June 2003 • NREL/TP-540-33433

Technical Report

Advanced Vehicle Testing Activity: Overview of Advanced Technology Transportation

Update for CY 2003

Leslie Eudy

National Renewable Energy Laboratory

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Prepared for the U.S. Department of Energy, FreedomCAR and Vehicle Technologies Program, Advanced Vehicle Testing Activity

Prepared under Task No. FC03.0710

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Introduction

Since fiscal year (FY) 2000, the U.S. Department of Energy's (DOE) Advanced Vehicle Testing Activity (AVTA), formally 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 test and evaluation activities that focus resources where they have the greatest impact. This document is the update for CY 2003. To download overviews from previous years, visit www.ott.doe.gov/otu/field_ops/prog info.html.

The information in this document is based on several sources, which are listed in the List of Sources in the Appendix. Most of the statistics, however, were pulled from the following:

- 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 22)
- The U.S. Environmental Protection Agency's (EPA) National Air Pollution Emissions Trends Web site, www.epa.gov/ttn/chief/trends/index.html

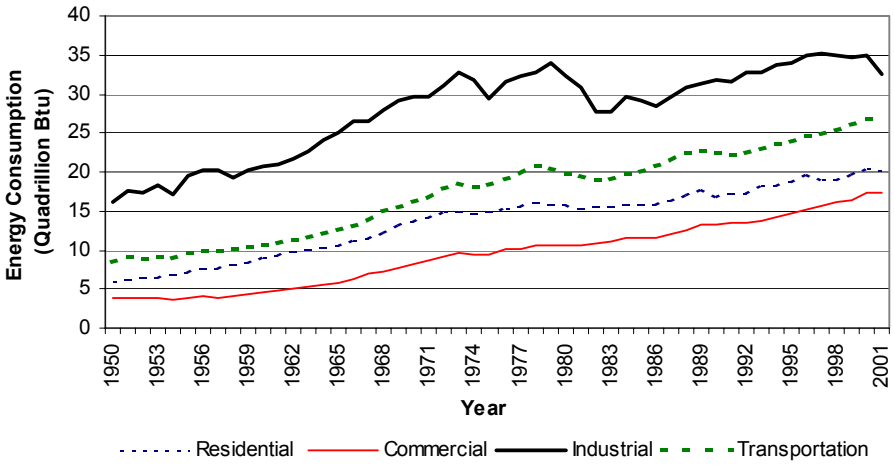
Although basic transportation information is available from other sources, the AVTA team finds it useful to summarize statistics and trends in this report.

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, 2003, 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, www.ott.doe.gov/otu/field_ops/prog_info.html.

Transportation Energy Use

The United States' transportation sector is a major consumer of energy. Figure 1 shows total U.S. energy consumption from 1950 to 2001. It is categorized by transportation, residential, commercial, and industrial consumption. During 2001, transportation accounted for 27.6% of the total energy consumption of roughly 96.9 quadrillion Btu (source: EIA's *Annual Energy Review*). Although transportation energy use increased slightly, total energy use decreased by 2.4% from 2000 to 2001, mainly because of a 6.5% decrease in energy use for the industrial sector.

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



While U.S. petroleum consumption has steadily increased, domestic production of petroleum has decreased. Figure 2 shows the dramatic difference between consumption and production. Although the gap only increased by 1.5% from 2000 to 2001, the average increase in the gap since 1985 was 4.3% per year. The balance of petroleum consumed in the United States is imported. According to EIA's *Monthly Energy Review*, more than 59% of the petroleum consumed in the United States during 2001 (19.6 million barrels per day) was imported. In 2001, almost 52% of the total U.S. petroleum imports came from OPEC countries. (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*)

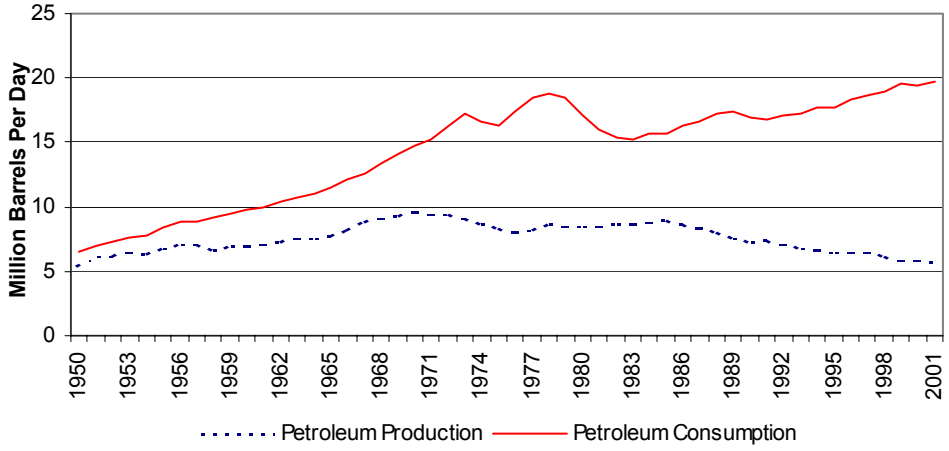
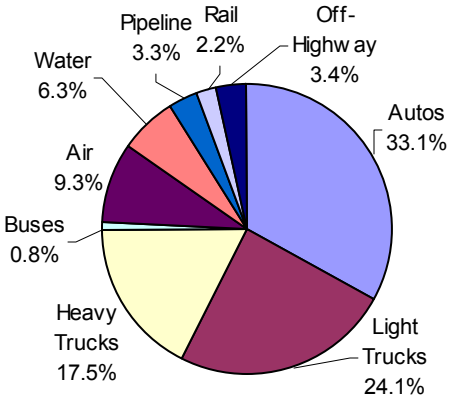
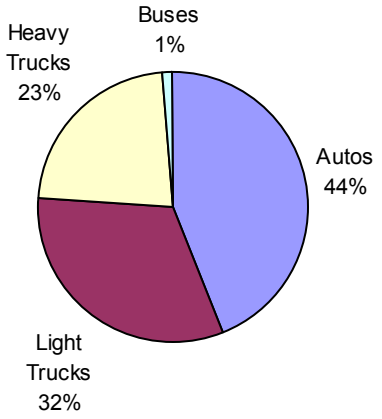


