

DIMENSIONAL ANALYSIS

Example 1:

$$2 \text{ yards} \times \frac{3 \text{ feet}}{1 \text{ yard}} = 6 \text{ feet}$$

Example 2:

What we need to know:

1 hp = 746 watts

Billed Electricity Rate: \$.09/kWhr

So:

$$1 \text{ hp} \times \frac{746 \text{ watts}}{\text{hp}} \times \frac{1 \text{ kilowatt}}{1000 \text{ watts}} \times \frac{\$0.09}{\text{kWhr}} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{365 \text{ days}}{1 \text{ year}} = \$588.15/\text{yr}$$

Example 3:

What we need to know:

Billed water cost = \$2.64/1000 gallons

So:

$$\frac{200 \text{ ml}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{24 \text{ hrs}}{1 \text{ day}} \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{1 \text{ liter}}{1000 \text{ ml}} \times \frac{1 \text{ gallon}}{3.78 \text{ liters}} \times \$2.64 = \$73.42$$

Prefixes	Mass	Distance	Volume
Metric	1 kg = 2.205 lb	1 cm = 0.4 in	1 L = 0.264 gal = 1000 cm ³ (ml)
pico (p) = 10 ⁻¹²	1 lb = 453.6 g = 16oz	1 m = 3.281 ft = 1.094 yd	1 m ³ = 1000 L = 35.3 ft ³ = 264 gal
nano (n) = 10 ⁻⁹	1 metric tonne = 1,000kg = 2,205lb	1 km = 0.62137 mi = 199 rod	1 gal = 3.785 L = 4 qt = 16 c = 128 oz
micro (μ) = 10 ⁻⁶	1 US short ton = 907kg = 2,000lb	1 mi = 1.609km	1 ft ³ = cf = 28.32 L = 7.482 gal
deca (da) = 10 ¹	1 UK long ton = 1,016kg = 2,239lb	1 smoot = 1.702 m = 5.83 ft	1 bbl = 42 U.S. gal = 159 L = 5.6 ft ³
kilo (k) = 10 ³	Temperature	Area	1 cord = 128 ft ³ = 3.62 m ³
mega (M) = 10 ⁶	°F = 1.8 • °C + 32	1 m ² = 10.765 ft ²	1 ac-ft = 43560 ft ³ = 325,851 gal
giga (G) = 10 ⁹	°K = (°F - 32) • 5/9 + 273.15	1 km ² = 0.386 mi ² = 10 ⁶ m ²	1 km ³ = 0.24 mi ³ = 810,713 acre-ft
tera (T) = 10 ¹²	Time	1 ha = 10 ⁴ m ² = .01 km ² = 2.47 ac	1 bu = 4 pck = 8 gal = 35.2 L = 2,150 in ³
peta (P) = 10 ¹⁵	3,600 sec/hour 730 hour/month	1 mi ² = 2.6 km ² = 640 ac	Flow Rates
exa (E) = 10 ¹⁸	365.25 day/year 8,766 hour/year	1 ac = 4,047 m ² = 43,560 ft ²	1 mbd = 1 Mbbl/day = 15.34 Ggal/yr
zetta (Z) = 10 ²¹	31,536,000 sec/year	Pressure	= 694.4 bbl/min = 11.57 bbl/sec
Roman	Fuel Economy	1MPa = 10bar = 9.87atm = 145psi	= 485.9 gal/sec
m = 10 ³	1mpg = 0.4251 km/L	1atm = 1.0132 bar = 760 mmHg	1 ft ³ /s = 641 bbl/hr = 449 gal/min (gpm)
mm = 10 ⁶	1mpg = 235.2/ L/100 km	= 14.696 psi = 10.33 ton/m ³	1 bbl oil/day ≈ 50 metric ton oil/yr
quad = 10 ¹⁵			1 gpm = 0.063 L/s = 0.00442 ac-ft/day

Energy Unit Conversion

1 J = 1 Nm = 1 kgm²/s² = 0.239 cal = 0.74 ft-lb
 1 Cal = 1 kcal = 1000 cal = 4.187 KJ = 3.968 Btu
 1 KJ = 0.239 Cal = 0.947817 Btu ≈ 0.95 Btu
 1 Btu = 1,055.056 J = 0.252 kcal
 1 kWh = 3.6 MJ = 3,412 Btu; (1MWh = 3.6 GJ = 3.412 mmBtu)
 1 mmBtu = 10⁶ Btu = 1.055 GJ = 1 decatherm
 1 mcf nat. gas (LHV) = 10.27 therm = 1.027 mmBtu = 1.082 GJ
 1 toe = 41.868 GJ = 39.683 mmBtu = 11.63 MWh = 7.33bbl
 1 tce = 29.308 GJ = 27.778 mmBtu = 8.141 MWh
 1 Quad = 10¹⁵ Btu = 1.055 EJ = 293 TWh = 25.2 Mtoe = .974 TCF
 1 EJ = 10⁹ GJ = 10¹⁸ J = .95 Quad
 1 TWyr = 31.5 EJ = 29.86 Quad

