Alternative Fuels Data Center
Fuel Properties Comparison

Clean Cities and Communities

	Gasoline/E10	Low Sulfur Diesel	Biodiesel	Renewable Diesel	Propane (LPG)	Compressed Natural Gas (CNG)	Liquefied Natural Gas (LNG)	Ethanol/E100	Methanol	Hydrogen	Electricity
Chemical Structure [1]	C_4 to C_{12} and Ethanol ≤ to 10%	C_8 to C_{25}	Methyl esters of C_{12} to C_{22} fatty acids	C_8 to C_{25}	C_3H_8 (majority) and C_4H_{10} (minority)	CH_4 (majority), C_2H_6 and inert gases	CH_4 same as CNG with inert gasses <0.5% (a)	CH_3CH_2OH	CH_3OH	H_2	N/A
Fuel Material (feedstocks)	Crude Oil	Crude Oil	Fats and oils from sources such as soybeans, waste cooking oil, animal fats, and rapeseed	Fats, oils, and greases (including used cooking oil)	A by-product of petroleum refining or natural gas processing	Underground reserves and renewable biogas	Underground reserves and renewable biogas	Corn, grains, or agricultural waste (cellulose)	Natural gas, coal, or woody biomass	Natural gas, methanol, and electrolysis of water	Natural gas, coal, nuclear, wind, hydro, solar, and small percentages of geothermal and biomass
Gasoline or Diesel Gallon Equivalent (GGE or DGE)	1 gal = 1.00 GGE 1 gal = 0.88 DGE	1 gal = 1.12 GGE 1 gal = 1.00 DGE	*B100* 1 gal = 1.05 GGE 1 gal = 0.93 DGE *B20* 1 gal = 1.11 GGE 1 gal = 0.99 DGE	RD 100 1 gal = 1.08 GGE 1 gal = 0.96 DGE	1 gal = 0.74 GGE 1 gal = 0.66 DGE	1 lb. = 0.18 GGE 1 lb. = 0.16 DGE	1 lb. = 0.19 GGE 1 lb. = 0.17 DGE	1 gal = 0.67 GGE 1 gal = 0.59 DGE	1 gal = 0.50 GGE 1 gal = 0.45 DGE	1 lb. = 0.45 GGE 1 lb. = 0.40 DGE 1 kg = 1 GGE 1 kg = 0.9 DGE	1 kWh = 0.030 GGE 1 kWh = 0.027 DGE
Energy Comparison [2]	1 gallon of gasoline has 97%–100% of the energy in 1 GGE. Standard fuel is 90% gasoline, 10% ethanol.	1 gallon of diesel has 113% of the energy in 1 GGE due to the higher energy density of diesel fuel.	1 gallon of B100 has 93% of the energy in 1 DGE, and 1 gallon of B20 has 99% of the energy in 1 DGE due to a lower energy density in biodiesel.	1 gallon of RD100 has 96% of the energy of 1 DGE due to slightly lower energy density in renewable diesel.	1 gallon of propane has 73% of the energy in 1 GGE due to the lower energy density of propane.	5.66 lb., or 123.57 ft^3, of CNG has the same energy as 1 GGE, and 6.37 lb., or 139.30 ft^3, of CNG has the same energy as 1 DGE. [3][4](b)	5.37 lb. of LNG has the same energy as 1 GGE, and 6.06 lb. of LNG has the same energy as 1 DGE. (a)	1 gallon of E85 contains 73%–83% of the energy in 1 GGE. 1 gallon of E100 has 67% of the energy in 1 GGE. Ethanol is blended with blendstock for oxygenate blending (gasoline component). [5]	1 gallon of methanol contains 50% of the energy as 1 GGE.	2.2 lbs. (1 kg) of H_2 has the same energy as 1 GGE.	A typical battery that is the same size as a gallon of gas (0.134 ft^3), when used for transportation, can store 15.3% of the energy in 1 GGE. [6][7]
Energy Content (lower heating value)	112,114–116,090 Btu/gal (c)	128,488 Btu/gal (c)	*B100* 119,550 Btu/gal *B20* 126,700 Btu/gal (c)	123,710 Btu/gal	84,250 Btu/gal (c)	20,160 Btu/lb [3](b)	21,240 Btu/lb (a)	76,330 Btu/gal for E100 (c)	57,250 Btu/gal (c)	51,585 Btu/lb (c) 33.3 kWh/kg	3,414 Btu/kWh