Figure 3. Transportation Energy Use by Mode (Total = 27.4 trillion Btu - 2000)



(Source: *Transportation Energy Data Book 22-2002*

Figure 4. Highway Energy Use By Mode (Total = 20.7 trillion Btu - 2000)

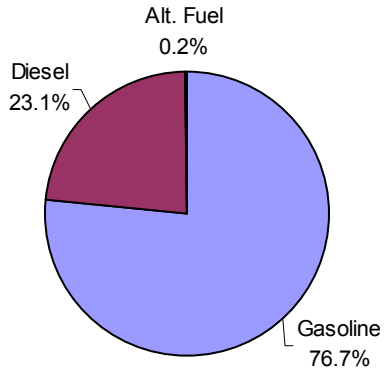


(Source: *Transportation Energy Data Book 22-2002*)

Figure 3 shows that in 2000, highway vehicles (including automobiles, light- and heavy-duty trucks, and buses) accounted for 75.5% of total transportation energy use. This is a 2% decrease from the previous year. Figure 4 offers a breakdown of highway-only energy use by mode for 2000.

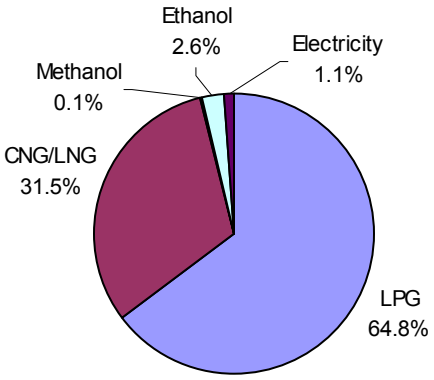
In 2002, an estimated 170 billion gallons of fuel were consumed in the United States—an increase of almost 2% over the previous year. Figure 5 shows the breakdown of fuel use by fuel type. Gasoline continues to make up approximately 77% of the fuel consumed. This percentage includes oxygenated fuels (methyl tertiary butyl ether—MTBE—and ethanol), which make up about 3% of the gasoline total. Diesel fuel comprised 23.1% of total vehicle fuel consumption in 2002—a slight increase over 22.9% in 2001.

Figure 5. Estimated Consumption of Fuels in the U.S. (2002)*



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

Figure 6. Estimated Consumption of Alternative Fuels in the U.S. (2002)



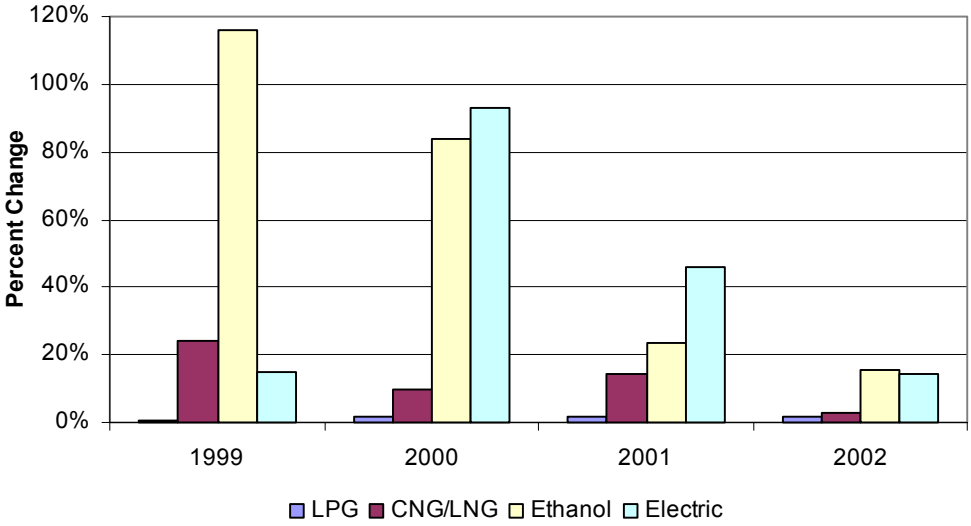
(Source: EIA's *Alternatives to Traditional Transportation Fuels*)

*Note: The breakdown of alternative fuel in Figure 5 does not include biodiesel.

Figure 6 breaks down alternative fuel use by fuel type. Although alternative fuel makes up only 0.2% of the total fuel consumed in the United States, its use has increased by a little more than 5% per year since 1998. Figure 7 shows the percent difference in alternative fuel use by fuel type for the past five years. Natural gas continues to increase slightly, a trend that started in 1997. Ethanol use also continues to climb, probably because original equipment manufacturers (OEM) continue to increase the number of E85 compatible vehicle models manufactured as standard offerings. Ethanol growth can also be attributed to government and industry initiatives dramatically increasing the number of fueling stations offering E85. Electricity use is also growing, especially in California where approximately 30% of the total U.S. electric vehicles reside.

However, this trend is expected to reverse as OEMs stop producing battery electric vehicles and those currently in use are retired from service.

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



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

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 has increased an average of 2.3% per year since 1995. The majority of these vehicles were used for personal transportation; fleet vehicles typically account for only 5% to 6% of the total. Figures 8a-8b show the annual sales of vehicles for 2000 through 2002. For the first time, total sales of light-duty trucks surpassed those of automobiles—if only slightly. In 2002, light-duty truck sales were 50.6% of the total sales, while automobiles made up 49.4%. Sales of heavy-duty trucks (class 4-8) decreased by 6.5% in 2002, although not as dramatically as 2001 when sales decreased by 25%. The class 8 sector, however, saw a 4.5% increase over 2001 figures, which is a slight rebound from last year's drop of 32%.

