Fuel Energy Content

The energy content of traditional carriers (methane, CR2032 button cell, Lead-acid battery, Li-ion battery) and alternative sources (hydrogen, urea, urine). Comparison per mass [Wh/kg] and volume [Wh/l].

Common Energy Sources

Methane CH4

- Source: https://en.wikipedia.org/wiki/Methane
- Source: https://people.wou.edu/~courtna/GS361/Energy_From_Fossil_Fuels.htm
- 0.657 g/l (liquid at 116 K would be 442.8 g/l)
- 16.043 g/mol
- 810 kJ/mol
- 810 kJ/mol / 16.043 g/mol = 50.489 kJ/g = 14025 Wh/kg = 14 Wh/g
- Link 2 says: 51.6 kJ/g
- 0.657 g/l * 14.025 Wh/g = 9 Wh/l

Button cell CR2032

- Source: https://www.digchip.com/datasheets/parts/datasheet/915/CR2032.php
- 3 V * 240 mAh = 0.72 Wh = 0.00072 kWh
- pi/4 * 0.20 dm * 0.20 dm * 0.032 dm = .0010053096 l = 1 cm3
- 3 g = 0.003 kg
- 0.72 Wh / 0.003 kg = 240 Wh/kg
- 0.72 Wh / 0.0010053096 l = 716 Wh/l

Lead-acid battery

- Source: https://batteryguy.com/files/technical-docs/tech-spec-sheets/bg-121000nb-technical-specification-sheet.pdf
- 20 h * 5 A * 10.8 V = 1080 Wh = 1.08 kWh
- 28.2 kg
- 3.30 dm * 1.71 dm * 2.14 dm = 12.06 l
- 1080 Wh / 28.2 kg = 38 Wh/kg
- 1080 Wh / 12.06 l = 90 Wh/l

Li-ion battery

- Source: https://emergoplus.com/product/powerxtreme-x10/
- 12.8 V * 10 Ah = 128 Wh = 0.128 kWh
- 2.1 kg
- 182 mm * 120 mm * 90 mm = 1.82 dm * 1.20 dm * 0.90 dm = 1.9656 l
- 128 Wh / 2.1 kg = 61 Wh/kg
- 128 Wh / 1.9656 l = 65 Wh/l

Alternative Energy Sources

Hydrogen H2 (gas)

- Source: https://en.wikipedia.org/wiki/Hydrogen
- Source: https://www.convertunits.com/molarmass/Hydrogen
- Source: https://people.wou.edu/~courtna/GS361/Energy_From_Fossil_Fuels.htm
- 0.08988 g/l
- 1.00794 g/mol
- 482 kJ/mol
- Link 3 says: 120 kJ/g
- 482 kJ/mol / 1.00794 g/mol = 478 kJ/g = 133 Wh/g = 133 kWh/kg
- 0.08988 g/l / 1000 g/kg = 0.00008988 kg/l
- 133 kWh/kg * 0.00008988 kg/l = 0.012 kWh/l = 12 Wh/l

Urea

- Source: https://en.wikipedia.org/wiki/Urea
- 1.32 g/cm3
- 60.056 g/mol
- 837 kJ/mol = 232.5 Wh/mol
- 232.5 Wh/mol / 60.056 g/mol = 3871 Wh/kg = 4 Wh/g
- 3.871 Wh/g * 1.32 g/cm3 = 5.11 Wh/cm3 = 5110 Wh/l = 5 kWh/l

Urine

- Source: https://en.wikipedia.org/wiki/Urine
- Source: https://en.wikipedia.org/wiki/Urea
- urine 1.5 kg/person/day
- urea 30 g/person/day
- concentration urea / urine = 30 g / 1500 g = 0.02 = 2%
- 2% of 3871 Wh/kg = 77 Wh/kg
- 2% of 5110 kWh/l = 102 Wh/l

Summary

Carrier	[Wh/kg]	[Wh/l]
Methane	14025	9
CR2032	240	716
Lead acid battery	38	90
Li-ion battery	51	65
Hydrogen gas	133000	12
Urea	3871	5110
Urine	77	102