

## Chapter 9

### Alternative Fuel Vehicles and Characteristics

#### Summary Statistics from Tables in this Chapter

Source		
Table 9.1	Light alternative fuel vehicles, 1997	303,306
	<i>LPG</i>	211,181
	<i>CNG</i>	57,534
	<i>LNG</i>	170
	<i>M85</i>	21,034
	<i>E85</i>	9,130
	<i>Electric</i>	4,257
Table 9.2	Heavy alternative fuel vehicles, 1997	66,684
	<i>LPG</i>	52,002
	<i>CNG</i>	13,318
	<i>LNG</i>	643
	<i>M85/M100</i>	178
	<i>E95</i>	347
	<i>Electric</i>	196
Table 9.5	Number of alternative fuel refuel sites, 1998	7,271
	<i>LPG</i>	5,318
	<i>CNG</i>	1,268
	<i>LNG</i>	66
	<i>M85</i>	91
	<i>E85</i>	40
	<i>Electric</i>	486

***Fuel type abbreviations are used throughout this chapter.***

<i>LPG</i>	=	<i>liquified petroleum gas</i>
<i>CNG</i>	=	<i>compressed natural gas</i>
<i>M-85</i>	=	<i>85% methanol, 15% gasoline</i>
<i>E-85</i>	=	<i>85% ethanol, 15% gasoline</i>
<i>M-1 00</i>	=	<b><i>100% methanol</i></b>
<i>E-95</i>	=	<i>95% ethanol, 5% gasoline</i>
<i>LNG</i>	=	<i>liquified natural gas</i>



## 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 vehicles, including automobiles, light trucks, and mini-vans; (2) heavy 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>**.



There are more LPG vehicles in use than any other alternative fuel vehicle. The population of E85 vehicles, however, has grown the most since 1992. For details on alternative fuel use by fuel type, see Table 2.10

**Table 9.1**  
**Estimates of Alternative Fuel Vehicles in Use, 1992-99**

Fuel type	1992	1993	1994	1995	1996	1997	1998	1999	Percentage change 1992-99
LPG	221,000	269,000	264,000	259,000	263,000	263,000	269,000	274,000	3.1%
CNG	23,191	32,714	41,227	50,218	60,144	70,852	85,730	96,017	22.5%
LNG	90	299	484	603	663	813	1,358	1,517	49.7%
M85	4,850	10,263	15,484	18,319	20,265	21,040	21,578	21,829	24.0%
M100	404	414	415	386	172	172	378	378	-0.9%
E85	1 7 2	441	605	1,527	4,536	9,130	11,743	17,892	94.2%
E95	38	27	33	136	361	347	14	14	-13.3%
Electricity	1,607	1,690	2,224	2,860	3,280	4,453	5,824	6,481	22.0%
<b>Total</b>	<b>251,352</b>	<b>314,848</b>	<b>324,472</b>	<b>333,049</b>	<b>352,421</b>	<b>369,807</b>	<b>395,625</b>	<b>418,128</b>	<b>7.5%</b>

**Source:**

U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1997*, Washington, DC, 1998, web site [http://www.eia.doe.gov/cneaf/solar.renewables/alt\\_trans\\_fuel97/atf.html](http://www.eia.doe.gov/cneaf/solar.renewables/alt_trans_fuel97/atf.html).  
(Additional resources: <http://www.eia.doe.gov>)

“Based on plans or projections.



**Table 9.2**  
**Estimates of Light Alternative Fuel Vehicles, 1995, 1997, and 1999**

Fuel type	Private			State and local government			Federal Government		
	1995	1997	1999 <sup>a</sup>	1995	1997	1999 <sup>a</sup>	1995	1997	1999 <sup>a</sup>
LPG	166,000	168,000	175,000	42,000	43,000	44,000	139	181	695
CNG	22,950	30,530	44,224	10,670	13,594	19,889	9,432	13,410	13,855
LNG	49	58	58	47	25	25	47	87	239
M-85	5,198	9,875	12,750	3,569	6,982	7,596	9,552	4,177	1,477
M-100	0	0	0	0	0	0	0	0	0
E-85	54	2,483	3,201	1,084	3,759	4,605	389	2,888	10,086
E-95	1	0	0	0	0	0	0	0	0
Electricity	2,400	3,187	4,128	160	801	1,400	191	269	685
<b>Total</b>	<b>196,652</b>	<b>214,133</b>	<b>239,361</b>	<b>57,530</b>	<b>68,161</b>	<b>77,515</b>	<b>19,750</b>	<b>21,012</b>	<b>27,037</b>

**Source:**

U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1997*, Washington, DC, 1998, web site [http://www.eia.doe.gov/cneaf/solar.renewables/alt\\_trans\\_fuel97/atf.html](http://www.eia.doe.gov/cneaf/solar.renewables/alt_trans_fuel97/atf.html).  
 (Additional resources: <http://www.eia.doe.gov>)

<sup>a</sup>Based on plans or projections.

