WOODGAS

FUEL DENSITIES

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We usually find the mass energy content of fuels tabulated on an energy/mass basis. Yet the energy/volume is often equally important for shipment, storage and use. This table includes the densities of various fuels and calculates the volumetric energy density.

	FUEL PROPERTIES: From Reed, Jamie & Andries					LHV-base	HHV-base	LHV-base		HHV-base		LHV-base	LHV-base	LHV-base	HHV-base	HHV-base	HHV-base						
		Mass				Mass		Volumetric		Volumetric		Relative	Relative	Relative	Relative	Relative	Relative						
ref nr	FUEL TYPE	Density		Moisture	Ash*	Energy Density		Energy Density		Energy Density		Mass	Bulk Vol.	Bulk Vol.	Mass	Bulk Vol.	Bulk Vol.	Unit**	Cost	Co2 Emissions			
		kg/m3		% MC	%	MJ/kg or GJ/ton		GJ/m3		GJ/m3		Ener. Dsy	Ener.Dsy	Multiplier	Ener. Dsy	Ener.Dsy	Multiplier	Cost $	$/Gj	kg/Gj1	kg/Gj2		
		solid	bulk					Solid	bulk	Solid	bulk	(to coal AW)	(to coal AW)	(to coal AW)	(to coal TR)	(to coal TR)	(to coal TR)						
1	Brown Coal - VIC	1120	860	62.5	2	8.0		9.0	6.9			0.33	0.34	2.97				5/t	0.63	93.3	87.7		
2	Black Coal - NSW	1450	940	8	22	24.0		34.8	22.6			1.00	1.11	0.90				30/t	1.25	90.7	89.4		
3	Petrol		n/a	<1	<1	34.2/l												0.73/l	21.35		71.3		
4	Auto Diesel	842	n/a	<1	<1	45.7		38.5				1.90						0.74/l	19.25	69.7	74.9		
5	LPG		n/a	<1	<1	26.2/l														59.4	64.7		
6	Natural Gas	n/a	n/a	<1	<1	37.2/l												n/a	13.81	50.9	59.4		
7	Sawdust (wet)	1100	367	50%	<1 variable	11.85		13.0	4.3			0.49	0.21	4.69				20/t	1.69	90.0			
8	Sawdust (air dry)	800	267	10%	<1 variable	17.06		13.6	4.6			0.71	0.22	4.48				20/t		90.0			
9	Woodchips (wet)	1100	550	50%	<1 variable	11.85		13.0	6.5			0.49	0.32	3.13				35/t	2.95	90.0			
10	Woodchips (forest dry)	800	400	10%	<1 variable	17.06		13.6	6.8			0.71	0.33	2.99				35/t		90.0			
11	Wood Pellets	n/a	705	6+- 2%	0.33 to 1	19.75			13.9			0.82	0.68	1.47				165/t	8.35	90.0			
12	US Forest Residues	n/a	340	50%	<1 variable	11.6			3.9			0.48	0.19	5.17				38/t	1.64	90.0			
13	Bagasse (wet)			50%		8.2						0.34											
14	Bagasse (air dry)			13%		16.2						0.68											
15	Charcoal			5%		30						1.25											
16	Torrefied Wood	600	300	10%	<1 variable	21.5		12.9	6.5			0.90	0.32	3.16				n/a					
17	Internatl steam coal		850			24			20.4			1.00	1.00	1.00									
18	Loose saw dust (dry)		200			18			3.6			0.75	0.18	5.67									
19	Wood pellets (dry)	1300	650			18		23.4	11.7			0.75	0.57	1.74									
20	Torrefied pellets	1300	650	3%		22		28.6	14.3			0.92	0.70	1.43									
21	softwood chips (dry)		190	7%			20				3.8				0.62	0.11	9.42						
22	HD 1/4"sawdust pellets		680				20				13.6				0.62	0.38	2.63						
23	3/8" peanut shell pellets		650				19.8				12.9				0.61	0.36	2.78						
24	Corn		760				19				14.4				0.58	0.40	2.48						
25	Soybeans		770				21				16.2				0.65	0.45	2.21						
26	Coconut shells 1/4"		540				20.5				11.1				0.63	0.31	3.23						
27	Coal bitumous		1100				32.5				35.8				1.00	1.00	1.00						
28	Biodiesel	920					41.2			37.9					1.27								
29	Diesel	880					45.7			40.2					1.41								
	* Percentages by weight.																						

