Chapter 6
Alternative Fuel and Advanced Technology Vehicles and Characteristics

Summary Statistics from Tables in this Chapter

Source		
Table 6.1	Alternative fuel vehicles in use, 2005 estimates	592,122
	LPG	*173,795*
	CNG	*117,699*
	E85[a]	*246,363*
	Electric	*51,398*
	M85	*0*
	LNG	*2,748*
Table 6.4	Number of alternative fuel refuel sites, 2008	5,648
	LPG	*2,290*
	CNG	*790*
	Biodiesel	*651*
	Electric	*435*
	Hydrogen	*33*

Fuel type abbreviations are used throughout this chapter.

B20	=	*20% biodiesel, 80% petroleum diesel*
CNG	=	*compressed natural gas*
E85	=	*85% ethanol, 15% gasoline*
E95	=	*95% ethanol, 5% gasoline*
H_2	=	*hydrogen*
LNG	=	*liquified natural gas*
LPG	=	*liquified petroleum gas*
M85	=	*85% methanol, 15% gasoline*
M100	=	*100% methanol*

[a]Does not include flex-fuel vehicles.

Alternative Fuels

The Energy Policy Act of 1992 defines alternative fuels and allows the U.S. Department of Energy (DOE) to add to the list of alternative fuels if the fuel is substantially nonpetroleum, yields substantial energy security benefits, and offers substantial environmental benefits. DOE currently recognizes the following as alternative fuels:

- methanol, ethanol, and other alcohols,
- blends of 85% or more of alcohol with gasoline,
- natural gas and liquid fuels domestically produced from natural gas,
- liquefied petroleum gas (propane),
- coal-derived liquid fuels
- hydrogen and electricity
- biodiesel,
- P-series.

Alternative Fuels & Advanced Vehicles Data Center

DOE established the Alternative Fuels Data Center (AFDC) in 1991 to support its work aimed at fulfilling the Alternative Motor Fuels Act directives. Since then, the AFDC has exp anded its focus to include all advanced transportation fuels, vehicles, and technologies. It has been renamed the Alternative Fuels & Advanced Vehicles Data Center to reflect this broader scope. 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.

Much of the AFDC data can be obtained through their web site: **www.eere.energy.gov/afdc**. Several tables and graphs in this chapter contain statistics which were generated by the AFDC. Below are some links to specific areas of the AFDC website.

Alternative & Advanced Fuels - www.eere.energy.gov/afdc/fuels/index.html

Alternative Fueling Station Locator - www.eere.energy.gov/afdc/fuels/stations_locator.html

Alternative & Advanced Vehicles - www.eere.energy.gov/afdc/vehicles/index.html

Fleet Information - www.eere.energy.gov/afdc/fleets/index.html

State & Federal Incentives & Laws - www.eere.energy.gov/afdc/incentives_laws.html

Data Analysis & Trends - www.eere.energy.gov/afdc/data/index.html

The 2005 data are the latest released by the Energy Information Administration.

Table 6.1
Estimates of Alternative Fuel Vehicles in Use[a], 1992–2005

Year	LPG	CNG	LNG	M85	M100	E85 [b]	E95	Electricity	Hydrogen [c]	Total
1995	172,806	50,218	603	18,319	386	1,527	136	2,860	0	**246,855**
1996	175,585	60,144	663	20,265	172	4,536	361	3,280	0	**265,006**
1997	175,679	68,571	813	21,040	172	9,130	347	4,453	0	**280,205**
1998	177,183	78,782	1,172	19,648	200	12,788	14	5,243	0	**295,030**
1999	178,610	91,267	1,681	18,964	198	24,604	14	6,964	0	**322,302**
2000	181,994	100,750	2,090	10,426	0	87,570	4	11,830	0	**394,664**
2001	185,053	111,851	2,576	7,827	0	100,303	0	17,847	0	**425,457**
2002	187,680	120,839	2,708	5,873	0	120,951	0	33,047	0	**471,098**
2003	190,369	114,406	2,640	0	0	179,090	0	47,485	9	**533,999**
2004	182,864	118,532	2,717	0	0	211,800	0	49,536	43	**565,492**
2005	173,795	117,699	2,748	0	0	246,363	0	51,398	119	**592,122**
					Average annual percentage change					
1995-2005	0.1%	8.9%	16.4%	-10.8%	-100%	66.3%	-100%	33.5%		**9.1%**

