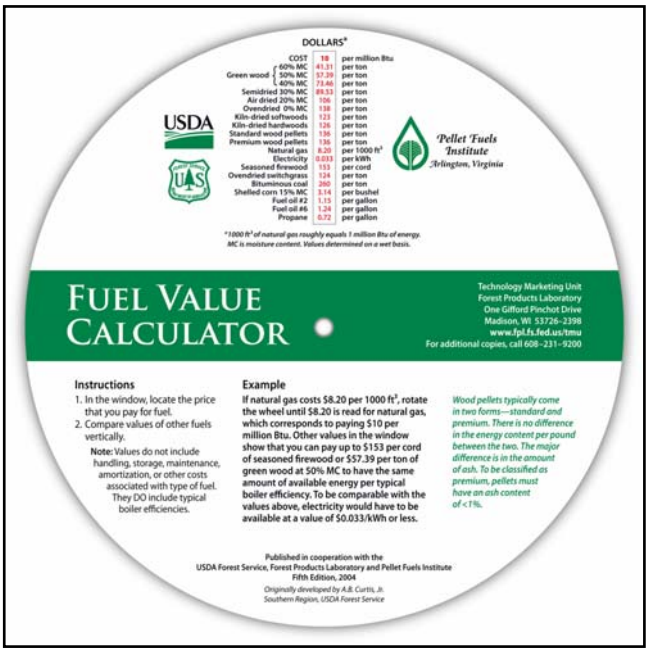
TechLine

Forest Products Laboratory

Fuel Value Calculator

(or use this easy-to-use spreadsheet to calculate)

The *Fuel Value Calculator* is a tool that can be used to compare typical unit costs of various fuels. Originally developed by A.B. Curtis, Jr., of the USDA Forest Service's Southern Region, the fifth edition of the *Calculator* has been published in cooperation with the USDA Forest Service, Forest Products Laboratory, and the Pellet Fuels Institute in Arlington, Virginia. The following information is to be used in conjunction with the *Calculator*, which is available by contacting the Forest Products Laboratory.



Cost Comparison

Here, two examples are provided to show how wood can be a competitive alternative to fossil fuels. Based on typical boiler efficiencies[1] for fuel costing $3/million Btu ($15/million Btu), the examples show that you can buy green wood (at 50% moisture content (MC) on a wet basis) with the same heat content as natural gas or electricity for $17.22/ton ($86.10/ton) compared with $2.46/1000 ft³ ($12.30/1000 ft³) for natural gas or $0.010/kWh ($0.050/kWh) for electricity. The calculations are useful in developing a budget for annual fuel costs.

$3/million Btu

1. **Green wood (50% MC):** 5.74 million Btu/ton

$$\frac{\$3}{million\,Btu} \times \frac{5.74\ million\ \ Btu}{ton} = \$17.22/ton$$

2. **Natural gas:** 0.820 million Btu/1000 ft^3

$$\frac{\$3}{million\,Btu} \times \frac{820{,}000\,Btu}{1000\,ft^3} = \$2.46/1000\,ft^3$$

3. **Electricity:** 3,340 Btu/kWh

$$\frac{\$3}{million\,Btu} \times \frac{3{,}340Btu}{kWh} = \$0.010/kWh$$

Fuel	Net heating value	Cost/unit
Premium wood pellets	13.6 million Btu/ton	$40/ton
Propane	71,000 Btu/gal	$0.22/gal
Fuel oil #2	115,000 Btu/gal	$0.34/gal
Fuel oil #6	124,000 Btu/gal	$0.37/gal
Seasoned firewood	15.3 million Btu/cord	$46/cord
Ovendried switchgrass	14.4 million Btu/ton	$37/ton
Bituminous coal	26 million Btu/ton	$78/ton
Shelled corn @15% MC	314,000 Btu/bushel	$0.94/bushel

$15/million Btu

1. **Green wood (50% MC):** 5.74 million Btu/ton

$$\frac{\$15}{million\,Btu} \times \frac{5.74\,million\ \ Btu}{ton} = \$86.10/ton$$

