

Chapter 9

Alternative Fuel Vehicles and Characteristics

Summary Statistics from Tables in this Chapter

Source		
Table 9.1	Light alternative fuel vehicles, 1998	313,258
	<i>LPG</i>	212,000
	<i>CNG</i>	63,739
	<i>LNG</i>	118
	<i>M85</i>	19,627
	<i>E85</i>	12,778
	<i>Electric</i>	4,996
Table 9.2	Heavy alternative fuel vehicles, 1998	70,589
	<i>LPG</i>	54,000
	<i>CNG</i>	15,043
	<i>LNG</i>	1,054
	<i>M85/M100</i>	221
	<i>E85/E95</i>	24
	<i>Electric</i>	247
Table 9.5	Number of alternative fuel refuel sites, 1999	6,058
	<i>LPG</i>	4,153
	<i>CNG</i>	1,267
	<i>LNG</i>	490
	<i>M85</i>	51
	<i>E85</i>	49
	<i>Electric</i>	46

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-100</i>	=	<i>100% methanol</i>
<i>E-95</i>	=	<i>95% ethanol, 5% gasoline</i>
<i>LNG</i>	=	<i>liquified natural gas</i>

Alternative Fuels

The U.S. Department of Energy (DOE) defines alternative fuels as fuels which are substantially non-petroleum and yield energy security and environmental benefits. DOE currently recognizes the following as alternative fuels:

- methanol and denatured ethanol as alcohol fuels (alcohol mixtures that contain no less than 70% of the alcohol fuel),
- natural gas (compressed or liquefied),
- liquefied petroleum gas,
- hydrogen,
- coal-derived liquid fuels
- fuels derived from biological materials, and
- electricity (including solar 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. Much of the AFDC data can be obtained through their web site: www.afdc.doe.gov. Several tables and graphs in this chapter contain statistics which were generated by the AFDC.

DOE 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 www.afdc.doe.gov/hotline.html.

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, 1992–2000

Fuel type	1992	1993	1994	1995	1996	1997	1998	1999 ^a	2000 ^a	Average annual percentage change 1992–2000
LPG	221,000	269,000	264,000	259,000	263,000	263,000	266,000	268,000	270,000	2.5%
CNG	23,191	32,714	41,227	50,218	60,144	68,571	78,782	89,633	101,991	20.3%
LNG	90	299	484	603	663	813	1,172	1,422	1,682	44.2%
M85	4,850	10,263	15,484	18,319	20,265	21,040	19,648	19,497	18,725	18.4%
M100	404	414	415	386	172	172	200	200	200	-8.4%
E85 ^b	172	441	605	1,527	4,536	9,130	12,788	22,359	30,017	90.6%
E95	38	27	33	136	361	347	14	14	14	-11.7%
Electricity	1,607	1,690	2,224	2,860	3,280	4,453	5,243	6,417	7,590	21.4%
Total	251,352	314,848	324,472	333,049	352,421	369,526	383,847	407,542	430,219	6.9%

Source:

U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1998*, Washington, DC, 1999, web site www.eia.doe.gov/cneaf/solar.renewables/alt_trans_fuel98/table1.html.
(Additional resources: www.eia.doe.gov)

^aBased on plans or projections.

^bDoes not include flex-fuel vehicles.

Table 9.2
Estimates of Light Alternative Fuel Vehicles, 1996, 1998, and 2000

Fuel type	Private			State and local government			Federal Government		
	1996	1998	2000 ^a	1996	1998	2000 ^a	1996	1998	2000 ^a
LPG	167,000	170,000	170,000	43,000	42,000	42,000	193	159	839
CNG	25,020	35,357	47,400	11,305	15,913	21,415	13,945	12,469	13,569
LNG	10	75	75	45	43	43	72	0	0
M-85	6,633	10,773	10,111	5,958	8,313	8,252	7,668	541	341
M-100	0	0	0	0	0	0	0	0	0
E-85	793	2,595	4,944	1,995	5,906	8,786	1,748	4,277	16,277
E-95	0	0	0	0	0	0	0	0	0
Electricity	2,451	8,219	4,307	487	1,432	2,083	188	146	846
Total	201,907	222,218	236,837	62,790	73,607	82,579	23,814	17,592	31,872

Source:

U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1998*, Washington, DC, 1999, web site www.eia.doe.gov/cneaf/solar.renewables/alt_trans_fuel98/atf1-13_99.html.

(Additional resources: www.eia.doe.gov)

Note: Light vehicles are less than or equal to 8,500 lbs. gross vehicle weight

^aBased on plans or projections.

