Firewood, Facts, Follies and Forest Management

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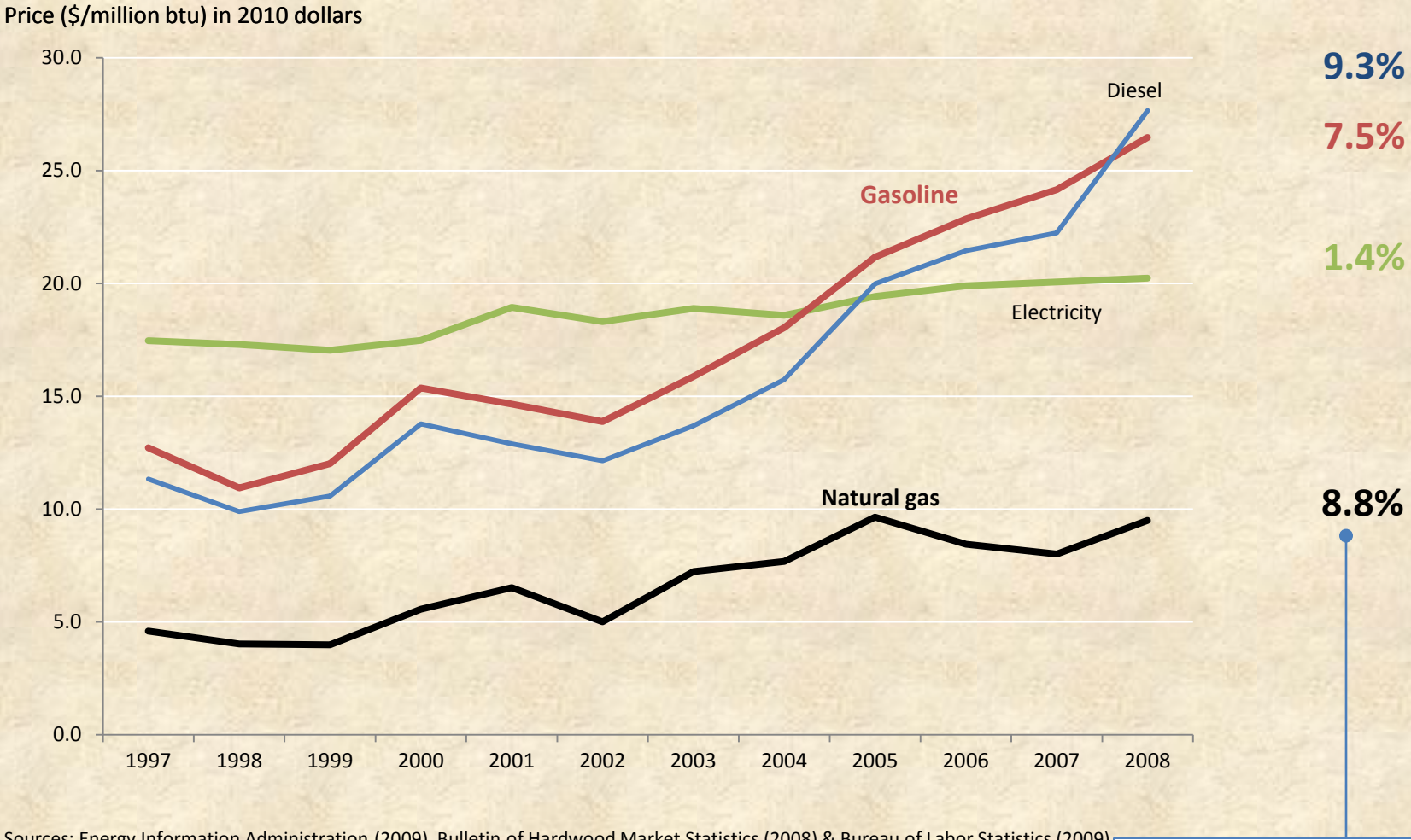
Outline

- Introduction
- What burns best and why?
  - Species
  - Density
  - Moisture
  - Burning efficiency
- Firewood volumes
- Comparing Fuels
- Cautions

Heating with firewood is likely to continue to increase in popularity as the cost of energy continues to rise.



Sources: Energy Information Administration (2009), Bulletin of Hardwood Market Statistics (2008) & Bureau of Labor Statistics (2009)
* Prices in 2010 dollars, using PPI.

The Warmth of Wood

What Wood Burns Best?

