Chapter 8

Alternative Fuel Vehicles and Characteristics

Summary Statistics

Table		
8.1	Light-duty alternative fuel vehicles, 1996	288,511
	LPG	*210,193*
	CNG	*50,270*
	LNG	*127*
	M85	*20,259*
	E85	*4,536*
	Electric	*3,126*
8.2	Heavy-duty alternative fuel vehicles, 1996	64,105
	LPG	*53,002*
	CNG	*9,874*
	LNG	*536*
	M85/M100	*178*
	E85	*361*
	Electric	*154*
8.5	Number of alternative fuel refuel sites, 1997	6,240
	LPG	*4,255*
	CNG	*1,426*
	LNG	*71*
	M85	*106*
	E85	*71*
	Electric	*310*

Fuel type abbreviations are used throughout this chapter.

LPG	=	*liquified petroleum gas*
CNG	=	*compressed natural gas*
M-85	=	*85% methanol, 15% gasoline*
E-85	=	*85% ethanol, 15% gasoline*
M-100	=	*100% methanol*
E-95	=	*95% ethanol, 5% gasoline*
LNG	=	*liquified natural gas*

THE ALTERNATIVE FUELS DATA CENTER

The Department of Energy (DOE) has established the Alternative Fuels Data Center (AFDC) in support of its work aimed at fulfilling the Alternative Motor Fuels Act (AMFA) directives. The AFDC is operated and managed by the National Renewable Energy Laboratory (NREL) in Golden, Colorado.

The purposes of the AFDC are:

- to gather and analyze information on the fuel consumption, emissions, operation, and durability of alternative fuel vehicles, and
- to provide unbiased, accurate information on alternative fuels and alternative fuel vehicles to government agencies, private industry, research institutions, and other interested organizations.

The data are collected for three specific vehicle types: (1) light-duty vehicles, including automobiles, light trucks, and mini-vans; (2) heavy-duty vehicles such as tractor-trailers and garbage trucks; and (3) urban transit buses. An Oracle Relational Database Management System is used to manage the data, along with a statistical software package capable of providing statistical, graphic, and textual information to users. Several tables and graphs in this chapter contain statistics which were generated by the AFDC. Future editions of the *Transportation Energy Data Book* will continue to present graphical and statistical information from the AFDC.

The Department of Energy is sponsoring the **National Alternative Fuels Hotline** for Transportation Technologies in order to assist the general public and interested organizations in improving their understanding of alternative transportation fuels. The Hotline can be reached by dialing **1-800-423-1DOE,** or on the Internet at **http://www.afdc.nrel.gov**.

Table 8.1
Estimates of Light-Duty Alternative Fuel Vehicles, 1994, 1996, and 1998

	Private			State and local government			Federal Government		
Fuel type	1994	1996	1998[a]	1994	1996	1998[a]	1994	1996	1998[a]
LPG	169,000	167,000	178,000	43,000	43,000	45,000	33	193	380
CNG	21,496	25,020	37,755	7,452	11,305	16,823	7,022	13,945	14,156
LNG	27	10	12	32	45	74	35	72	181
M-85	2,675	6,633	9,302	2,410	5,958	7,329	9,291	7,668	4,733
M-100	0	0	0	0	0	0	0	0	0
E-85	58	793	1,906	408	1,995	4,830	139	1,748	4,136
E-95	1	0	0	1	0	0	0	0	0
Electricity	2,047	2,451	3,398	14	487	764	102	188	400
Total	**196,304**	**201,907**	**230,373**	**53,317**	**62,790**	**74,820**	**16,622**	**23,814**	**23,986**

Source:
U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1996*, Washington, DC, December 1997, pp. 16–18.
(Additional resources: http://www.eia.doe.gov)

[a]Based on plans or projections.

