

# Conversion Factors for Units and Useful Quantities

All factors have been rounded to the significant digits given in accordance with accepted practice.

## Energy Conversion Factors<sup>a</sup>

To:	<i>GJ</i>	<i>Gcal</i>	<i>Quad</i>	<i>GWh</i>	<i>Mtoe<sup>b</sup></i>
From:	<i>Multiply by</i>				
<i>GJ</i>	1	0.239	$9.479 \times 10^{-10}$	$2.778 \times 10^{-4}$	$2.4 \times 10^{-8}$
<i>Gcal</i>	4.184	1	$3.968 \times 10^{-9}$	$1.163 \times 10^{-3}$	$1 \times 10^{-7}$
<i>Quad</i>	$1.055 \times 10^9$	$2.520 \times 10^8$	1	$2.931 \times 10^5$	25
<i>GWh</i>	$3.600 \times 10^3$	860	$3.412 \times 10^{-6}$	1	$8.6 \times 10^{-5}$
<i>Mtoe<sup>b</sup></i>	$4.2 \times 10^7$	$1 \times 10^7$	$4.0 \times 10^{-2}$	$11.6 \times 10^3$	1

<sup>a</sup>1 quad =  $10^{15}$  BTU; 1 BTU = 1055 J; 1 calorie = 4.184 J; 1 kWh = 3600 kJ.

<sup>b</sup>The calorific value of crude oil varies by a few percent, as determined by its origin and composition. These values are therefore approximate.

## Volume Conversion Factors

To:	<i>Gal US</i>	<i>Gal UK</i>	<i>Barrels<sup>a</sup></i>	<i>Litres</i>	<i>m<sup>3</sup></i>	<i>ft<sup>3</sup></i>
From:	<i>Multiply by</i>					
US gallon	1	0.8327	0.02381	3.785	0.0038	0.1336
UK gallon	1.201	1	0.02859	4.546	0.0045	0.1606
Barrel	42	34.97	1	159.0	0.159	5.616
Litre	0.2642	0.220	0.0063	1	0.001	0.0353
Cubic metre	264.2	220.0	6.289	1000	1	35.32
Cubic feet	7.480	6.227	0.1781	28.32	0.0283	1

<sup>a</sup>There are approximately 7.4 barrels of crude oil to a tonne, as determined by the density of the crude.

## Pressure Conversion Factors

1 standard atmosphere (atm) = 1.01325 bar = 101.325 kPa = 14.696 psi.

## Hydrogen Data

1 mol hydrogen = 2.016 g = 22.414 L (gas at NTP).  
(NTP is defined as:  $T = 273.15$  K;  $P = 1$  standard atm).

Density of gaseous hydrogen =  $0.0899 \text{ g dm}^{-3}$  (NTP).

1 kg hydrogen occupies  $11.12 \text{ m}^3$  at NTP.

$1 \text{ m}^3$  hydrogen at NTP weighs 89.9 g.

Density of liquid hydrogen =  $70.8 \text{ g dm}^{-3}$ .

Higher heating value (HHV) of hydrogen =  $142 \text{ MJ kg}^{-1} = 39.4 \text{ kWh kg}^{-1}$ .

HHV (volumetric) =  $12.77 \text{ MJ N-m}^{-3} = 3.55 \text{ kWh N-m}^{-3}$ .

Lower heating value (LHV) of hydrogen =  $120 \text{ MJ kg}^{-1} = 33.3 \text{ kWh kg}^{-1}$ .

LHV (volumetric) =  $10.79 \text{ MJ N-m}^{-3} = 29.98 \text{ kWh kg}^{-1}$ .

Energy content of pressurized hydrogen gas:

<i>Pressure/MPa</i>	<i>Energy content/MJ dm<sup>-3</sup></i>
20	2.53
55	6.96
70	8.86
80	10.12

## Energy supplies

Total world energy supply in 2004 = 11 059 Mtoe = 440 quads.<sup>1</sup>

World production of crude oil in 2004 = 3793 Mtoe  $\approx$  28 000 M barrels =  
76.7 M barrels per day.<sup>1</sup>

World production of hydrogen = 45–50 Mt per year.

Energy content of 50 Mt (using HHV) =  $7.1 \times 10^{18}$  J = 6.7 quads = 169 Mtoe.

Hydrogen production represents around 1.5% of total world energy supply.

## Calorific Values of Fuels

### Natural gas

Values range from 38.1 to 42.0 MJ m<sup>-3</sup>, as determined by origin.

(A notable exception is Netherlands gas, which gives only 33.3 MJ m<sup>-3</sup>.)

### Petrol (gasoline)

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By volume:	32.80 MJ L <sup>-1</sup> = 9.11 kWh L <sup>-1</sup> (HHV)
	31.17 MJ L <sup>-1</sup> = 8.66 kWh L <sup>-1</sup> (LHV)
By mass:	46.70 MJ kg <sup>-1</sup> = 12.97 kWh kg <sup>-1</sup> (HHV)
	44.38 MJ kg <sup>-1</sup> = 12.33 kWh kg <sup>-1</sup> (LHV)

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### Methanol

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By volume:	18.60 MJ L <sup>-1</sup> = 5.17 kWh L <sup>-1</sup> (HHV)
	16.02 MJ L <sup>-1</sup> = 4.45 kWh L <sup>-1</sup> (LHV)
By mass:	23.30 MJ kg <sup>-1</sup> = 6.47 kWh kg <sup>-1</sup> (HHV)
	20.10 MJ kg <sup>-1</sup> = 5.58 kWh kg <sup>-1</sup> (LHV)

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Note: not all of these units are necessarily employed in this book, but they are commonly encountered in the energy literature.

## References

1. *Key World Energy Statistics*, 2006 edition. International Energy Agency, Paris, 2006.