Source:
U. S. Department of Energy, Energy Information Administration, Annual Energy Review, Table 10.4 Estimated Number of Alternative-Fueled Vehicles in Use and Replacement Fuel Consumption, 1992-2005, web site www.eia.doe.gov/emeu/aer/renew.html. (Additional resources: www.eere.energy.gov/afdc/data/vehicles.html)

[a] Vehicles in Use represent accumulated acquisitions, less retirements, as of the end of each calendar year. They do not include concept and demonstration vehicles.

[b] Includes only those E85 vehicles believed to be using E85. Primarily fleet-operated vehicles; excludes other vehicles with E85-fueling capability. In 1997, some vehicle manufacturers began including E85-fueling capability in certain model lines of vehicles. For total number of E85 vehicles on the road, see "E85 FFVs in Use."

[c] Excludes HEVs.

Table 6.2
Alternative Fuel Vehicles Available by Manufacturer, Model Year 2007

Model	Fuel	Type	Emission class
Daimler Chrysler: 1-800-999-FLEET; www.fleet.chrysler.com			
Chrysler Sebring	E85 flex fuel	Sedan	LEV 2, Tier-2 Bin 8A
Chrysler Aspen	E85 flex fuel	SUV	Tier-2 Bin 8A
Dodge Durango	E85 flex fuel	SUV	Tier-2 Bin 8A
Dodge Caravan	E85 flex fuel	Minivan	Tier-2 Bin 8A
Dodge Grand Caravan	E85 flex fuel	Minivan	Tier-2 Bin 8A
Chrysler Town & Country	E85 flex fuel	Minivan	Tier-2 Bin 8A
Dodge Dakota	E85 flex fuel	Pickup	Tier-2 Bin 8A
Dodge Ram 1500	E85 flex fuel	Pickup	Tier-2 Bin 10A
Jeep Grand Cherokee	E85 flex fuel	SUV	Tier-2 Bin 10A
Jeep Commander	E85 flex fuel	SUV	Tier-2 Bin 10A
Ford: 1-800-34-FLEET; www.fleet.ford.com; www.fordvehicles.com			
Crown Victoria	E85 flex fuel	Sedan	ULEV, Tier-2 Bin 5
Lincoln Town Car	E85 flex fuel	Sedan	ULEV, Tier-2 Bin 5
Mercury Grand Marquis	E85 flex fuel	Sedan	ULEV, Tier-2 Bin 5
Ford F-150	E85 flex fuel	Pickup	LEV, Tier-2 Bin 8A
General Motors: 1-800-25Electric, 313-556-7723 or 1-888-GM-AFT-4U (CNG)			
Chevrolet Impala	E85 flex fuel	Sedan	LEV2, Tier-2 Bin 5
Chevrolet Monte Carlo	E85 flex fuel	Sedan	LEV2, Tier-2 Bin 5
Chevrolet Tahoe	E85 flex fuel	SUV	LEV2, Tier-2 Bin 4
Chevrolet Police Tahoe	E85 flex fuel	SUV	LEV2, Tier-2 Bin 4
GMC Yukon	E85 flex fuel	SUV	LEV2, Tier-2 Bin 4
Chevrolet Suburban	E85 flex fuel	SUV	LEV2, Tier-2 Bin 4
GMC Yukon XL	E85 flex fuel	SUV	LEV2, Tier-2 Bin 4
Chevy Silverado	E85 flex fuel	Pickup	LEV2, Tier-2 Bin 8A
GMC Sierra	E85 flex fuel	Pickup	LEV2, Tier-2 Bin 8A
Chevy Avalanche	E85 flex fuel	Pickup	LEV2, Tier-2 Bin 8A
Chevy Express	E85 flex fuel	Van	LEV2, Tier-2 Bin 8A
GMC Savana	E85 flex fuel	Van	LEV2, Tier-2 Bin 8A
Chevrolet Uplander	E85 flex fuel	Minivan	LEV2, Tier-2 Bin 5
Buick Terraza	E85 flex fuel	Minivan	LEV2, Tier-2 Bin 5
Honda: 1-888-CCHonda; www.honda.com			
Civic GX	CNG dedicated	Sedan	ILEV, AT-PZEV, Tier 2 Bin 2
Mercedes-Benz USA: 800-FOR-MERCEDES; www.mbusa.com			
C230 Sport Sedan	E85 flex fuel	Sedan	ULEV
Nissan: 1-800-NISSAN-1; www.nissanusa.com			
Armada	E85 flex fuel	SUV	LEV
Titan	E85 flex fuel	Pickup	LEV