- How much heat can you get from wood?
  - Btu's available.
    - A Btu (British Thermal Unit)
      - basic measure of thermal (heat) energy.
    - One BTU is the amount of energy needed to 1 lb. of water 1 ^{o}F
- How many Btu's in wood?

Combustion of Wood

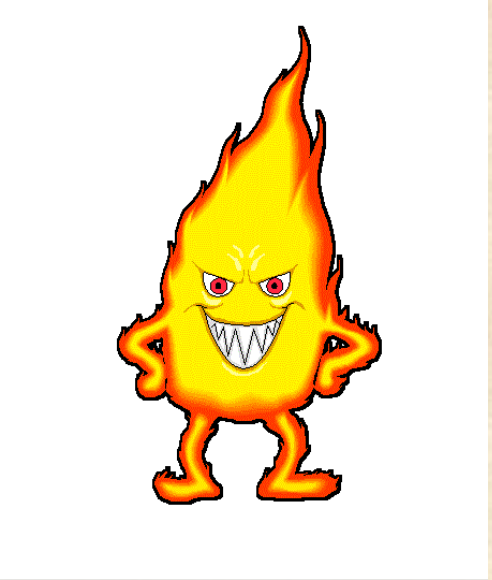
Three consecutive and overlapping stages of combustion

1. **Ignition and 500ºF**
   - Heat of the fire absorbed by the fuel and the wood dries
   - Greatly impacted by the amount of water in wood,
     - The wetter wood is, the less BTU's that will be available
   - The heating value per kiln dry pound is approximately 8,000 to 9,500 Btu/oven dry pound for all species!
2. **500 to 1100 ºF**
   - Wood breaks down, emitting flammable gases (volatiles) that contain more than half of the heat energy of the wood.
3. **Over 1100 ºF**
   - the remaining material, charcoal, burns until it is consumed.

Ideally, well-dried wood will burn through the second stage evenly, without sparks, and with minimum smoke, and spend a long time burning in the third stage.

What Wood Burns Best?

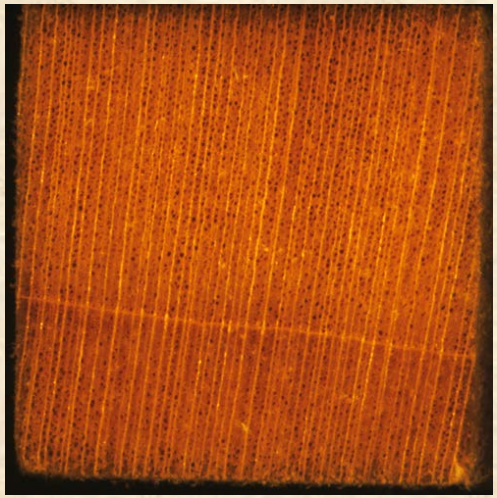
- How many Btu's in wood?
  - Depends:
    - Density
    - Moisture in the wood
    - Efficiency of your wood burning device

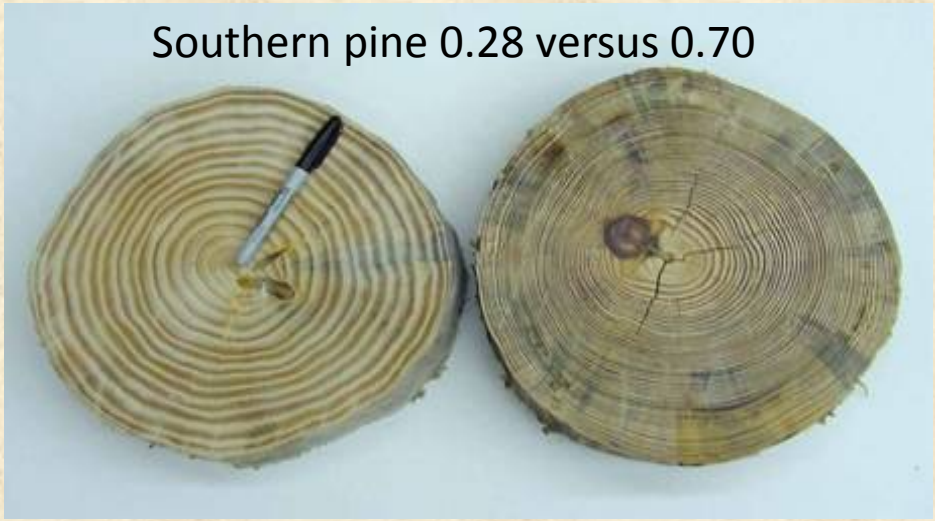


Weight per cord given a 20% moisture content and the average BTU’s produced.

