Advanced Vehicle Testing Activity

July 2004
DOE/GO-102004-1849

Overview of Advanced Technology Transportation, 2004 Update

TECHNICAL REPORT

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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Introduction

Since 2000, the U.S. Department of Energy's (DOE) Advanced Vehicle Testing Activity (AVTA), formerly the Field Operations Program, has produced an annual overview of the transportation market. The document—which covers energy use, vehicle sales, emissions, potential partners, advanced technology vehicle availability, and other factors—offers a "snapshot" of current vehicle technologies and trends. DOE program managers use this document to plan testing and evaluation activities that focus resources where they have the greatest impact. This document is the update for 2004. To download overviews from previous years, visit www.avt.nrel.gov/overview.html.

The information in this document is based on numerous sources, which are listed in the Appendix. Most of the statistics were collected from the following sources:

- The Energy Information Administration's (EIA) *Annual Energy Review*, *Monthly Energy Review*, and *Alternatives to Traditional Transportation Fuels*
- DOE Oak Ridge National Laboratory's *Transportation Energy Data Book* (Edition 23)
- The U.S. Environmental Protection Agency's (EPA) Air Trends Web site, www.epa.gov/airtrends/index.html.

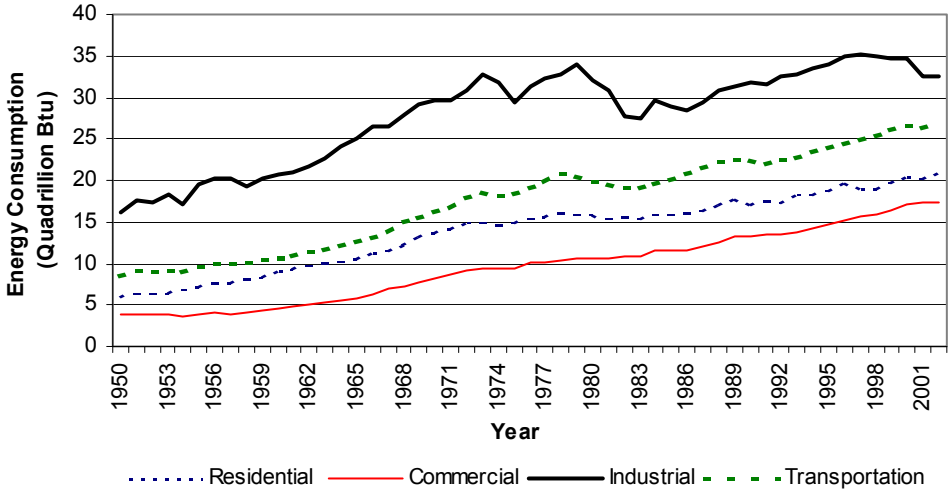
Although basic transportation information is available from these and other sources, the AVTA team finds it useful to summarize statistics and trends in this report.

The above information sources are typically updated annually. In each case, we used the most recent volumes available. The information on advanced technology vehicles in development came from various sources, including vehicle manufacturers and news services. Because this information changes daily, we set February 1, 2004 as the cut-off date for inclusion in this document. However, the vehicle tables are updated quarterly and posted as separate documents on the AVTA Web site at www.avt.nrel.gov/overview.html.

Transportation Energy Use

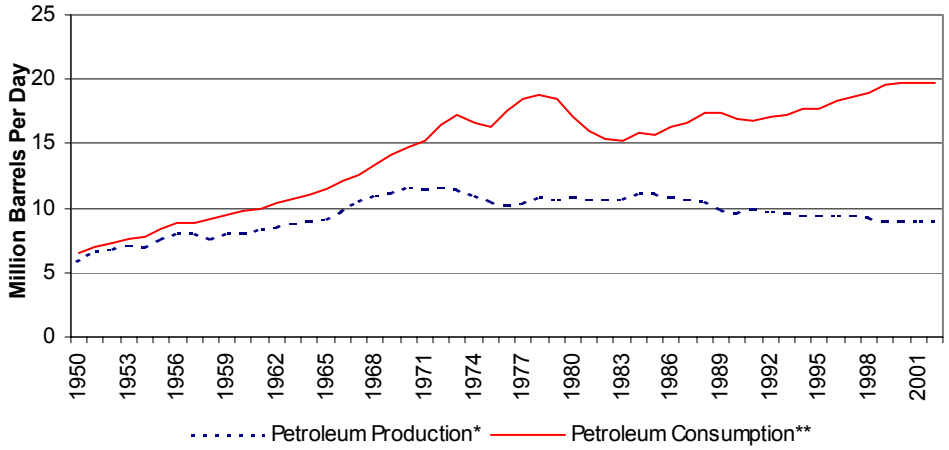
The U.S. transportation sector is a major consumer of energy. Figure 1 shows total U.S. energy consumption from 1950 to 2002, categorized by transportation, residential, commercial, and industrial consumption. During 2002, transportation accounted for 27.3% of the total energy consumption of roughly 97.6 quadrillion Btu (source: EIA's *Annual* and *Monthly Energy Review*). Transportation energy consumption increased 1.5% and total energy consumption increased 1.4% from 2001 to 2002, with the largest increase from the residential sector (3.3%). From 1950 to 2002, the increase in transportation energy consumption averaged 2.3% per year, slightly faster than the increase in total energy consumption, which averaged 2.1% per year during this period.

Figure 1. Energy Use by Sector
(Source: EIA's *Annual* and *Monthly Energy Review*)



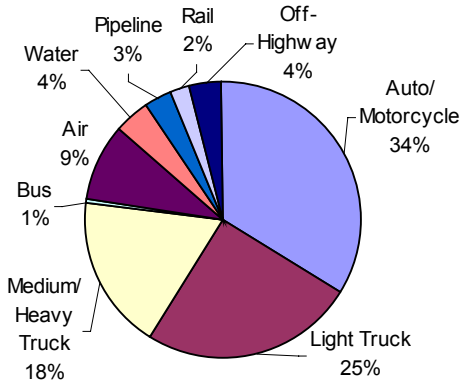
While U.S. petroleum consumption has increased, domestic production of petroleum continues to decrease. Figure 2 shows the dramatic difference between consumption and production. Although the gap decreased by 1% from 2001 to 2002, the average increase in the gap since 1985 was 4.9% per year. The balance of petroleum consumed in the United States is imported. According to EIA's *Monthly Energy Review*, net U.S. importation (imports minus exports) of petroleum was 54% of total consumption (19.7 million barrels per day) during 2002. In 2002, approximately 40% of total U.S. petroleum imports came from the Organization of Petroleum Exporting Countries (OPEC). Table A in the Appendix lists U.S. crude oil imports by country.

Figure 2. U.S. Petroleum Consumption vs. Production
(Source: EIA's *Annual Energy Review*)



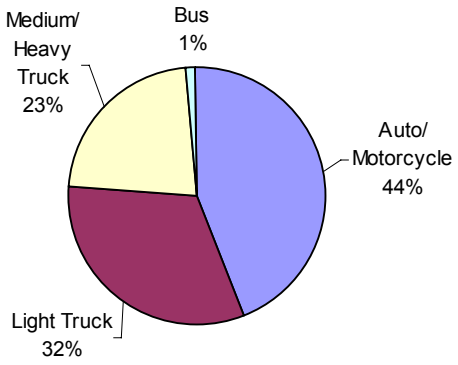
*Petroleum Production includes crude oil and natural gas plant liquids, refinery processing gains and field production of other hydrocarbons, hydrogen, oxygenates (ethers and alcohols), gasoline blending components, and finished petroleum products.
**EIA denotes this data as "Products Supplied," an approximate representation of petroleum consumption.

Figure 3. Transportation Energy Use by Mode (2001) (Total = 26.9 quadrillion Btu)



(Source: *Transportation Energy Data Book 23-2003*)

Figure 4. Highway Energy Use By Mode (2001) (Total = 20.8 quadrillion Btu)

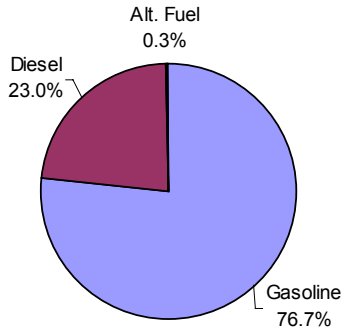


(Source: *Transportation Energy Data Book 23-2003*)

Figure 3 shows that in 2001, highway vehicles (including automobiles; motorcycles; light-, medium-, and heavy-duty trucks; and buses) accounted for 77.3% of total transportation energy use. This is a 1.6% increase from the previous year. Figure 4 categorizes highway-only energy use by mode for 2001; these proportions have remained relatively constant over the past 5 years.