Table 9.3
Estimates of Heavy Alternative Fuel Vehicles, 1996, 1998, and 2000

Fuel type	Private			State and local government			Federal government		
	1996	1998	2000 ^a	1996	1998	2000 ^a	1996	1998	2000 ^a
LPG	43,000	43,000	45,000	10,000	11,000	12,000	2	16	16
CNG	5,485	7,972	10,396	4,389	6,378	8,318	0	693	893
LNG	77	204	280	453	836	1,144	6	14	140
M85	0	0	0	6	19	19	0	2	2
M100	0	0	0	172	200	200	0	0	0
E85	0	0	0	0	0	0	0	10	10
E95	4	0	0	357	14	14	0	0	0
Electricity	32	43	43	113	189	296	9	15	15
Total	48,598	51,219	55,719	15,490	18,636	21,991	17	734	1,076

Source:

U. S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1998*, Washington, DC, 1999, web site www.eia.doe.gov/cneaf/solar.renewables/alt_trans_fuel98/atf1-13_99.html.

(Additional resources: www.eia.doe.gov)

Note: Heavy vehicles are above 8,500 lbs. gross vehicle weight.

^aBased on plans or projections.

Table 9.4
Alternative Fuel Vehicles Available by Manufacturer, Model Year 2000

Model	Fuel	Type	Emission class
Daimler Chrysler: 1-800-999-FLEET			
EPIC (CA, NY—lease only)	Electric-lead acid or NiMH	Minivan	ZEV
Minivan	E-85	Minivan	N/A
Ram Wagon	CNG dedicated	Large van	ULEV/ILEV/SULEV
Ram Van	CNG dedicated	Large van	ULEV/ILEV/SULEV
Ford: 1-877-ALT-FUEL			
Ranger	Electric-lead acid	Standard pickup	ZEV
Ranger	E-85 flex-fuel	Standard pickup	TLEV
Contour (QVM)	CNG bi-fuel	Compact	TLEV
Crown Victoria	CNG dedicated	Large car	ULEV/ILEV
Econoline	CNG dedicated	Full-size van	ULEV/ILEV/SULEV
F-Series	CNG dedicated or CNG/LPG bi-fuel	Standard pickup	LEV/ULEV/ILEV/SULEV
Taurus	E-85 flex-fuel	Large car	TLEV
Th!nk (select markets)	Electric-NiCd	Two-seater	ZEV
General Motors: 1-800-25Electric, 313-556-7723 or 1-888-GM-AFT-4U (CNG)			
EV1 (CA and AZ only)	Electric-lead acid or NiMH	Two-seater	ZEV
Chevrolet S-10	Electric-lead acid or NiMH	Small pickup	ILEV/ZEV
Chevrolet S-10	E85 flex-fuel	Small pickup	LEV
Chevrolet Cavalier	CNG bi-fuel	Subcompact	LEV
Honda: 1-888-CCHonda			
Insight	Hybrid EV-NiMH	Two-seater	LEV/ULEV
Civic GX (CA, NY fleets only)	CNG dedicated	Subcompact	ILEV/ULEV
Mazda: 1-800-222-5500			
B3000	E85 flex fuel	Standard pickup	LEV/TLEV
Nissan: 1-310-771-3422			
Altra EV (CA fleets only)	Electric lithium-ion	Mid-size wagon	ZEV
Solectria Corporation: 1-508-658-2231			
Flash	Electric-lead acid	Small pickup truck	ZEV
Force	Electric-lead acid, NiMH, NiCd	Compact	ZEV
Toyota: 1-800-331-4331 (Press 3 for Alternative Fuel Information) (Fleet sales only)			
RAV4-EV (select markets)	Electric-lead acid, NiMH	Sports utility vehicle	ZEV
Camry	CNG dedicated	Compact	N/A
Prius (Summer 2000)	Hybrid EV	Compact	SULEV

Source:

U.S. Department of Energy, National Alternative Fuels Data Center, web site, www.afdc.doe.gov/pdfs/my00.pdf, November 1999.
(Additional resources: 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.

