Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

<sup>28</sup> Information about non-alternative-fuel uses of ethanol can be found in the EIA article "Outlook for Biomass Ethanol Production and Demand," which is available online at [www.eia.doe.gov/oiaf/analysispaper/biomass.html](http://www.eia.doe.gov/oiaf/analysispaper/biomass.html).

<sup>29</sup> National Conference of State Legislatures, *Alternative Fuels: A Case Report*. Online. <http://www.ncsl.org/programs/esnr/altmfex.html> (extracted June 30, 1999).

<sup>30</sup> Governor's Ethanol Coalition, Press Release (June 3, 1997).

<sup>31</sup> Renewable Fuels Association, *Ethanol Report*, Issue #108 (December 16, 1999).



It is widely understood that, with just 52 E85 refueling sites currently operating in the United States, most of these flexible-fuel vehicles will never operate on E85. Some environmental groups have criticized the automakers for making these vehicles only to better their average fuel economy ratings to meet Corporate Average Fuel Economy (CAFE) standards. The ethanol industry, however, argues that the large numbers of vehicles in place will encourage the development of infrastructure in many areas.

In its analysis of E85 vehicles in use, EIA has attempted to include only those vehicles which are intended for use as AFVs (e.g., to fulfill mandates or to reach environmental or economic goals that cannot be reached by traditionally fueled vehicles). Such vehicles are, for the most part, operated by fleets. With only those vehicles included, EIA estimates that the number of E85 vehicles in use experienced an average annual growth rate of approximately 105 percent from 1992 to 1998. The number of these E85 vehicles is expected to continue growing rapidly, reaching a level of more than 30,000 in 2000.<sup>32</sup> Government fleets are using a number of E85 vehicles. On the Form EIA-886, Federal and State governments reported about 8,000 E85 vehicles in use in 1998, which were split about 60/40 between Federal and State governments. The greatest concentration of ethanol vehicles is in the Midwest, in States such as Illinois, Iowa, Missouri, Wisconsin, and Nebraska.

Now that there are a large number of ethanol vehicles in the marketplace nationwide, the success of increasing E85 use depends on making the cost of ethanol competitive with gasoline and building an E85 fueling infrastructure. The U.S. Department of Energy (DOE) recently awarded \$1 million to recipients of its "Bridge to the Corn Ethanol Industry" initiative. The DOE initiative is designed to help expand domestic ethanol production by bringing together the corn ethanol industry with newer technologies that produce ethanol from agricultural forest wastes and other biomass. DOE stated that the benefits would include "reducing the cost

of domestic ethanol production, creating new markets for U.S. corn growers, encouraging the production of a clean-burning alternative to gasoline, and helping to reduce the United States' dependence on imported oil."<sup>33</sup>

## Methanol

Methanol is a liquid alcohol fuel commonly made from natural gas. It can also be derived from coal or renewable resources containing carbon, such as seaweed, waste wood, and garbage.<sup>34</sup> Methanol can provide a diversity of fuel applications in several different types of vehicles. The most typical application today is M85, a mixture of 85 percent methanol and 15 percent gasoline, which is primarily used as an alternative fuel in light-duty vehicles. M100 (pure methanol) works best in heavy-duty vehicles. Methanol is also being tested as a source of hydrogen to power fuel cells in electric vehicles. In another transportation application, methanol is used to produce the oxygenate, methyl tertiary butyl ether (MTBE), which is added to gasoline to enhance octane levels and reduce emissions. MTBE is often a component of reformulated gasoline, in which it qualifies as a replacement fuel and clean fuel, but not as an alternative fuel.<sup>35</sup>

The California Energy Commission (CEC) first used methanol in a test fleet in 1978 and, since then, M85 and M100 have been most widely used in California. In the 1980s and 1990s, several thousand methanol-powered vehicles were operated by California fleets as part of CEC-sponsored programs conducted in partnership with the automobile industry. The numbers increased most dramatically after 1987, when the first flexible-fueled autos designed for M85 were commercially produced. To support methanol programs, the CEC provided assistance in the development of a methanol reserve to supply fuel and a refueling infrastructure to distribute the fuel in California. At its peak, more than 100 locations in California hosted methanol fueling facilities.<sup>36</sup>

<sup>32</sup> It is estimated that, in 1999, there were about 550,000 additional vehicles that were capable of operating on E85, but were not being used for AFV purposes. Thus, they were not included in EIA's estimates.

<sup>33</sup> Renewable Fuels Association, *Ethanol Report*. Online. <http://www.ethanolrfa.org/er022599.html> Issue #90 (extracted February 25, 1999).

<sup>34</sup> American Methanol Institute, *Global Climate Benefits of Methanol*. Online. <http://www.methanol.org/fuelcell/fact/climate.html> (extracted January 1999).

<sup>35</sup> A replacement fuel is defined in EPACT as the portion of any motor fuel that is one of the EPACT-defined alternative fuels or an ether. A clean fuel is a vehicle fuel that meets the standards for "clean fuels" as specified in the Clean Air Act Amendments of 1990. Recently, MTBE has come under attack as having detrimental effects on water quality, especially with contamination in wells. Eight States have passed legislation which would eliminate or reduce the use of MTBE. A Blue Ribbon Panel convened by the EPA has recommended the reduced use of MTBE in gasoline. Because ethanol is an alternative to MTBE, a ban on MTBE could also affect the use of ethanol in gasoline.

<sup>36</sup> California Energy Commission, *California's Methanol Experience*. Online. <http://www.energy.ca.gov/afvs/altfuelbriefs/afbvol6no5.html> (extracted June 30, 1999), p. 1.

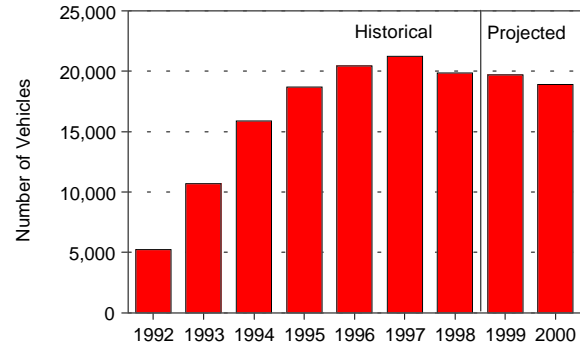
Today, methanol is mainly used in light-duty flexible-fuel vehicles which operate on either methanol or gasoline or a combination of the two fuels. Methanol FFV's cost about the same as a gasoline vehicle, but because of the lower energy content of methanol, their range is somewhat less. The price of methanol is subject to volatility as its demand for other uses (particularly MTBE) fluctuates.

Methanol fuel use has decreased significantly within the last 5 years. A sharp increase in the price of methanol in 1994 and another less severe one in 1997 contributed to the decline in methanol use as an alternative fuel. The CEC stated that in California the decline was due to the expiration of agreements with major fuel retailers and many FFVs being removed from service. By 1999, only 35 of the CEC-sponsored refueling sites remained and the CEC estimated that the number of methanol refueling sites in California would drop to less than 20 by early 2000.<sup>37</sup> Outside of California, about 15 methanol refueling sites are currently available.<sup>38</sup>

Although the OEM's continued to manufacture M85 FFVs through 1998, the number of M85 vehicles made available began declining after 1996. EIA estimates that the number of M85 vehicles in use is now declining, and will continue to decline as older vehicles are retired (Figure 10). The greatest concentration of both M85 and M100 vehicles remains in California, where more than 75 percent of all methanol vehicles are located.

If methanol is to have a significant role in future AFV markets, it is likely to be in methanol fuel cell vehicles. The American Methanol Institute (AMI) suggests that further development of methanol fuel cell technologies will offer potential growth for methanol demand. AMI states that starting in 2004, Daimler-Benz/Chrysler plans to annually produce 100,000 methanol fuel cell vehicles, which will consume 100 million gallons of methanol.<sup>39</sup> The AMI also states that "A clear consensus has now been reached that methanol is the automotive industry's preferred energy source for fuel cell vehicles."<sup>40</sup>

**Figure 10. Estimated Number of Methanol Vehicles in Use, 1992-2000**



Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1998*, DOE/EIA-0585(98) (Washington, DC, December 1998), Table 1.