Species	Weight per Cord	Heating value per cord (Btu's)
American elm	3,000	20.2
Apple	4,140	26.5
Aspen	2,295	14.7
Basswood	2,108	13.5
Beech	3,757	24
Black birch	3,890	26.8
Black locust	4,200	29.3
Black cherry	2,880	19.9
Cottonwood	2,108	13.5
Hackberry	3,247	20.8
Hard maple	3,757	24
Hemlock	2,482	15.9
Hickory	4,327	27.7
Paper birch	3,179	20.3
Red oak	3,757	24
Soft maple	2,924	18.7
Sycamore	2,900	20.2
White ash	3,689	23.6
White oak	3,800	26.5
White pine	2,236	14.3

Wood Density or S.G.





What Wood Burns Best?

- Moisture in Wood
- How much moisture is in wood is usually described as its moisture content (MC%)
  - MC%
    - the ratio of the weight of water in wood relative to the dry wood mass, expressed as a percentage.

Moisture Content

$$\%MC = \frac{\text{Wet Weight} - \text{Oven Dry Weight}}{\text{Oven Dry Weight}} X 100$$

$$\%MC = \left(\frac{\text{Wet Weight}}{\text{Oven Dry Weight}} - 1 \right) X 100$$

Moisture Content (oven dry basis)

$$\%MC = \frac{\text{Wet Weight - Oven Dry Weight}}{\text{Oven Dry Weight}} X 100$$

$$\%MC = \frac{0.90\ \text{kg} - 0.60\ \text{kg}}{0.60\ \text{kg}} X 100 =$$

50%MC

Green Moisture Content

Species	Heartwood	Sapwood
Douglas-fir	30	112
Shortleaf pine	32	122
Eastern hemlock	97	119
Red oak	80	70
Yellow poplar	83	106
Hickory	70	50
White oak	64	78

- When first cut, the wood is at its highest moisture content
- The "green" or fresh cut moisture content of wood is typically higher than 60% for most hardwoods and for some species, over 100%.

How Do I get More BTU's?

- Dry the wood

http://nhfirewood.com

Drying Firewood

Hearth.com

- Airdrying is most common
  - Drying times will depend on:
    - your location
    - how you pile it
    - protection from rain and snow
    - How its split
      - Splitting wood will increase drying since there will be more exposed wood surface to the air
- For most locations it takes approximately 9-12 months to dry firewood from green to 20% moisture content

How you stack it matters!

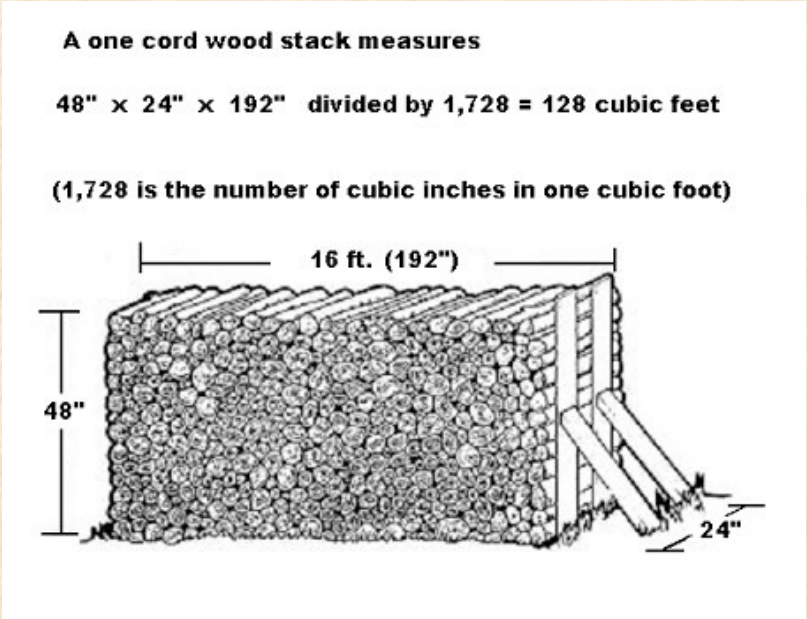
Reddit.com

Kiln Drying

- Steam, direct fired or indirect fired kilns
- Green firewood can be kiln dried from 52% to 20% in 30 hours using temperatures of 220F.
- Temperatures of 140 and 180 F require drying times of 260 and 90 hours respectively.