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, 1999

State	M85 sites	CNG sites	E85 sites	LPG sites	LNG sites	Electric sites	Total
Alabama	0	16	0	151	2	0	169
Alaska	0	0	0	12	0	0	12
Arizona	1	28	0	81	3	46	159
Arkansas	0	6	0	133	0	0	139
California	36	208	0	517	9	336	1106
Colorado	0	44	1	93	2	0	140
Connecticut	0	27	0	48	0	1	76
Delaware	0	6	0	2	0	0	8
District of Columbia	0	4	0	0	0	1	5
Florida	1	43	0	109	1	5	159
Georgia	0	70	0	80	2	29	181
Hawaii	0	0	0	24	0	3	28
Idaho	0	7	1	29	0	1	38
Illinois	0	24	5	65	0	2	96
Indiana	0	38	1	46	3	1	89
Iowa	0	5	5	69	0	1	80
Kansas	0	6	1	123	1	0	131
Kentucky	0	9	2	24	0	0	35
Louisiana	0	15	0	25	0	0	40
Maine	0	1	0	57	0	0	58
Maryland	0	27	0	18	2	1	48
Massachusetts	0	17	0	69	0	4	90
Michigan	0	32	2	267	1	7	309
Minnesota	0	15	11	82	1	0	109
Mississippi	0	3	0	63	0	0	66
Missouri	0	10	4	295	0	0	309
Montana	0	11	1	56	1	0	69
Nebraska	0	6	6	44	0	0	57
Nevada	0	18	0	56	0	0	74
New Hampshire	0	2	0	68	0	1	71
New Jersey	0	22	0	25	0	0	47
New Mexico	0	14	0	243	1	0	258
New York	12	57	0	98	0	6	173
N. Carolina	0	9	0	94	0	7	110
N. Dakota	0	4	2	14	0	0	20
Ohio	0	49	0	57	1	1	108
Oklahoma	0	61	0	34	0	0	95
Oregon	0	9	0	30	1	0	40
Pennsylvania	0	59	0	100	1	1	161
Rhode Island	0	4	0	9	0	0	13
S. Carolina	0	4	0	74	0	1	79
S. Dakota	0	4	6	29	0	0	39
Tennessee	0	5	0	36	0	2	43
Texas	0	73	0	231	8	2	314
Utah	0	62	0	22	1	0	85
Vermont	0	1	0	62	0	7	70
Virginia	0	27	0	40	3	18	88
Washington	1	28	0	88	1	6	124
W. Virginia	0	39	0	14	0	0	53
Wisconsin	0	20	1	112	0	0	133
Wyoming	0	18	0	35	1	0	54
Total	51	1,267	49	4,153	46	490	6,058

Source:

U.S. Department of Energy, Alternative Fuels Data Center web site, www.afdc.doe.gov/refuel/state_tot.shtml, January 2000.