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Energy Content (higher heating value)	120,388–124,340 Btu/gal (c)	138,490 Btu/gal (c)	127,960 Btu/gal for B100 (c)	N/A	91,420 Btu/gal (c)	22,453 Btu/lb [1](c)	23,726 Btu/lb (c)	84,530 Btu/gal for E100 (c)	65,200 Btu/gal (c)	61,013 Btu/lb (c)	3,414 Btu/kWh
Physical State	Liquid	Liquid	Liquid	Liquid	Pressurized liquid (heavier than air as a gas)	Compressed gas (lighter than air)	Cryogenic liquid (lighter than air as a gas)	Liquid	Liquid	Compressed gas (lighter than air) or liquid	Electricity
Cetane Number	N/A	40–55 (d)	45–65 (d)	70–85	N/A	N/A	N/A	0–54 (e)	N/A	N/A	N/A
Pump Octane Number	84–93 (f)	N/A	N/A	N/A	105 (g)	120+ (h)	120+ (h)	110 (i)	112 (i)	130+ (g)	N/A
Flash Point	-45°F (j)	165°F (j)	266° to 338°F (d)	>125.6°F	-100° to -150°F (j)	-300°F (j)	-306°F (k)	55°F (j)	52°F (j)	N/A	N/A
Autoignition Temperature	495°F (j)	~600°F (j)	N/A	N/A	850° to 950°F (j)	1,004°F (j)	1,004°F (k)	793°F (j)	897°F (j)	1,050° to 1,080°F (j)	N/A
Maintenance Issues			Lubricity is improved over that of conventional low sulfur diesel fuel. For more maintenance information, see the Biodiesel Handling and Use Guidelines—Sixth Edition. (d)	Requires lubricity additive, like ultra-low-sulfur diesel		High-pressure tanks require periodic inspection and certification.	LNG is stored in cryogenic tanks with a specific hold time before the pressure build is relieved. The vehicle should be operated on a schedule to maintain a lower pressure in the tank.	Special lubricants may be required. Practices are very similar, if not identical, to those for conventionally fueled operations.	Special lubricants must be used as directed by the supplier as well as M85-compatible replacement parts. Can cause serious damage to organs in the body if swallowed, breathed in, or gotten on skin.	When hydrogen is used in fuel cell applications, maintenance should be very minimal. High-pressure tanks require periodic inspection and certification.	
Energy Security Impacts	Manufactured using oil. Transportation accounts for approximately 30% of total	Manufactured using oil. Transportation accounts for approximately 30% of total	Biodiesel is domestically produced, renewable, and reduces petroleum use	Renewable diesel is domestically produced, renewable, and reduces	Approximately half of U.S. LPG is derived from oil, but no oil is imported specifically for	CNG is domestically produced from natural gas and renewable	LNG is domestically produced from natural gas and renewable biogas. The United States	Ethanol is domestically produced. E85 reduces lifecycle petroleum use by 70%, and E10	Methanol is domestically produced, sometimes from renewable resources.	Hydrogen is domestically produced and can be produced from	Electricity is domestically produced from a wide range of sources, including

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	U.S. energy needs and 70% of petroleum consumption. (l)	U.S. energy needs and 70% of petroleum consumption. (l)	95% throughout its lifecycle. (m)	petroleum use 95% throughout its lifecycle.	LPG production.	biogas. The United States has vast natural gas reserves.	has vast natural gas reserves.	reduces petroleum use by 6.3%. (n)		renewable sources.	through coal-fired power plants and renewable sources, making it a versatile fuel.

Notes

[1] Standard chemical formulas represent idealized fuels. Some table values are expressed in ranges to represent typical fuel variations that are encountered in the field.
[2] GGE table values reflect Btu range for common gasoline baseline references (E0, E10, and indolene certification fuel).
[3] The type of meter or dispensing equipment being used to fuel vehicles must be taken into consideration. For fast-fill stations that dispense CNG with Coriolis flow meters, which measure fuel mass and report fuel dispensed on a GGE basis, the lbs./GGE factor should be used. For time-fill stations or other applications that use traditional residential and commercial gas meters that measure/register in units of cubic feet, the CF/GGE factor should be used.
[4] See Compressed Natural Gas Gasoline & Diesel Gallon Equivalency Methodology at http://afdc.energy.gov/fuels/equivalency_methodology.html.
[5] E85 is a high-level gasoline-ethanol blend containing 51% to 83% ethanol, depending on geography and season. Ethanol content is lower in the winter months in cold climates to ensure a vehicle starts. Based on composition, E85's lower heating value varies from 83,950 to 95,450 Btu/gal.
[6] Lithium-ion battery density of 400 Wh/l from Linden and Reddy, Handbook of Batteries, 3rd ed., McGraw-Hill, New York, 2002.
[7] Lithium-ion energy densities increased by a factor of 3.4, when used for transportation, to account for the increased efficiencies of electric vehicle drivetrains relative to the internal combustion engine.

Sources

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(c) Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model. 2023. Input Fuel Specifications. Argonne National Laboratory. Chicago, IL. https://greet.es.anl.gov/
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