**Table 9.3**  
**Estimates of Heavy Alternative Fuel Vehicles, 1995, 1997, and 1999**

Fuel type	Private			State and local government			Federal government		
	1995	1997	1999 <sup>a</sup>	1995	1997	1999 <sup>a</sup>	1995	1997	1999 <sup>a</sup>
LPG	41,000	42,000	44,000	10,000	10,000	11,000	2	2	2
CNG	3,981	7,398	10,026	3,185	5,919	8,022	0	1	1
LNG	34	140	262	426	497	920	0	6	13
M85	0	0	0	0	6	6	0	0	0
M100	0	0	0	386	172	378	0	0	0
E85	0	0	0	0	0	0	0	0	0
E95	1	0	0	134	347	14	0	0	0
Electricity	26	40	40	83	146	214	0	10	14
<b>Total</b>	<b>45,042</b>	<b>49,578</b>	<b>54,328</b>	<b>14,214</b>	<b>17,087</b>	<b>20,554</b>	<b>2</b>	<b>19</b>	<b>30</b>

**Source:**

U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1997*, Washington, DC, 1998, web site [http://www.eia.doe.gov/cneaf/solar.renewables/alt\\_trans\\_fuel97/atf.html](http://www.eia.doe.gov/cneaf/solar.renewables/alt_trans_fuel97/atf.html).  
 (Additional resources: <http://www.eia.doe.gov>)

<sup>a</sup>Based on plans or projections.

**Table 9.4**  
**Alternative Fuel Vehicles Available by Manufacturer, Model Year 1999<sup>a</sup>**

Model	Fuel	Type	Emission class
<b>Chrysler Products: 1-800-255-2616</b>			
EPIC (CA, NY-lease only)	Electric-lead acid or NiMH	Minivan	ZEV
Minivan	Electric-lead acid or NiMH	Minivan	ZEV
Minivan	E-85	Minivan	N/A
Ram Wagon	CNG dedicated	Large van	ULEV and ILEV
Ram Van	CNG dedicated	Large van	WLEV and ILEV
<b>Ford Products: 1-800-ALT-FUEL</b>			
Ranger	Electric-lead acid	Light truck	ZEV
Ranger	E-85	Light truck	TLEV
Contour (QVM)	CNG bi-fuel	Compact sedan	TLEV
Crown Victoria	CNG Dedicated	Full-size sedan	ULEV/ILEV
Econoline	CNG/LPG dedicated or bi-fuel	Full-size van	Various
F-Series	CNG/LPG dedicated or bi-fuel	Light truck	Various
Taurus	E-85 or M-85 gasoline	Mid-size sedan	TLEV
<b>General Motors Products: 1-800-25Electric, 313-556-7723 or 1-888-GM-AFT-4U (CNG)</b>			
EV1 (CA and AZ only)	Electric-lead acid or NiMH	Sedan two-seater	ZEV
Chevrolet S-10	Electric-lead acid	Compact pickup	ZEV
Chevrolet Cavalier	CNG bi-fuel	Subcompact sedan	TLEV
<b>Honda: 1-888-CCHonda</b>			
Honda EV Plus	Electric-NiMH	Compact sedan	ZEV
Civic GX	CNG dedicated	Subcompact sedan	ULEV California ILEV Federal
<b>Nissan: 1-310-771-3422 (Demonstration fleets only)</b>			
Altra EV	Electric lithium-ion	Compact sedan	ZEV
<b>Solectria Corporation: 1-508-658-2231</b>			
Flash	Electric-lead acid	Pickup truck	ZEV
Force	Electric-lead acid or NiMH	Sedan	ZEV
<b>Toyota: 1-800-331-4331 (Press 3 for Alternative Fuel Information) (Fleet sales only)</b>			
RAV4-EV	Electric-lead acid/NiMH	Sports utility vehicle	ZEV

**Source:**

U.S. Department of Energy, National Alternative Fuels Data Center, web site,  
[http://www.afdc.nrel.gov/vehicles/OEM\\_YEAR.html](http://www.afdc.nrel.gov/vehicles/OEM_YEAR.html), February 1999.

(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.

<sup>a</sup>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.