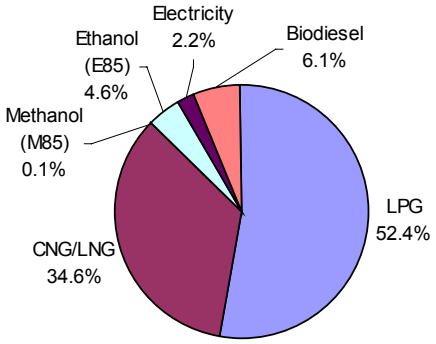
In 2003, an estimated 173 billion gasoline equivalent gallons of vehicle fuel were consumed in the United States—an increase of almost 2% over the previous year. Figure 5 shows the breakdown of fuel use by fuel type. Gasoline continued to make up approximately 77% of the fuel consumed. This percentage includes oxygenated fuels (containing methyl tertiary butyl ether [MTBE] or ethanol). Diesel fuel constituted approximately 23% of total vehicle fuel consumption in 2003. Alternative fuels constituted 0.3% of the total. From 1993 to 2003, alternative fuel use increased 59%. Figure 6 breaks down alternative fuel use by fuel type.

Figure 5. Estimated Consumption of Fuels in the U.S. (2003)



(Source: EIA's *Alternatives to Traditional Transportation Fuels*)

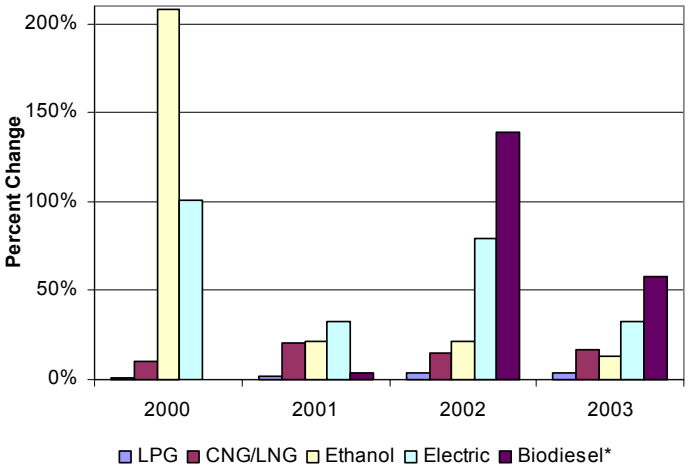
Figure 6. Estimated Consumption of Alternative Fuels in the U.S. (2003)



(Source: EIA's *Alternatives to Traditional Transportation Fuels*)

Figure 7 shows the percent difference in alternative fuel use by fuel type for the past 4 years. EIA's estimates for 2003 show that consumption increases for liquefied petroleum gas (LPG, also known as propane, 3%), natural gas (17%), and a fuel mixture of 85% ethanol and 15% gasoline (E85, 13%) were similar to increases seen during the previous 2 years. Biodiesel (58%) and electricity (32%) consumption increased the most in 2003. The increase in biodiesel consumption was likely due to improved methods of measuring consumption as well as increased use. The increase in electricity consumption was due in part to the addition of neighborhood electric vehicles to the total count of electric vehicles (see sidebar).

Figure 7. Percent Difference in Alternative Fuel Use From Previous Year



*EIA began measuring biodiesel use in 2000.
(Source: EIA's *Alternatives to Traditional Transportation Fuels*)

A note on the alternative fuel data: In 2003, EIA changed its data collection and analysis techniques, resulting in significant revisions to estimates of fuel use in 2003 and previous years. The results of this change are most significant for the LPG, E85, and electricity vehicle data and corresponding fuel consumption data. The number of LPG vehicles was revised down for the past several years based on data from the U.S. Census Bureau's Vehicle Inventory and Use Survey (VIUS). The number of E85 vehicles was revised up for the past several years based on reevaluation of the proportion of FFVs assumed to be operating on E85 instead of gasoline (only fleet FFVs are assumed to be operating on E85). The number of electric vehicles was revised up over the past several years because EIA began adding neighborhood electric vehicles to its count of electric vehicles.

Vehicle Stock and Yearly Sales

The Federal Highway Administration estimates that the total number of vehicles (including automobiles, trucks, and buses) registered in the United States increased an average of 2.4% per year from 1995 to 2001. The majority of these vehicles were used for personal transportation; fleet vehicles typically account for only 5%-6% of the total. Figures 8a-8b show the annual sales of vehicles for 2000 through 2003. Total light- and medium-duty vehicle sales decreased 1% from 2002 to 2003. Sales of light- and medium-duty trucks, having exceeded automobile sales for the first time in 2002, continued that trend in 2003, making up 53% of total light- and medium-duty sales. Sales of heavy-duty trucks increased 1.9% from 2002 to 2003, reversing the declining sales trend of the past several years, mainly because of a 15% increase in sales of class 4-6 trucks. Sales of class 7-8 trucks decreased by 3% during the same period.

Figure 8a. Vehicle Annual Sales: Light- and Medium-Duty

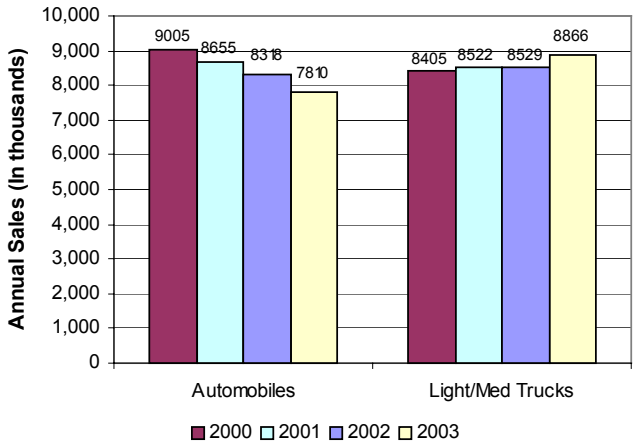
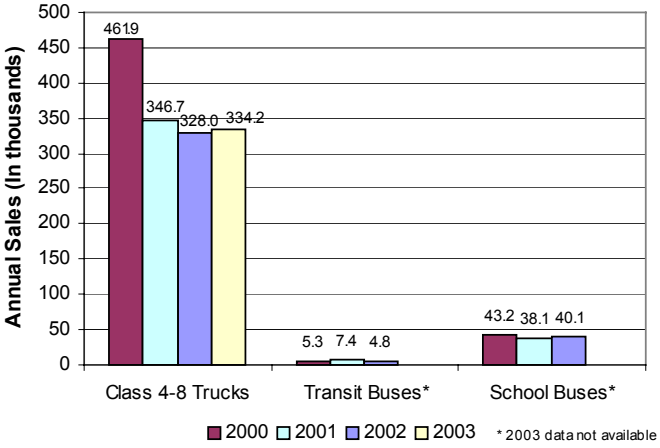


Figure 8b. Vehicle Annual Sales: Heavy-Duty



(Sources: *Automotive News*, *Transport Topics*, American Public Transportation Association, and *School Bus Fleet)*

Alternative Fuel Vehicles

The use of alternative fuel vehicles (AFVs) has seen a slow but steady increase during the past decade. EIA reports that in 2003, there were 510,805 AFVs in the United States, representing an average 9.6% increase per year since 1995. Currently, 18 light-duty original equipment manufacturer (OEM) AFV models are available in the United States. These models operate on a variety of fuels, including compressed natural gas (CNG), LPG, electricity, and E85. Manufacturers are producing AFVs in different body styles to meet various fleet needs, from sedans to full-size trucks and vans. Table 1 lists the model year 2004 AFVs available in the United States. Ford's recent decision to discontinue production of its CNG and LPG vehicles after model year 2004 may reduce the selection of AFVs in the future.