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 12/1/99 by Designation

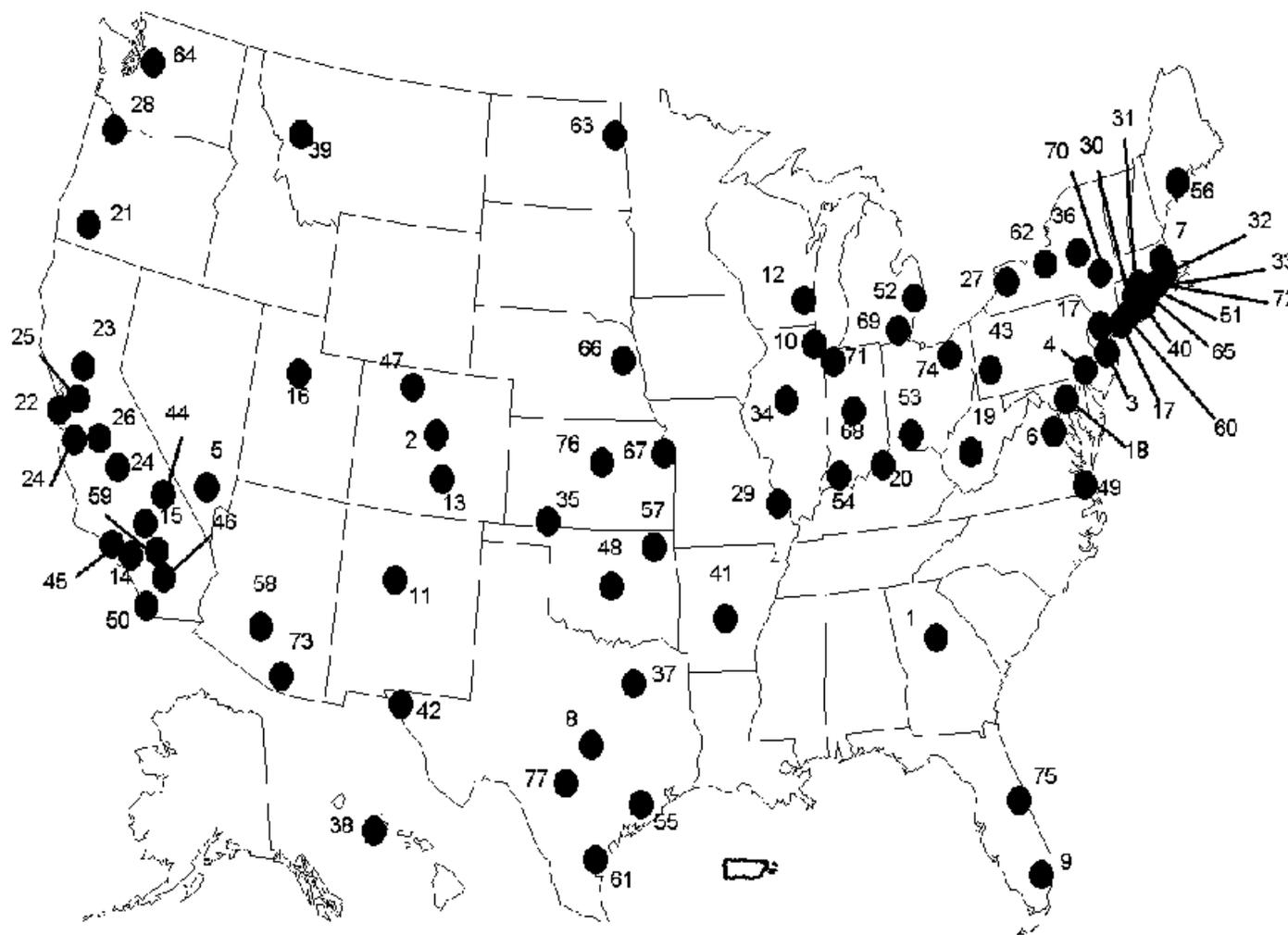
1. Atlanta, GA - 9/8/93	40. New Haven, CT - 10/5/95
2. Denver, CO - 9/13/93	41. Central Arkansas - 10/25/95
3. Philadelphia, PA - 9/22/93	42. Paso Del Norte - 11/17/95
4. State of Delaware - 10/12/93	43. Pittsburgh, PA - 12/5/95
5. Las Vegas, NV - 10/18/93	44. S. California Assn. Gov. - 3/1/96
6. Washington, DC - 10/21/93	45. Los Angeles, CA - 3/22/96
7. Boston, MA - 3/18/94	46. Coachella Valley, CA - 4/22/96
8. Austin, TX - 4/18/94	47. Weld/Larimer/Rocky Mountain National Park - 5/21/96
9. Florida Gold Coast - 5/3/94	48. Central Oklahoma - 5/29/96
10. Chicago, IL - 5/13/94	49. Hampton Roads, VA - 10/4/96
11. Land of Enchantment, NM - 6/1/94	50. San Diego, CA - 12/12/96
12. Wisconsin - SE Area - 6/30/94	51. Long Island, NY - 10/18/96
13. Colorado Springs, CO - 7/13/94	52. Detroit, MI/Toronto, ON - 12/18/96
14. Long Beach, CA - 8/31/94	53. Cincinnati, OH - 1/29/97
15. Lancaster, CA - 9/22/94	54. Evansville, IN - 1/30/97
16. Salt Lake City, UT - 10/3/94	55. Houston-Galveston, TX - 9/4/97
17. White Plains, NY - 10/4/94	56. Portland, ME - 9/4/97
18. Baltimore, MD - 10/7/94	57. Tulsa, OK - 9/22/97
19. State of WV - 10/18/94	58. Maricopa Assn. of Govts. - 10/8/97
20. Commonwealth CC Partnership, KY - 10/18/94	59. Riverside, CA - 10/24/97
21. Rogue Valley, OR - 11/10/94	60. North Jersey, NJ - 10/31/97
22. San Francisco, CA - 10/21/94	61. Texas Coastal (Corpus Christi), TX - 3/30/98
23. Sacramento, CA - 10/21/94	62. Genesee Region (Rochester), NY - 5/28/98
24. South Bay (San Jose), CA - 10/21/94	63. Red River Valley/Grand Forks, ND - 8/10/98
25. East Bay, CA - 10/21/94	64. Puget Sound, WA - 8/13/98
26. San Joaquin Valley, CA - 10/21/94	65. RI - Ocean States - 9/14/98
27. Western New York - 11/4/94	66. Omaha, NE - 9/18/98
28. Columbia-Willamette, OR - 11/10/94	67. Kansas City, KS/MO - 11/18/98
29. St. Louis, MO - 11/18/94	68. Central Indiana CC Alliance, IN - 3/4/99
30. Waterbury, CT - 11/21/94	69. Ann Arbor, MI - 4/19/99
31. Connecticut Southwestern Area, - 11/21/94	70. Capital District (Albany), NY - 4/26/99
32. Norwich, CT - 11/22/94	71. South Shore, IN - 6/15/99
33. New London, CT - 11/22/94	72. Capital Clean Cities of CT - 6/21/99
34. Peoria, IL - 11/22/94	73. Tuscon, AZ - 8/24/99
35. Kansas - SW Area - 3/30/95	74. NE Clean Fuels Coalition (Cleveland) - 9/14/99
36. Central New York - 6/15/95	75. Florida Space Coast - 10/1/99
37. Dallas/Ft. Worth, TX - 7/25/95	76. Manhattan Area, KS - 10/4/99
38. Honolulu, HI - 8/29/95	77. The Alamo Area (San Antonio) - 11/10/99
39. Missoula, MT - 9/21/95	

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 2000.
(Additional resources: www.cities.doe.gov)

Figure 9.1 Map of Clean Cities as of 12/1/99



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 2000. (Additional resources: www.cities.doe.gov)

Electric and hybrid-electric vehicles are required to be sold in California under the California Low-Emission Vehicle (LEV) program. Other states, such as New York, Texas, and Massachusetts, have indicated that they will also enforce the LEV program. 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 (Daimler-Chrysler, Ford, General Motors), the Electric Power Research Institute, and the U.S. Department of Energy.

Table 9.7
U.S. Advanced Battery Consortium Goals for Electric Vehicle Batteries

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

Additional information about USABC is available at: www.uscar.org/techno/store.htm.

^aFor interim commercialization (Reflects USABC revisions of September 1996).

^bSpecifics on criteria can be found in "USABC Electric Vehicle Battery Test Procedures Manual Revision 2" DOE/ID-10479, Rev. 2, January 1996.

^cCost to the Original Equipment Manufacturers.

^dRoundtrip charge/discharge efficiency.

The Partnership for a New Generation of Vehicles (PNGV) is an historic public/private partnership between the U.S. federal government (led by the Technology Administration at the Department of Commerce, and including 7 agencies and 19 federal laboratories) and DaimlerChrysler, Ford, and General Motors that aims to strengthen America's competitiveness by developing technologies for a new generation of vehicles.

PNGV's long term goal is to develop an environmentally friendly car with up to triple the fuel efficiency of today's midsize cars-- without sacrificing affordability, performance, or safety. Two other PNGV goals are to significantly improve national competitiveness in automotive manufacturing and to apply commercially viable innovation to conventional vehicles.

Table 9. 8
PNGV Goals and Specifications of Hybrid-Electric Vehicles

Parameter	PNGV Goals	PNGV Concept Vehicles				Toyota Prius	Honda Insight
		Dodge ESX3	Ford Prodigy	GM Precept			
Fuel economy	up to 80 mpg (3x current mpg)	72 mpg gas equiv. 80 mpg diesel ^a	72 mpg gas equiv. 80 mpg diesel ^a	80 mpg gas equiv. 90 mpg diesel ^a	56 mpg gas	64 mpg gas	
Range	380 miles	400 miles	660 miles	380 miles	550 miles	600 miles	
Acceleration (0–60 mph)	12.0 seconds	11.0 seconds	12.0 seconds	11.5 seconds	14.1 seconds	12.0 seconds	
Emissions	Default Tier 2	Target is Tier 2	Target is Tier 2	Target is Tier 2	SULEV	ULEV	
Aerodynamics	0.20 Cd	0.22 Cd	0.199 Cd	0.163 Cd	0.30 Cd	0.25 Cd	
Curb weight	1,980 lbs.	2,250 lbs.	2,387 lbs.	2,592 lbs.	2,734 lbs.	1,856 lbs.	
Passenger capacity	Up to 6	5	5	5	5	2	
Dimensions: Length		192.8 in.	186.9 in.	193.2 in.	168.3 in.	155.1 in.	
Width		74.2 in.	69.1 in.	67.9 in.	66.7 in.	66.7 in.	
Cargo Capacity	16.8 ft ³	16.0 ft ³	14.6 ft ³	4.4 ft ³	10.0 ft ³	7.0 ft ³	
Safety	Meet FMVSS ^b	Meet FMVSS ^b	Meet FMVSS ^b	Meet FMVSS ^b	Meet FMVSS ^b	Meet FMVSS ^b	

Source:

Partnership for a New Generation of Vehicles, Media Information, 2000. (Additional resources: www.ta.doc.gov/pngv/cover/pngvcover.htm)

^aFuel economy for Dodge using “Designer” diesel (0 ppm sulfur); Ford using Swedish clean diesel (<10 ppm sulfur); GM using California low-sulfur diesel (<30 ppm sulfur).

^bFederal Motor Vehicle Safety Standards.