Measurements and Conversion Factors

UNECE/FAO-IRENA

Bioenergy from the Forest Sector – Capacity Building Workshop

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What to measure

Converting between units

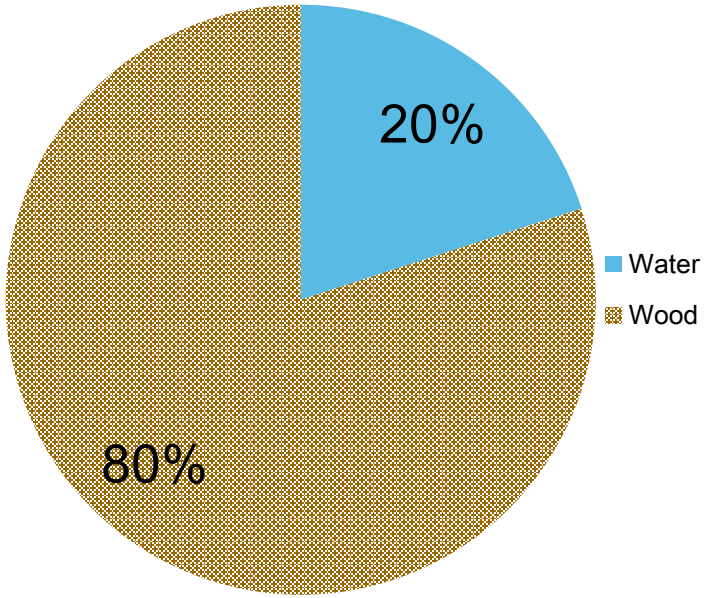
Issues

- Trying to reconcile forest sector with energy sector
- Take into account the moisture in products
- Provide scope for national variations, particularly in species of wood

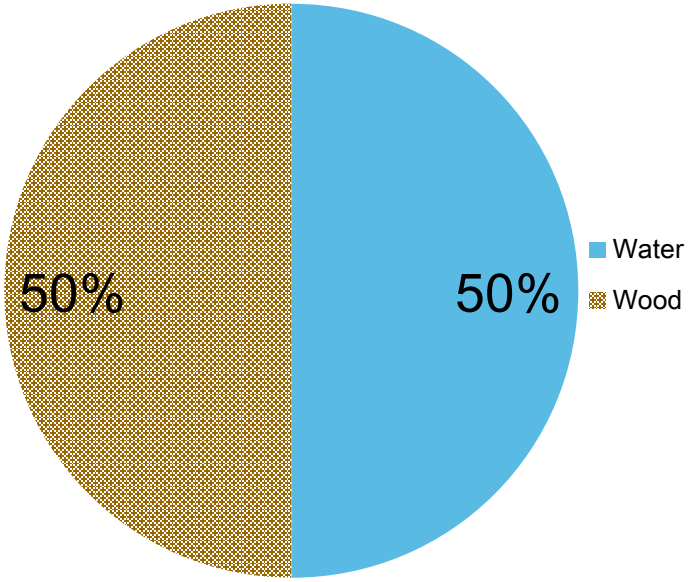
Measurement Units (fuel wood)

Weight units: the best correlation between energy value and the fuel wood measurement unit is dry weight (odmt).

Seasoned wood



Green wood



Volumetric units

- Woods of different species have a wide range of density, which drives dry weight and energy content, however there is good data, especially at a species level, for converting from volume to dry weight
- The dry weight and energy content per m3 of a dense hardwood, such as beech, can easily be 50% higher than a low density softwood, such as spruce)
- Bark: fuelwood volume measured inside bark, which ignores the volume of combustible energy included in this material (typically a 5-15% add-on depending on the losses incurred during harvest and handling).

Higher heating value or lower heating value

- LHV is more descriptive of the heat that can be generated during combustion as it accounts for heat loss from moisture, but requires knowledge of the moisture content and the hydrogen content of the fuel source
- HHV measures the maximum potential, simpler, as it doesn't require that the H content be measured, and more accurate, as it only introduces errors from the calorific measurement whereas the LLV carries potential errors in measuring the calorific value as well as errors from sampling and determining the H content.
- There is often confusion between surrounding LHV and and efficiency loss, which is the losses from heat that escapes in the exhaust stack as well as other combustion inefficiencies from incomplete combustion and the temperature of incoming air
- As a result, many find HHV a more consistent measure

Measuring

- Start with wood from forest, measured in 1000 m3
- Take into account the moisture in products
- Provide scope for national variations, particularly in species of wood

Black liquor

Black liquor

black liquor tons = chemical wood pulp [metric tonnes] X 0.9 [water content] X 1.9 (black liquor/unit chemical pulp=1.9) / (1-moisture content of black liquor=20%)

Converting tons black liquor to energy is 13.9 GJ per tdm (using higher heating value)