Table 1. Light-Duty AFVs Available in Model Year 2004

Manufacturer	Model	Fuel	Design	Body
DaimlerChrysler	Dodge Ram Pickup 1500 Series	E85	FFV	Pickup Truck
DaimlerChrysler	Chrysler Sebring/Dodge Stratus	E85	FFV	Sedan
Ford	F-150	CNG	Bi-fuel	Pickup Truck
Ford	E-Series Van (E250 & E350), E-Series Wagon (E350)	CNG	Dedicated	Van, Wagon
Ford	F-150	CNG	Dedicated	Pickup Truck
Ford	Crown Victoria	CNG	Dedicated	Sedan
Ford	Taurus/Mercury Sable	E85	FFV	Sedan, Wagon
Ford	Explorer/Explorer Sport Trac/Mercury Mountaineer	E85	FFV	SUV
Ford	F-150	LPG	Bi-fuel	Pickup Truck
General Motors	Chevrolet Silverado/GMC Sierra	CNG	Bi-fuel, Dedicated	Pickup Truck
General Motors	Chevrolet Express/GMC Savana	CNG	Bi-fuel, Dedicated	Van
General Motors	Chevrolet Cavalier	CNG	Bi-fuel	Sedan
General Motors	Chevrolet Tahoe/GMC Yukon	E85	FFV	SUV
General Motors	Chevrolet Suburban/GMC Yukon XL	E85	FFV	SUV
General Motors	Chevrolet Silverado/GMC Sierra	E85	FFV	Pickup Truck
Honda	Civic GX	CNG	Dedicated	Sedan
Mercedes-Benz	C320	E85	FFV	Sedan, Wagon, Sport Coupe
Solectria	CitiVan	Electric	Dedicated	Van

(Source: Alternative Fuels Data Center [AFDC] www.eere.energy.gov/cleancities/afdc)

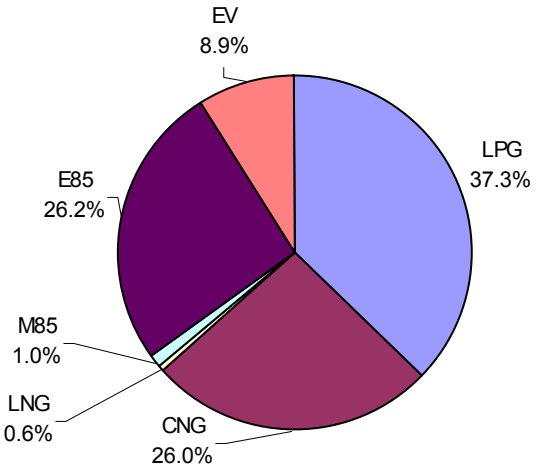
Table 2 lists the estimated number of AFVs in the United States by fuel type and census region for 2003. Figure 9 breaks down the percentages of AFVs in use in 2003 by fuel type. These numbers include light-, medium-, and heavy-duty AFVs.

Table 2. Estimated Number of AFVs in the U.S. by Census Region, 2003

Region	LPG	CNG/LNG	Methanol (M85)	Ethanol (E85)*	Electric Vehicles (EV)	Total by Region
Northeast	9,935	24,339	198	16,018	13,955	64,445
South	90,375	42,687	239	50,899	10,196	194,395
Midwest	35,642	15,289	209	37,236	2,957	91,333
West	54,486	53,703	4,271	29,623	18,549	160,632
Total by Fuel	**190,438**	**136,018**	**4,917**	**133,776**	**45,657**	**510,805**

*Numbers represent only vehicles expected to operate on E85.
(Source: EIA's *Alternatives to Traditional Transportation Fuels*)

Figure 9. Estimated Percent of AFVs in the U.S. (2003)



(Source: EIA's *Alternatives to Traditional Transportation Fuels*)

LPG vehicles made up 37.3% of U.S. AFVs in 2003. Most LPG vehicles are aftermarket conversions. Only one OEM (Ford) offered a LPG vehicle (F-150) in 2003. The second most commonly used alternative fuel was natural gas, including CNG and liquefied natural gas (LNG), which together made up 26.6% of the total. Next were E85-fueled vehicles at 26.2%, electric vehicles at 8.9%, and methanol vehicles at 1.0%.

EIA estimates that there were about 4.1 million flexible fuel vehicles (FFVs, which can run on E85 or gasoline) in the United States in 2002. The number counted as AFVs reflects those FFVs believed to be fueled with E85 instead of gasoline; these are primarily fleet vehicles. EIA assumes that most FFVs owned by individuals are not fueled with E85 because of a lack of available E85 fueling stations.

A note on the AFV data: In 2003, EIA changed its data collection and analysis techniques, resulting in significant revisions to estimates of AFV numbers in 2003 and previous years. For details, see the sidebar in the *Transportation Energy Use* section above.

Alternative fuel heavy-duty vehicles are also commercially available. The major engine manufacturers currently offer 22 alternative fuel engines (Table 3), including those than run on natural gas and LPG. Bus and heavy-duty truck manufacturers use these engines in a number of different vehicles. Because of these engine choices, the majority of heavy-duty AFVs run on natural gas.

Table 3. Heavy-Duty Alternative Fuel Engines Available

Manufacturer	Model	Displacement (L)	Fuel	HP	Torque (ft-lb)
Alternative Fuel Technologies	AFT 466 NG	7.6	CNG/LNG	250	643
Baytech	4.3 ILEV	4.3	CNG	118	184
Baytech	5.7 ILEV	5.7	CNG	211	275
Baytech	5.7 ULEV	5.7	CNG	211	275
Baytech	6.0 ILEV	6.0	CNG	300	360
Baytech	6.0 ULEV	6.0	CNG	300	360
Clean Air Power/Caterpillar	Dual-Fuel 3126	7.2	CNG/LNG dual fuel	250	660
Clean Air Power/Caterpillar	Dual-Fuel C10	10.3	CNG/LNG dual fuel	315	1,050
Clean Air Power/Caterpillar	Dual-Fuel C12	12.0	CNG/LNG dual fuel	410	1,250
Cummins Westport	B Gas Plus—BG 195	5.9	CNG/LNG	195	420
Cummins Westport	B LPG Plus—BG 195	5.9	LPG	195	420
Cummins Westport	B Gas Plus—BG 200	5.9	CNG/LNG	200	465
Cummins Westport	B Gas Plus—BG 230	5.9	CNG/LNG	230	500
Cummins Westport	C Gas Plus—CG 250	8.3	CNG/LNG	250	660
Cummins Westport	C Gas Plus—CG 275	8.3	CNG/LNG	275	750
Cummins Westport	C Gas Plus—CG 280	8.3	CNG/LNG	280	850
Detroit Diesel	Series 50G	8.5	CNG/LNG	275	900
Jasper Alternate Fuels	Jasper 466	7.6	CNG	250	632
John Deere	6081H 250	8.1	CNG	250	800
John Deere	6081H 275	8.1	CNG	275	800
John Deere	6081H 280	8.1	CNG	280	900
Mack Trucks	Eco-Tech E7G 325	12.0	CNG/LNG	325	1,050

(Source: Heavy Vehicle and Engine Resource Guide, available from the AFDC www.eere.energy.gov/cleancities/afdc)

Characterization of alternative fuel penetration for the majority of the heavy-duty vehicle market is difficult because of a lack of information. Although there are excellent transit bus statistics available through the American Public Transportation Association (APTA), there are very few detailed data on heavy truck applications (class 4-8). EIA reports heavy-duty vehicles as being more than 8,500 lb gross vehicle weight. This includes some light- and all medium-duty vehicles.

CNG is the most common alternative fuel for heavy-duty applications. According to APTA, CNG use in public transit buses increased more than 25-fold between 1993 and 2003, growing to an estimated 10.7% of the bus population in 2003. As of January 2003, more than 20% of all new public transit buses on order were powered by CNG, according to APTA. CNG also is being used for heavy truck applications, such as refuse haulers and delivery vehicles. Although not as common, LNG use is growing in heavy-duty vehicles, mainly because of the increased range this fuel offers.