## Electricity

Onroad vehicles such as automobiles, pickups, vans, buses, and trucks are all capable of being electric vehicles (EVs). Smaller vehicles, such as motorcycles, forklifts, and cargo tugs can also be designed as EVs. Three types of EVs are in use: battery-powered, hybrid, and fuel cell. A battery-powered EV uses the electricity from onboard rechargeable batteries to run an electric motor, which turns the vehicle's wheels. A hybrid electric vehicle has two sources of motive energy. For example, it may use a lean burn gasoline engine in combination with batteries. A fuel cell vehicle uses electricity from fuel cells instead of batteries. A fuel cell operates like a battery in that it converts chemical energy directly into electricity. A fuel cell combines oxygen from the air with hydrogen gas. Unlike a battery, a fuel cell does not run down or need recharging; it produces electricity as long as fuel, in the form of hydrogen, is supplied.<sup>41</sup> Fuels other than pure hydrogen can be utilized by fuel cells if they are processed or reformed to provide a hydrogen-rich mixture. Alternative fuels being considered for use in fuel cells include methanol, ethanol, natural gas, propane, and hydrogen.<sup>42</sup>

<sup>37</sup> California Energy Commission, *California's Methanol Experience*. Online. <http://www.energy.ca.gov/afvs/altfuelbriefs/afbv06no5.html> (extracted June 30, 1999), p. 2.

<sup>38</sup> Alternative Fuels Data Center, *Count of U.S. Refueling Sites by State*. Online. [http://www.afdc.doe.gov/refuel/state\\_tot.shtml](http://www.afdc.doe.gov/refuel/state_tot.shtml) (extracted 1/6/00).

<sup>39</sup> American Methanol Institute, *Methanol Industry Challenges and Opportunities*. Online. <http://www.methanol.org/altfuel/press/pr990511.html> (extracted June 30, 1999).

<sup>40</sup> American Methanol Institute, *Methanol Key to DaimlerChrysler's Fuel Cell Vehicle Plan*, Press release (March 17, 1999). Online. <http://www.methanol.org/fuelcell/press/pr99317.html> (extracted March 29, 2000).

<sup>41</sup> California Air Resources Board, *Fuel Cell Electric Vehicles*. Online. [http://www.arb.ca.gov/msprog/zevprog/fuelcell/fcell\\_fs.pdf](http://www.arb.ca.gov/msprog/zevprog/fuelcell/fcell_fs.pdf) (Extracted August 26, 1999).

<sup>42</sup> U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Fuel Cells for Transportation: Program Implementation Strategy* (Washington, DC), p. 8.

Around the turn of the 20th century, onroad electric vehicles outnumbered gasoline-powered automobiles. During the early 1900s, 50,000 EVs traveled the roads and streets of the United States. Their popularity decreased, however, once less-expensive methods of making gasoline were discovered and the electric starter replaced the crank for gasoline-powered automobiles.<sup>43</sup>

Electric vehicle and battery technology continues to improve and experience rapid growth, however, today's battery-powered EV still does not offer the range of a gasoline-powered vehicle. The typical driving range for these EVs is 50 to 130 miles, depending upon the vehicle's weight, number and type of batteries, and engineering and design features. Weather extremes and use of accessories (such as heating and air conditioning) can also affect the range. Battery pack replacement costs are high, so battery replacement is usually included in the price of leased vehicles.<sup>44</sup> Well-designed battery-powered EVs can travel at the same speeds as conventional vehicles and provide the same safety and performance capabilities.<sup>45</sup> But, with typical battery recharging times of 6 to 8 hours, most vehicles, especially fleet vehicles, must be recharged overnight.<sup>46</sup>

Hybrid EVs have longer ranges than battery-powered vehicles and don't require a charging infrastructure. Hybrid EVs have several advantages over traditional internal combustion engine vehicles, including regenerative braking capability which helps minimize the energy lost when driving, reduced engine weight, increased fuel efficiency, and decreased emissions. Hybrid EVs can also be operated using alternative fuels. Therefore, they need not be dependent on fossil fuels.<sup>47, 48</sup> However, nearly all the hybrid vehicles currently in the marketplace are gasoline/battery combinations.

A fuel cell EV produces very little or no tailpipe emissions, like a battery-powered EV, and it has the driving range and convenience of a conventional gasoline-

powered engine.<sup>49</sup> Fuel cell vehicle technology is currently in the development stage.

EVs cost more than gasoline-powered vehicles. Initial commercial production EVs are priced in the \$15,000 to \$40,000 range.<sup>50</sup> Many OEMs only offer EVs on a lease basis, with lease prices at \$349 per month or more. Tax incentives often help to defray costs.

More than 5,000 EVs were estimated to be in use in 1998 in the United States, with California leading all other States by a wide margin. In 1998, California was estimated to have more than 2,200 EVs in use, followed by Michigan with 311, Arizona with 274, Colorado with 258, and New York with 231. Estimates show a 22-percent average annual growth for EVs in use between 1992 and 1998.

Vehicle manufacturers continue to improve technology and produce more and more EVs. The number of EVs made available grew from a level of about 500 in 1996 to more than 1,800 in 1998. Although 99 percent of the electric vehicles made available were battery-powered, hybrid vehicles increased slightly. Most of the battery-powered vehicles in use have lead or advanced lead acid batteries. But real-world use of battery technology is broadening and other battery types (including nickel metal hydride and nickel cadmium batteries) were used in 43 percent of the EVs supplied in 1998 (Figure 11).

Due to future requirements for zero-emission vehicles in California, Massachusetts, and New York, OEMs are obligated to develop EVs. Production of battery-powered EVs will probably continue at a moderate pace, as improvements in battery technology help to increase ranges. The price of advanced batteries must decrease, and the performance of advanced batteries must improve in order to produce and market an EV that will be widely accepted by today's consumer.<sup>51</sup>

<sup>43</sup> California Energy Commission, *Alternative Fuel Vehicles, They're in Your Future*. Online. <http://www.energy.ca.gov/education/AFVs/electric.html>.

<sup>44</sup> U.S. Department of Energy, Alternative Fuels Data Center. Online. <http://www.afdc.doe.gov/afv/electric.html>, pp. 1-2.

<sup>45</sup> U.S. Department of Energy, Alternative Fuels Data Center. Online. <http://www.afdc.doe.gov/afv/electric.html>, p. 1.

<sup>46</sup> U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Library. Online. <http://www.bts.gov/ntl/DOCS/CAP.html> (extracted August 25, 1999).

<sup>47</sup> U.S. Department of Energy, *Hybrid Electric Vehicle-What is an HEV?* Online. <http://www.hev.doe.gov/general/whatshev.html> (extracted August 27, 1999).

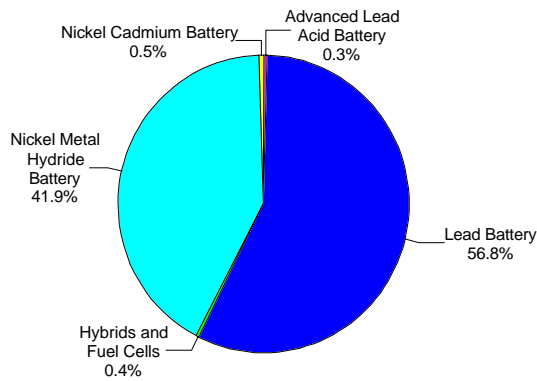
<sup>48</sup> Hybrid vehicles which use gasoline or diesel engines in conjunction with an electric motor are not defined as alternative fueled vehicles by EPACT.

<sup>49</sup> California Air Resources Board, *Fuel Cell Electric Vehicles*. Online. [http://www.arb.ca.gov/msprog/zevprog/fuelcell/fcell\\_fs.pdf](http://www.arb.ca.gov/msprog/zevprog/fuelcell/fcell_fs.pdf) (extracted August 26, 1999).

<sup>50</sup> U.S. Department of Energy, Alternative Fuels Data Center. Online. <http://www.afdc.doe.gov/afv/electric.html>, p. 2.