Source:
U.S. Department of Energy, National Alternative Fuels Data Center, web site, www.eere.energy.gov/afdc/pdfs/my2007_afv_atv.pdf, April 2008. (Additional resources: www.eere.energy.gov/afdc/progs_vehicles_search.php)

Note: LEV=low emission vehicle. ILEV=inherently low emission vehicle. ULEV=ultra low emission vehicle. ZEV=zero emission vehicle. TLEV=transitional low emission vehicle. SULEV=super ultra low emission vehicle. See Chapter 12 for details on emissions.

Table 6.3
Hybrid Electric Vehicles Available by Manufacturer, Model Year 2007

Model	Battery Type[a]	Type	Emission class
Ford: 1-800-34-FLEET; www.fleet.ford.com; www.fordvehicles.com			
Ford Escape Hybrid	NiMH	SUV	SULEV 2, AT-PZEV
Mercury Mariner	NiMH	SUV	SULEV 2, AT-PZEV
General Motors: 1-800-25Electric, 313-556-7723 or 1-888-GM-AFT-4U (CNG)			
Chevrolet Silverado	PbA	Pickup	SULEV
GMC Sierra	PbA	Pickup	SULEV
Saturn VUE Green Line	NiMH (Mild hybrid)	SUV	ULEV 2, Tier-2 Bin 5
Honda: 1-888-CCHonda; www.honda.com			
Accord Hybrid	NiMH	Sedan	ULEV, AT-PZEV
Civic Hybrid	NiMH	Sedan	SULEV, AT-PZEV
Lexus: 800-255-3987; www.lexus.com			
GS 450h	NiMH	Sedan	SULEV
RX 400h	NiMH	SUV	SULEV
Nissan: 1-800-NISSAN-1; www.nissanusa.com			
Altima	NiMH	Sedan	AT-PZEV
Toyota: 1-800-GO-Toyota; www.toyota.com			
Prius	NiMH	Sedan	SULEV, AT-PZEV, Tier-2 Bin 3
Camry	NiMH	Sedan	AT-PZEV
Highlander	NiMH	SUV	SULEV

Source:
U.S. Department of Energy, National Alternative Fuels Data Center, web site, www.eere.energy.gov/afdc/pdfs/my2007_afv_atv.pdf, April 2008. (Additional resources: www.eere.energy.gov/afdc/progs_vehicles_search.php)

Note: LEV = low emission vehicle; ILEV = inherently low emission vehicle; ULEV = ultra low emission vehicle; ZEV = zero emission vehicle; TLEV = transitional low emission vehicle; SULEV = super ultra low emission vehicle; AT-PZEV = avanced technology - partial zero emissions vehicle. See Chapter 12 for details on emissions.

[a] NiMH = Nickel-Metal Hydride; PbA = Lead-Acid; Mild hybrid = A vehicle that shuts down the engine when coasting, breaking or stopped while continuing to power accessories. There is however, no electric drivetrain like that found on a full hybrid vehicle.