Energy Content (Lower Heating Values) (ton = metric tonne)

Crude Oil = 6.119 GJ/bbl = 5.8 mmBtu/bbl = 39.7 mmBtu/ton
 = 145.7 MJ/gal = 38.5 MJ/L = 43.8 MJ/kg (GJ/ton)
 Gasoline = 121.3 MJ/gal (= 32.1 MJ/L = 43.1 MJ/kg = 115 mBtu/gal)
 Diesel = 135.5 MJ/gal (= 35.8 MJ/L = 42.8 MJ/kg = 128 mBtu/gal)
 Biodiesel = 124.8 MJ/gal (= 33.0 MJ/L = 37.5 MJ/kg = 121 mBtu/gal)
 Ethanol = 80.2 MJ/gal (= 21.2 MJ/L = 26.9 MJ/kg = 76 mBtu/gal)
 Methanol = 60.4 MJ/gal (= 15.9 MJ/L = 20.1 MJ/kg = 57 mBtu/gal)
 UN Standard Coal = 30 GJ/ton
 Bituminous = 27-30 GJ/ton (MJ/kg) = 25-28 mmBtu/ton
 Sub-Bitum. = 20-26 GJ/ton (MJ/kg) = 19-24 mmBtu/ton
 Lignite = 10-19 GJ/ton (MJ/kg) = 9-18 mmBtu/ton
 Nat Gas @ STP = 53.2 MJ/kg = 38.2 MJ/m³ = 1027 Btu/ft³
 CNG @ 20 MPa = 50.0 MJ/kg = 9.3 MJ/L = 249.6 mBtu/ft³
 H₂ @ 35MPa (HHV) = 120.0 MJ/kg = 2.7 MJ/L = 72.5 mBtu/ft³
 LPG @ 1.5 MPa = 88.1 MJ/gal = 23.3 MJ/L = 625.5 mBtu/ft³
 Air-Dried Wood(20% Moisture Content) = 15 GJ/ton
 Uranium = 80 GJ/g fissioned = 400 GJ/kg mined (fn'd = 5% mn'd)

Energy of Familiar Phenomena/Society

Quart of Boiling Water = 3 MJ 1 wooden match = 1 Btu
 Melt 1 lb Ice = 151 kJ = 143 Btu
 1-GWe Plant running 24 hrs = 260 TJ
 Daily Human Metabolism = 2500 kCal/day = 120 W
 Compact Passenger Car at steady 60 mph:
 Chem. Energy Consumption = 70 kW = 94 hp
 Mech. Energy Production = 15 kW = 20 hp
 '05 US Oil Use = 20.55 Mbpd = 7.506 Gbbl/yr = 238 bbl/sec
 '05 Global Oil Use = 84.37 Mbpd = 31.89 Gbbl/yr = 976.5 bbl/sec
 '05 US Primary Energy Use ≈ 3.35 TW ≈ 105 EJ/yr ≈ 100 quad/yr
 '05 Global ≈ 16 TW ≈ 504 EJ/yr ≈ 480 quad/yr
 Solar Influx at Earth Surface ≈ 100 PW = 3.1 YJ/yr = 200 W/m²