LPG use in heavy-duty vehicles is not as prevalent as it is in light- and medium-duty vehicles, primarily due to a lack of heavy-duty engine availability. Cummins Westport offers several alternative fuel heavy-duty engines, but only one runs on LPG. The B LPG Plus engine is suitable for some trucks and small buses, but it is not adequate for typical 40-foot transit coaches and larger truck tractors.

Use of biodiesel has increased in the past few years (Figure 7). Because it can be used in unmodified diesel engines, B20 (a mixture of 20% biodiesel and 80% diesel) is the most common form of biodiesel in use today. Estimating the number of vehicles operating on biodiesel is difficult because any diesel vehicle potentially could be operated using biodiesel. The National Biodiesel Board estimates that 400 fleets currently use biodiesel.

Alternative Fuel Stations

According to the AFDC, there were 6,326 stations in the United States that offer alternative fuels as of January 2004—a 12% increase over last year's count. The number of stations offering biodiesel continues to increase at a rapid pace, growing 157% since 2002 and almost 10-fold since 2001. The number of LNG stations almost doubled since 2002 because of California's addition of 37 stations. California also added three hydrogen fueling stations. Table 4 summarizes the number of U.S. alternative fueling stations in 2003.

Table 4. Number of Fueling Stations by Census Region and Fuel Type (As of 1/14/04)

Region	CNG	E85	LPG	Electric*	Biodiesel	Hydrogen	LNG	Total
Northeast	186	0	375	87	8	0	1	657
South	299	14	1,844	149	40	0	13	2,359
Midwest	151	148	829	5	23	0	4	1,160
West	419	20	960	634	55	7	55	2,150
Total	1,055	182	4,008	875	126	7	73	6,326

*Multiple chargers at the same station may be included in the count of electric stations.
(Source: AFDC, http://www.eere.energy.gov/cleancities/afdc)

Emissions

The following discussion is derived from the EPA report *Latest Findings on National Air Quality: 2002 Status and Trends* (www.epa.gov/airtrends/2002_airtrends_final.pdf).

The EPA monitors air pollution from thousands of locations across the United States. Although air quality levels measured at these monitoring stations have shown improvements over the past 20 years, more than 160 million tons of pollution are emitted into the air each year. Many Americans live in areas where the air is unhealthy at times because of high levels of one or more of the six principal air pollutants (see sidebar). Many efforts are underway to control these pollutants, but more must be done to protect air quality for the future.

Air pollution is caused by various sources, including stationary sources such as power plants, mobile sources such as vehicles, and natural sources such as fires and wind. Passage of the Clean Air Act allowed the EPA to establish air quality standards to protect the public from the harmful effects of pollution. Over the past 20 years, U.S. emissions levels (Table 5a) and overall air quality (Table 5b) have improved.

Six Principal Air Pollutants Tracked Nationally by the EPA:

- Nitrogen Dioxide (NO_2)
- Ozone (O_3)—formed by volatile organic compounds (VOC) and nitrogen oxides (NO_x)
- Sulfur dioxide (SO_2)
- Particulate Matter (PM)—formed by SO_2, NO_x, ammonia, VOCs, and direct particle emissions
- Carbon Monoxide (CO)
- Lead (Pb)

Table 5a. Percent Change in U.S. Emissions

	1983-2002	1993-2002
NO_x	-15	-12
VOC	-40	-25
SO_2	-33	-31
PM_{10}[c]	-34[d]	-22
$PM_{2.5}$[c]	—	-17
CO	-41	-21
Pb[e]	-93	-5

Table 5b. Percent Change in U.S. Air Quality

	1983-2002	1993-2002
NO_2	-21	-11
O_3 1-h	-22	-2[a]
O_3 8-h	-14	+4[a]
SO_2	-54	-39
PM_{10}	—	-13
$PM_{2.5}$	—	-8[b]
CO	-65	-42
Pb	-94	-57

–Trend data not available; [a] Not statistically significant; [b] Based on percent change from 1999; [c] Includes only directly emitted particles; [d]Based on percent change from 1985 (estimates before 1985 uncertain); [e] Lead emissions are included in the toxic air pollutant emissions inventory and are presented for 1982-2001.
(Source: *Latest Findings on National Air Quality: 2002 Status and Trends*, www.epa.gov/airtrends/2002_airtrends_final.pdf)

Of the EPA's six principal pollutants, motor vehicles are major contributors to the formation of NO_2, ozone, PM, and CO. This is because motor vehicles are responsible for a large proportion of the nation's NO_x, VOC, and CO emissions. NO_x, in addition to forming NO_2, plays a major role in the formation of ozone and PM. VOCs also play a major role in ozone formation. Motor vehicles directly contribute approximately 60% of U.S. CO emissions.

Advanced Technology Vehicles

The following sections provide a snapshot of the current market of advanced technology vehicles (ATVs). The tables concentrate on the vehicles most likely to be available in the U.S. market. For a more complete listing of ATVs around the world, refer to the companion tables at www.avt.nrel.gov/overview.html.

Hybrid Electric Technology

Light-Duty Vehicles

Automotive manufacturers continue to work on hybrid technology in the light-duty market. Although there are currently only three different vehicle models available for sale in the United States, plans to introduce many more are in the works. Table 6 lists light-duty hybrid vehicles in production, those planned for introduction in the next few years, and some of the more recent concept vehicles. (For more information on these and other light-duty hybrid vehicles introduced around the world, refer to the companion tables at www.avt.nrel.gov/overview.html.)

In 2003, U.S. sales of hybrid vehicles—including the Honda Civic, Honda Insight, and Toyota Prius—reached 49,569, a 31% increase from 2002. U.S. sales of hybrid vehicles since 1999 have totaled 113,050. Strong sales growth trends continue. For example, Toyota Prius sales averaged about 1,700 vehicles per month in 2002 and 1,200 vehicles per month from January through September 2003. Then the Model Year 2004 Prius was released, to accolades including *Motor Trend* Car of the Year, and Prius sales jumped to more than 4,500 per month from October through December 2003.

Table 6. Light-Duty Hybrid Electric Vehicles

OEM	Model	Body Style	Power Type	Fuel	Date Introduced/ Announced	Projected Limited Production Date
Currently in Production						
Honda	Insight	Coupe	IMA[1] Hybrid	Gasoline	Dec-99	2000
Honda	Civic	Sedan	IMA[1] Hybrid	Gasoline	Jan-00	2002
Toyota	Prius	Sedan	Parallel Hybrid	Gasoline	Jun-00	2000
Suzuki	Twin	Mini	Hybrid	Gasoline	Nov-02	2003 (Japan)
Toyota	Estima	Minivan	Parallel Hybrid	Gasoline	Jun-01	In Japan Only
Toyota	Crown	Sedan	Mild Hybrid	Gasoline	Aug-01	In Japan Only
Toyota	Alphard	Minivan	Hybrid	Gasoline	Jul-03	In Japan Only
Planned for Production						
Ford	Escape	SUV	Hybrid	Gasoline	Jan-01	2004
Ford	TBD	Sedan	Full Hybrid	Gasoline	Apr-03	2006
Dodge	Ram Pickup Contractor Special	Truck	Mild Hybrid	Diesel	Nov-00	2004
General Motors	Silverado/Sierra & Tahoe/Yukon	Truck & SUV	Strong Hybrid	Gasoline	Nov-03	2007
General Motors	Silverado/Sierra	Truck	Mild Hybrid	Gasoline	Jan-01	2004
General Motors	Equinox	SUV	Hybrid	Gasoline	Jan-03	2006
General Motors	Malibu	Sedan	BAS[2] Hybrid	Gasoline	Jan-03	2007
Honda	Accord	Sedan	IMA[1] Hybrid	Gasoline	Jan-04	Fall 2004
Honda	ASM	Minivan	IMA[1] hybrid	Gasoline	Oct-03	2003 (Japan)
Hyundai	Click	Sedan	Hybrid	Gasoline	Nov-03	2004 (Korea)
Lexus	RX400H	SUV	Hybrid	Gasoline	Jan-03	2005
Mercury	Mariner	SUV	Full Hybrid	Gasoline	Apr-04	2007
Nissan	Altima	Sedan	Hybrid	Gasoline	Unknown	2006
Saturn	Vue	SUV	BAS[2] Hybrid	Gasoline	Jan-03	2005
Toyota	Highlander	SUV	Hybrid	Gasoline	Jan-04	2005
Toyota	Sienna	Minivan	Hybrid	Gasoline	2003	2005
Recent Concepts - Production Plans Unknown						
BMW	X5	SUV	Mild Hybrid	Unknown	Research	Unknown
Ford	H2RV	Wagon	Full Hybrid	Hydrogen	Jun-03	Unknown
Ford	Model U	Sedan	Hybrid	Hydrogen	Jan-03	Unknown
Daihatsu	UFE II	Coupe	Hybrid	Gasoline	Oct-03	Unknown
Honda	IMAS	Sedan	IMA[1] hybrid	Gasoline	Oct-03	Unknown
Lexus	LF-S	Sedan	Hybrid	Gasoline	Oct-03	Unknown
Mazda	Ibuki	Sports car	Hybrid	Gasoline	Oct-03	Unknown
Mercedes-Benz	F500 Mind	Sedan	Hybrid	Diesel	Oct-03	Unknown
Mercedes-Benz	Vision-R	SUV	Hybrid	Diesel	Jan-04	Unknown
Mitsubishi	Eclipse Concept-E	Coupe	Hybrid	Gasoline	Jan-04	Unknown
Peugeot-Citroen	Berlingo	Sedan	Parallel Hybrid	Diesel	Dec-03	Unknown
Subaru	B9 Scrambler	Sports car	Series Hybrid	Gasoline	Oct-03	Unknown
Suzuki	Landbreeze	SUV	Hybrid	Gasoline	Oct-03	Unknown
Toyota	CS&S	Sports car	Parallel Hybrid	Gasoline	Sep-03	Unknown
Toyota	FTX	Truck	Full Hybrid	Gasoline	Jan-04	Unknown
Toyota	SU-HV1	SUV	Parallel Hybrid	Gasoline	Oct-03	Unknown
Volvo	Versatility Concept	Wagon	Hybrid	Gasoline	Mar-03	Unknown