<sup>51</sup> Electric Transportation Coalition, *Electric Vehicle Community Market Launch Manual: A Guide to Prepare Your Community for Electric Vehicles*. Online. <http://www.ccities.doe.gov/pdfs/launchvol1.shtml> (extracted August 24, 1999).

**Figure 11. Electric Vehicles Made Available by Configuration and Battery Type, 1998**



Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

More use of hybrid EVs is expected in the future. Toyota has been selling its hybrid Prius in Japan and introduced the vehicle to the U.S. market in 2000. Honda started selling its hybrid, Insight, in the United States at the end of 1999.<sup>52</sup> On the user side, Tempe, Arizona, recently ordered 31 hybrid electric buses that will use LNG as their power source, with delivery expected by February 2001.<sup>53</sup>

The introduction of fuel cell EVs is also expected in the future. Although fuel cell applications for buses have been implemented, special emphasis is placed on development for light-duty vehicles since these vehicles offer the greatest potential in energy and environmental benefits.<sup>54</sup>

The international divisions of OEMs and organizational partnerships seem to be spearheading the research,

development, and market testing of fuel cell vehicles, as evidenced by an extensive listing of global fuel cell activity from the Fuel Cells 2000/Breakthrough Technologies Institute (BTI). The California Fuel Cell Partnership, a unique collaboration of auto manufacturers, fuel providers, a fuel cell developer, and government agencies, expects to place about 50 fuel cell passenger cars and fuel cell buses on California roads for demonstration purposes between 2000 and 2003.<sup>55</sup>

Some OEMs have announced plans to make fuel cell EVs commercially available as early as 2004.<sup>56</sup> Several concept vehicles have been built. In Spring 1999, DaimlerChrysler made public its first fuel cell vehicle, called NECAR 4 (short for New Electric Car), which is based on a Mercedes-Benz compact car.<sup>57</sup> DaimlerChrysler is also developing NECAR 5 and a concept vehicle, based on the Jeep Commander, that utilizes a methanol hybrid fuel cell system.<sup>58</sup> DaimlerChrysler has said that for fleet applications, emphasis will be placed on using pure hydrogen fuel; for vehicles sold to the public, hydrogen reformed from methanol will be emphasized.<sup>59</sup> Ford Motor Company produced a concept fuel cell vehicle called the P2000 Prodigy, which operates using on-board stored hydrogen and performs with the same efficiency as Ford's Taurus.<sup>60</sup> Ford and Toyota have both designed a concept fuel cell Sport Utility Vehicle (SUV).<sup>61</sup> The goal of the OEMs is to ensure that safety, performance, and reliability of fuel cell vehicles meets the expectations of the driving public.<sup>62</sup>

## Hydrogen

Hydrogen is not a primary fuel found in nature; it needs to be transformed from water, biomass, renewable fuels, fossil fuels, and other materials that are rich in

<sup>52</sup> U.S. Department of Energy, "Hybrid Electric Vehicle Program-Where Can I Buy an HEV?" Online. <http://www.hev.doe.gov/general/where.html> (extracted August 27, 1999).

<sup>53</sup> Digital Revolution, EV World. Online. <http://www.evworld.com> (extracted August 31, 1999).

<sup>54</sup> U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Fuel Cells for Transportation: Program Implementation Strategy* (Washington, DC), p. 9.

<sup>55</sup> California Fuel Cell Partnership, "About the California Fuel Cell Partnership." Online. <http://www.drivingthefuture.org/aboutus.html> (extracted August 26, 1999).

<sup>56</sup> California Air Resources Board, "Fuel Cell Electric Vehicles" Online. [http://www.arb.ca.gov/msprog/zevprog/fuelcell/fcell\\_fs.pdf](http://www.arb.ca.gov/msprog/zevprog/fuelcell/fcell_fs.pdf) (August 26, 1999).

<sup>57</sup> Environmental News Network, Inc. "DaimlerChrysler unveils fuel-cell vehicle." Online. [http://www.enn.com/enn-news-archive/1999/03/031899/necar4\\_2203.asp](http://www.enn.com/enn-news-archive/1999/03/031899/necar4_2203.asp) (extracted August 17, 1999).

<sup>58</sup> "Fuel Cells in Transportation: What in the World is Going On?" (Washington, DC: Fuel Cells 2000/Breakthrough Technologies Institute (BTI), February 1999).

<sup>59</sup> "DaimlerChrysler Still Leads on Fuel Cells - But Fueled by Hydrogen or Reformed Methanol?" Online. [http://www.calstart.org:80/panda/homepage\\_news/990317\\_daimlerchrysler.html](http://www.calstart.org:80/panda/homepage_news/990317_daimlerchrysler.html) (extracted August 26, 1999).

<sup>60</sup> "Fuel Cells in Transportation: What in the World is Going On?" (Washington, DC: Fuel Cells 2000/Breakthrough Technologies Institute (BTI), February 1999).

<sup>61</sup> "Fuel Cells for Transportation," brochure (Washington, DC: Fuel Cells 2000).

<sup>62</sup> U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Fuel Cells for Transportation: Program Implementation Strategy* (Washington, DC), p. 18.

hydrogen. Natural gas, petroleum, coal, ethanol, methanol, and landfill waste all serve as possible fuel sources for hydrogen.<sup>63</sup> Today, the use of hydrogen in vehicles is primarily limited to experimental and prototype vehicles. A number of prototype vehicles burn hydrogen directly using modified automotive engines. There are also a few vehicles that use hydrogen in a fuel cell to produce electric power for electric motor drives.<sup>64</sup> In addition to the direct use of hydrogen, there has been a demonstration program involving blends of up to 15 percent in volume of hydrogen added to natural gas to create "hythane." In this case, the hydrogen provides up to 5 percent of the energy content of the blend.<sup>65</sup>

Cost is the largest single obstacle preventing hydrogen from becoming a popular ATF. Technological and economic constraints, including safety, the form of the fuel, and production and storage, also serve as obstacles.<sup>66</sup> Maintenance, however, is one area where lower costs are expected if hydrogen is used with fuel cell technology.<sup>67</sup>

Hydrogen may be stored in compressed gas storage tanks or condensed into a dense liquid form, enabling a larger quantity of hydrogen to be stored and transported. Other storage methods include chemical hydrides, gas-on-solid adsorption, and microspheres.<sup>68</sup> All these methods are costly.

The typical form for transporting hydrogen will be in a liquefied state (LH2), which will need to be delivered by a specially designed tanker truck, similar to that used for transporting LNG. The transfer of LH2 from the tanker truck to fleet storage is as complex as that for LNG. A number of steps are involved. Before pumping hydrogen from the storage tank to a vehicle, it must be converted from liquid to gas. The gas is odorless and colorless and if it touches human skin, cryogenic burns will result.<sup>69</sup>

The DOE expects the use of hydrogen as an alternative fuel to increase in the next 20 years. The agency suggests that fuel cell technology will provide a basis for the establishment of hydrogen into the transportation market.<sup>70</sup> Hydrogen use as a transportation fuel will occur gradually, with increased research, development, and testing. Other alternative fuels will probably gain popularity sooner than hydrogen.

## Biodiesel

In 1998, the DOE designated neat (100 percent) biodiesel, or B100, as an alternative fuel and established a credit program for biodiesel use. Biodiesel is an ester-based fuel oxygenate derived from renewable resources (e.g., soybeans, rapeseed, peanuts and other vegetable oils, such as used cooking oil, as well as animal waste, such as beef tallow). Biodiesel can be used in pure form (100 percent biodiesel) or blended in any ratio with petroleum diesel (petrodiesel) for use in compression-ignition (diesel) engines.<sup>71</sup>

Blended biodiesel, the most common of which is B20 (20 percent biodiesel; 80 percent petrodiesel), has not been designated as an alternative fuel. The biodiesel industry spent several years of intensive lobbying to seek approval for B20 to be categorized as an alternative fuel. After legislation was introduced in the House in favor of B20, criticism followed, most of which focused on the definition of an ATF and an AFV. Finally, in 1998, a credit program was enacted. It allows B20 users to claim credits for consuming biodiesel that can be applied against their AFV purchase requirements.<sup>72</sup>

Biodiesel was introduced in South Africa before World War II to power heavy-duty vehicles. Biodiesel plants are now being built by several companies in Europe.