Table 8.2
Estimates of Heavy-Duty Alternative Fuel Vehicles, 1994, 1996, and 1998

	Private			State and local government			Federal government		
Fuel type	1994	1996	1998[a]	1994	1996	1998[a]	1994	1996	1998[a]
LPG	42,000	43,000	45,000	10,000	10,000	11,000	2	2	2
CNG	2,935	5,485	9,104	2,322	4,389	7,284	0	0	0
LNG	12	77	136	378	453	727	0	6	6
M85	0	0	0	108	6	6	0	0	0
M100	1	0	0	414	172	172	0	0	0
E85	0	0	0	0	0	0	0	0	0
E95	5	4	0	26	357	357	0	0	0
Electricity	8	32	42	53	113	148	0	9	9
Total	**44,961**	**48,598**	**54,282**	**13,301**	**15,490**	**19,694**	**2**	**17**	**17**

Source:
U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels,1996*, Washington, DC, December 1997, pp. 16–18.
(Additional resources: http://www.eia.doe.gov)

[a]Based on plans or projections.

Table 8.3
Alternative Fuel Vehicles Available by Manufacturer[a]

Model	Model Year Availability	Fuel	Type	Emission Class
Chrysler Products: 1-800-255-2616				
EPIC	MY 1997 (limited)	Electric lead acid	Minivan	ZEV
Minivan	MY 1998	Ethanol	Minivan	N/A
Ram Wagon	Fall 1998	CNG dedicated	Passenger van	SULEV
Ram Van	Fall 1998	CNG dedicated	Full-size van	SULEV
Ford Products: 1-800-ALT-FUEL				
Ranger	MY 1997 MY 1998	Electric lead acid	Light truck	ZEV
Contour (QVM)	MY 1997 MY1998	CNG bi-fuel	Compact sedan	Gasoline equivalent
Crown Victoria	MY 1997 MY 1998	CNG dedicated	Full-size sedan	ULEV
Econoline	MY 1997 MY 1998	CNG/LPG dedicated or bi-fuel	Full-size van	Various
F-Series	MY 1997 MY 1998	CNG/LPG dedicated or bi-fuel	Light truck	Various
Taurus	MY 1997 MY 1998	E-85 or M-85 gasoline	Mid-size sedan	TLEV
General Motors Products: 1-800-25Electric, 313-556-7723 or 1-888-GM-AFT-4U (CNG)				
EV1	MY 1997 MY 1998	Electric lead acid Nickel-metal hydride option	Sedan two-seater	ZEV
Chevrolet S-10	MY 1997 MY 1998	Electric lead acid	Light truck	California Certified ZEV
GMC Sierra 2500	MY 1997 MY 1998	CNG bi-fuel	Medium truck	LEV
Honda: 1-888-CCHonda				
Honda EV Plus	MY 1997	Electric-NiMH batteries	Sedan	ZEV
Civic GX	MY 1998	CNG dedicated	Compact sedan	ULEV California ILEV Federal
Nissan: 1-310-771-3422 (Demonstration fleets only)				
Altra EV	MY 1998	Electric lithium batteries	Minivan	ZEV
Toyota: 1-800-331-4331 (Press 3 for Alternative Fuel Information) (Fleet sales only)				
RAV4-EV	MY 1998-US	Electric-lead acid/NiMH	Sports utility vehicle	ZEV

Source:
U.S. Department of Energy, National Alternative Fuels Hotline, "Light-Duty Alternative Fuel Vehicle Resource Guide," January 1998. (Additional resources: http://www.afdc.nrel.gov)

Note:
LEV=low emission vehicle. ILEV=inherently low emission vehicle. ULEV=ultra low emission vehicle. ZEV=zero emission vehicle. TLEV=transitional low emission vehicle.

[a]In addition, Mazda (1-800-248-0459) and Volvo (1-800-970-0888) have experimental alternative fuel vehicles which are not yet on the market.