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

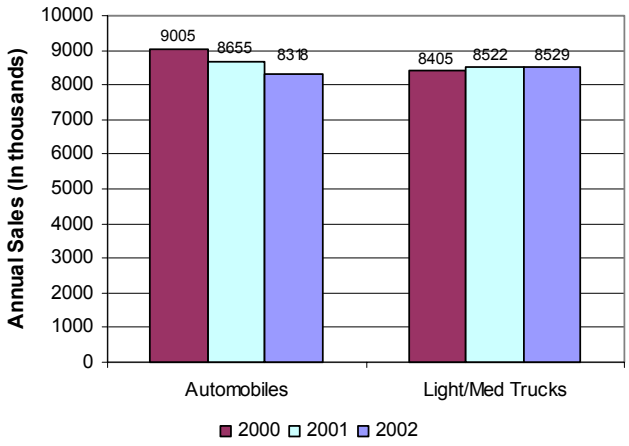
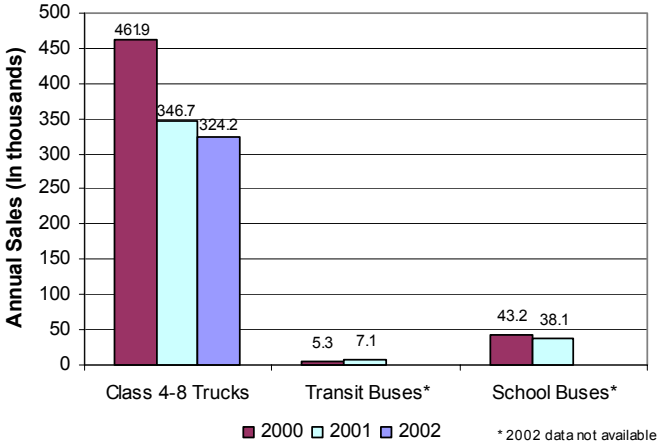


Figure 8b. Vehicle Annual Sales: Heavy-Duty



(Sources: *Automotive News*, 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 last decade. In 2001, there were 518,919 AFVs in the United States, representing an average 6.9% increase per year since 1992. Currently 23 light-duty OEM AFV models are available in the United States. These models operate on a variety of fuels, including CNG, electricity, and ethanol. Manufacturers are producing AFVs in all body styles to meet various fleet needs, from small two-seaters to full-size trucks and vans. Table 1 lists the model year 2003 AFVs available in the United States.

Table 1. Light-Duty AFVs Available in Model Year 2003 (including EVs)

Manufacturer	Model	Fuel	Design	Body
DaimlerChrysler	Dodge Ram	CNG	Dedicated	Van
DaimlerChrysler	Dodge Caravan, Grand Caravan/ Chrysler Town & Country	E85	FFV	Minivan
DaimlerChrysler	Chrysler Sebring/ Dodge Stratus	E85	FFV	Sedan
Ford	F-150	CNG	Bi-fuel	Truck
Ford	F-150	CNG	Dedicated	Truck
Ford	Crown Victoria	CNG	Dedicated	Sedan
Ford	E-Series	CNG	Dedicated	Van/Wagon
Ford	Ford Taurus/ Mercury Sable	E85	FFV	Sedan
Ford	Ford Explorer, Explorer Sport, Mercury Mountaineer	E85	FFV	SUV
Ford	F-150	LPG	Bi-fuel	Truck
Ford	Ranger	E85	FFV	Truck
General Motors	GMC Sierra/Chevrolet Silverado	CNG	Bi-fuel	Truck
General Motors	Chevrolet Express/GMC Savana	CNG	Bi-fuel, Dedicated	Van
General Motors	Chevrolet Cavalier	CNG	Bi-fuel	Sedan
General Motors	GMC Yukon/Chevy Tahoe	E85	FFV	SUV
General Motors	GMC Yukon XL/Chevrolet Suburban	E85	FFV	SUV
General Motors	Chevrolet Silverado/GMC Sierra	E85	FFV	Truck
Honda	Civic GX	CNG	Dedicated	Sedan
Mazda	B3000	E85	FFV	Truck
Nissan	Altra-EV*	EV	Dedicated	Wagon
Nissan	Hypermini*	EV	Dedicated	Two-seater
Solectria	Citivan	EV	Dedicated	Van
Toyota	Rav4*	EV	Dedicated	SUV

(Source: www.afdc.nrel.gov/afvehicles.html) *Availability limited to California

Table 2 lists the estimated number of AFVs in the United States by fuel type and census region for 2002. Figure 9 breaks down the percentages of AFVs in use in 2002 by fuel type. These numbers include light-, medium-, and heavy-duty AFVs.

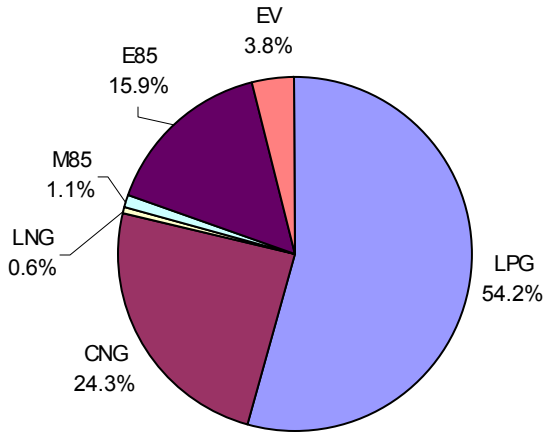
Table 2. Estimated Number of AFVs in the U.S. by Census Region, 2002

Region	LPG	CNG/LNG	Methanol	Ethanol*	Electric Vehicles	Total by Region
Northeast	29,780	18,162	237	4,171	2,316	54,666
South	105,134	41,288	284	23,594	4,047	174,347
Midwest	79,337	18,522	249	43,344	1,258	142,710
West	67,035	51,556	5,103	11,368	12,134	147,196
Total by Fuel	**281,286**	**129,528**	**5,873**	**82,477**	**19,755**	**518,919**

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

*Numbers represent only vehicles expected to operate on E85. Actual number of E85 vehicles estimated at 2.3 million.