<sup>63</sup> "Fuel Cells for Transportation" brochure (Washington, DC: Fuel Cells 2000).

<sup>64</sup> U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Library. Online. <http://www.bts.gov/ntl/DOCS/CAP.html> (extracted August 25, 1999).

<sup>65</sup> U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Library. Online. <http://www.bts.gov/ntl/DOCS/CAP.html> (extracted August 25, 1999).

<sup>66</sup> U.S. Department of Energy, National Renewable Energy Laboratory, "Hydrogen: The Fuel for the Future," DOE/GO-10095-099 (Washington, DC: March 1995).

<sup>67</sup> National Hydrogen Association, NHA News. Online. [Http://www.ttcorp.com/nha/advocate/ad31cta.htm](http://www.ttcorp.com/nha/advocate/ad31cta.htm) (extracted August 25, 1999).

<sup>68</sup> U.S. Department of Energy, National Renewable Energy Laboratory, "Hydrogen: The Fuel for the Future," DOE/GO-10095-099 (Washington, DC: March 1995).

<sup>69</sup> U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Library. Online. <http://www.bts.gov/ntl/DOCS/CAP.html> (extracted August 25, 1999).

<sup>70</sup> U.S. Department of Energy, "Outreach and Coordination Plan - Hydrogen Program," DOE/GO-10099-741 (Washington, DC, February 1999), p. 1.

<sup>71</sup> "Transesterification," (Green Teach Publishing, 1999). Online. <http://www.veggievan.org/transes.html> (extracted August 25, 1999).

<sup>72</sup> For more information about the B20 credits, see <http://www.ott.doe.gov/legislation.shtml>.

Using biodiesel in pure or blended form does not require engine or storage modifications as do other fuels, such as natural gas or propane.<sup>73</sup> Because using biodiesel requires no engine modifications, conventional heavy-duty vehicles, such as farm equipment and buses, can operate on the fuel. However, biodiesel is more expensive than diesel fuel.

Vehicle engines running on biodiesel produce less particulate, smoke, hydrocarbons, and carbon monoxide emissions than conventional diesel engines.<sup>74</sup> Nitrogen oxide (NO<sub>x</sub>) emissions, however, are similar to those of conventional diesel. Biodiesel's emissions, however, are expected to be less toxic.<sup>75</sup>

When comparing biodiesel used in an unmodified diesel engine with petroleum diesel used in an engine, similar engine performance (i.e., power, acceleration, and fuel consumption) is found. Lubricant consumption and wear are also comparable to conventional diesel engines. Biodiesel users also state that the fuel is safe to handle because it is biodegradable and non-toxic and is safe to transport because it has a high flash point (ignition temperature).<sup>76</sup> Some transit authorities who use biodiesel blends have reported lower maintenance costs than for those vehicles fueled solely on petrodiesel.<sup>77</sup>

Any fleet that includes heavy-duty vehicles with diesel engines can use biodiesel. The National SoyDiesel Development Board concentrates its onroad marketing efforts on bus fleets, environmentally sensitive areas (e.g., parks), and government and military fleets.

The use of biodiesel as an alternative fuel (i.e., B100) is not expected to be significant. However, biodiesel use as a replacement fuel is expected to increase significantly, as the credit program takes effect.

## P-Series fuels

In mid-1999, the DOE determined that Pure Energy Corporation's P-series fuel is "substantially non-petroleum," and added P-Series fuels to the definition of

"alternative fuel" under its Alternative Fuel Transportation Program regulations.<sup>78</sup> P-series fuels are blends of ethanol, methyltetrahydrofuran (MTHF), and pentanes plus, with butane added for blends that would be used in severe cold-weather conditions to meet cold start requirements. The ethanol and MTHF are derived from renewable domestic feedstocks, such as corn stalks, paper-mill sludge, oat hulls, wood waste from construction, and other wastes.<sup>79</sup> Emissions from P-series fuels are well below Federal emissions standards.<sup>80</sup>

P-series fuels are designed to operate in vehicles with flexible-fueled engine technology that can operate on E85 or gasoline, or any blend of the two. Although Ford and Chrysler are mass producing flexible-fueled vehicles, such as the Chrysler minivan and Ford Ranger pickup, the two OEMs do not warrant the operation of their vehicles on P-series fuels because of the fuels' current lack of demand. If the demand for P-Series increases, the OEMs may decide to revise their warranting position.

P-Series is currently only available in limited quantities. To help produce P-Series, funding (\$500,000) has been approved by the Senate Appropriations Committee. Using this funding, the University of Louisville will conduct research and design a full-scale, economically viable refinery that will manufacture P-Series for commercial sale. The first commercial facility is planned for construction in 2000.<sup>81</sup>

In July 1999, Philadelphia, Pennsylvania, began a year-long trial using P-Series in two flexible-fueled sedans. The city will test the fuel while operating the cars for administrative purposes, primarily in the northern portion of the city, where the P-Series fuel tank will be located. Drivers will test the FFVs on P-Series as well as gasoline, for comparison, and will then analyze the results.<sup>82</sup> The Department of Energy estimates that P-series fuels have the potential to displace approximately one billion gallons (almost 1 percent) of gasoline annually by 2005.<sup>83</sup>

<sup>73</sup> National Biodiesel Board, "Fuel Facts" and "Commonly Asked Questions," included in the Board's Information Kit, Jefferson City, MO.

<sup>74</sup> "Why Biodiesel?" (Green Teach Publishing, 1999). Online. <http://www.veggievan.org/biodiesel.html> (extracted August 25, 1999).

<sup>75</sup> *An Introduction to Biodiesel: European and North American Activities* (Overland Park, KS: Midwest Biofuels, Inc.).

<sup>76</sup> *An Introduction to Biodiesel: European and North American Activities* (Overland Park, KS: Midwest Biofuels, Inc.).

<sup>77</sup> National Renewable Energy Laboratory, *Biofuels Update*, "Soy-Based Biodiesel Available to Midwest Farmers" (Spring 1997).

<sup>78</sup> *Federal Register*. Vol. 64, No. 94 (May 17, 1999), pp. 26822 and 26826.

<sup>79</sup> *Federal Register*. Vol. 63, No. 144 (July 28, 1998), pp. 40202-40208.

<sup>80</sup> U.S. Department of Energy, "What's An Alternative Fuel?" Press Release (July 28, 1998).

<sup>81</sup> *Butane-Propane News*, Vol. 31, No. 7 (Arcadia, CA: Butane-Propane News, Inc., July 1999), pp. 10-11.

<sup>82</sup> National Association of Fleet Administrators, *FleetFocus*, Vol. 2, No. 12 (Iselin, NJ: National Association of Fleet Administrators, Inc., June 9, 1999), p. 1.

<sup>83</sup> U.S. Department of Energy, "DOE Designates New Alternative Fuel?" Press Release (May 17, 1999).

## Market Trends by Vehicle Type

A frequent complaint of potential AFV users, and one of the identified barriers to penetration of AFVs in the transportation market, is that the types of AFVs supplied do not meet the needs of vehicle users. The demand for AFVs has been, and continues to be, primarily from fleets.<sup>84</sup> Fleet demand for vehicles differs somewhat from non-fleet demand. Fleets use larger numbers of cargo-carrying vehicles (e.g, pickup trucks) and are the primary users of heavy-duty vehicles. Table 3 shows the average vehicle composition of fleets in the United States. One would expect that the types of AFVs demanded would be similar to fleet vehicle demand. In 1998, according to data reported by AFV users on the EI-886 survey, about one-third of AFVs in use were light-duty trucks and vans, 24 percent were medium-duty trucks, and 7 percent were heavy-duty trucks. Twenty-nine percent were autos and passenger vans. (Table 4) It appears, then, that the demand for AFVs by vehicle type is similar to the demand for fleet vehicles in general.