2. **Natural gas:** 0.820 million Btu/1000 ft^3

$$\frac{\$15}{million\,Btu} \times \frac{820{,}000\,Btu}{1000\,ft^3} = \$12.30/1000\,ft^3$$

3. **Electricity:** 3,340 Btu/kWh

$$\frac{\$15}{million\,Btu} \times \frac{3{,}340\,Btu}{kWh} = \$0.050/kWh$$

Fuel	Net heating value	Cost/unit
Premium wood pellets	13.6 million Btu/ton	$200/ton
Propane	71,000 Btu/gal	$1.10/gal
Fuel oil #2	115,000 Btu/gal	$1.72/gal
Fuel oil #6	124,000 Btu/gal	$1.86/gal
Seasoned firewood	15.3 million Btu/cord	$230/cord
Ovendried switchgrass	14.4 million Btu/ton	$186/ton
Bituminous coal	26 million Btu/ton	$390/ton
Shelled corn @15% MC	314,000 Btu/bushel	$4.70/bushel

USDA FOREST SERVICE

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Heating Values

The concept of latent heat of vaporization is important to understand in order to know the useful energy available from any type of fuel that contains water, including wood, coal, and peat. In wood or wood products, this water is referred to as moisture content (MC). Commonly, water makes up half the weight of a living tree and, if wood is used for fuel, its MC is a factor in determining its energy value.

In the combustion process of wood, energy in the fuel is needed to change water into vapor, and the amount of energy required is dependent on the MC of the wood—the higher the MC, the more energy required. The amount of energy absorbed as water changes from a liquid to a gas at its normal boiling point is called latent heat of vaporization. The quantity of heat generated by a combustion process is called the heating value, heat of combustion, or the calorific value. The higher heating value (HHV) of a fuel is the amount of energy available from its complete combustion, including the energy from condensing the water vapor that results from the combustion. The lower heating value (LHV) is the HHV minus the energy from condensing the water vapor that results from the combustion. All fuels generate some water from hydrogen during the combustion process; this also results in a lower heating value.

In the operation of heating boilers, the exhaust (flue gas) temperature is generally kept high enough to prevent condensation of water vapor. When condensed water mixes with other flue gas constituents, such as sulfides and chlorides, corrosive acids are formed. These corrosive acids can damage breachings, flues, heat exchangers, or other vents. Therefore, the latent heat of vaporization, or the heat required to increase the temperature to the boiling point, is not available for making steam, hot water, or useful heat.

The attached chart shows efficiency, heating values (gross and net), and cost comparisons for various fuel types.

Residential Heating Example

During a heating season, between 50 and 150 million Btu of energy are typically used to heat an average-sized home. For comparison, the following chart shows an example of expected annual costs of heating a home (assuming 100 million Btu of energy for the heating season) using natural gas, propane, fuel oil #2, seasoned firewood, wood pellets, and electricity. Note: Although natural gas, fuel oil, and propane can be sold per therm, which measures heat content of the fuel, the example uses volume (1000 ft^3 of natural gas ≈ 1 million Btu; 1 million Btu = 10 therms).

The comparison shows that seasoned firewood is the least expensive fuel, with natural gas and wood pellets a close second and third. To determine whether seasoned firewood is the fuel of choice, you need to compare heating systems and determine how much time and effort you are willing to spend processing and handling this fuel. Wood pellets require less handling but still more than fossil fuels. Also, fossil fuel heating systems typically cost less, sometimes significantly so, than firewood and wood pellet furnaces.