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	unit in/ unit out	Austria	Czech Republic	Finland	France	Germany	Ireland	Norway	Slovakia	Spain	Sweden	United Kingdom	United States	Median	Average
Fuelwood	m^3rw/odmt	2.40	--	2.45	1.90	2.30	1.82	2.50	1.72	1.60	2.22	--	--	2.22	2.10
Product basic density (solid volume, oven dry)	kg/m^3	417	--	460	526	432	550	450	780	625	450	--	--	460	521
Higher heating value	m^3 rw/gj	0.12	--	0.12	0.1	--	0.15	0.12	0.08	--	--	--	--	0.12	0.12
Pellets	m^3rw/m^3p solid	--	--	2.86	2.86	--	2.20	--	2.23	--	--	--	--	2.55	2.54
Roundwood input to bulk m^3 pellets	m^3rw/m^3p bulk	1.44	--	1.51	1.79	1.44	--	--	--	--	--	--	1.44	1.44	1.52
Product basic density (solid volume, oven dry)	kg/m^3	--	--	1 080	1 200	1 120	920	--	1 070	1 010	--	--	--	1 075	1 067
Bulk density (loose volume, 5-10% mcw)	kg/m^3	652	--	650	750	650	--	--	670	--	--	--	689	661	677
Higher heating value (bulk volume)	m^3bulk/gj	.083	--	0.09	0.78	0.09	0.13	--	0.08	0.07	--	--	0.08	0.08	0.09
Pressed logs and briquettes	m^3rw/odmt	2.38	--	0.87	2.38	--	2.2	--	--	--	--	--	--	2.29	1.96
Product basic density (solid volume, oven dry)	kg/m^3	--	--	1 080	1 000	1 200	950	--	1 120	1 100	--	--	--	1 090	1 075
Bulk density (loose volume)	kg/m^3	761	--	--	--	--	--	--	--	--	--	--	--	761	761
Higher heating value	m^3bulk/gj	0.07	--	0.09	0.13	--	0.13	--	0.05	--	--	--	--	0.09	0.09
Bark and chipped fuel	m^3rw/odmt	2.38	--	2.5	--	--	--	--	1.83	--	2.85	--	--	2.44	2.39
Product basic density (solid volume, oven dry)	kg/m^3	393	350	400	--	--	--	--	--	--	350	--	--	372	373
Bulk density (loose volume at 50% mcw)	kg/m^3	236	--	--	--	--	--	--	--	--	--	--	--	236	236
Higher heating value	m^3 rw/gj	0.12	--	--	--	--	--	--	.08	--	--	--	--	0.10	0.10
Charcoal	m^3rw/odmt	--	--	6.1	7.0	5.0	--	--	5.7	--	--	6.0	--	6.00	5.96
Wood-based ethanol	m^3rw/kilolitre	--	--	--	--	8.62	--	--	--	--	--	--	6.80	7.71	7.71

Conversion Factors – JWEE

* please adjust conversion factors where necessary

			Original Unit [1 000]	conversion factor (tdm or t) Table I and II to IV	Unit
Primary solid biomass	Woody Biomass from Forests	Industrial Roundwood (C & NC)	m³	0.42	tdm / m³
		Fuelwood (C & NC)	m³	0.42	tdm / m³
	Woody Biomass Outside Forests	Industrial Roundwood (C & NC)	m³	0.42	tdm / m³
		Fuelwood (C & NC)	m³	0.42	tdm / m³
	Unspecified primary solid biomass		m³	0.42	tdm / m³
Forest based Industry	Solid co-products (C & NC)	Chips and particles	m³	0.42	tdm / m³
		Wood residues	m³	0.42	tdm / m³
		Bark	m³	0.47	tdm / m³
		Unspecified solid co-products	m³	0.42	tdm / m³
	Liquid co-products (C & NC)	Black liquor (without crude tall oil)	t	0.80	tdm / t
		Crude tall oil	t	1.00	t / t
		Unspecified liquid co-products	t		
Processed wood-based fuel production	Processed solid biofuels from wood	Wood Charcoal	t	0.94	tdm / t
		Wood Pellets	t	0.92	tdm / t
		...of which: torrified	t	0.97	tdm / t
		Wood Briquettes	t	0.92	tdm / t
	Processed liquid biofuels from wood	Pyrolysis Oils	Million L	880	t / Million L
		Cellulose based ethanol	Million L	792.39	t / Million L
		Wood based biodiesel	Million L	880	t / Million L

Species Compostion – JWEE

Conversion Factors Energy

be aware that this will change the conversion factors calculated in columns G to P

Weighted density (dry weight/green volume) (tdm/m³)	CW & NCW	Density for CW & NCW (dry weight/green volume) (tdm/m³)	select species	Density (dry weight/green volume) (tdm/m³)	select species	C and weigh
0.42	100%	0.42		-	0%	
0.42	100%	0.42		-	0%	
0.42	100%	0.42		-	0%	
0.42	100%	0.42	0%	-	0%	
0.42	100%	0.42	0%	-	0%	
0.42	100%	0.42	0%	-	0%	

select species
CW & NCW
coniferous wood
Cedar
Cypress
Douglas Fir
English Yew
Fir

T I fibre sources | T II processed wood based fuels | T III pulp origins | T IV energy use | Con

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Thank you!

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