A look at vehicles supplied in 1998 (excluding E85 vehicles, which include large volumes of light-duty vans and trucks destined for non-fleet use) shows that, 31 percent of the AFVs made available were light-duty trucks and vans, 19 percent were medium-duty trucks and 7.5 percent were heavy-duty trucks. About one-third were autos and passenger vans. (Table 4) Overall, AFVs made available seem to meet demand with perhaps slightly too many autos and too few medium-duty trucks. However, fuel type differs significantly by vehicle type. For instance, about two-thirds of AFV automobiles (excluding E85) supplied in 1998 were CNG vehicles with the remainder split between electricity, methanol, and propane. Fifty-six percent of the medium-duty trucks supplied were propane vehicles and 43

percent were CNG vehicles. Ninety-eight percent of the heavy-duty trucks were propane vehicles.

Overall, about 40 percent of AFVs in use are dedicated vehicles (as reported by AFV users on the EI-886 survey). Propane, LNG, and electric (treating non-hybrids as dedicated) vehicles have larger concentrations of dedicated vehicles. Vehicles designed for CNG and alcohols are more often nondedicated vehicles. By vehicle type, autos are mostly nondedicated vehicles. Heavier trucks and buses are mostly dedicated and mid-size trucks are split about evenly between nondedicated and dedicated vehicles (Figure 12).

If E85 vehicles (which are all nondedicated) are excluded, about half of the AFVs made available in 1998 were dedicated vehicles. More than half of the non-E85 AFVs currently produced by OEM's are dedicated and less than half of the converted AFVs are dedicated. If this trend continues, as OEM's supply more AFVs than converters, the overall percentage of dedicated AFVs (excluding E85 vehicles) in use should rise. Because dedicated vehicles cannot be operated on traditional fuels, a larger concentration of dedicated vehicles in the AFV market would increase consumption of ATFs.

## Focus on Niche Markets

Suppliers and promoters of AFVs recognize that concentrating the use of AFVs in specific niche markets is likely to be a key to success. In fact, the Clean Cities program, organized by the Department of Energy to promote AFV use, has made a focus on niche markets one of its primary components. And DOE's State Energy Program Special Project Grants give high priority to projects that will increase the number of AFVs in niche

**Table 3. Fleet Vehicle Composition by Vehicle Type, 1991\***  
(Percent)

Fleet Type	Cars	Light Trucks and Vans	Medium Trucks	Heavy Trucks	Total
Business . . . . .	24.2	21.1	45.8	8.9	100
Utility . . . . .	22.6	39.0	15.0	23.4	100
Government . . . . .	48.5	42.8	6.8	1.8	100

\*These fleet data, which were generated from a 1991-92 ORNL study, are still the latest available data of this kind.

Source: S.P. Miaou, et. al., *Fleet Vehicles in the United States: Composition, Operating Characteristics, and fueling Practices*, (ORNL-6717), Oak Ridge National Laboratory, (Oak Ridge, TN, May 1992). As reprinted in *Transportation Energy Data Book*, Edition 19 (Oak Ridge, TN, September 1999), Table 10.2.

<sup>84</sup> As defined in the EPACT, a fleet is a group of 20 or more vehicles owned, operated, or controlled by one entity.

**Table 4. Vehicle Composition of Alternative-Fueled Vehicles (AFVs) in Use and AFVs Made Available, 1998**

	Reported AFVs in Use <sup>a</sup> (Percent of Total)	AFVs Made Available, Excluding E85 Vehicles (Percent of Total)	AFVs Made Available, Including E85 Vehicles (Percent of Total)
Autos and Passenger Vans . . . . .	28.7	33.1	67.2
Autos . . . . .	21.9	31.9	4.5
Vans . . . . .	6.8	1.2	62.7
Light Trucks and Cargo Vans . . . . .	32.5	31.3	29.9
Light-duty Cargo Vans . . . . .	4.2	4.7	0.4
Light-duty Pickup Trucks . . . . .	19.2	26.4	29.5
Light-duty Other Trucks . . . . .	9.1	0.1	*
Medium Trucks . . . . .	24.4	19.3	1.4
Medium-duty Pickup Trucks . . . . .	4.6	2.7	0.2
Medium-duty Other Trucks . . . . .	19.8	16.6	1.2
Heavy Trucks . . . . .	7.1	7.5	0.6
Buses . . . . .	7.2	8.0	0.6
School Buses . . . . .	2.9	1.3	0.1
Transit Buses . . . . .	4.2	6.7	0.5
Other Buses . . . . .	0.1	*	*
Other . . . . .	*	0.8	0.1
<b>Total . . . . .</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
<b>Total Number of Vehicles . . . . .</b>	<b>93,310</b>	<b>18,941</b>	<b>235,106</b>

<sup>a</sup>Reported AFVs in use includes all AFVs reported on the EI-886 survey. These vehicles do not represent the entire population of AFVs, which is shown in Figure 1. The total number of AFVs reported is believed to be about one-fourth of the entire AFV population.

\*Less than .05 percent rounded to 0.

Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

markets.<sup>85</sup> Niche markets are specific markets that are particularly suited for AFVs. Some of the characteristics that make fleets well-suited for AFVs are: high fuel usage accompanied by high responsibility for pollution, urban locations, central fueling, fixed and/or limited routes; susceptibility to government mandates, placement of special orders, and high visibility with a desire to promote goodwill. Some targeted niche markets are transit and other passenger transportation, law enforcement applications, and airport facilities. This section describes activity in some of the targeted niche markets.

### Transit Buses

The transit industry consists of mostly local-government agencies that operate public bus, commuter rail, heavy

rail, or ferryboat systems. Buses in both transit and paratransit service are a growing market for AFVs. Paratransit (aka demand response) vehicles, instead of running regular routes, are dispatched upon demand, often to transport elderly or disabled passengers. Buses used in paratransit service are often "mini-buses," or buses less than 27.5 feet in length, while transit service buses are usually full-size buses. There were 69,513 transit buses in operation in 1997 across the United States.<sup>86</sup> Each year, about 6,000 new transit and paratransit vehicles are delivered.<sup>87</sup>

Transit buses are heavy fuel users, consuming on average nearly 10,000 gallons of fuel per vehicle per year.<sup>88</sup> They are also heavy polluters and, because many operate in urban areas, they are often subject to

<sup>85</sup> U.S. Department of Energy, *Alternative Fuel News*. Vol 2. No 6. (March 1999), p. 9.

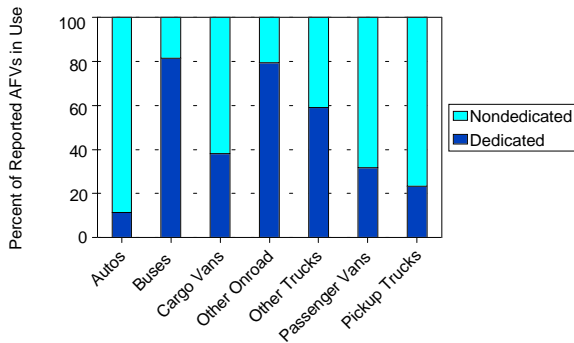
<sup>86</sup> Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 19*, (Oak Ridge, TN, September 1999), Table 8.14.

<sup>87</sup> American Public Transit Association, *1999 Transit Vehicle Data Book* (Washington, DC, May 1999), Table 16.

<sup>88</sup> Diesel-equivalent gallons, derived from Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 19* (Oak Ridge, TN, September 1999), Table 8.14.



**Figure 12. Reported Alternative-Fueled Vehicles in Use by Configuration, 1998**



Source: Energy Information Administration, Form EIA-886, “Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey.”

pollution reduction requirements. Some transit agencies are already subject to clean fuel requirements of the Clean Air Act. If alternative fuel mandates under EPACT are implemented for local and private fleets, transit buses are nearly always centrally-fueled, operate on fixed routes, are usually purchased by special vehicle orders, and have high public visibility. All these factors make transit buses a good “niche” market for alternative fuels.

The use of alternative fueled buses for transit has increased during the 1990s as more and more transit agencies choose the alternative fuel option. In 1995, 749 alternative fuel transit buses were made available. In 1998, 1,269 alternative fuel buses—about one-fourth of all transit buses delivered that year—were made available.

Almost all of the alternative fuel transit buses made available in 1998 were supplied by OEM’s.<sup>89</sup> Fifty percent of the transit buses supplied were CNG buses and another 30 percent were LNG buses, making natural gas the clear leader of ATFs used in transit buses. (Table 5). Of the transit buses made available in 1998, 80 percent were dedicated, i.e., designed to operate on only one fuel.