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

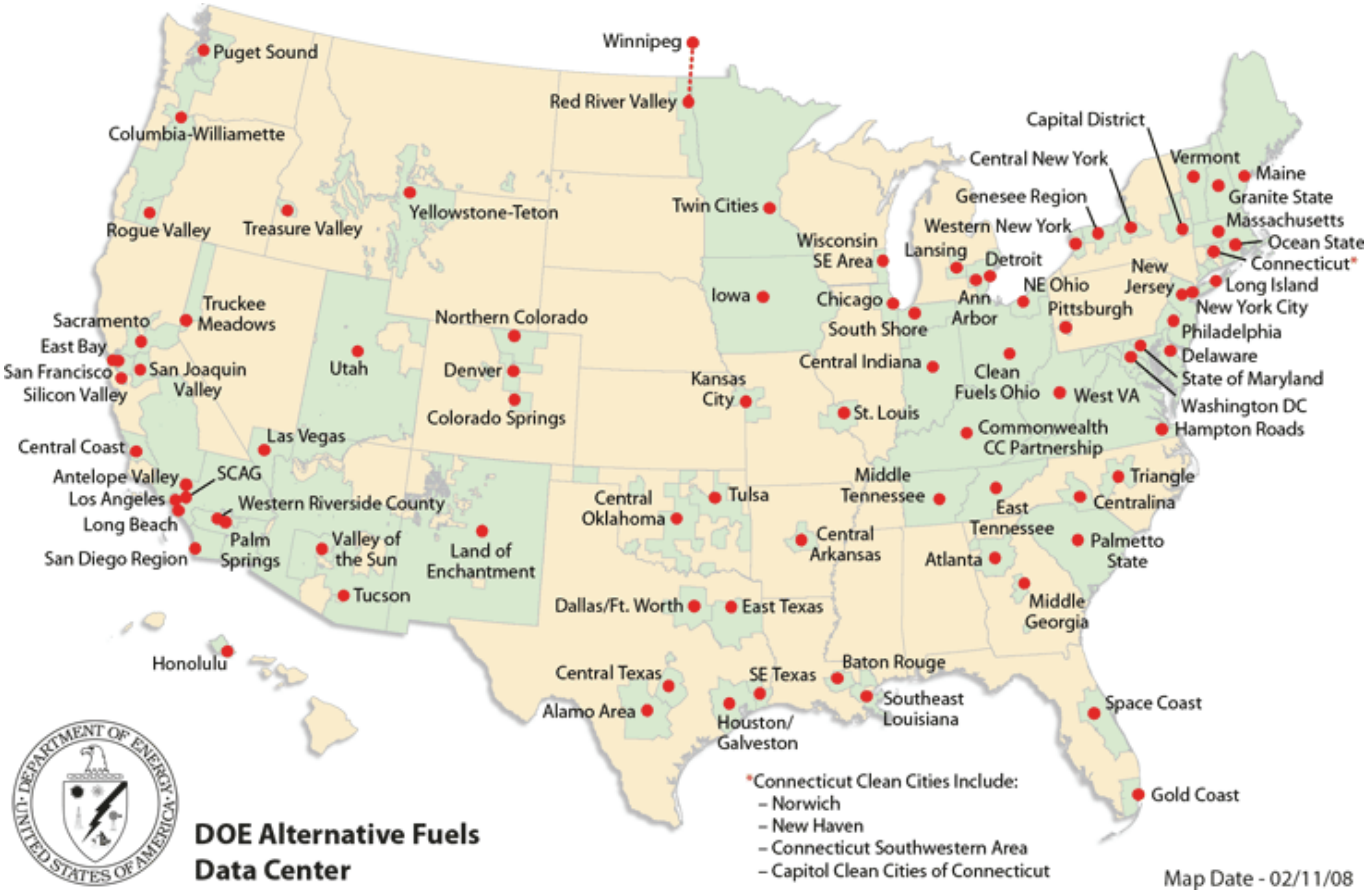
Table 6.4
Number of Alternative Refuel Sites by State and Fuel Type, 2008