[1] Integrated Motor Assist.
[2] Belt Alternator Starter.
(Source: Collected by Leslie Eudy, National Renewable Energy Laboratory, from various sources)

U.S. vehicle manufacturers are expected to enter the hybrid market with several models in the next few years. Ford plans to begin selling its Escape Hybrid in mid-2004, which is a delay from previous plans. Ford had originally planned to test the Escape with a limited number of fleet customers by late 2003 but opted to complete the final tests internally before releasing to retail customers.

In early 2003, General Motors (GM) announced plans to market multiple hybrid models by 2007, including a full hybrid version of the Saturn Vue. Later in the year, GM changed its strategy to focus on increasing efficiency in its highest volume products. As planned, GM's introduction of a mild hybrid version of its full-size pickup is on-track for fleet customers in 2004 and will be available to retail customers as a 2005 model. The company plans to introduce a "strong" hybrid system in its full-size pick-ups and SUVs. The system is a scaled-down version of the GM Allison hybrid drive used for transit buses. Instead of a full hybrid system, the Saturn Vue will use a belt alternator starter hybrid system expected to improve fuel economy by 12%-15%. Dodge plans to enter the hybrid market with a mild hybrid pick-up designed with commercial fleets in mind. This hybrid uses a diesel engine and can double as a mobile generator.

The number of hybrid concept vehicles increased in the past year. The introduction of hybrid models by several of the smaller OEMs might indicate an increasing acceptance of the technology. Several concept vehicles use hydrogen as a fuel for ICEs instead of gasoline. Using hydrogen in mature technologies could help build infrastructure for the fuel while manufacturers continue to perfect fuel cell vehicle systems. Although many of these newly introduced hybrids likely never will be produced, some of the advanced technology options could show up in future products.

Heavy-Duty Vehicles

The past 2 years have seen an increase in orders for heavy-duty hybrid vehicles. Most of these orders were for transit applications, but several hybrid electric trucks are being developed for delivery applications. Most of these hybrid bus and truck projects involve partnerships between vehicle OEMs, companies specializing in integration of systems, and fleets. These partnerships help push advanced vehicles from the prototype stage into commercial products.

Many transit agencies are investigating hybrids because of increasing pressure to reduce pollution. Several successful demonstration projects over the past 2 years have led to larger orders. According to the APTA 2003 *Vehicle Databook*, there were 135 hybrid buses in active service as of January 1, 2003, with 371 on order and a potential for 307 more. Table 7 lists some of the more recent heavy vehicle projects in the United States. Of note is an order for articulated diesel-hybrid buses for King County Metro in Seattle, Washington. The agency successfully operated a pilot bus for several months in revenue service, resulting in an order for more than 200 hybrids to replace a large portion of its aging fleet.

Another hybrid of interest is the gasoline-hybrid bus designed by ISE Research. This 40-foot bus uses a ULEV-certified Ford V10 engine. Early emission tests of the bus show very low levels of criteria pollutants. Several transit agencies in southern California have plans to add these hybrids to their operations.

Table 7. Heavy-Duty Hybrid Electric Vehicles

Project	Vehicles Deployed	Vehicle Type	Fuel Used	Start Date	No. in Project
Active Vehicle Projects					
Allison	Capital Metro, Austin, TX	40-ft Bus	Diesel	Oct-03	2
Allison	Connecticut Transit, Hartford, CT	40-ft Bus	Diesel	Mid-03	2
Allison/Gillig	Metro Transit, Minneapolis, MN	40-ft Bus	Diesel	Nov-02	3
Allison/MCI/ISE Research	NJ Transit	40-ft Bus	Diesel	Fall 2002	4
Allison/New Flyer	OCTA	40-ft Bus	Diesel	Dec-00	1
Allison/New Flyer	SEPTA	40-ft Bus	Diesel	Oct-02	12
Allison/New Flyer	Sound Transit, Seattle, WA	60-ft Bus	Diesel	May-03	1
Allison/New Flyer	Tri-Met, Portland, OR	40-ft Bus	Diesel	Apr-02	2
Allison/New Flyer	UTA, Salt Lake City, UT	40-ft Bus	Diesel	Unknown	3
Allison/Stewart & Stevenson	Metro, Houston, TX	40-ft Bus	Diesel	Aug-03	4
AVS/Capstone	Coconut Creek, FL	22 ft Bus	Unknown	Unknown	6
AVS/Capstone	Lane Transit, Eugene, OR	22 ft Bus	Diesel	Sep-01	6
AVS/Capstone	Silicon Valley Power	35-ft Bus	LPG	Nov-01	3
Ebus/Capstone	IndyGo, Indianapolis, IN	22-ft Trolley	Diesel	Jul-03	5
Ebus/Capstone	Knoxville Area Transit, TN	22-ft Trolley	LPG	Oct-03	4
Ebus/Capstone	Pasadena Area Rapid Transit System (ARTS), CA	22-ft Trolley	Diesel	Oct-03	5
Ebus/Capstone	Monrovia Transit, Monrovia, CA	22-ft Trolley	LPG	Nov-02	2
Ebus/Capstone	Visalia, CA	22-ft Trolley	Diesel	Mar-02	3
ISE Research (Novabus chassis)	NJ Transit	40-ft Bus	Diesel	2003	3
ISE Research/New Flyer	Omnitrans, San Bernardino, CA	40-ft Bus	Gasoline	Apr-02	3
Orion VI Hybrid Bus	NYCT MTA	40-ft Bus	Diesel	Sep-98	10
Orion VI/BAE	Boston, MA	40-ft Bus	Diesel	May-99	2
Orion/BAE	Fresno Area Express, Torrance, CA	40-ft Bus	Diesel	May-01	2
Orion/BAE	MUNI, San Francisco, CA	40-ft Bus	Diesel	May-01	2
Transteq	Denver RTD	45-ft Bus	CNG	Oct-98	36
Vehicles on Order					
Allison/Gillig	Transit Authority of River City - Louisville, KY	40-ft Bus	Diesel	Jun-04	5
Allison/New Flyer	King County Metro, Seattle, WA	Articulated bus	Diesel	Late 04	213
Allison/New Flyer	Sound Transit, Seattle, WA	40-ft Bus	Diesel	Late 04	22
Allison/New Flyer	Lane Transit District, Eugene, OR	Articulated bus	Diesel	Aug-06	5
Eaton	FedEx	Delivery Truck	Diesel	Feb-01	20
ISE Research/New Flyer	Long Beach Transit, CA	40-ft Bus	Gasoline	2004	27
ISE Research/New Flyer	Omnitrans, San Bernardino, CA	40-ft Bus	Gasoline	2004	10
Orion VII/BAE	NYCT MTA	40-ft Bus	Diesel	2004	200
Orion VII/BAE	NYCT MTA	40-ft Bus	Diesel	Nov-03	125
Heavy Vehicle Projects Under Development					
Azure Dynamics	USPS	Step van	Diesel	Unknown	1
Azure Dynamics/ Canada Post	Vancouver, Calgary, Toronto, Ottawa, Montreal	Delivery Step Van	Unknown	Aug-03	5
DaimlerChrysler/EPRI	SCAQMD, LA Area	Sprinter van	Gasoline	Late 2004	2
DaimlerChrysler/EPRI	KC Regional Transit Authority	Sprinter van	Diesel	Late 2004	1
EPRI (Plug-in hybrid)	Roosevelt Island, NY	Transit bus	Unknown	Jun-05	4
Kansas City ATA, FTA, EPRI, MEC	Kansas City Transportation Auth., Long Island Power	Shuttle Bus	Diesel	Mid-04	2
NABI/SCAQMD	Development project	45-ft Compobus	CNG	Jan-03	2
Purolator Courier/Azure Dynamics	Vancouver, Canada	Delivery truck	Diesel	Unknown	30
Solectria (Kenworth T300 truck)	Prototype	Class 7 Truck	Diesel	Jul-03	1
Allison/Gillig	Port Authority of Alleghany County, Pittsburgh, PA	40-ft Bus	Diesel	Unknown	6