It is estimated that, in 1998, about 4,900 (about 7 percent) transit buses in operation were AFVs. The EIA-886 survey collected data on about 3,900 transit buses in use in 1998. Of the buses reported, over 70 percent were designed for CNG, 15 percent for LNG, 6 percent for propane, and 4 percent for electricity (Figure 13). Eighty-six percent of the transit buses reported were dedicated or nonhybrid vehicles, so they ran exclusively on alternative fuels. According to the EI-886 survey of alternative fuel users, alternative fuel transit buses currently operate in 39 States. Thirty-seven percent operated in California and 15 percent in Texas. Other States where more than 100 transit buses were reported are Arizona, Georgia, Nevada, New Mexico, New York, Ohio, and Washington.

Incentives are available to transit agencies to acquire alternative fuel buses through the Transportation Equity Act for the 21st Century (TEA-21). TEA-21 established the “Clean Fuels Formula Grant Program,” under which transit systems may apply for grants to purchase or lease clean fuel buses and related equipment and facilities as well as improve existing facilities to accommodate clean fuel buses.<sup>90</sup> Available funds will be allocated using a formula based on an area’s nonattainment rating,

**Table 5. Number of Onroad Alternative-Fueled Transit Buses Made Available, by Fuel Type, 1995-1998**

	1995	1996	1997	1998
Propane . . . . .	23	67	67	153
Compressed Natural Gas (CNG) . . .	445	707	879	690
Liquefied Natural Gas (LNG) . . . . .	24	0	17	378
Electricity . . . . .	247	133	25	48
Other <sup>a</sup> . . . . .	10	5	0	0
<b>Total . . . . .</b>	<b>749</b>	<b>912</b>	<b>988</b>	<b>1269</b>

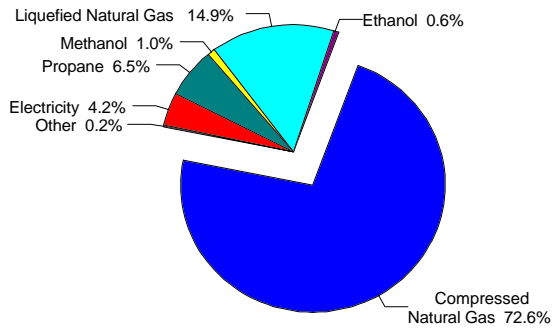
<sup>a</sup>Includes hydrogen, neat biodiesel, and other alternative fuels.

Source: Energy Information Administration, Form EIA-886, “Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey.”

<sup>89</sup> Contact information for transit and school bus manufacturers can be found in the *Heavy Vehicle and Engine Resource Guide*, published by the U.S. Department of Energy. It is available online at [http://www.afdc.doe.gov/resource\\_guide.html](http://www.afdc.doe.gov/resource_guide.html).

<sup>90</sup> Washington State University. Online. <Http://www.energy.wsu.edu/altfuels/clean/files/pscexecsum.htm> (May 12, 1999), p. 6.

**Figure 13. Reported Alternative-Fueled Transit Buses in Use, by Fuel Type, 1998**



Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

number of buses, and bus passenger-miles.<sup>91</sup> Each recipient in an urban area with more than 1 million people may receive a maximum of \$25 million in an annual grant; an annual maximum of \$15 million is available to each recipient in an urban area with a population less than 1 million people.<sup>92</sup>

With financial incentives and current momentum in the market, the number of transit buses designed for alternative fuels is expected to continue growing. Because of high fuel use, and the large proportion of AFV transit buses which are dedicated, it is expected that transit buses will be a strong market for the use of alternative fuels in the future.

## School Buses

Predictable routes, centralized refueling, and high fuel usage, as well as the opportunity to educate future energy consumers, are things that make school buses a desirable application for alternative fuel vehicles. Several school systems are currently using alternative fuel buses. The California Energy Commission (CEC) started a Safe School Bus Demonstration Program in 1988 and, since then, has placed more than 400 new alternative fuel school buses within California school systems. About 270 of those are powered by natural gas

and 150 operate on methanol. Although California users expressed dissatisfaction with some of the buses used earlier in the program, there was satisfaction with newer-technology CNG buses delivered in 1997.<sup>93</sup> Elsewhere in California, the Desert Sands School District was the first in California to commit to converting 100 percent of its fleet to CNG.<sup>94</sup> Dallas, TX, where several hundred propane school buses are in use, may have the largest fleet of alternative fuel school buses. In Tulsa, OK, the school system began using CNG buses in 1988 and by 1998 had 148 CNG school buses in its fleet. The Evansville/Vanderburgh school district in Indiana also operates one of the largest fleets of CNG school buses.

It is estimated that there are currently 4 thousand to 7 thousand alternative fuel school buses being used across the nation. Respondents to the EI-886 survey reported 2,732 school buses in use in 1998. More than 99 percent of those reported were propane or CNG buses, with propane having a slight edge over CNG. A few methanol and electric school buses were reported. About 70 percent of the reported school buses were dedicated vehicles. AFV school buses are reportedly used in 23 States, although over half are in Texas. Relatively large numbers (>100) were reported in California, Oklahoma, Indiana and Arizona (Figure 14).

About 300 AFV school buses have been made available each year since 1995, except for 1996, when more than 800 were made available. Nearly all of the AFV school buses were designed for either propane or CNG (Table 6), and 80 percent of those made available in 1998 were dedicated vehicles.

In 1997, there were 568,113 school buses in operation in the United States, using on average 1,000 gallons of fuel per vehicle per year.<sup>95</sup> With less than 2 percent of operating school buses designed for alternative fuels, this niche market seems to have much room to expand.

## Taxi Cabs

Using ATFs in taxis is ideal because of their high mileage, limited driving range, location, and visibility to the public. In 1998, 190,000 fleet automobiles were used

<sup>91</sup> U.S. Department of Transportation, *A Summary: Transportation Equity Act for the 21st Century*, FHWA-PL-98-038, HPP-20/7-98 (15M)E (Washington, DC), p. 22.

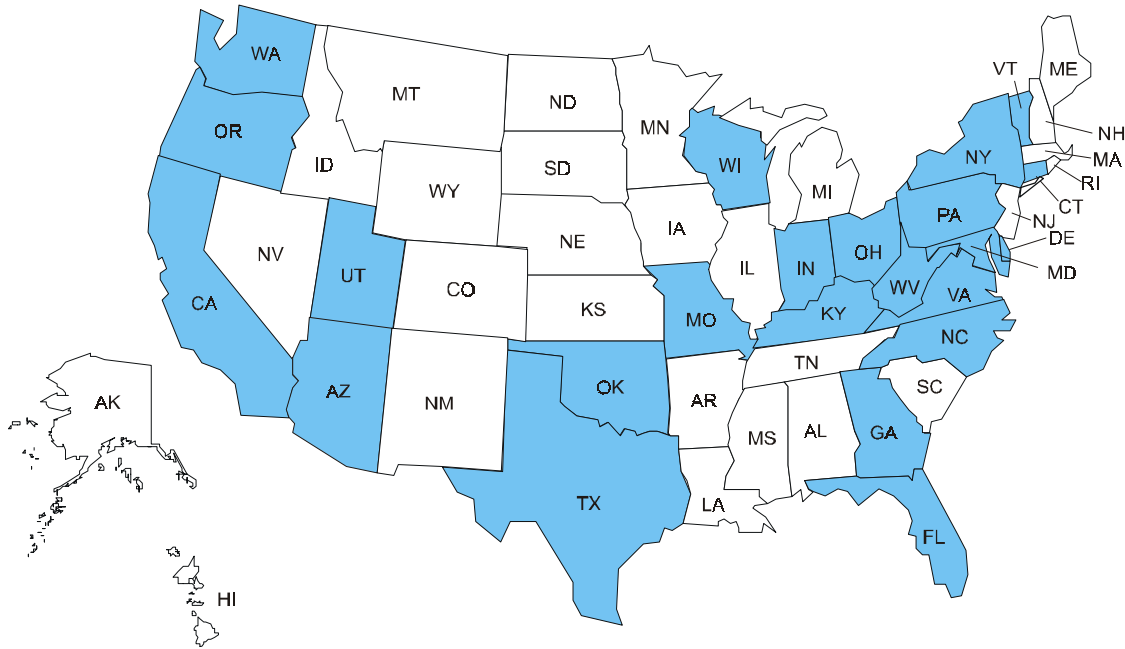
<sup>92</sup> Washington State University. Online. <http://www.energy.wsu.edu/altfuels/clean/files/pscexecsum.htm> (May 12, 1999), p. 6.