Mass energy density (in MJ/kg or GJ/ton) and Solid and Bulk Volumetric density (in GJ/m3) on Low Heat Value or High Heat Value

Costs - Unit cost for Black and Brown coal from Brockway (1997).

Energy density - effects volume of throughput required, storage, cost of transport per btu etc

Figures for Wood Pellets based on 8500 btu/lb. Wood pellets range in energy from just under 8000 to almost 9000 btu/lb.

Figures for sawdust and woodchips are based on an energy value for oven dry eucalypt hardwood of about 19Kj/g. Figures for energy value by weight for softwoods such as pine, would be about 10% higher.

Figures were converted to energy values at various moisture contents using the formula EV (energy value @ mc%) = EV (od)*(100-(MC/8))/(100+MC)

Density of wood reflect approximate averages for common East coast Australian hardwoods. Green density varies considerably less than air dry density (700- to 900+), relfecting variation in moisture contents of 'green' timber.

Bulk Density of woodchips and sawdust are taken to be 50% and 33% of the original woods density respectively.

1 - Co2 emission factors from www.gas.asn.Australia/gas1.htm

2 - Co2 emission factors from Oz inst energy site

35.315 cu foot per cu metre

1055.056 joules per btu

British thermal units(International table)x 1055.056

Btu (th) x 1054.350

Btu (mean) x 1055.87

** - Unit cost is the cost of the fuel to the end user in units common for that fuel. Hence coal is cost to power station, petrol to consumers etc. Pellet costs are USD.

^ - Bulk densities for coal as sized for transporting on conveyors.

In terms of value on the world market, 1 green tonne of woodchips is worth $75/tonne, compared with $60 for coal and $30 for iron ore

	FUEL SOURCE references
1	Pers Comm Mr. Michael Laird Mine Strategy Manager Loy Yang Power - email 31 Oct 2000
2	Pers Comm Ross Shirtly - Sevices Manager Eraring Power Station, email 2/11/00.
	Pers Comm Ministry of Energy & Utilities - Pers Comm 31 Oct 2000
3	Australian Instituite of Energy web site - www.aie.org.Australia/melb/material/resource/fuels.htm
4	Australian Instituite of Energy web site - www.aie.org.Australia/melb/material/resource/fuels.htm
5	Energy value from OzInst energy av of two figures given.
6	Gross calorific value after extraction of NGL's WEC 2000. Price (1998) from Energy at a Glance 1999 NSW
7	
8	
9	
10	
11	from Pellet Flame web site - www.pelletflame.com/pelletanalysis.htm, price averige retail from
	Pellet Fuels Inst Arlington, VA USA in $US
	energy varies by +- 6% depending on fuel quality
12	Pers Comm Steve Jolley Dec1 00 @ 38$ per bdt
13	Energy and mc from Greenhouse Gas Assessment handbook
14	Energy and mc from Greenhouse Gas Assessment handbook
15	5mc and 29 according to GGAH
16	Assumed a 20% weight loss TW from "forest dry" chips.
17	approximate plant data from A. Weststeijn
18	approximate plant data from A. Weststeijn
19	approximate plant data from A. Weststeijn
20	data from Tom Reed via A.Weststeijn
21	data from Tom Reeds posting of May 28th, 2001
22	data from Tom Reeds posting of May 28th, 2001
23	data from Tom Reeds posting of May 28th, 2001
24	data from Tom Reeds posting of May 28th, 2001
25	data from Tom Reeds posting of May 28th, 2001
26	data from Tom Reeds posting of May 28th, 2001
27	data from Tom Reeds posting of May 28th, 2001
28	data from Tom Reeds posting of May 28th, 2001
29	data from Tom Reeds posting of May 28th, 2001