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

**Table 9.5**  
**Number of Alternative Refuel Sites by State and Fuel Type, 1998**

State	M85 sites	CNG sites	ES5 sites	LPG sites	LNG sites	Electric sites	Total
Alabama	0	16	0	152	0	2	170
Alaska	0	0	0	12	0	0	12
Arizona	1	28	0	92	46	2	169
Arkansas	0	6	0	144	0	0	150
California	66	209	0	279	335	18	907
Colorado	2	44	1	91	0	3	141
Connecticut	0	27	0	25	1	0	53
Delaware	0	6	0	8	0	0	14
District of Columbia	0	4	0	0	1	0	5
Florida	2	42	0	265	5	0	314
Georgia	1	70	0	111	25	3	210
Hawaii	0	0	0	0	3	0	4
Idaho	0	7	1	44	1	1	54
Illinois	1	24	3	188	2	0	218
Indiana	0	38	1	137	1	3	180
Iowa	0	5	4	133	1	0	143
Kansas	0	5	1	58	0	1	65
Kentucky	0	9	2	46	0	0	57
Louisiana	0	15	0	55	0	0	70
Maine	0	1	0	20	0	0	21
Maryland	1	27	0	26	1	3	58
Massachusetts	0	17	0	53	4	0	74
Michigan	2	32	2	205	10	2	253
Minnesota	0	14	9	169	0	1	193
Mississippi	0	3	0	83	0	0	86
Missouri	0	10	3	134	0	0	147
Montana	0	11	0	82	0	1	94
Nebraska	0	6	6	77	0	0	90
Nevada	0	18	0	46	0	0	64
New Hampshire	0	2	0	42	1	0	45
New Jersey	0	22	0	45	0	0	67
New Mexico	0	17	0	102	0	1	120
New York	13	58	0	126	4	0	201
N. Carolina	0	9	0	98	7	0	114
N. Dakota	0	4	1	23	0	0	28
Ohio	0	49	0	119	1	1	170
Oklahoma	0	60	0	78	0	0	138
Oregon	0	9	0	42	0	1	52
Pennsylvania	0	59	0	184	1	1	245
Rhode Island	0	4	0	6	0	0	10
S. Carolina	0	4	0	94	1	0	99
S. Dakota	0	4	5	45	0	0	54
Tennessee	1	5	0	109	2	0	117
Texas	0	73	0	890	2	15	980
Utah	0	62	0	35	0	1	98
Vermont	0	1	0	39	7	0	47
Virginia	0	27	0	69	18	3	117
Washington	1	28	0	131	6	1	167
W. Virginia	0	39	0	24	0	0	63
Wisconsin	0	20	1	225	0	0	246
Wyoming	0	18	0	57	0	2	77
Total	91	1,268	40	5,318	486	66	7,271

**Source:**

U.S. Department of Energy, Alternative Fuels Data Center web site, [http://www.afdc.nrel.gov/newrefuel/state\\_tot.cgi](http://www.afdc.nrel.gov/newrefuel/state_tot.cgi), February 1999.



*Clean Cities is a locally-based government/industry partnership, coordinated by the U.S. Department of Energy to expand the use of alternatives to gasoline and diesel fuel. By combining the decision-making with voluntary action by partners, the "grass-roots" approach of Clean Cities departs from traditional "top-down" Federal programs. It establishes a plan, carried out at the local level, for creating a sustainable, nationwide alternative fuels market.*