Figure 9. Estimated Percent of AFVs in the U.S. (2002)



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

Propane (LPG) vehicles made up the bulk of AFVs at 54.2%. Although LPG vehicles make up more than half of the AFVs in the United States, the majority of these are aftermarket conversions. Only one OEM (Ford) offered a LPG vehicle (F-150) in 2002. The second most commonly used alternative fuel is natural gas, including compressed natural gas (CNG) and liquefied natural gas (LNG), which together make up 25% of the total AFVs in the United States. Alcohol-fueled vehicles that run on methanol and ethanol make up a combined 17% of the total AFVs, and electric vehicles (EVs) make up 3.8%.

According to EIA, there are about 82,500 E85 compatible vehicles in the United States. This number is deceptive, however, as EIA's count only includes vehicles that are intended to be used as flex-fuel vehicles (FFVs). The National Ethanol Vehicle Coalition estimates there are approximately 2.3 million E85 vehicles on the road today. Because of a limited infrastructure, many of these FFVs operate only on gasoline.

Alternative fuel heavy-duty vehicles are also commercially available. The major engine manufacturers currently offer 22 alternative fuel engines (see 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	Fuel	HP	Torque
Cummins Westport	B5.9G 230	5.9	CNG/LNG	230	500
Cummins Westport	B5.9G 195	5.9	CNG/LNG	195	420
Cummins Westport	B5.9G 150	5.9	CNG/LNG	150	375
Cummins Westport	B5.9LPG	5.9	CNG/LNG	195	420
Cummins Westport	C8.3G Plus 275	8.3	CNG/LNG	275	750
Cummins Westport	C8.3G Plus 250	8.3	CNG/LNG	250	660
Cummins Westport	C8.3G Plus 280	8.3	CNG/LNG	280	850
Cummins Westport	B5.9 LPG	5.9	LPG	195	420
Jasper Alternative Fuels	Jasper 460	7.5	LPG	110	393
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
Detroit Diesel	Series 50G	8.5	CNG/LNG	275	890
Detroit Diesel	Series 60G 330	12	CNG/LNG	330	1400
Detroit Diesel	Series 60G 400	12	CNG/LNG	400	1450
Mack	E7G-325	12	CNG/LNG	325	650
Mack	E7G 325	12	CNG/LNG	325	1180
Mack	E7G-350	12	CNG/LNG	350	1250
Caterpillar	3126B	7.2	CNG/LNG dual fuel	190	520
Caterpillar	3126B	7.2	CNG/LNG dual fuel	250	640
Caterpillar	C10	10.3	CNG/LNG	305	1050
Caterpillar	C12	12	CNG/LNG	410	1250

(Source: DOE Heavy Vehicle and Engine Resource Guide. For more information, visit www.ctts.nrel.gov/heavy_vehicle/library.html.)

Characterization of alternative fuel penetration for the majority of the heavy-duty vehicle market is difficult due to a lack of information. While 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 gross vehicle weight. This includes some light- and all medium-duty vehicles.

CNG is the most common alternative fuel for heavy-duty applications. Between 1993 and 2002, CNG use in public transit buses increased more than tenfold, growing to an estimated 9.5% of the bus population in 2002*. Recently, more than 20% of all new public transit buses ordered and built were powered by CNG. CNG is also being used for heavy truck applications, such as refuse haulers and delivery vehicles. Although not as common, LNG use is also growing in heavy-duty vehicles, mainly because of the increased range this fuel offers.

Propane use in heavy-duty vehicles is not as prevalent as it is in light-duty vehicles, primarily due to a lack of heavy-duty engine availability. Cummins offers several alternative fuel heavy-duty engines, but only one runs on LPG. The B5.9 LPG engine is suitable for some trucks and small buses, but it is not adequate for typical 40-foot transit coaches and larger truck tractors. However, with almost 3,400 publicly accessible facilities across the country, propane is still the most accessible of all alternative fuels. In comparison to conventional diesel vehicles, other propane benefits include lower emissions, high domestic production (90% of all propane used in the United States), and the potential for reduced maintenance from a cleaner burning fuel.

*Source: American Public Transportation Association (APTA)

Use of biodiesel has increased in the past few years. 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. Compared to diesel, it offers lower emissions of most controlled pollutants (except NOx) and similar performance. Additional benefits include increased fuel lubricity, which reduces engine maintenance, and production from renewable sources, which reduces petroleum use. More than 100 major U.S. fleets currently use B20, including federal and state government, public transit, school districts, national parks, and recycling companies. Estimating the number of vehicles operating on biodiesel is difficult because any diesel vehicle could potentially be operated using biodiesel. The National Biodiesel Board estimates that 15 million gallons of biodiesel were sold in the United States in 2002.

Alternative Fuel Stations

According to DOE's Alternative Fuels Data Center (AFDC), there are 5,646[**] stations in the United States that offer alternative fuels—a 3.7% increase over last year's count. Most notable for 2002, is a four-fold increase in biodiesel fueling stations and a 40.4% increase in electric charging stations. It's also interesting to note the emergence of four hydrogen stations in the Western region of the United States. In response to the new nationwide push toward a hydrogen future, the AFDC began to include hydrogen fueling stations in its fueling database. Table 4 further summarizes the types of U.S. alternative fueling stations in 2002.