State	CNG sites	E85 site	LPG sites	Electric sites	Biodiesel sites	Hydrogen sites	LNG sites	Total
Alabama	3	4	46	0	13	0	0	66
Alaska	1	0	10	0	0	0	0	11
Arizona	39	14	54	12	9	1	3	132
Arkansas	3	4	40	0	1	0	0	48
California	189	7	206	370	35	23	29	859
Colorado	20	47	55	2	30	0	0	154
Connecticut	9	2	16	3	1	0	0	31
Delaware	1	1	3	0	3	0	0	8
Dist. of Columbia	1	3	0	0	1	1	0	6
Florida	17	11	49	2	12	1	0	92
Georgia	19	11	39	0	27	0	0	96
Hawaii	0	0	3	4	7	1	0	15
Idaho	7	5	27	0	4	0	1	44
Illinois	7	175	54	0	4	0	0	240
Indiana	15	98	32	0	7	0	0	152
Iowa	0	88	24	0	6	0	0	119
Kansas	3	22	46	0	4	0	0	75
Kentucky	0	8	16	0	1	0	0	25
Louisiana	10	1	11	0	2	0	0	24
Maine	1	0	8	0	2	0	0	11
Maryland	15	8	15	0	7	0	0	45
Massachusetts	11	0	23	18	7	0	0	59
Michigan	14	52	79	2	17	0	0	164
Minnesota	1	334	31	0	1	0	0	367
Mississippi	0	1	36	0	5	0	0	42
Missouri	7	70	75	0	8	0	0	160
Montana	3	2	31	0	4	0	0	40
Nebraska	2	31	19	0	5	0	0	57
Nevada	11	6	28	1	14	1	0	60
New Hampshire	3	1	11	9	13	0	0	37
New Jersey	11	0	10	0	0	0	0	21
New Mexico	10	6	52	0	5	0	0	73
New York	98	8	28	1	9	0	0	144
North Carolina	11	12	50	0	69	0	0	142
North Dakota	4	24	14	0	0	0	0	42
Ohio	11	48	68	0	17	0	0	144
Oklahoma	50	4	68	1	8	0	0	130
Oregon	13	7	31	8	35	0	0	94
Pennsylvania	29	14	70	0	36	1	0	120
Rhode Island	7	0	4	2	0	0	0	13
South Carolina	3	55	27	1	72	0	0	158
South Dakota	0	68	17	0	0	0	0	85
Tennessee	4	12	52	0	50	0	0	118
Texas	15	33	525	1	55	0	2	631
Utah	60	4	23	0	6	0	0	93
Vermont	1	0	5	1	5	1	0	13
Virginia	9	4	21	1	13	1	0	49
Washington	13	7	55	0	34	0	0	109
West Virginia	2	3	7	0	0	0	0	12
Wisconsin	19	93	45	0	3	0	0	160
Wyoming	8	5	31	0	14	0	0	58
Totals by Fuel:	790	1,413	2,290	435	651	33	35	5,648

Source:
U.S. Department of Energy, Alternative Fuels Data Center web site,
www.eere.energy.gov/afdc/infrastructure/station_counts.html, March 2008.

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.

Figure 6.1. Clean Cities Coalitions



Source:
U.S. Department of Energy, Alternative Fuel Data Center, February 2008. (Additional resources: www.eere.energy.gov/cleancities)

Vehicle Technologies Program

www.eere.energy.gov/vehiclesandfuels

The Vehicle Technologies Program is administered by the Department of Energy's Office of Energy Efficiency and Renewable Energy. The mission of this program is to develop more energy efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum. The long-term aim is to develop "leap frog" technologies that will provide Americans with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment. For additional information about the Vehicle Technologies Program, visit the website listed above.