(Source: Collected by Leslie Eudy, National Renewable Energy Laboratory, from various sources)

Fuel Cell Technology

Light-Duty Vehicles

Most manufacturers continue to develop prototype vehicles powered by fuel cells. Table 8 provides a list of models introduced in the past few years, some of which are currently being tested in California as part of the California Fuel Cell Partnership (CaFCP). The most significant development over the past year is that manufacturers are beginning to place fuel cell vehicles into selected fleets. In December 2002, Honda and Toyota announced demonstrations of fuel cell vehicles in the City of Los Angeles fleet and the campus fleets at the University of California, at Davis and Irvine. The CaFCP planned to have up to 60 vehicles in demonstrations by the end of 2003. Manufacturers are also testing their fuel cell vehicles in other parts of the world.

Table 8. Light-Duty Fuel Cell Vehicles

OEM	Model	Body Style	Fuel Type	Date of Introduction
Vehicles in Demonstration Programs				
DaimlerChrysler	F-Cell	Sedan	Hydrogen	Oct-02
Ford	Focus FCV	Sedan	Hydrogen	Mar-02
GM	HydroGen 3	Minivan	Liquid Hydrogen	Sep-01
Honda	FCX	Sedan	Hydrogen	Sep-01
Hyundai	Tuscon	SUV	Hydrogen	Mar-04
Hyundai	Santa Fe FCEV	SUV	Hydrogen	Nov-01
Mercedes-Benz	Sprinter	Van	Hydrogen	2001
Nissan	Xterra	SUV	Hydrogen	Nov-00
Nissan	X-Trail FCV	SUV	Hydrogen	Dec-02
Toyota	FCHV	SUV	Hydrogen	Jun-01
Volkswagen	Bora HyMotion	Sedan	Hydrogen	Nov-00
Recently Introduced Concept Vehicles				
Audi	A2H2	Sedan	Hydrogen	Apr-04
DaimlerChrysler	Natrium	Minivan	Sodium Borohydride	Dec-01
Fiat	Panda	Unknown	Hydrogen	Oct-03
Fiat	Seicento	Unknown	Hydrogen	Oct-03
Honda	KIWAMI	Sedan	Unknown	Oct-03
Hyundai	Santa Fe FCHEV	SUV	Hydrogen	Unknown
Jeep	Treo	Mini SUV	Unknown	Oct-03
Mazda	RX-8	Sports car	Hydrogen/gasoline	Oct-03
Mitsubishi	Grandis	Minivan	Hydrogen	Unknown
Nissan	Effis	Subcompact	Hydrogen	Oct-03
Suzuki	Mobile Terrace	Minivan	Unknown	Oct-03
Suzuki	MR Wagon FCV	Mini	Hydrogen	Unknown
Toyota	Fine-N	Sedan	Hydrogen	Oct-03

(Source: Collected by Leslie Eudy, National Renewable Energy Laboratory, from various sources)

Heavy-Duty Vehicles

Heavy-duty fuel cell vehicles, mainly transit buses, continue to be developed. Table 9 lists projects worldwide involving fuel cell and hydrogen internal combustion engine (ICE) heavy vehicles. For more details, see the companion tables at www.avt.nrel.gov/overview.html.

Table 9. Heavy-Duty Fuel Cell and Hydrogen Vehicles

Project Partners	Deployed	Vehicle Type	Fuel	Technology Type	Project Status	No. in Project
Projects in the United States						
Cummins Westport	SunLine, Thousand Palms, CA	40-ft Bus	Hydrogen/CNG blend	HCNG ICE	Demonstration	2
Enova/High Technology Development Corp.	Hickam Air Force Base, Honolulu, HI	30-ft Bus	Hydrogen	PEM	Active	1
Freightliner/Ballard	Testing in VA	Class 8 Truck	Methanol	Unknown	Testing	1
Georgetown (Gen III)	In development	40-ft Bus	Unknown	Fuel cell	Development	3
Georgetown Univ./DOE/FTA (Gen I)	Univ. Fla., Gainesville, Univ. of CA, Davis, Georgetown Univ., Washington, DC	30-ft Bus	Methanol	Fuel cell	Inactive	3
Georgetown/Novabus/Ballard (Gen II)	SunLine, Thousand Palms, CA	40-ft Bus	Methanol	PEM	Active	1
Georgetown/Novabus/UTC (Gen II)	Washington, DC - WMATA	40-ft Bus	Methanol	PAFC	Active	1
Gillig/Ballard	VTA, San Jose, CA	40-ft Bus	Hydrogen	PEM	In delivery	3
ISE/UTC (Van Hool)	AC Transit, Oakland, CA	40-ft Bus	Hydrogen	PEM	Ordered	3
ISE/UTC (Van Hool)	SunLine, Thousand Palms, CA	40-ft Bus	Hydrogen	PEM	Ordered	1
UTC/Thor/ISE Research (30-ft)	AC Transit, Oakland, CA	30-ft Bus	Hydrogen	PEM	Demonstration	1
Projects Outside the United States						
Cheung Kong Infrastructure Holdings, Ltd./Stuart Energy	Hong Kong	Bus	Hydrogen	H_2 ICE hybrid	Planning	1
Cheung Kong Infrastructure Holdings, Ltd./Stuart Energy	Hong Kong	Shuttle Bus	Hydrogen	H_2 ICE	Planning	1
DaimlerChrysler (EvoBus) Citaro/CUTE project	Europe, various cities	40-ft Bus	Hydrogen	PEM	Active	27
DaimlerChrysler (EvoBus) Citaro/ECTOS project	Reykjavik, Iceland	40-ft Bus	Hydrogen	PEM	Active	3
DaimlerChrysler/Hermes Versand	Stuttgart and Hamburg, Germany	Van	Hydrogen	PEM	Active	1
Hino/Toyota FCHV-BUS2 (JHFC Project)	Tokyo-Yokohama	Bus LF	Hydrogen	PEM	Active	5
Irisbus - City Class	Turin, Italy	40-ft Bus	Hydrogen	PEM	Demonstration	1
MAN/Ballard	Munich Airport	Bus LF	Hydrogen	PEM	Planning	1
Natural Resources Canada/Hydrogenics/New Flyer	Winnipeg Transit (first)	40-ft Bus	Hydrogen	PEM	Planning	1
Sustainable Transport Energy for Perth (STEP)	Perth Central Area Transit, Australia	Transit Bus	Hydrogen	PEM	Planning	3
Tsinghua Univ., Beijing/Beijin Green Power Co.	China	Shuttle bus	Hydrogen	PEM	Active	Unknown
Tsinghua Univ/Shanghai Shen-Li High-Tech Co.	Beijing (2008 Olympics)	Transit Bus	Unknown	Unknown	Planning	Unknown
UNDP-GEF China	Beijing, China	Transit Bus	Hydrogen	PEM	Planning	3
UNDP-GEF Mexico	Mexico City, Mexico	Transit Bus	Hydrogen	Unknown	Planning	10
UNDP-GEF Brazil	Sao Paulo, Brazil	Transit Bus	Hydrogen	Unknown	Planning	10
Univ. of Zaragoza/Hispano	Zaragoza, Spain	40-ft Bus	Hydrogen	PEM	Unknown	Unknown
Volvo/Proton Motor	Berlin, Germany	Double decker bus	Hydrogen	Unknown	Planning	Unknown