Example of Annual Home Heating Costs Using Various Fuels[a]

Fuel	Gross heating value[b]	Efficiency (%)	Net heating value[b]	Fuel required for 1 million Btu of usable heat	Average cost/unit	Total annual fuel cost
Natural gas	1.03 million Btu/1000 ft^3	80	0.82 million Btu/1000 ft^3	1,220 ft^3	$7/1000 ft^3	**$854**
Propane	91,200 Btu/gal	79	72,000 Btu/gal	13.86 gal	$1.25/gal	**$1,730**
Fuel oil #2	138,800 Btu/gal	83	115,000 Btu/gal	8.68 gal	$1.40/gal	**$1,220**
Seasoned firewood	20 million Btu/cord	77	15.4 million Btu/cord	0.065 cord	$115/cord	**$747**
Electricity	3,413 Btu/kWh	98	3,340 Btu/kWh	299 kWh	$0.08/kWh	**$2,390**
Premium wood pellets	16.4 million Btu/ton	83	13.6 million Btu/ton	0.073 ton	$120/ton	**$882**

[a]Based on 100 million Btu of energy for the heating season.

[b]1000 ft^3 ≈ 1 million Btu; 1 million Btu = 10 therms.

[1]Typical boiler efficiencies are dependent upon several factors. For additional information, contact the Technology Marketing Unit. The *Fuel Value Calculator* was developed with commercial boilers in mind, not residential units.

Efficiency, Heating Values (Gross and Net), and Cost Comparisons for Various Fuel Types