<sup>93</sup> *CNG Shows Promise*, Online. <http://www.schoolbusfleet.com/Archives/Sept98/sepsurvey.htm>.

<sup>94</sup> U.S. Department of Energy, *Alternative Fuel News*. Vol. 2, No. 4 (November 1998), p. 8.

<sup>95</sup> Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 19* (Oak Ridge, TN, September 1999), Table 8.14. Average consumption is in terms of diesel-equivalent gallons.

**Figure 14. States with Reported Alternative Fueled School Buses in Use, 1998**



Note: Shaded States are those that reported alternative fueled school buses in use.

Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

**Table 6. Number of Onroad Alternative-Fueled School Buses Made Available, by Fuel Type, 1995-1998**

	1995	1996	1997	1998
Propane . . . . .	134	493	120	66
Compressed				
Natural Gas (CNG)	205	383	160	181
Liquefied				
Natural Gas (LNG) . .	0	0	1	0
Electricity . . . . .	1	11	3	0
<b>Total . . . . .</b>	<b>340</b>	<b>887</b>	<b>284</b>	<b>247</b>

Source: Energy Information Administration, Form EIA- 886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

as taxis in the United States.<sup>96</sup> The average taxi travels 60 to 80 thousand miles per year.<sup>97</sup> Taxis generally operate within a 30 mile radius from their home base and most taxi fleets are found in urban areas that are highly

congested. Also, some taxis are centrally fueled and could be under government mandates for private fleets. The general public's knowledge of AFVs will increase with taxis' use of ATFs.

The use of alternative fuels in taxi fleets in the United States continues to increase. Throughout the country, several projects are demonstrating the benefits of alternative fuel use in the taxi market. Yellow-Checker-Star Cab Co., which operates several hundred propane taxis in Las Vegas, is probably the largest AFV taxi fleet in the country. In Long Beach, CA, Checker Cab Company has established a goal of incorporating 140 natural gas taxicabs into its fleet. In Atlanta, GA, Checker Cab operates 70 natural gas vehicles. Most of these vehicles are Ford Crown Victoria sedans. Natural gas Crown Victorias are used in the taxicab fleets of Barwood Cab Company in Montgomery County, MD, and New York City's taxi program. The natural gas Honda Civic is also being used as a taxi. Yellow Cab Co. in Bloomfield, CT, has operated 31 of them since 1999. In general, taxi companies have experienced reduced fuel

<sup>96</sup> U.S. Department of Transportation, National Transportation Statistics 1999 (Washington, DC), Table 1-11. Online. <http://www.bts.gov/ntda/nts/NTS99/data/Chapter1/1-11.htm>.

<sup>97</sup> U.S. Department of Energy, *Alternative Fuel News*. Vol. 2, No. 5 (May 1999). Online. [http://www.afdc.doe.gov/documents/altfuelnews/2\\_5niche.html](http://www.afdc.doe.gov/documents/altfuelnews/2_5niche.html).

and maintenance costs with AFVs, although lack of refueling sites and smaller trunk space have been problems.

New York City is strongly encouraging the use of AFVs in its 12,000-vehicle taxicab fleet through its Clean-Fuel Taxi Program. By arranging rebates and discounts with natural gas vehicle suppliers, the program allows purchasers of natural gas taxis to buy the vehicles at a price comparable to gasoline vehicles.<sup>98</sup> The city's Taxi and Limousine Commission (TLC) also permits extending the life of alternative fuel vehicles 2 years beyond the mandatory 5-year retirement deadline that applies to gasoline-powered cabs.<sup>99</sup> The use of AFVs for taxi service could see a large increase in the future as a result of New York City's taxi program.

## Airports

The use of alternative fuels to reduce exhaust emissions from vehicles operating around airports has recently gained the attention of the alternative fuel industry. Other than aircraft themselves, the common sources of transportation emissions around airports are land-side vehicles and ground support equipment. Land side vehicles generally include shuttle vans and buses that transport passengers from airport terminals to hotels, parking, or rental car lots. In a broader sense, they could also include taxis, limousines, and private automobiles that transport passengers to and around airports. Ground support equipment includes service vehicles that travel along the tarmac, such as tractors that push airplanes, baggage carriers, and baggage belt loaders. Many of these vehicles operate on fixed and/or short routes close to the airport. Many are fueled at refueling facilities located on site. And many operate in large urban areas where emissions are controlled. These operational and locational characteristics make airport-related vehicles a good niche market for alternative fuels.

Alternative fuel vehicles are becoming more visible in shuttle fleets and ground support vehicles. At Dallas-Ft. Worth International Airport, SuperShuttle has used

propane shuttle vans since 1971. The director of maintenance calculated that SuperShuttle saves \$200,000 annually on the fuel cost differential.<sup>100</sup> Also, at Dallas-Ft. Worth, American Airlines will purchase \$20 million worth of electric ground equipment, including 350 electric tow tugs, baggage carts, and cargo loaders. The airport has also requested \$1.3 million from the North Central Texas Council of Governments to help fund initiatives that will replace the airport's transportation fleet with alternative fuel vehicles.<sup>101</sup> At Logan Airport in Boston, MA, plans are in place to replace most of the diesel-fueled shuttle bus fleet with shuttle buses running on CNG. The transportation manager stated that the CNG buses have a reliability rate of about 90 percent, surpassing that of some of the diesel shuttle buses.<sup>102</sup> Other airports where alternative-fueled vehicles are in use are: Denver, Los Angeles, Phoenix, Salt Lake City, New York, Newark, Philadelphia, San Diego, Chicago, and Sacramento.

As new airports are built, or older ones expand, alternative fuels are being taken into consideration. When Denver's airport was built in the 1990s, CNG and electric vehicles were incorporated in the plan. Denver now has at least 500 CNG vehicles in operation. Philadelphia International Airport, which introduced 18 dedicated CNG employee shuttle buses into its fleet in 1998, is taking steps to promote clean air and emissions reductions as it expands. It plans to continue the acquisition of alternative fuel vehicles (AFVs) to meet those objectives.<sup>103</sup>

Most airport officials involved with AFVs state that a reduction in vehicle emissions, whether motivated by self-interest or mandates, stimulates their AFV-related programs. The U.S. Senate recently passed the Airport Air Quality Improvement Act.<sup>104</sup> Originally introduced in the House of Representatives in 1999 by Congressman Boehlert, the bill directs the Department of Transportation to provide up to \$2 million in grants to each of 10 public-use airports for the acquisition of inherently low-emission vehicles and the infrastructure needed to support them. To qualify, airports must be in metropolitan areas in nonattainment for Federal air quality

<sup>98</sup> NYSERDA, "Energy Efficiency Services - Alternative-Fuel Vehicle Fleet Assistance." Online. <http://www.nyserda.org/afv.html> (June 30, 1999).

<sup>99</sup> Inform, "New York's Alternative Fuels: State Emerging as Leader in Drive for Clean Air." Online. <http://www.informinc.org/spring97fuel.html> (June 30, 1999).

<sup>100</sup> "Powered by Propane Pride," *Propane Vehicle*, Vol. 3, No. 6 (Denver, CO: RP Publishing, December 1998), pp. 9-10.

<sup>101</sup> Electric Vehicle Association of the Americas, "American Airlines named EVAA Hero," Press Release. (April 15, 1998).

<sup>102</sup> "Boston Airport to Dump Diesel for Natural Gas," *Natural Gas Fuels*, Vol. 7, No. 11 (Denver, CO: RP Publishing, November 1998), p. 6.