Table 8.4
Number of Onroad Alternative Fuel Vehicles Made Available,[a] by Fuel Type and Vehicle Type, 1996

Fuel type	Automobiles	Passenger vans	Cargo vans/ pickups	Other trucks	Buses	Other onroad vehicles	Total
Liquefied Petroleum Gas (LPG)	1,158	238	2,221	3,506	564	28	7,715
Dedicated	390	70	524	3,294	480	18	4,776
Nondedicated	768	168	1,697	212	84	10	2,939
Compressed Natural Gas (CNG)	2,764	599	4,083	2,054	1,125	9	10,634
Dedicated	411	357	600	179	926	9	2,482
Nondedicated	2,353	242	3,483	1,875	199	0	8,152
Liquefied Natural Gas (LNG)	0	0	33	29	12	0	74
Dedicated	0	0	0	26	12	0	38
Nondedicated	0	0	33	3	0	0	36
Methanol, 85 percent[b] (M85)	2,011	0	0	0	0	0	2,011
Dedicated	0	0	0	0	0	0	0
Nondedicated	2,011	0	0	0	0	0	2,011
Methanol, Neat (M100)	0	0	0	0	60	0	60
Dedicated	0	0	0	0	60	0	60
Nondedicated	0	0	0	0	0	0	0
Ethanol, 85 percent[b] (E85)	3,273	0	0	0	0	0	3,273
Dedicated	0	0	0	0	0	0	0
Nondedicated	3,273	0	0	0	0	0	3,273
Ethanol, 95 percent[b] (E95)	0	0	0	0	0	0	0
Dedicated	0	0	0	0	0	0	0
Nondedicated	0	0	0	0	0	0	0
Electricity	370	2	84	62	146	29	693
Nonhybrid	369	2	83	62	144	29	689
Hybrid	1	0	1	0	2	0	4
Other[c]	0	0	0	0	5	0	5
Dedicated	0	0	0	0	0	0	0
Nondedicated	0	0	0	0	5	0	5
Total	**9,576**	**839**	**6,421**	**5,651**	**1,912**	**66**	**24,465**
Dedicated and Nonhybrid	1,170	429	1,207	3,561	1,622	56	8,045
Nondedicated and Hybrid	8,406	410	5,214	2,090	290	10	16,420

Source:
U.S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1996*, Washington, DC, December 1997, p. 28.
(Additional resources: http://www.eia.doe.gov)

[a]Vehicles made available are vehicles that are completed and made available for delivery to dealers or users in a given year.
[b]The remaining portion of 85-percent methanol and both ethanol fuels is gasoline.
[c]Includes hydrogen, neat biodiesel, and other alternative fuels.

This list includes public and private refuel sites; therefore, not all of these sites are available to the public.