**Table 9.6**  
**List of Clean Cities as of 9/1/99 by Designation**

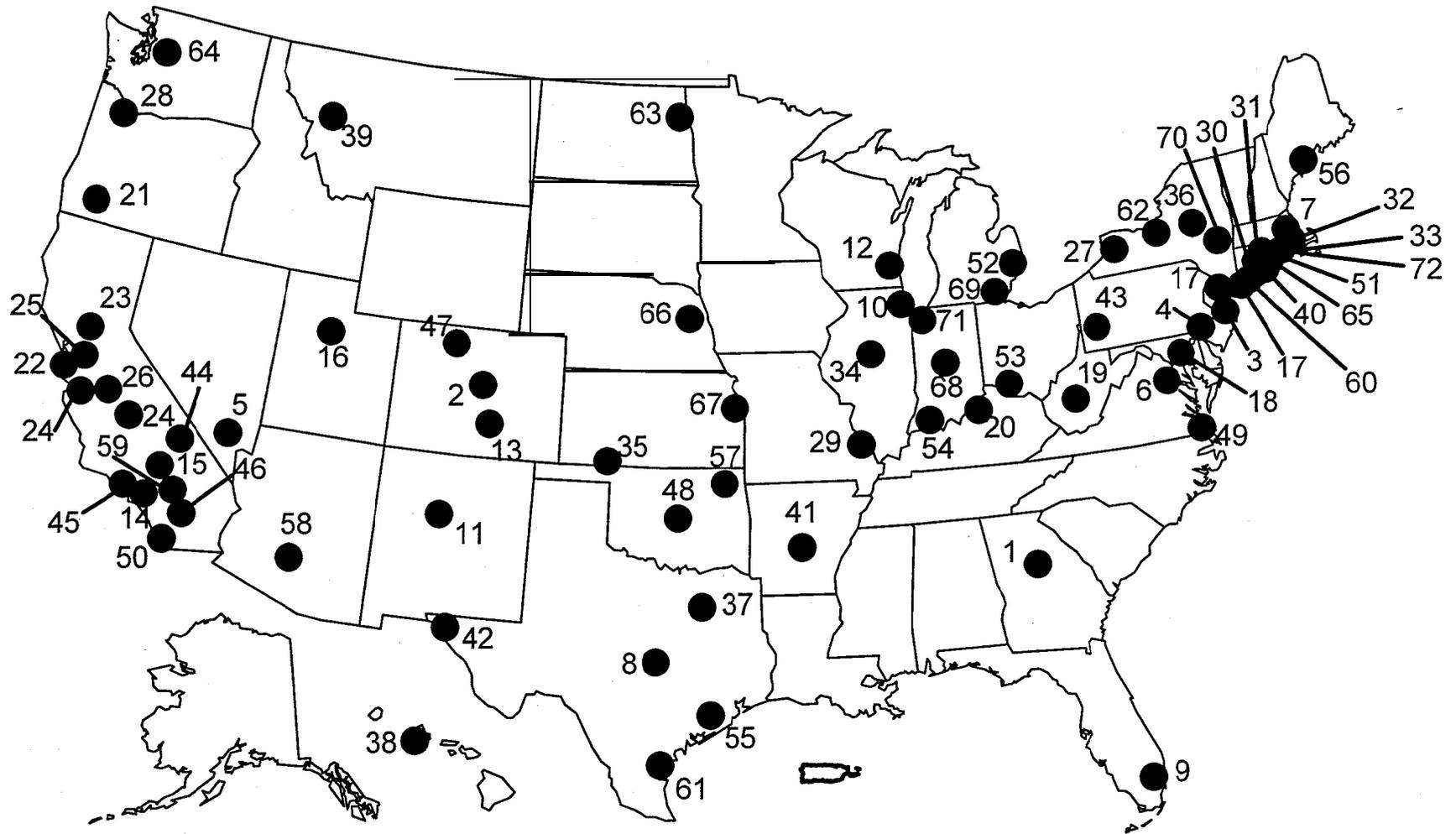
1. Atlanta, GA - 9/8/93	38. Honolulu, HI - 8/29/95
2. Denver, CO - 9/13/93	39. Missoula, MT - 9/21/95
3. Philadelphia, PA - 9/22/93	40. New Haven, CT - 10/5/95
4. State of Delaware - 10/12/93	41. Central Arkansas - 10/25/95
5. Las Vegas, NV - 10/18/93	42. Paso Del Norte - 11/17/95
6. Washington, DC - 10/21/93	43. Pittsburgh, PA - 12/5/95
7. Boston, MA - 3/18/94	44. S. California Assn. Gov. - 3/1/96
8. Austin, TX - 4/18/94	45. Los Angeles, CA - 3/22/96
9. Florida Gold Coast - 5/3/94	46. Coachella Valley, CA - 4/22/96
10. Chicago, IL - 5/13/94	47. Weld/Larimer/Rocky Mountain National Park - 5/21/96
11. Albuquerque, NM - 6/1/94	48. Central Oklahoma - 5/29/96
12. Wisconsin - SE Area - 6/30/94	49. Hampton Roads, VA - 10/4/96
13. Colorado Springs, CO - 7/13/94	50. San Diego, CA - 12/12/96
14. Long Beach, CA - 8/31/94	51. Long Island, NY - 10/18/96
15. Lancaster, CA - 9/22/94	52. Detroit, MI/Toronto, ON - 12/18/96
16. Salt Lake City, UT - 10/3/94	53. Cincinnati, OH - 1/29/97
17. White Plains, NY - 10/4/94	54. Evansville, IN - 1/30/97
18. Baltimore, MD - 10/7/94	55. Houston, TX - 9/4/97
19. State of WV - 10/18/94	56. Portland, ME - 9/4/97
20. Louisville, KY - 10/18/94	57. Tulsa, OK - 9/22/97
21. Rogue Valley, OR - 11/10/94	58. Maricopa Assn. of Govts. - 10/8/97
22. San Francisco, CA - 10/21/94	59. Riverside, CA - 10/24/97
23. Sacramento, CA - 10/21/94	60. North Jersey, NJ - 10/31/97
24. South Bay (San Jose), CA - 10/21/94	61. Corpus Christi, TX - 3/30/98
25. East Bay, CA - 10/21/94	62. Genesee Region, Rochester, NY - 5/28/98
26. San Joaquin Valley, CA - 10/21/94	63. Red River Valley/Grand Forks, ND - 8/10/98
27. Western New York - 11/4/94	64. Puget Sound, WA - 8/13/98
28. Portland, OR - 11/10/94	65. Providence, RI - 9/14/98
29. St. Louis, MO - 11/18/94	66. Omaha, NE - 9/18/98
30. Waterbury, CT - 11/21/94	67. Kansas City, KS/MO - 11/18/98
31. Connecticut Southwestern Area, - 11/21/94	68. Central Indiana CC Alliance, IN - 3/4/99
32. Norwich, CT - 11/22/94	69. Ann Arbor, MI - 4/19/99
33. New London, CT - 11/22/94	70. Capital District (Albany), NY - 4/26/99
34. Peoria, IL - 11/22/94	71. South Shore, IN - 6/15/99
35. Kansas - SW Area - 3/30/95	72. Capital Clean Cities of CT - 6/21/99
36. Central New York - 6/15/95	
37. Dallas/Ft. Worth, TX - 7/25/95	