Table 4. Number of Fueling Stations by Census Region and Fuel Type (As of 2/7/03)

Region	LPG	CNG	LNG	E85	Electricity	Biodiesel	Hydrogen	Total
Northeast	368	189	1	0	65	3	0	626
South	1,266	387	16	11	144	13	0	1,837
Midwest	795	176	7	123	0	7	0	1,108
West	943	438	13	16	635	26	4	2,075
Total	3,372	1,190	37	150	844	49	4	5,646

(Source: Alternative Fuels Data Center Web site, www.afdc.doe.gov)

Emissions

The transportation sector accounts for a large share of the national emissions of criteria pollutants. Highway vehicle emissions are somewhat less but still make up a significant portion of the overall contribution (see Table 5). The most significant change in the highway's share of emissions from 2000 to 2001 was in carbon monoxide, which increased 6.9%, and oxides of nitrogen, which decreased by 12%.

Table 5. Highway's Share of U.S. Emissions in 2001

Pollutant	Highway's Share
Carbon Monoxide (CO)	62.0%
Oxides of Nitrogen (NO_x)	36.9%
Volatile Organic Compounds (VOC)	27.1%
Particulate Matter (PM10)	0.9%
Particulate Matter (PM2.5)	2.2%
Sulfur Dioxide (SO_2)	1.7%
Ammonia (NH_3)	5.6%

(Source: EPA's Air Pollution Trends Web Site, www.epa.gov/ttn/chief/trends/index.html)

[**] As of February 7, 2003

Figures 12a-12d show emissions of highway vehicles broken down by class. According to EPA's emission inventory, light-duty automobiles and trucks account for the majority of carbon monoxide and volatile organic compounds emissions, while heavy vehicles account for more than half the oxides of nitrogen and particulate matter emissions.

Figure 12a. Highway CO Emissions

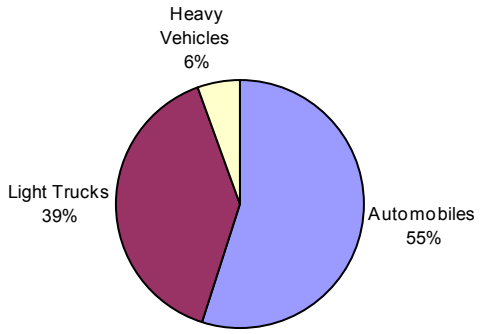


Figure 12b. Highway NOx Emissions

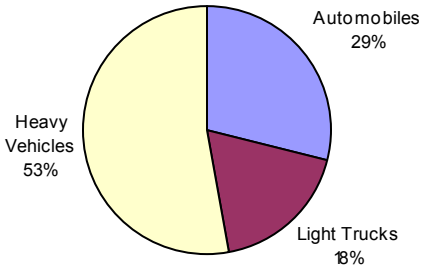


Figure 12c. Highway VOC Emissions

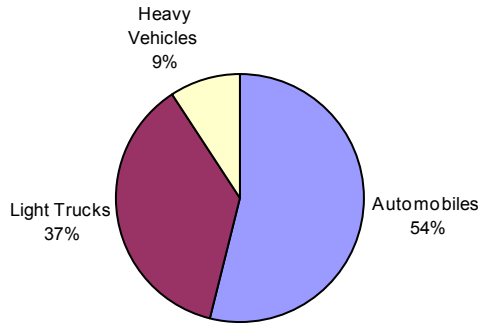
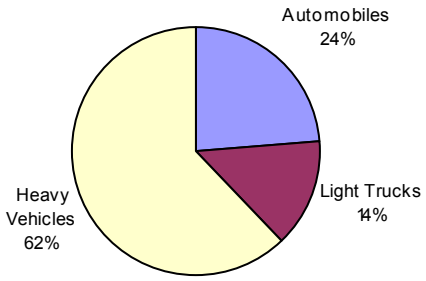


Figure 12d. Highway PM10 Emissions



(Source: EPA's Air Pollution Trends Web site, www.epa.gov/ttn/chief/trends/index.html)

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.ott.doe.gov/otu/field_ops/prog_info.html.

Hybrid Electric Technology

Light-Duty Vehicles

Automotive manufacturers continue to work on hybrid technology, especially for the light-duty market. In 2002, Honda introduced its second advanced technology model, a hybrid electric Civic. The Civic joins the Honda Insight and Toyota Prius, bringing the total number of hybrid electric vehicle (HEV) models available in the United States to three. Total U.S. HEV sales for 2002 were up by nearly 70% over 2001. With the planned entry into the hybrid market by American automotive manufacturers, the total sales for this segment should continue to rise. Toyota has introduced three hybrid models in the Japanese market

since 1997 and surpassed 100,000 vehicles sold in April 2002. This figure represents cumulative Toyota hybrid sales worldwide.

Table 6. Light-Duty Hybrid Electric Vehicles

OEM	Model	Body Style	Power Type	Fuel	Date Introduced/ Announced	Projected Production Date
Currently in Production						
Honda	Insight	Coupe	IMA[1] hybrid	Gasoline	Dec-99	2000
Toyota	Prius	Sedan	Parallel/series hybrid	Gasoline	Jun-00	2000
Honda	Civic	Sedan	IMA[1] hybrid	Gasoline	Jan-00	2002
Toyota	Estima	Minivan	Parallel hybrid	Gasoline	Jun-01	In Japan Only
Toyota	Crown	Sedan	Mild Hybrid	Gasoline	Aug-01	In Japan Only
Planned for Production						
Ford	Escape	SUV	Hybrid	Gasoline	Jan-01	2003
DaimlerChrysler	Liberty	SUV	Hybrid	Gasoline	Dec-01	2004 (Limited)
Dodge	Ram Pickup Contractor Special	Truck	Mild Hybrid	Gasoline or Diesel	Nov-00	2004
General Motors	Silverado/Sierra	Truck	ParadiGM Hybrid	Gasoline	Jan-01	2004
General Motors	Equinox	SUV	Hybrid	Gasoline	Jan-03	2006
General Motors	Malibu	Sedan	Hybrid	Gasoline	Jan-03	2007
Lexus	RX300	SUV	Hybrid	Gasoline	Jan-03	2005
Saturn	Vue	SUV	Full Hybrid	Gasoline	Jan-03	2005
Production Plans Unknown						
Acura	RD-X	SUV	Hybrid	Gasoline	Jan-02	Unknown
Acura	DN-X	Sports Sedan	Hybrid	Gasoline	Mar-02	Unknown
Daihatsu	UFE	Coupe	Hybrid	Gasoline	Oct-01	Unknown
Dodge	PowerBox	SUV	Hybrid	CNG	Jan-01	Unknown
Ford	Model U	Sedan	Hybrid	Hydrogen	Jan-03	Unknown
Honda	DualNote	Sports car	IMA[1] hybrid	Gasoline	Oct-01	Unknown
Toyota	ES3	Sedan	Mild Hybrid	Diesel	Sep-01	Unknown
Mazda	MX Sport Tourer	Sedan	Parallel hybrid	Gasoline	Feb-01	Unknown

[1] Integrated Motor Assist

Table 6 lists the hybrid vehicles in production, as well as some of the most recent vehicles introduced in the past few years. (For more information on these and other light-duty hybrid vehicles introduced around the world, refer to the companion tables on the Internet.) U.S. vehicle manufacturers are expected to enter the hybrid market with several models in the next few years. Ford will begin selling its Hybrid Escape to fleet customers late in 2003, with release to the general public planned for 2004. General Motors (GM), which had one HEV planned for 2004, announced at the North American International Auto Show (NAIAS) plans to market multiple hybrid models by 2007. The previously announced Silverado/Sierra pickup will be its first model available in 2004. The mild hybrid system, targeted to fleet customers, will feature a GM VORTEC engine and 110-volt electrical outlets. The Saturn Vue is a full hybrid system planned for production in 2005. The dual electric motor system is expected to increase the fuel economy of this sport utility vehicle (SUV) by up to 50%. A new concept of note is the Ford Model U. Introduced at the 2003 NAIAS, this hybrid will employ a hydrogen fueled internal combustion engine.

Heavy-Duty Vehicles

The market for heavy-duty hybrids continues to grow. Although hybrid electric powertrains are beginning to show up in heavy truck applications, the majority are in buses. Bus manufacturers typically develop advanced vehicles differently than do light-duty vehicle manufacturers. The smaller number of sales for a given bus manufacturer limits the funds available for developing new technologies. Many of the current

hybrid buses in development involve partnerships between bus OEMs, companies specializing in integration of systems, and transit agencies. These partnerships help push advanced vehicles from the prototype stage into a commercial product.

The past two years have seen an increase in heavy-duty vehicles on order. According to the APTA 2002 Vehicle Databook, there were 87 hybrid buses in active service as of January 1, 2002, with nearly 350 on order and a potential for another 320 more. Table 7 lists some of the more recent heavy vehicle projects in the United States.

Table 7. Heavy-Duty Hybrid Electric Vehicles

Project	Vehicles Deployed	Vehicle Type	Fuel Used	Project Start Date	No. in Project
Active Vehicle Projects					
AVS/Capstone	Lane Transit, Eugene, OR	22-ft Bus	Diesel	Sep-01	6
AVS/Capstone	Silicon Valley Power	35-ft Bus	Propane	Nov-01	3
Ebus	Visalia, CA	22-ft trolley	Diesel	Mar-02	3
Ebus	Southland Transit, Monrovia, CA	Trolley	LPG	Nov-02	2
ISE Research/New Flyer	Omnitrans - San Bernadino, CA	40-ft Bus	Gasoline	Apr-02	3
MCI/Allison/ISE Research	NJ Transit	Coach	Diesel	Late 2002	4
New Flyer/Allison	Orange County Transit Agency	40-ft Bus	Diesel	Dec-00	1
New Flyer/Allison	SEPTA - Philadelphia, PA	40-ft Bus	Diesel	Late 2002	2
New Flyer/Allison	King County Metro, Seattle, WA	60-ft. Bus	Diesel	Demo 8/02	1
Orion	MUNI - San Francisco, CA	40-ft Bus	Diesel	Mar-01	2
Orion VI/BAE	MTA New York City Transit	40-ft Bus	Diesel	Sep-98	10
Orion/BAE	Boston, MA	40-ft Bus	Diesel	May-99	2
Orion/BAE	Fresno Area Express, Torrance, CA	40-ft Bus	Diesel	May-01	2
Transportation Techniques (Transteq)	Denver RTD	45-ft Bus	CNG	Oct-98	36
AVS/Capstone	Chattanooga Area RTA, TN	22-ft Bus	Diesel	Jun-01	11
Vehicles on Order					
ISE Research (Novabus chassis)	NJ Transit	40-ft Bus	Diesel	2003	3
Nova Bus/ISE Research	Foothills Transit, CA	40-ft Bus		2001	1
Orion VII/BAE	MTA New York City Transit	40-ft Bus	Diesel	2003	125
Orion VII/BAE	MTA New York City Transit	40-ft Bus	Diesel	2004	200
Orion/BAE	Minneapolis, MN	40-ft Bus	Diesel	2001	5
Heavy Vehicle Prototypes					
Trolley Enterprises/SK International	Prototype	Trolley	Diesel	Prototype	N/A
FedEx	Planned for multiple locations	Delivery Trucks	Diesel	Prototype	N/A

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 at the California Fuel Cell Partnership (CaFCP). The most significant development over the last year is that manufacturers are beginning to place fuel cell vehicles into the hands of selected fleets. Both Honda and Toyota in December 2002 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 plans 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 Cell Type	Fuel Type	Date of Announcement	Projected Demonstration Date
Vehicles Included in the CaFCP						
DaimlerChrysler	NECAR 4	Sedan	PEM	Hydrogen	1999	2002
DaimlerChrysler	NECAR 5	Sedan	PEM	Methanol	2000	Unknown
Ford	Focus FCV	Sedan	PEM	Hydrogen	Mar-02	2003
Ford	P2000	Sedan	PEM	Hydrogen	Aug-01	Unknown
GM/Opel	HydroGen 3	Minivan		Liquid Hydrogen	Sep-01	2003
Honda	FCX-V4	Sedan	PEM	Hydrogen	Sep-01	2002
Hyundai	Santa Fe	SUV	PEM	Hydrogen	Nov-01	2003
Nissan	Xterra	SUV	PEM	Hydrogen	Nov-00	2003
Toyota	FCHV V4	SUV		Hydrogen	Jun-01	2002
Volkswagen	Bora HyMotion	Sedan		Hydrogen	Nov-00	Unknown
Other Fuel Cell Vehicles in Design or Demonstrations						
Daihatsu	MOVE FCV	Microvan	PEM	Methanol	Oct-01	Unknown
DaimlerChrysler	F-Cell	Sedan	PEM	Hydrogen	Oct-02	Unknown
DaimlerChrysler	Natrium	Minivan	PEM	Sodium Boro-hydride	Dec-01	Unknown
GM	Autonomy	Sports Coupe		Hydrogen	Jan-02	Unknown
GM	Hy-Wire	Sedan	PEM	Hydrogen	Sep-02	Unknown
GM	S-10	Truck		Gasoline	Aug-01	Unknown
Honda	FCX-V3	Sedan	PEM	Hydrogen	Sep-00	2003
Jeep	Commander 2	SUV	PEM	Methanol	Oct-00	Unknown
Mazda	Demio FCEV	Sedan/Wagon	PEM	Hydrogen	Dec-97	Unknown
Mazda	Premacy FC-EV	Sedan/Wagon	PEM	Methanol	Feb-01	Testing in Japan 2/15
Nissan	X-Trail FCV	SUV	PEM	Hydrogen	Dec-02	Unknown
Toyota	FCHV V5	SUV		Methanol	Oct-01	Unknown

Heavy-Duty Vehicles

Fuel cell vehicles continue to be developed for the heavy-duty market, mainly in transit buses. Table 9 lists projects involving fuel cell heavy vehicles, including projects underway worldwide. For more details on these heavy-duty fuel cell projects, see the companion tables at www.ott.doe.gov/otu/field_ops/prog_info.html.

Several U.S. transit agencies are in the process of procuring fuel cell buses for demonstration programs required by the California Air Resources Board (CARB). AC Transit of Oakland, California, Santa Clara Valley Transportation Authority of San Jose, California, and SunLine Transit Agency of Thousand Palms, California, are finalizing plans to order several fuel cell buses for this demonstration. DOE, through NREL, is working with all three agencies to evaluate this new technology. Another fuel cell bus being evaluated by DOE/NREL is a prototype 30-foot bus with a fuel cell system integrated by ISE Research. The bus is currently in service at SunLine.

One of the more significant projects demonstrating fuel cell buses is the Clean Urban Transport for Europe (CUTE) project in Europe. A total of 30 full-size fuel cell buses will be deployed in nine European cities and in Iceland. Each city will receive three buses with delivery beginning in May 2003. The various locations will allow for comparison in performance of the buses 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.

Table 9. Heavy-Duty Fuel Cell Vehicles

Project Partners	Deployed	Vehicle Type	Fuel	Fuel Cell Type	Project Start Date	No. in Project
Projects in the United States						
UTC/Thor/ISE Research (30-foot)	SunLine Thousand Palms, CA	30-ft Bus	Hydrogen	PEM	Aug-02	1
ISE/UTC (Van Hool)	AC Transit, Oakland, CA	40-ft Bus	Hydrogen	PEM	In Service ~6/04	3
Gillig/Ballard	VTA, San Jose, CA	40-ft Bus	Hydrogen	PEM	2004	3
ISE/UTC (Van Hool)	SunLine, Thousand Palms, CA	40-ft Bus	Hydrogen	PEM	In Service ~6/04	1
Georgetown Univ./ DOE/FTA/ (Gen I)	Gainsville, FL	30-ft Bus	Methanol	PAFC	R&D Testing 93	3
Georgetown/Novabus/UTC (Gen II)	WMATA, Washington, DC	40-ft Bus	Methanol	PAFC	1998	1
Georgetown/Novabus/Ballard (Gen II)	SunLine, Thousand Palms, CA	40-ft Bus	Methanol	PEM	Dec-01	1
Georgetown (Gen III)	In Development	40-ft Bus	Methanol	PEM	In Development	Unknown
Freightliner/Ballard	Demonstration vehicle	Class 8 Truck	Hydrogen	PEM	Unknown	1
Ballard/Newflyer/CTA (P3)	Chicago, IL, Vancouver, BC	40-ft Bus	Liquid Hydrogen	PEM	Project Complete	6
Ballard (P4 bus)	SunLine, AC Transit, CA	40-ft Bus	Hydrogen	PEM	Project Complete	1
Projects Outside the United States						
ATM/Irisbus	Torino, Italy	12m Bus	Hydrogen	PEM	Jun-01	1
DaimlerChrysler NEBUS	Mexico, Hamburg	Bus	Hydrogen		Unknown	Unknown
DaimlerChrysler(EvoBus) Citaro/CUTE project	Europe, various cities	40-ft Bus	Hydrogen	PEM	Mid 2003	30
DaimlerChrysler/Hermes Versand	Stuttgart and Hamburg, Germany	Van	Hydrogen	PEM	Sep-01	1
Global Environment Facility	Brazil, Egypt, India, China, Mexico	Bus	Hydrogen		Begin 2002 to 2003	40 to 50
Hino/Toyota FCHV-BUS1	Japan	10.5m Bus	Hydrogen	PEM	Prototype	Unknown
Hino/Toyota FCHV-BUS2	Tokyo-Yokohama	10.5m Bus	Hydrogen		Prototype	4
MAN/Siemens Bavaria I	Nuernberg & Erlangen	12m Bus	Hydrogen	PEM	Prototype May-00	1
Proton Motor/Neoplan Bavaria II	introduced 5/00, Munich	10.6m Bus	Hydrogen	PEM	Prototype May-00	1
Scania/European Union		12m Bus	Hydrogen		Prototype	Unknown
Tsinghua Univ., Beijing/Beijin Green Power Co.	China	Shuttle	Hydrogen	PEM	Unknown	Unknown
Natural Resources Canada/Hydrogenics	Winnipeg Transit (first)	40-ft Bus	Hydrogen	Unknown	2004	1