Table 8.5
Number of Alternative Refuel Sites by State and Fuel Type, 1997

State	M85 sites	CNG sites	E85 sites	LPG sites	LNG sites	Electric sites	Total
Alabama	0	17	0	114	2	0	133
Alaska	0	1	0	9	0	0	10
Arizona	1	31	0	71	3	40	146
Arkansas	0	9	0	156	0	0	165
California	66	203	0	219	18	197	703
Colorado	2	45	1	48	3	0	99
Connecticut	0	22	0	18	0	1	41
Delaware	0	6	0	6	0	0	12
District of Columbia	1	8	1	0	0	2	12
Florida	3	60	0	222	0	4	289
Georgia	1	89	0	80	3	0	173
Hawaii	0	0	0	0	0	3	3
Idaho	0	7	1	20	1	1	30
Illinois	2	24	14	163	0	0	203
Indiana	0	47	2	125	3	1	178
Iowa	0	5	10	107	0	1	123
Kansas	0	18	2	38	1	0	59
Kentucky	0	13	3	35	0	0	51
Louisiana	0	21	0	44	2	0	67
Maine	0	0	0	12	0	0	12
Maryland	2	31	0	21	3	0	57
Massachusetts	0	18	0	42	0	4	64
Michigan	2	39	3	187	2	10	243
Minnesota	0	17	11	125	2	0	155
Mississippi	0	3	0	75	0	0	78
Missouri	0	11	3	83	0	0	97
Montana	0	13	0	48	1	0	62
Nebraska	0	11	6	47	1	0	66
Nevada	0	13	0	20	0	0	33
New Hampshire	0	1	0	31	0	1	33
New Jersey	0	24	0	37	0	0	61
New Mexico	0	18	0	46	1	0	65
New York	18	59	0	100	0	5	182
N. Carolina	0	11	0	72	0	1	84
N. Dakota	0	5	1	17	0	0	23
Ohio	2	70	0	98	1	1	172
Oklahoma	0	56	0	56	0	0	112
Oregon	0	9	0	21	1	0	31
Pennsylvania	1	61	0	141	1	1	205
Rhode Island	0	3	0	6	0	0	9
S. Carolina	0	3	0	67	0	1	71
S. Dakota	0	5	10	30	0	0	45
Tennessee	2	7	0	95	0	2	106
Texas	0	92	0	862	15	0	969
Utah	0	67	0	23	1	0	91
Vermont	0	1	0	40	0	9	50
Virginia	0	30	0	51	3	18	102
Washington	2	32	0	69	1	6	110
W. Virginia	1	42	0	21	0	1	65
Wisconsin	0	29	3	190	0	0	222
Wyoming	0	19	0	47	2	0	68
Total	**106**	**1,426**	**71**	**4,255**	**71**	**310**	**6,240**

Source:
U.S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1996*, Washington, DC, December 1997, p. 15.

U.S. ADVANCED BATTERY CONSORTIUM

Electric and hybrid-electric vehicles are the subject of intense research and development because they are required to be sold in California (10% in 2003) under the California Low-Emission Vehicle (LEV) program. Other states, such as New York and Massachusetts, have indicated that they will also enforce the LEV program. One of the greatest advantages in using electric vehicles is that there are no tailpipe emissions. The U.S. Advanced Battery Consortium (USABC) was established in January 1991 to concentrate efforts on battery development for future electric vehicles. The USABC consists of the Big Three U.S. auto manufacturers (Chrysler, Ford, General Motors), the Electric Power Research Institute, and the U.S. Department of Energy. Five major U.S. electric utilities are also direct participants in USABC.

The USABC has established research contracts with several companies for the development of advanced batteries. Also, a series of Cooperative Research and Development Agreements (CRADAs) with several DOE National Laboratories have been established.

Table 8.6
U.S. Advanced Battery Consortium Research Agreements, Phase II

Research contracts	
General Motors–Ovonic Joint Venture	Cost reduction program for nickel-metal hydride battery and testing of nickel-metal hydride pilot production modules
SAFT	Cost reduction program for nickel-metal hydride battery
3M Hydro-Quebec	Phase II development of lithium-polymer battery
Duracell/VARTA	Phase II development of lithium-ion battery
CRADAs for advanced battery testing	
Argonne National Laboratory, Argonne, IL	
Sandia National Laboratory, Albuquerque, NM	
Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID	

Source:
U.S. Advanced Battery Consortium, February, 1998.

Today's lead acid batteries provide 30–40 watt hours per kilogram, cost between $50–150 per kilowatt hour, and have a two- to three-year lifetime. However, the batteries currently used in electric vehicles do not provide the energy or performance sufficient to make these vehicles competitive with gasoline-fueled vehicles. When attained, the Advanced Battery Technology goals will effectively double the range and performance of electric vehicles compared to the range and performance possible with today's battery technology.