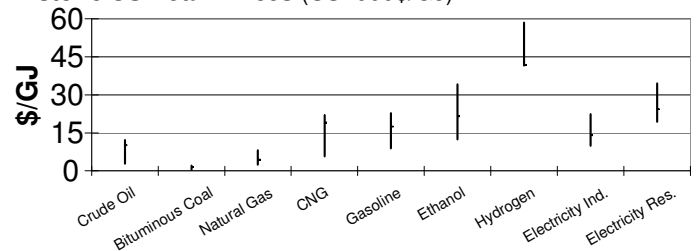
Density

Water = 1 g/cm³ = 1 g/ml = 1 kg/L = 1 metric tonne/m³
 Air at Sea Level = 1.2 kg/m³
 Crude Oil = 0.88 (0.75 -0.98) kg/L = 7.34 lb/gal = 140 kg/bbl
 Gasoline = 0.745 kg/L = 6.22 lb/gal
 Diesel = 0.837 kg/L = 7.00 lb/gal; Biodiesel = 0.880 kg/L
 Ethanol = 0.789 kg/L = 6.58 lb/gal
 Methanol = 0.792 kg/L = 6.61 lb/gal
 Nat. Gas = 0.717 kg/m³ = 44.8 lb/mcf
 CNG @ 20MPa = 0.185 kg/L = 11.5 lb/ft³ = 5.66 lb/gge
 LPG (propane) = 0.540 kg/L = 33.7 lb/ft³
 Hydrogen = 0.025 kg/L (35MPa); 0.08988 kg/m³ (STP)
 Coal ≈ 1.32 kg/L = 1230 metric ton/ha-m = 1800 sht ton/acre-foot
 API Gravity = (141.5/[Density in g/cm³ at 60 °F]) - 131.5
 Light Crude API > 31.1°; Heavy API < 22.3°; Bitumen API ~ 8°

Power Unit Conversion

1 W = 1 J/s = 3.6 kJ/hour = 31.5 MJ/year
 1 kW = 1.341 hp = 738ft-lb/s
 1 hp = 745.7 W = 0.7068 Btu/s
 1 TW = 10¹² W = 31.5 EJ/year
 1 ton-refrigeration = 12,000 Btu/hr = 200 Btu/min = 3.517 kW

Historic US Retail Prices (US2000\$/GJ)



Carbon Dioxide (CO₂) Emission Factors

Note: 44/12 or 3.667 ton CO₂ emissions per ton C emissions

Natural Gas = 121 lb/mcf = 117.1 lb/mmBtu = 50.3 kg/GJ
 Gasoline = 19.56 lb/gal = 156.4 lb/mmBtu = 67.2 kg/GJ
 Diesel = 22.38 lb/gal = 161.4 lb/mmBtu = 69.4 kg/GJ
 Bt. Coal = 4,931 lb/sht ton = 205.3 lb/mmBtu = 88.3 kg/GJ
 Petrol Coke = 32.40 lb/gal = 225.1 lb/mmBtu = 96.8 kg/GJ
 Electric US Av = 1.34 lb/kWh = 0.608 ton/MWh = 168.8 kg/GJ
 Coal-fired Elec = 2.095 lb/kWh = .95 kg/kWh = 260 kg C/MWh

Global Warming Potential (GWP) (τ = 100yr)

CO₂ = 1 CH₄ = 23 N₂O = 296 SF₆ = 22,200
 HFCs = 12 - 12,000 PFCs = 5,700 - 11,900

Rules of Thumb

- 1 Btu = 1,055 J
- 1 kWh = 3.6 MJ = 3,412 Btu
- 1 hp = 746 W
- 1 TW \approx 30 Quad/yr \approx 32 EJ/yr
- 23.52 mpg \rightarrow 10 L/100km \rightarrow
234 g TtW CO₂/km \rightarrow 0.832 lb TtW CO₂/mi
- 1 Quad = 10¹⁵ Btu \approx 1.05 EJ \approx 25 Mtoe \approx 300TWh \approx 0.974 tcf natural gas
- 1 gallon gasoline equivalent (gge) =
121 MJ = 115,000 Btu = 1 kg H₂ = 1.5 gal EtOH
- 1 million barrel oil per day (mbd) =
486 gal/sec = 2.2TJ/yr = 4232 metric ton C/yr
- Nat.Gas: 1 mscf = 0.2832 Nm³ = 1.027 mmBtu = 10.27 therm
- 3.667 (44/12) ton CO₂ per ton C

Sources

This sheet was compiled based on several other useful fact sheets and online resources:

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http://www.eia.doe.gov/emeu/aer/pdf/pages/sec13_13.pdf
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- Oak Ridge National Lab (ORNL) Bioenergy Program, Conversion Factor Reference
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Other Physical Property (LHV, Density, Emission Factor) Data Sources

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- EIA, Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source Codes and Emission Coefficients <http://www.eia.doe.gov/oiaf/1605/factors.html>
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http://www.grida.no/climate/ipcc_tar/wg1/020.htm#c6

Historic Price Range Data Sources

- EIA (2006) Annual Energy Review 2005 and Monthly Energy Review http://www.eia.doe.gov/overview_hd.html
- EIA Petroleum Navigator http://tonto.eia.doe.gov/dnav/pet/pet_pri_top.asp
- EIA Coal News and Markets <http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html>
- Bloomberg Energy Market Data <http://www.bloomberg.com/energy/>
- State of Nebraska Energy Statistics <http://www.neo.state.ne.us/statshtml/66.html>