(Source: Collected by Leslie Eudy, National Renewable Energy Laboratory, from various sources)

Plans to demonstrate fuel cell buses in the United States are progressing. Santa Clara Valley Transportation Authority of San Jose, California expects delivery of the first of three buses in April 2004. The 40-foot Gillig buses are powered by Ballard fuel cell systems. AC Transit of Oakland, California and SunLine Transit Agency of Thousand Palms, California expect to begin demonstrating fuel cell buses later in 2005. Their demonstration includes four buses with a fuel cell system designed and integrated by ISE Research. These buses, three of which will be operated by AC Transit and one by SunLine, are 40-foot Van Hool buses using fuel cells by UTC.

The most significant demonstration of fuel cell buses to date involves 33 full-size DaimlerChrysler (Citaro) buses with Ballard fuel cell systems. The buses will be demonstrated as part of three projects that will run in

parallel: Clean Urban Transport for Europe (CUTE), Ecological City Transport System (ECTOS), and Sustainable Transport Energy Project (STEP). A total of 30 full-size fuel cell buses will be deployed in nine European cities, in Iceland, and in Perth, Australia. Each city will operate three buses for 2 years. The various locations will allow for bus performance to be compared in multiple climates and topographical conditions. The cities are developing infrastructure for providing hydrogen in a variety of ways, 50% of which will employ renewable sources. (For more information on these projects visit www.fuel-cell-bus-club.com.)

The United Nations Development Programme and the Global Environmental Facility are supporting another fuel cell bus initiative. The 5-year program plans to introduce up to 46 fuel cell buses in six cities in developing countries: Beijing, Cairo, Mexico City, New Delhi, Sao Paulo, and Shanghai. The demonstrations for each city are in various stages of development. (For more information on the initiative visit www.undp.org/gef.)

An international effort is underway to bring representatives from these various demonstrations together to collaborate and share results and experiences. These projects provide a unique opportunity to collaborate in validating this advanced technology in real-world applications. The U.S. Federal Transit Administration and DOE are working together to facilitate this collaboration. A major goal of the effort is to develop a standardized set of data items and methods to allow comparison of projects worldwide.

Additional Developments

Several developments in the past year could have an effect on ATVs and AFVs in the United States. The following are some of the most recent:

Ford Discontinues AFV Production: Ford is discontinuing production of its CNG and LPG vehicles after model year 2004. This may reduce the selection of AFVs and lead to fewer AFVs being added to fleets in the future. Ford is reportedly dropping its AFV efforts to focus on production of hybrid electric vehicles and development of hydrogen ICE vehicles.

International Partnership for the Hydrogen Economy (IPHE) Established: In June 2003, the DOE Secretary invited other countries to join the United States in forming the IPHE. The Partnership will provide a mechanism to organize, evaluate, and coordinate multinational research, development, and deployment programs that advance the transition to a global hydrogen economy. The ultimate goal is to give consumers in each participating country the practical option of purchasing a competitively priced hydrogen-powered vehicle and the ability to access convenient fueling infrastructure. A total of 15 countries are participating.

ICEs Developed to Operate on Hydrogen and Hydrogen/Natural Gas Blends: Several automotive and truck engine manufacturers are developing ICEs that operate on hydrogen or a blend of hydrogen and CNG. Using hydrogen in current technology engines could help justify adding hydrogen infrastructure while fuel cell vehicle technology is being perfected.

Fuel Cell Vehicles Hit the Streets in Demo Programs Around the World: Automotive OEMs are placing FCVs in fleets around the globe. Demonstrations are being conducted in various countries including the United States, Japan, Germany, and Canada. The demonstrations include vehicles in all classes from heavy-duty transit buses to light-duty cars. These demonstrations will show manufacturers how the new technology works in real-world applications and will help to optimize systems to meet the needs and expectations of consumers.

California Air Resources Board (ARB) Zero Emission Vehicle (ZEV) Mandate Modified: Although the ARB remains committed to continued progress toward commercialization of ZEVs, it recognizes there are

constraints because of cost and technical challenges. In April 2003, the ZEV mandate was modified to allow more flexibility for manufacturers to meet the requirements. These modifications work toward addressing issues brought forth in a lawsuit that resulted in a preliminary injunction prohibiting the ARB from enforcing the rule. The ZEV percentage requirements will take effect in the 2005 model year, but manufacturers have a variety of paths to meet the requirements and can earn and bank credits for vehicles produced prior to the 2005 model year.

National Highway Traffic Safety Administration (NHTSA) Modifies Corporate Average Fuel Economy (CAFE) Requirements: In April 2003, the NHTSA approved a modification to CAFE that would result in a 1.5 mpg increase in fuel economy for SUVs, minivans, and light trucks during the next 3 years. This marks the first increase since 1996 and the greatest increase in fuel economy in 20 years. Average fuel economy of these vehicles must increase from the current 20.7 mpg to 21.0 mpg in 2005, 21.6 mpg in 2006, and 22.2 mpg in 2007. The standard for cars has been 27.5 mpg since 1990. In late 2003, the agency announced a proposal aimed at reforming the standards to increase fuel economy while maximizing safety and maintaining a healthy economy. The proposed reforms are partly based on recommendations by the National Academy of Sciences and should modernize regulations to reflect today's typical vehicle fleet.

Hybrid Electric Vehicle Named *Motor Trend* Car of the Year: Hybrid electric vehicles are becoming more mainstream in the United States. In late 2003, Toyota began selling its model year 2004 Toyota Prius. When sales were higher than expected, Toyota raised its U.S. sales plans from 37,000 to 47,000 units. In November, the Prius became the first hybrid vehicle to win *Motor Trend's* Car of the Year award. The editor-in-chief of *Motor Trend* said, "We realize the selection of a hybrid vehicle is going to stir controversy, but we believe the performance, engineering advancements, and overall significance of the Toyota Prius merits the distinction." The national recognition for a hybrid vehicle could result in increased interest in ATVs among consumers.

Summary

The focus, direction, and funding of transportation programs and the marketplace for advanced technologies continues to change and develop. Understanding these trends within the context of today's marketplace is critical to focusing public and private resources where they can have the most impact. Key points from this document include the following:

- Highway vehicles account for 21% of total U.S. energy consumption; 76% of highway consumption is due to light-duty trucks and automobiles, and 24% is due to medium- and heavy-duty trucks and buses.
- The gap between U.S. consumption and production of petroleum is widening at the rate of 4.9% per year (average from 1985 through 2002).
- Alternative fuel use increased 5% each year from 1998 to 2002 but makes up only 0.2% of total fuel use.
- The number of alternative fuel stations increased by 12% from 2002 to 2003, with biodiesel and LNG stations experiencing rapid growth.
- Sales of light-duty trucks, having exceeded automobile sales for the first time in 2002, continued that trend in 2003, making up 53% of total light- and medium-duty sales.
- Total U.S. sales of light-duty hybrid vehicles topped 100,000 in 2003; increasing sales, rapid proliferation of hybrid models planned for release, and increasing mainstream acceptability (the 2004 Toyota Prius won *Motor Trend's* Car of the Year) suggest a bright future for this technology.
- Heavy-duty hybrid vehicles continue to gain market acceptance, particularly in the transit bus sector.
- Although industry experts don't expect full commercialization until after 2010, development of pre-production fuel cell vehicles is progressing rapidly, with numerous demonstrations of light- and heavy-duty vehicles being conducted worldwide.