Table 8.7
U.S. Advanced Battery Consortium Goals for Electric Vehicle Batteries

Primary criteria	Mid-term goals (1997)	Long-term goals[a] (2000)
Power density[b] W/L	250	460
Specific power[b] W/kg (80% DOD/30 sec)	150 (200 desired)	300
Energy density[b] Wh/L (C/3 discharge rate)	135	230
Specific energy[b] Wh/kg (C/3 discharge rate)	80 (100 desired)	150
Life (years)	5	10
Cycle life[b] (cycles) (80% DOD)	800	1000 1800 (@ 50% DOD) 2670 (@ 30% DOD)
Power and capacity degradation[b] (% of rated spec)	20%	20%
Ultimate price[c] ($/kWh) (10,000 units @ 40 kWh)	< $150	< $150 (desired to75)
Operating environment	-30 to 65°C	-30 to 65°C
Recharge time[b]	< 6 hours	< 6 hours
Continuous discharge in 1 hour (no failure)	75% (of rated energy capacity)	75% (of rated energy capacity)
Secondary criteria		
Efficiency (C/3 discharge & C/3 charge)[d]	75%	80%
Self discharge[b]	< 15% in 48 hours	< 20% in 12 days
Maintenance	No maintenance. Service by qualified personnel only.	No maintenance. Service by qualified personnel only.
Thermal loss[b]	3.2 W/kWh; 15% of capacity; 48 hour period	Covered by self discharge
Abuse resistance[b]	Tolerant Minimized by on-board controls	Tolerant Minimized by on-board controls

Source:
U.S. Department of Energy, Office of Transportation Technologies, Washington, DC, February, 1998.
Note:
W=watt; kg=kilogram; L=liter; DOD=depth of discharge; Wh=watt-hour; kWh=kilowatt-hour.

[a]For interim commercialization (Reflects USABC revisions of September 1996).
[b]Specifics on criteria can be found in "USABC Electric Vehicle Battery Test Procedures Manual Revision 2" DOE/ID-10479, Rev. 2, January 1996.
[c]Cost to the Original Equipment Manufacturers.
[d]Roundtrip charge/discharge efficiency.

Hybrid Electric Vehicle Program

The U.S. Department of Energy (DOE) is working closely with other Federal agencies and key auto industry partners to develop hybrid electric vehicles (HEVs) as a practical way of providing clean and efficient transportation for the future that will significantly contribute to reducing our Nation's growing dependence on imported oil. HEV R&D is a key component of DOE's Advanced Automotive Technologies Program and is focused on two strategic goals:

1. Develop a production-feasible hybrid propulsion system by 1998 that will enable subsequent market introduction of a 50-mpg light-duty vehicle.
2. Develop production-feasible hybrid vehicle technologies by 2004 that will enable subsequent market introduction of an 80-mpg light-duty vehicle.

The 50-mpg and 80-mpg fuel economy targets represent two- and three-fold improvements over current six-passenger family sedans. In addition, the HEV technologies must meet Environmental Protection Agency Tier II light-duty emission standards; be acceptable to consumers with respect to performance, range, safety, and cost; and support the introduction of alternative fuels.

The Hybrid Electric Vehicle (HEV) Program is managed by DOE's Office of Transportation Technologies with technical program support from the National Renewable Energy Laboratory. Hybrid Propulsion System Development is focused on systems-driven development, system design, integration, and testing. This is a two-phased effort with the Phase I major milestone of 50-mpg capable hybrid propulsion system by 1998. Phase II, which will be initiated in the near future, will combine further advances in the hybrid propulsion system with other vehicle advances (in materials, etc.) to achieve the 80-mpg goal by 2004. In the first phase of the effort, DOE is supporting three versatile system development teams led by GM, Ford, and Chrysler through 50/50 cost-shared contracts. These teams have successfully mobilized the extensive internal resources of the three major automakers as well as that of key suppliers.

Enabling Technologies Development is focused on technologies that will ensure HEVs will be marketplace-acceptable. The key technologies are:

- Fuel-efficient, low-emission engines (gas turbine and four-stroke, direct-injection engine)
- High-power energy storage (battery, ultra-capacitor, and flywheel)
- Cost-effective, high-efficiency power electronics

To learn more about the DOE HEV Program, visit the Internet site: http://www.ott.doe.gov