Additional Projects/Developments

Several developments in the last year could have an effect on advanced technology and AFVs in the United States. Some of the most recent are:

CARB Zero Emission Vehicle (ZEV) Mandate Delayed for Two Years: In January 2003, CARB recommended postponing the ZEV sales quotas for auto OEMs from 2003 to 2005. The original rule would have required 10% of all vehicles sold in California to have zero or near zero emissions. Last year, auto manufacturers filed a suit against the emissions rule, which resulted in a federal judge's preliminary injunction delaying enforcement of the rule for two years. The board plans to reword language in the ruling to avoid uncertainty.

President Bush Announces Hydrogen Fuel Initiative: In the State of the Union Address in January 2003, the President announced a $1.2 billion initiative to address America's ever-increasing dependence on foreign

oil. The funds will help develop technologies for fuel cell vehicles and hydrogen infrastructure. Building on the FreedomCAR (Cooperative Automotive Research) Initiative, which was launched in January 2002, President Bush is proposing a total of $1.7 billion over the next five years to develop hydrogen-powered fuel cells, hydrogen infrastructure, and advanced automotive technologies.

Potential Increase in CAFE for Light-Duty Trucks: In late 2002, the Administration 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 three years. Although the increase from 20.7 mpg to 22.2 mpg for this vehicle segment is not as much as environmentalists would like, it would be the first time any increase has been made to CAFE in over a decade.

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:

- Transportation energy use is at an all time high of 27.6% of total energy use.
- The gap between U.S. consumption and production of petroleum is widening at the rate of 4.3% per year (average from 1985 through 2001).
- Light-duty trucks and automobiles continue to be major consumers in terms of transportation energy use.
- In 2002, sales of light-duty trucks for the first time surpassed the sales of automobiles.
- Alternative fuel use continues to increase by 5% each year. This is insignificant compared to the increasing gap between production and consumption of petroleum.
- The number of alternative fuel stations increased by 3.7% versus the previous year.
- There is significant development in HEVs and fuel cell electric vehicles for light-, medium-, and heavy-duty vehicle markets.
- Although industry experts don't expect full commercialization until after 2010, fuel cell vehicles are beginning to be placed in the hands of selected fleets to demonstrate the technology in real-world service.

Appendix

Table A. Total U.S. Crude Oil Imports in 2001 by Source
(Thousand Barrels)

Country	Number of Barrels
Arab OPEC	
Algeria	3,966
Iraq	289,998
Kuwait	86,535
Qatar	69
Saudi Arabia	588,075
United Arab Emirates	7,802
Total Arab OPEC	*976,445*
Other OPEC	
Indonesia	14,759
Nigeria	307,173
Venezuela	471,243
Total Other OPEC	*793,175*
Non-OPEC	
Angola	117,254
Argentina	21,013
Australia	12,567
Brazil	4,667
Brunei	8,174
Cameroon	1,255
Canada	494,796
China	4,684
Colombia	94,844
Congo (Brazzaville)	14,430
Congo (Kinshasa)	345
Ecuador	41,403
Gabon	51,065
Guatemala	6,485
Ivory Coast	1,517
Malaysia	5,643
Mexico	508,715
Norway	102,724
Oman	7,138
Peru	2,524
Thailand	1,751
Trinidad and Tobago	18,562
United Kingdom	89,142
Yemen	8,702
Other	15,874
Total Non-OPEC	*1,635,274*
Total Persian Gulf	*972,479*
Total Imports for 2001	*3,404,894*

(Source: EIA's Monthly Energy Review)

List of Sources

Fuel Cell/Hydrogen

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California Hydrogen Business Council	http://www.ch2bc.org/indexh.htm
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/
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H Power Corporation	http://www.hpower.com/
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Xcellsis Fuel Cell Engines	http://www.xcellsis.com/
Nuvera	http://www.nuvera.com/

Government/Other Organizations

Advanced Vehicle Technologies Program	http://scitech.dot.gov/partech/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/
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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/
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DaimlerChrysler Corporate Web Site	http://www.daimlerchrysler.com/index_e.htm
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Ford Motors Environmental Vehicles Site	http://www.ford.com/en/ourVehicles/environmentalVehicles/default.htm
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Ford's Hybrid Web Site	http://www.hybridford.com/
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/article.asp?ArticleID=2003010430621&Category=currenthonda
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
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Suzuki News	http://www.suzukiauto.com/news/index.html
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