Hydrogen Analysis Resource Center

hydrogen.pnl.gov/cocoon/morf/hydrogen

The Hydrogen Analysis Resource Center was developed to provide reliable data and information for hydrogen-related analytical activities. The Center's website includes:

- Hydrogen Data Book - contains a wide range of factual information on hydrogen and fuel cells. hydrogen.pnl.gov/cocoon/morf/hydrogen/article/103
- Related Sites - provides links other sites with data relevant to hydrogen and fuel cell analysis.
- Guidelines and Assumptions for DOE Hydrogen Program Analysis - contains guidelines for conducting analysis (under development) and assumptions.
- Calculator Tools - provides tools to perform conversions of hydrogen and other calculations relevant to hydrogen and fuel cells.
- Analysis Tools - provides links to models and other tools relevant to hydrogen and fuel cells, such as H2A, GREET, PSAT, VISION, MOVES, and other transportation and energy models.

In 1999 (the latest year for which data are available) the U.S. accounted for about 20% of world hydrogen consumption. Ammonia producers made up 61% of World hydrogen consumption, but only 38% of U.S. hydrogen consumption.

Table 6.5
U.S. and World Hydrogen Consumption by End-Use Category, 1999

	United States		World total		U.S. share of World total
	(trillion cubic feet)	(share)	(trillion cubic feet)	(share)	
Captive users:					
Ammonia producers	1.185	38%	9.662	61%	12%
Oil refiners[a]	1.164	37%	3.721	23%	31%
Methanol producers	0.303	10%	1.428	9%	21%
Other	0.121	4%	0.482	3%	25%
Merchant users	0.379	12%	0.570	4%	67%
Total	3.153	100%	15.864	100%	20%

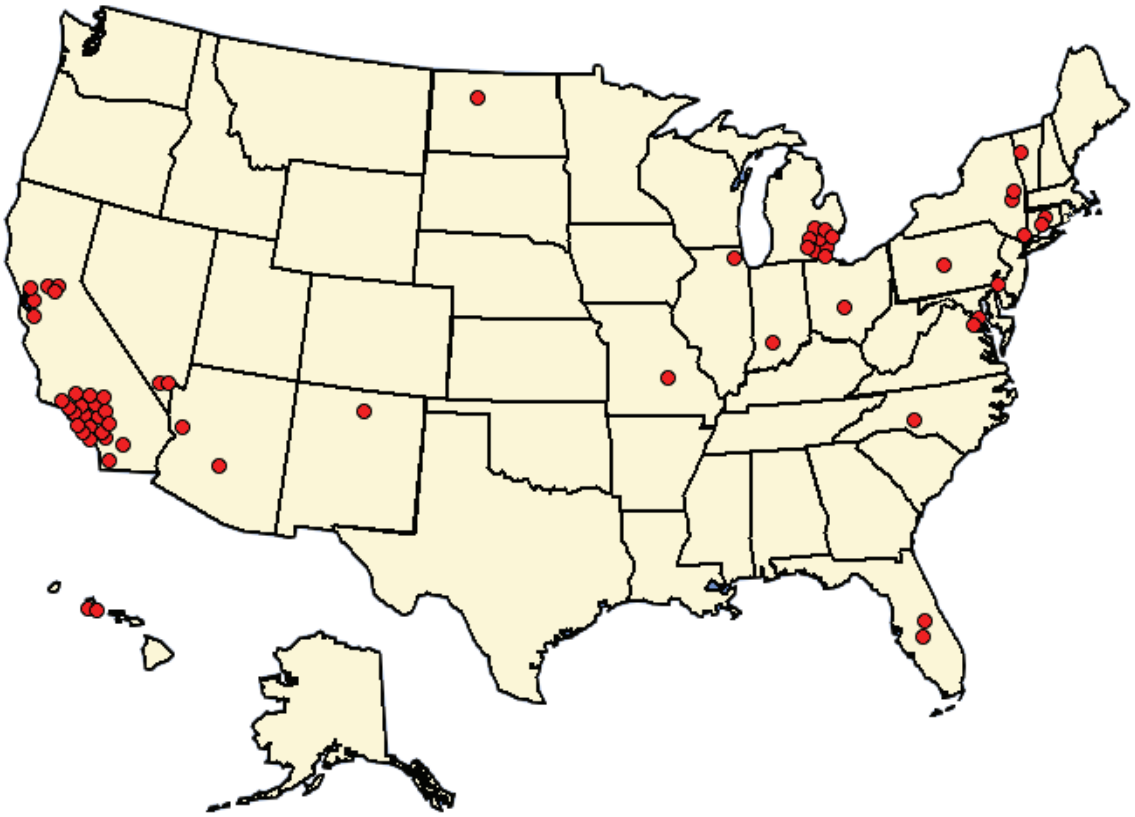
Source:
SRI Consulting, *Chemical Economics Handbook 2001*, Menlo Park, CA, July 2001.