**For more information, contact the Clean Cities Hotline at (800) CCITIES, or write to: U.S. Department of Energy, EE-33, Clean Cities Program, 1000 Independence Avenue SW, Washington, DC 20585.**

**Source:**

U.S. Department of Energy, Alternative Fuel Information, *Clean Cities: Guide to Alternative Fuel Vehicle Incentives & Laws*, Washington, DC, November 1996, and updates from web site, February 1999.  
(Additional resources: <http://www.cities.doe.gov>)

Figure 9.1 Map of Clean Cities as of 9/1/99



Source:

U.S. Department of Energy, Alternative Fuel Information, *Clean Cities: Guide to Alternative Fuel Vehicle Incentives & Laws*, Washington, DC, November 1996, and updates from the web site, February 1999. (Additional resources: <http://www.ccities.doe.gov>)



## 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 9.7**  
**U.S. Advanced Battery Consortium Research Agreements, Phase II**

<b>Research contracts</b>	
General Motors–Ovonic Joint Venture	Cost reduction program for nickel-metal hydride battery and testing of nickel-metal hydride pilot production modules (Completed 1998)
SAFT	Cost reduction program for nickel-metal hydride battery (Completed 1998)
3M Hydro-Quebec	Phase II development of lithium-polymer battery
Duracell/VARTA	Phase II development of lithium-ion battery (Completed 1999)
<b>CRADAs for advanced battery testing</b>	
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, 1999.



*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 9.8**  
**U.S. Advanced Battery Consortium Goals for Electric Vehicle Batteries**

Primary criteria	Mid-term goals (1997)	Long-term goals <sup>a</sup> (2000)
Power density <sup>b</sup> W/L	250	460
Specific power <sup>b</sup> W/kg (80% DOD/30 sec)	150 (200 desired)	300
Energy density <sup>b</sup> Wh/L (C/3 discharge rate)	135	230
Specific energy <sup>b</sup> Wh/kg (C/3 discharge rate)	80 (100 desired)	150
Life (years)	5	10
Cycle life <sup>b</sup> (cycles) (80% DOD)	800	1000 1800 (@ 50% DOD) 2670 (@ 30% DOD)
Power and capacity degradation <sup>b</sup> (% of rated spec)	20%	20%
Ultimate price <sup>c</sup> (\$/kWh) (10,000 units @ 40 kWh)	< \$150	< \$150 (desired to 75)
Operating environment	-30 to 65°C	-30 to 65°C
Recharge time <sup>b</sup>	< 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) <sup>d</sup>	75%	80%
Self discharge <sup>b</sup>	< 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 <sup>b</sup>	3.2 W/kWh; 15% of capacity; 48 hour period	Covered by self discharge
Abuse resistance <sup>b</sup>	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.

<sup>a</sup>For interim commercialization (Reflects USABC revisions of September 1996).

<sup>b</sup>Specifics on criteria can be found in "USABC Electric Vehicle Battery Test Procedures Manual Revision 2" DOE/ID-10479, Rev. 2, January 1996.

<sup>c</sup>Cost to the Original Equipment Manufacturers.

<sup>d</sup>Roundtrip charge/discharge efficiency.