Appendix

Table A. Total U.S. Petroleum Imports in 2002 by Source (Thousand Barrels)

Country	Number of Barrels
Arab OPEC	
Algeria	96,230
Iraq	167,638
Kuwait	83,177
Qatar	5,392
Saudi Arabia	566,512
United Arab Emirates	5,507
Total Arab OPEC	*924,456*
Other OPEC	
Indonesia	19,320
Nigeria	226,751
Venezuela	510,362
Total Other OPEC	*756,433*
Non-OPEC	
Angola	121,185
Australia	20,890
Bahama Islands	12,339
Brazil	42,242
Canada	719,334
China	9,329
Colombia	95,058
Ecuador	40,262
Gabon	52,208
Italy	12,287
Malaysia	5,893
Mexico	564,497
Netherlands	23,961
Netherlands Antilles	29,486
Norway	143,336
Puerto Rico	57
Russia	76,690
Spain	6,157
Trinidad and Tobago	29,164
United Kingdom	174,554
Virgin Islands	86,022
Other Non-OPEC	262,698
Total Non-OPEC	*2,527,649*
Total Imports for 2002	***4,208,539***

(Source: EIA's Monthly Energy Review)

List of Sources

Fuel Cell/Hydrogen

Ballard Power Systems	http://www.ballard.com/
California Hydrogen Business Council	http://www.ch2bc.org/index.html
Fuel Cells 2000	http://www.fuelcells.org/
Fuel Cell Bus Club –Info on European Fuel Cell Bus Demo	http://www.fuel-cell-bus-club.com/index.html
Fuel Cell Today	http://www.fuelcelltoday.com/index/
Georgetown University Fuel Cell Program	http://fuelcellbus.georgetown.edu/
German Hydrogen Association	http://www.dwv-info.de/
Hydrogen and Fuel Cell Information	http://www.hyweb.de/index-e.html
Hydrogen and Fuel Cell Letter	http://www.hfcletter.com/
UTC Fuel Cells	http ://www.utcfuelcells.com/
Hydrogenics	http://www.hydrogenics.com
National Fuel Cell Research Center	http://www.nfcrc.uci.edu/
National Hydrogen Association	http://www.hydrogenus.com/
Nuvera	http://www.nuvera.com/

Government/Other Organizations

Advanced Vehicle Technologies Program	http://scitech.dot.gov/partners/nextsur/avp/avp.html
Advanced Transportation Technology Institute	http://www.etvi.org/
American Public Transportation Association	http://www.apta.com/
California Fuel Cell Partnership	http://www.cafcp.org/
California Air Resources Board	http://www.arb.ca.gov/homepage.htm
CALSTART	http://www.calstart.org/
U.S. Department of Transportation	http://www.dot.gov/
DOE's Energy Information Administration	http://www.eia.doe.gov/
DOE's AVTA	http://avt.inel.gov/index.html
Electric Drive Transportation Association	http://www.electricdrive.org/
EPA's Emissions Trends Site	http://www.epa.gov/ttn/chief/trends/index.html
EPA's Fuel Economy Trends Site	http://www.epa.gov/orcdizux/fetrends.htm
EPA's Global Warming Site	http://www.epa.gov/oppeoee1/globalwarming/index.html
EPA's Office of Transportation and Air Quality	http://www.epa.gov/otaq/
Northeast Advanced Vehicle Consortium	http://www.navc.org/
Northeast Sustainable Energy Association	http://www.nesea.org/
Transportation Energy Data Book	http://www-cta.ornl.gov/data/Index.html

Manufacturers – Heavy-Duty

Allison Transmission	http://www.allisontransmission.com/
Caterpillar	http://www.cat.com/
Cummins Engine	http://www.cummins.com/
Designline Coach Builders	http://www.designline.co.nz/
Detroit Diesel Corporation	http://www.detroitdiesel.com/
Electric Vehicles International	http://www.evi-usa.com/
Fuji Heavy Industries	http://www.fhi.co.jp/english/index.html
ISE Corporation	http://www.isecorp.com/
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Mack Trucks	http://www.macktrucks.com/
Navistar/International	http://www.navistar.com/
New Flyer Bus	http://www.newflyer.com/
North American Bus Industries	http://www.nabiusa.com/
NovaBUS	http://www.novabus.com/
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Volvo Trucks	http://www.volvotrucks.volvo.com/
Trolley Enterprises	http://www.trolleyent.com/

Manufacturers – Light-Duty

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BMW	http://www.bmw.com/
Daihatsu	http://www.daihatsu.com/
DaimlerChrysler Corporate Web Site	http://www.daimlerchrysler.com/
DaimlerChrysler Fleet Vehicle Site	http://www.fleet.chrysler.com/
Ford Motors Environmental Vehicles Site	http://www.ford.com/en/vehicles/specialtyVehicles/environmental/default.htm
Ford News Web Site	http://media.ford.com/news/index.cfm?make_id=92
GM Alternative Fuel Vehicle Site	http://www.gm.com/automotive/innovations/altfuel/
GM News	http://www.gm.com/cgi-bin/pr_index.pl
Honda News	http://www.hondacars.com/info/news/landing.asp
Hyundai	http://www.hyundai-motor.com/eng/innovation/index.html
Mercedes-Benz	http://www.mercedes-benz.com/
Mitsubishi Advanced Technology	http://www.mitsubishi-motors.co.jp/inter/technology/technology.html
Mitsubishi News	http://www.mitsubishi-motors.co.jp/inter/NEWS/Index/news_index.html
Nissan	http://www.nissanusa.com/
Peugeot Alternative Energy Developments	http://www.psa-peugeot-citroen.com/en/afternoon.php
Renault	http://www.renault.com/gb/accueil.htm
Subaru Global	http://www.subaru-global.com/index.html
Suzuki News	http://www.suzukiauto.com/inside_suzuki/news_and_events.php
Toyota News	http://www.toyota.com/about/news/
Volvo	http://www.car.volvo.se/

Manufacturers – Other

BAE Systems	http://www.baesystems.com/
BAE Systems - Hybrid Drive Site	http://www.hybridrive.com/PowerSystems.htm
Capstone Turbine	http://www.capstoneturbine.com/
Arotech	http://www.arotech.com/
DRS Technologies	http://www.drs.com/
Enova Systems	http://www.enovasystems.com/
Saft Batteries	http://www.saftbatteries.com/010-Home/10-10_home.asp
Solectria	http://www.solectria.com/
UQM Technologies	http://www.uqm.com/

Miscellaneous

Asian Technical Information Program	http://www.atip.or.jp/
AC Transit Fuel Cell Transportation	http://www.actransit.org/onthehorizon/fuelcell.wu
SunLine Transit Agency	http://www.sunline.org/
Santa Clara VTA Zero Emission Bus Program	http://www.vta.org/projects/ZEBs.html

News Articles/Magazines

ATA's Green Truck	http://www.greentruck.com/
Automotive Engineering International: SAE Publication	http://www.sae.org/automag/current.htm
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REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 2004	Annual Report

4. TITLE AND SUBTITLE
Advanced Vehicle Testing Activity:
Overview of Advanced Technology Transportation, 2004 Update

5. FUNDING NUMBERS
FC04-0310

6. AUTHOR(S)
Leslie Eudy, Jarett Zuboy

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
N/A

8. PERFORMING ORGANIZATION REPORT NUMBER
NREL/BR-540-35419

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
DOE/GO-102004-1849

11. SUPPLEMENTARY NOTES
NREL Technical Monitor: Leslie Eudy

12a. DISTRIBUTION/AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Document offers a “snapshot” of current vehicle technologies and trends. DOE program managers use this document to plan test and evaluation activities that focus resources where they have the greatest impact.

14. SUBJECT TERMS
Advanced Vehicle Testing Activity; U.S. Department of Energy (DOE); fleet testing; alternative fuel vehicles; advanced technology vehicles; petroleum; evaluation

15. NUMBER OF PAGES
25

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL