Gasoline gallon equivalent

Gasoline gallon equivalent (**GGE**) or **gasoline-equivalent gallon** (**GEG**) is the amount of alternative fuel it takes to equal the energy content of one liquid gallon of gasoline. GGE allows consumers to compare the energy content of competing fuels against a commonly known fuel—gasoline. GGE also compares gasoline to fuels sold as a gas (natural gas, propane, hydrogen) and electricity.

In 1994, the US National Institute of Standards and Technology (NIST) defined "gasoline gallon equivalent (GGE) means 5.660 pounds of natural gas."[1] Compressed natural gas (CNG), for example, is a gas rather than a liquid. It can be measured by its volume in standard cubic feet (ft^3) (volume at atmospheric conditions), by its weight in pounds (lb) or by its energy content in joules (J) or British thermal units (BTU) or kilowatt-hours (kW·h). It is difficult to compare the cost of gasoline with other fuels if they are sold in different units. GGE solves this. One GGE of CNG and one GGE of electricity have exactly the same energy content as one gallon of gasoline. CNG sold at filling stations in the US is priced in dollars per GGE.

Using GGE to compare fuels for use in an internal combustion engine is only the first part of the equation whose bottom line is useful work. In the context of GGE, a real world kind of "useful work" is miles per gallon (MPG) as advertised by motor vehicle manufacturers.

Substituting one fuel for another in a given engine may start and may do useful work. However getting optimum efficiency from each fuel–engine combination requires adjusting the mix of air and fuel. This can be a manual adjustment using tools and test instruments or done automatically in computer-controlled fuel injected and multi-fuel vehicles. Fine tuning of the optimum fuel–air mix may be facilitated by using a supercharger or turbocharger.

In battery or electric vehicles, calculating efficiency of useful work begins with the charge–discharge rate of the battery pack, generally 80% to 90%. Next is the conversion of potential energy (BTU) of the charge to distance traveled under power. See table below translating retail electricity costs for a GGE in BTU.

Note that throughout this article, 'gallon' refers to the US gallon of approximately 3.8 litres, as opposed to the imperial gallon of approximately 4.5 litres

Gasoline gallon equivalent tables

GGE calculated for gasoline in US gallons at 114000 BTU per gallon,
or 7594 kilocalories per litre[2]

Fuel: liquid, US gallons	GGE	GGE %	BTU/gal	kWh/gal	HP-hr/gal	kcal/litre
Gasoline (base)[3]	**1.0000**	**100.00%**	**114,000**	**33.41**	**44.79**	**7594.0**
Gasoline (conventional, summer)[3]	0.9960	100.40%	114,500	33.56	44.99	7624.5
Gasoline (conventional, winter)[3]	1.0130	98.72%	112,500	32.97	44.20	7496.5
Gasoline (reformulated gasoline, E10 - ethanol)[3]	1.0190	98.14%	111,836	32.78	43.94	7452.4
Gasoline (reformulated gasoline, ETBE)[3]	1.0190	98.14%	111,811	32.77	43.93	7452.4
Gasoline (reformulated gasoline, MTBE)[3]	1.0200	98.04%	111,745	32.75	43.90	7445.1
Gasoline (10% MTBE)[4]	1.0200	98.04%	112,000	32.83	44.00	7445.1
Gasoline (regular unleaded)[5]	1.0000	100.00%	114,100	33.44	44.83	7594.0
Diesel #2[5]	0.8800	113.64%	129,500	37.95	50.87	8629.8
Biodiesel (B100)[5]	0.9600	104.17%	118,300	34.80	46.65	7880.5
Biodiesel (B20)[5]	0.9000	111.11%	127,250	37.12	49.76	8437.7
Liquid natural gas (LNG)[5]	1.5362	65.10%	75,000	21.75	29.16	4943.3
Liquefied petroleum gas (propane / autogas) (LPG)[5]	1.2470	80.19%	91,500	26.82	35.95	6089.8
Methanol fuel (M100)[5]	2.0100	49.75%	56,800	16.62	22.28	3778.1
Ethanol fuel (E100)[5]	1.5000	66.67%	76,100	22.27	29.85	5062.7
Ethanol (E85)[5]	1.3900	71.94%	81,800	24.04	32.23	5463.3
Jet fuel (naphtha)[6]	0.9700	103.09%	118,700	34.44	46.17	7828.9
Jet fuel (kerosene)[6]	0.9000	111.11%	128,100	37.12	49.76	8437.7
Nitromethane fuel	~2.3	41.23%	47,000			

GGE calculated on non-liquid fuels

Fuel: non-liquid	GGE	GGE %	BTU/unit	kWh/unit
Gasoline (base)[3][7]	**1.0000**	**100.00%**	**114,000 BTU/gal**	**33.41**
Compressed natural gas (CNG) at standard conditions [8]	126.67 cu ft (3.587 m^3)		20,268 BTU/lb	
Compressed natural gas (CNG) at 2400 psi (17 MPa)	0.77 cu ft (0.022 m^3)			
Hydrogen at 101.325 kPa	357.37 cu ft		319 BTU/cu ft[9]	
Hydrogen by weight	0.997 kg (2.198 lb)[10]		119.9 MJ/kg (51,500 BTU/lb)[11]	
Electricity	33.40 kilowatt-hours		3,413 BTU/(kW·h) [12][13]	33.40

Electricity costs for 1 GGE

1 GGE = 33.40 kWh	
For local rate per kWh	**$/gallon equivalent**
$0.03	$1.000
$0.04	$1.333
$0.05	$1.667
$0.06	$2.000
$0.07	$2.338
$0.08	$2.670
$0.09	$3.006
$0.10	$3.340
$0.11	$3.674
$0.12	$4.000
$0.13	$4.342
$0.14	$4.670
$0.15	$5.010
$0.16	$5.344
$0.17	$5.678
$0.18	$6.012
$0.19	$6.346
$0.20	$6.680
$0.25	$8.350
$0.27	$9.018
$0.28	$9.352
$0.29	$9.686
$0.30	$10.020

Rates per kWh for residential electricity in the USA range from $0.0728 (Idaho) to $0.166 (Alaska), $0.22 (San Diego Tier 1, while Tier 2 is $.40) and $0.2783 (Hawaii).[14][15]

Compressed natural gas

One GGE of natural gas is 126.67 cubic feet (3.587 m^3) at standard conditions. This volume of natural gas has the same energy content as one US gallon of gasoline (based on lower heating values: 900 BTU/cu ft of natural gas and 115,000 BTU/gal of gasoline).[16]

One GGE of CNG pressurized at 2,400 psi (17 MPa) is 0.77 cubic foot (21.8 liters or 5.75 Gallons). This volume of CNG at 2,400 psi has the same energy content as one US gallon of gasoline (based on lower heating values: 148,144 BTU/cu ft of CNG and 115,000 BTU/gal of gasoline.[16] Using Boyle's law, the equivalent GGE at 3,600 psi (25 MPa) is 0.51 cubic foot (14.4 L or 3.82 actual US gal).

The National Conference of Weights & Measurements (NCWM) has developed a standard unit of measurement for compressed natural gas, defined in the NIST Handbook 44 Appendix D as follows: "1 Gasoline [US] gallon equivalent (GGE) means 2.567 kg (5.660 lb) of natural gas."[17]

When consumers refuel their CNG vehicles in the USA, the CNG is usually measured and sold in GGE units. This is fairly helpful as a comparison to gallons of gasoline.

Ethanol and fuels like E85

1.5 gallons of ethanol has the same energy content as 1.0 gallon of gasoline.

The energy content of 1.0 US gallon of ethanol is 76,100 BTU, compared to 114,100 BTU for gasoline. (see chart above)

A flex-fuel vehicle will experience about 76% of the fuel mileage MPG when using E85 (85% ethanol) products as compared to 100% gasoline. Simple calculations of the BTU values of the ethanol and the gasoline indicate the reduced heat values available to the internal combustion engine. Pure ethanol provides 2/3 of the heat value available in pure gasoline.

In the most common calculation, that is, the BTU value of pure gasoline vs gasoline with 10% ethanol, the latter has just over 96% BTU value of pure gasoline. Gasoline BTU varies relating to the Reid vapor pressure (causing easier vaporization in winter blends containing ethanol(ethanol is difficult to start a vehicle on when it is cold out) and anti-knock additives. Such additives offer a reduction in BTU value.

Efficiency

A concept closely related to the BTU or kWh potential of a given fuel is engine efficiency, often called thermal efficiency in the case of internal combustion engines.

Generally speaking, an electrical motor is far more efficient than an internal combustion engine at converting potential energy into work - turning the wheels that may move a car down the road, as there is minimal waste heat coming off the motor parts, and zero heat cast off by the coolant radiator and out of the exhaust.

A diesel cycle engine can be as much as 40% to 50% efficient at converting fuel into work, where a typical automotive gasoline engine's efficiency is about 25% to 30%.

The efficiency of converting a unit of fuel to rotation of the driving wheels includes many points of friction loss and heat loss through the exhaust or cooling system. Friction inside the engine happens along the cylinder walls, crankshaft rod bearings and main bearings, camshaft bearings, drive chains or gears, plus other miscellaneous and minor bearing surfaces. An electric motor has internal friction only at the main axle bearings. Friction outside the motor/engine includes loads from the generator / alternator, power steering pump, A/C compressor, transmission, transfer case (if four-wheel-drive), differential(s) and universal joints, plus rolling resistance of the pneumatic tires.

The MPG of a given vehicle starts with the thermal efficiency of the fuel and engine, less all of the above elements of friction.

Miles per gallon of gasoline equivalent (MPGe)

The MPGe metric was introduced in November 2010 by EPA in the Monroney label of the Nissan Leaf electric car and the Chevrolet Volt plug-in hybrid. The ratings are based on EPA's formula, in which 33.7 kilowatt hours of electricity is equivalent to one gallon of gasoline, and the energy consumption of each vehicle during EPA's five standard drive cycle tests simulating varying driving conditions.[18][19] All new cars and light-duty trucks sold in the U.S. are required to have this label showing the EPA's estimate of fuel economy of the vehicle.[20]

See also

- Engine efficiency
- Thermal efficiency
- Potential energy
- Work (thermodynamics)
- Work (physics)
- Diesel cycle engines
- Efficiency
- Friction
- Kilowatt hour

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