<sup>103</sup> U.S. Department of Energy, "Clean Cities Chronicles." Online. <http://www.ccities.doe.gov/chronicles.shtml> (August 30, 1999).

<sup>104</sup> CALSTART, "Calstart News Notes." Online. [Http://www.calstart.org](http://www.calstart.org) (March 13, 2000).

quality standards and match the Federal funds.<sup>105</sup> If the bill is enacted into law, it could lead to a significant increase in the use of alternative fuels at airports.

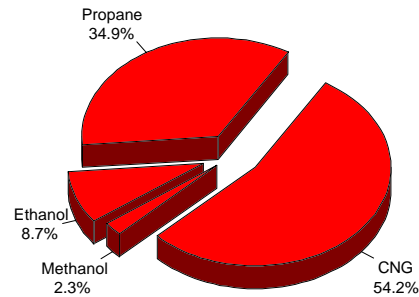
## Law Enforcement

In 1998, 289,000 of the fleet automobiles in the United States were used by police.<sup>106</sup> Although exempt from most alternative fuel vehicle mandates, law enforcement agencies have begun to embrace the use of AFVs. Because they operate high-mileage vehicles in urban areas, often have central fueling facilities, and usually place special orders for vehicles, law enforcement agencies have some characteristics of a good niche market. Their high visibility and opportunity to promote goodwill in communities also qualifies this market as a good place for AFVs. Some law enforcement agencies have discovered that AFVs make economic sense in terms of performance, maintenance, and fuel cost.

For instance, the police department in Rocky Hill, Connecticut, has had a positive experience incorporating natural gas vehicles into its fleet. Initially approached by Ford Motor Company and Connecticut Natural Gas with the idea, the Rocky Hill Police Department soon found the loaned dedicated CNG Crown Victoria to be on par with their gasoline-powered Crown Victorias, in terms of range, performance, refueling, and maintenance. The Department soon agreed to acquire more Crown Victorias, with financial assistance from Connecticut Natural Gas and the vehicle manufacturer, and now experiences savings in repair costs in addition to enhancing the area's air quality.<sup>107</sup>

Respondents to EIA's Form EI-886 reported 1,225 law enforcement AFVs that operated in 16 States in 1998. The largest numbers were reported in Arizona, Florida, and Texas. About half of the reported law enforcement AFVs were CNG vehicles, one-third were propane vehicles, and 10 percent were ethanol or methanol vehicles (Figure 15). More than 90 percent of the AFVs reported for use in law enforcement applications were automobiles. About three-fourths of the AFVs reported to be used in law enforcement were nondedicated vehicles.

**Figure 15. Reported Alternative-Fueled Vehicles Used in Law Enforcement, by Fuel Type, 1998**



Source: Energy Information Administration, Form EIA-886, "Alternative Transportation Fuels and Alternative Fueled Vehicles Annual Survey."

## Postal Delivery

With 208,000 vehicles traveling 1 billion miles annually, the U.S. Postal Service (USPS) is in a position to provide a leadership role in the use of AFVs. By doing so, it can reduce air emissions, increase Americans' knowledge of ATF technology, and increase the development of the AFV market. The USPS began experimenting with ATFs in the 1970s in response to the energy crisis.<sup>108</sup> Today, the USPS operates more than 7,500 CNG vehicles, the largest CNG vehicle fleet in the Nation. Most of its CNG vehicles are "long-life" mail delivery vehicles that were converted to run on either CNG or gasoline. As of the end of 1998, the USPS also had almost 700 ethanol vehicles and about 70 other AFVs that are used mostly for administrative functions.

Throughout the United States, local USPS branches have used AFVs. In El Paso, Texas, the U.S. Postal Service delivery fleet is 100 percent powered by CNG.<sup>109</sup> USPS in Dallas, Texas, converted one quarter of its entire vehicle fleet from gasoline to CNG. Dallas USPS also operates LNG-fueled heavy-duty trucks that transport mail from a bulk mail center to post offices. In 1998, USPS' website listed 63 cities where the agency used AFVs.<sup>110</sup> Dallas, San Diego, Atlanta, Phoenix, and El

<sup>105</sup> Library of Congress, THOMAS. Online. <http://thomas.loc.gov/cgi-bin/query> (extracted April 5, 2000).

<sup>106</sup> U.S. Department of Transportation, National Transportation Statistics 1999 (Washington, DC), Tables 1-11. Online. <http://www.bts.gov/ntda/nts/NTS99/data/Chapter1/1-11.htm>.

<sup>107</sup> *Natural Gas Fuels*, Vol. 8, No. 3 (Denver, CO: RP Publishing, Inc., March 1999), pp. 11-13.

<sup>108</sup> U.S. Postal Service, "Why AFV Makes Sense." Online. <http://usps.com/search97cgi> (extracted August 30, 1999).

<sup>109</sup> U.S. Department of Energy, *Communities of the Future* (April 1999), p. 11.

<sup>110</sup> U.S. Postal Service, "What Are Alternative Fuel Vehicles." Online. <http://www.usps.gov/enviro/> (extracted August 30, 1999).

Paso led in AFV usage. In an attempt to better utilize the alternative fuel capability of its bi-fuel natural gas vehicles, however, the Postal Service developed a relocation plan in 1999. The plan will relocate many of the natural gas vehicles to areas where CNG refueling sites are most widely available, such as Texas, California, Oklahoma, and Connecticut.<sup>111</sup>

The Postal Service's use of AFVs and ATFs will grow rapidly in the immediate future. In 1998, the Postal Service ordered 10,000 flexible-fuel ethanol (E85) mail-delivery vehicles, which are scheduled for delivery between mid-1999 and 2001. The ethanol vehicles will be placed in areas near existing refueling sites, primarily in the Midwest. In late 1999, USPS placed an unprecedented order for up to 6,000 electric vehicles. The electric vehicles will be specially-made, battery-powered, jeep-like vehicles, used for mail delivery. The first batch of 500 electric vehicles is scheduled to be delivered in 2000 and 2001. Purchase of the remaining 5,500 is still optional and depends on satisfaction with the first group. Nearly all of the electric vehicles will be placed in California. A few will go to the Washington, D.C., area.<sup>112</sup> The USPS states that by testing AFVs, such as their electric-powered long life vehicle to deliver mail, Postal Service leadership is helping America stay on the road to a cleaner environment.<sup>113</sup>

## For More Information

A complete set of EIA's most recent estimates and survey data for alternative fueled vehicles and alternative fuel consumption is available under the title "Alternatives to Traditional Transportation Fuels 1998." It can be found on EIA's website at [www.eia.doe.gov](http://www.eia.doe.gov). Many publications related to alternative transportation fuels can be obtained from the National Alternative Fuels Hotline, which can be reached by calling 1-800-423-1DOE. There are also numerous websites with information related to alternative fuels. Some of these are:

- The Alternative Fuels Data Center,  
[www.afdc.doe.gov](http://www.afdc.doe.gov)
- DOE's Clean Cities Program, [www.cities.doe.gov](http://www.cities.doe.gov)
- The Propane Vehicle Council,  
[www.propanegas.com/vehicle](http://www.propanegas.com/vehicle)
- The Natural Gas Vehicle Coalition, [www.ngvc.org](http://www.ngvc.org)
- The Governor's Ethanol Coalition,  
[www.ethanol-gec.org](http://www.ethanol-gec.org)
- American Methanol Institute, [www.methanol.org](http://www.methanol.org)
- Electric Vehicle Association of the Americas,  
[www.evaa.org](http://www.evaa.org)
- National Biodiesel Board, [www.biodiesel.org](http://www.biodiesel.org)
- CALSTART's Advanced Transportation website,  
[www.calstart.org](http://www.calstart.org).

<sup>111</sup> "Post Office Plays AFV Matchmaker" *Natural Gas Fuels*, Vol. 7, No. 5 (Denver, CO: RP Publishing, May 1998), p. 10.

<sup>112</sup> "U.S. Postal Service Delivers Clean Air as Holiday Gift to the Nation," Press Release (December 22, 1999).

<sup>113</sup> U.S. Postal Service, "Alternative Fuel Facts." Online. <http://www.usps.gov/enviro/textmirr/webpages/fuelct.htm> (August 30, 1999).