TYPE OF FUEL	Wood				Softwood (kiln dried) (13% MC)[a]	Hardwood (kiln dried) (8% MC)[a]	Wood pellets (premium)[b]	Natural gas	Electricity	Firewood (seasoned) (20% MC)[a]	Switchgrass (ovendried)	Bituminous coal	Shelled corn (15% MC)	Fuel oil		Propane
	Green (50% MC)[a]	Semidried (30% MC)[a]	Air-dried (20% MC)[a]	Ovendried (0% MC)										#2	#6	
GROSS HEATING VALUE	8,600,000 Btu/ton	12,040,000 Btu/ton	13,760,000 Btu/ton	17,200,000 Btu/ton	15,824,000 (Btu/ton)	15,996,000 (Btu/ton)	16,400,000 (Btu/ton)	1,025,000 (Btu/1000 ft³)	3,412 (Btu/kWh)	20,000,000 (Btu/cord)	15,500,000 (Btu/ton)	30,600,000 (Btu/ton)	392,000 (Btu/bu)	138,800 (Btu/gal)	150,000 (Btu/gal)	91,300 (Btu/gal)
EFFICIENCY	67%	74%	77%	80%	78%	79%	83%	80%	98%	77%	80%	85%	80%	83%	83%	79%
NET HEATING VALUE	5,740,000 Btu/ton	8,950,000 Btu/ton	10,560,000 Btu/ton	13,800,000 Btu/ton	12,300,000 Btu/ton	12,600,000 Btu/ton	13,600,000 Btu/ton	820,000 Btu/1000 ft³	3,340 Btu/kWh	15,300,000 Btu/cord	12,400,000 Btu/ton	26,000,000 Btu/ton	314,000 Btu/bu	115,000 Btu/gal	124,000 Btu/gal	71,900 Btu/gal
$/million Btu	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*$/1000 ft³*	*$/kWh*	*$/cord*	*$/ton*	*$/ton*	*$/bu*	*$/gal*	*$/gal*	*$/gal*
1.0	5.74	8.95	10.56	13.77	12.30	12.62	13.61	0.82	0.003	15.35	12.40	26.01	0.31	0.11	0.12	0.07
1.5	8.61	13.43	15.84	20.66	18.45	18.94	20.42	1.23	0.005	23.02	18.60	39.02	0.47	0.17	0.19	0.11
2.0	11.48	17.91	21.12	27.55	24.60	25.25	27.22	1.64	0.007	30.70	24.80	52.02	0.63	0.23	0.25	0.14
2.5	14.35	22.38	26.40	34.44	30.75	31.56	34.03	2.05	0.008	38.37	31.00	65.03	0.78	0.29	0.31	0.18
3.0	17.22	26.86	31.68	41.32	36.90	37.87	40.84	2.46	0.010	46.05	37.20	78.03	0.94	0.34	0.37	0.22
3.5	20.08	31.33	36.96	48.21	43.05	44.18	47.64	2.87	0.012	53.72	43.40	91.04	1.10	0.40	0.43	0.25
4.0	22.95	35.81	42.24	55.10	49.20	50.50	54.45	3.28	0.013	61.39	49.60	104	1.25	0.46	0.50	0.29
4.5	25.82	40.29	47.52	61.98	55.35	56.81	61.25	3.69	0.015	69.07	55.80	117	1.41	0.52	0.56	0.32
5.0	28.69	44.76	52.80	68.87	61.50	63.12	68.06	4.10	0.017	76.74	62.00	130	1.57	0.57	0.62	0.36
5.5	31.56	49.24	58.08	75.76	67.65	69.43	74.87	4.51	0.018	84.42	68.20	143	1.72	0.63	0.68	0.40
6.0	34.43	53.72	63.36	82.64	73.80	75.74	81.67	4.92	0.020	92.09	74.40	156	1.88	0.69	0.74	0.43
6.5	37.30	58.19	68.64	89.53	79.94	82.06	88.48	5.33	0.022	99.77	80.60	169	2.04	0.74	0.80	0.47
7.0	40.17	62.67	73.92	96.42	86.09	88.37	95.28	5.74	0.023	107	86.80	182	2.20	0.80	0.87	0.50
7.5	43.04	67.15	79.20	103	92	95	102	6.15	0.025	115	93.00	195	2.35	0.86	0.93	0.54
8.0	45.91	71.62	84.48	110	98	101	109	6.56	0.027	123	99.20	208	2.51	0.92	0.99	0.57
8.5	48.78	76.10	89.76	117	105	107	116	6.97	0.028	130	105	221	2.67	0.97	1.05	0.61
9.0	51.65	80.57	95.04	124	111	114	123	7.38	0.030	138	112	234	2.82	1.03	1.11	0.65
9.5	54.52	85.05	100	131	117	120	129	7.79	0.032	146	118	247	2.98	1.09	1.18	0.68
10.0	57.39	89.53	106	138	123	126	136	8.20	0.033	153	124	260	3.14	1.15	1.24	0.72
11.0	63.12	98.48	116	152	135	139	150	9.02	0.037	169	136	286	3.45	1.26	1.36	0.79
12.0	68.86	107	127	165	148	151	163	9.84	0.040	184	149	312	3.76	1.37	1.49	0.86
13.0	74.60	116	137	179	160	164	177	10.66	0.043	200	161	338	4.08	1.49	1.61	0.93
14.0	80.34	125	148	193	172	177	191	11.48	0.047	215	174	364	4.39	1.60	1.73	1.01
15.0	86.08	134	158	207	184	189	204	12.30	0.050	230	186	390	4.70	1.72	1.86	1.08
16.0	91.82	143	169	220	197	202	218	13.12	0.054	246	198	416	5.02	1.83	1.98	1.15
17.0	97.55	152	180	234	209	215	231	13.94	0.057	261	211	442	5.33	1.95	2.10	1.22
18.0	103	161	190	248	221	227	245	14.76	0.060	276	223	468	5.64	2.06	2.23	1.29
19.0	109	170	201	262	234	240	259	15.58	0.064	292	236	494	5.96	2.18	2.35	1.37
20.0	115	179	211	275	246	252	272	16.40	0.067	307	248	520	6.27	2.29	2.48	1.44
30.0	172	269	317	413	369	379	408	24.60	0.100	460	372	780	9.41	3.44	3.71	2.16
40.0	230	358	422	551	492	505	544	32.80	0.134	614	496	1040	12.54	4.58	4.95	2.87
50.0	287	448	528	689	615	631	681	41.00	0.167	767	620	1301	15.68	5.73	6.19	3.59
60.0	344	537	634	826	738	757	817	49.20	0.201	921	744	1561	18.82	6.87	7.43	4.31

[a]Wet basis.

[b]Presently, wood pellets come in two forms—standard and premium. There is no difference in the energy content per pound between the two. The major difference is the amount of ash. To be classified as premium, pellets must have an ash content less than 1%.

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