Note: Captive users consume hydrogen at the site where it is produced. Merchant users consume hydrogen at sites other than where it is produced.

[a] Excluding byproduct hydrogen.

Hydrogen refueling stations are still in the developmental stage and most are used to support test projects, often with fleet vehicles. The majority are concentrated in California with smaller concentrations of hydrogen stations around the Detroit area and along the East Coast.

Figure 6.2. Operational Hydrogen Refueling Stations, January 2008



Source:
U.S. Department of Energy, Hydrogen Analysis Resource Center, Hydrogen Energy Data Book, Operational Hydrogen Fueling Stations, January 2008.

Note: To see more detail on each of the sites displayed on the map, visit: http://hydrogen.pnl.gov/filedownloads/hydrogen/datasheets/Operational_Hydrogen_Fueling_Stations.xls

Table 6.6
Properties of Conventional and Alternative Fuels

Property	Gasoline	No. 2 diesel	Methanol	Ethanol
Chemical formula	C_8 to C_{12}	C_3 to C_{25}	CH_3OH	C_2H_5OH
Physical state	Liquid	Liquid	Liquid	Liquid
Molecular weight	100–105	≈200	32.04	46.07
Composition (weight %)				
Carbon	85–88	87	37.5	52.2
Hydrogen	12–15	13	12.6	13.1
Oxygen	0	0	49.9	34.7
Main fuel source(s)	Crude oil	Crude oil	Natural gas, coal, or woody biomass	Corn, grains, or agricultural waste
Specific gravity (60˚ F/ 60˚ F)	0.72–0.78	0.85	0.796	0.796
Density (lb/gal @ 60˚ F)	6.0–6.5	7.079	6.63	6.61
Boiling temperature (F˚)	80–437	356–644	149	172
Freezing point (F˚)	-40	-40–30	-143.5	-173.2
Autoiginition temperature (F˚)	495	≈600	867	793
Reid vapor pressure (psi)	8–15	<0.2	4.6	2.3

Property	Propane	CNG	Hydrogen
Chemical formula	C_3H_8	CH_4	H_2
Physical state	Compressed gas	Compressed gas	Compressed gas or liquid
Molecular weight	44.1	16.04	2.02
Composition (weight %)			
Carbon	82	75	0
Hydrogen	18	25	100
Oxygen	n/a	n/a	0
Main fuel source	Underground reserves	Underground reserves	Natural gas, methanol, and other energy sources
Specific gravity (60˚ F/ 60˚ F)	0.508	0.424	0.07
Density (lb/gal @ 60˚ F)	4.22	1.07	n/a
Boiling temperature (F˚)	-44	-263.2 to -126.4	-423
Freezing point (F˚)	-305.8	-296	-435
Autoiginition temperature (F˚)	842	900–1,170	932
Reid vapor pressure (psi)	208	2,400	n/a

Source:
Alternative Fuels Data Center, "Properties of Fuel," www.eere.energy.gov/afdc/pdfs/fueltable.pdf and "Fuel Comparison," www.eere.energy.gov/afdc/fuels/properties.html, April 2008.

Note: n/a = not applicable.