Firewood Measures

- Cord
- A standard cord of wood
  - the volume of stacked wood including air space occupying 128 cubic feet
  - defined as the volume of a stack of wood 4 feet high by 4 feet wide by 8 feet long



Firewood Measures

- Actual volume of wood in a 4x4x8-foot space can vary greatly depending on:
  - how tightly the wood is packed
  - the diameter of the pieces
  - the straightness of the piece
- Studies have shown that the volume of wood per standard cord can vary from **58 cubic feet to 94 cubic feet**!

Firewood Measures

- Face cord, rick, pile, truckload, etc. are not standardized
  - "truck load" of firewood may vary form a 1/5 cord in a short bed light pickup to 4 cords as in a pulpwood truck
  - Firewood capacity of different sized trucks varied from less than 1/5 cord to slightly +1/2 cord
  - capacities were noticeably affected by how they were loaded

Efficiency of Wood Burning

- The efficiency of wood burning devices is related to
  - efficiency of combustion
  - efficiency of heat exchange
- EPA approved wood stoves are a minimum of 60 percent efficient with some being as high as 80% efficient.

How We Burn Wood

- Fireplace
- Stove
- Indoor boiler
- Outdoor boiler
- Masonry stove

Fireplaces

- Least efficient
  - 10-15 %
  - Must draw in as much as 300 cubic feet per minute of heated room air for combustion but then send it straight up the chimney
- Limited ability to control a fire or to temperatures for combustion

Wood Stoves

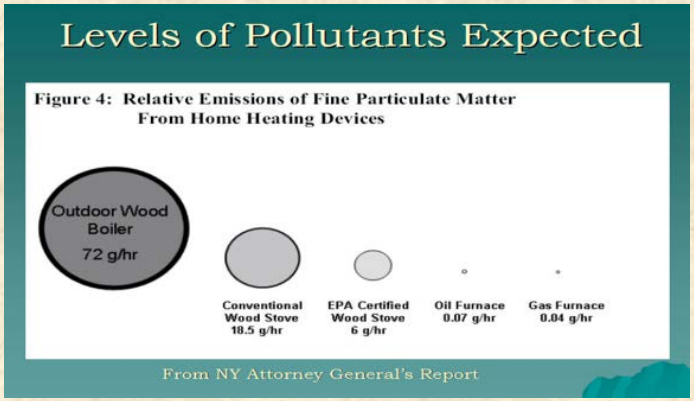
- **The modern wood stove**
- EPA is setting efficiency requirements
- 75 to 80 % efficient
- 30 to 40% more efficient than old stoves

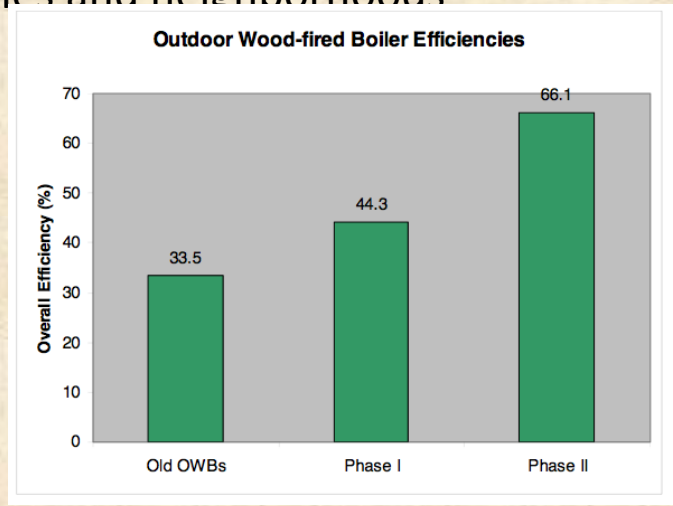
Indoor Boilers

- Outputs high enough to heat an entire house through forced air or radiator systems
  - Also provides household's hot water supply
- Highly efficient
- Meet EPA requirements
  - Reduced particulate and smoke

Outdoor Wood Boilers

- Located outdoors, heat water that is then circulated into the home through underground pipes.
- The heated water may be used directly or as a source of residential heating
- Employ very primitive combustion technology and are designed to burn wood at lower combustion temperatures and generally have shorter stacks
  - emit smoke closer to homes and neighborhoods

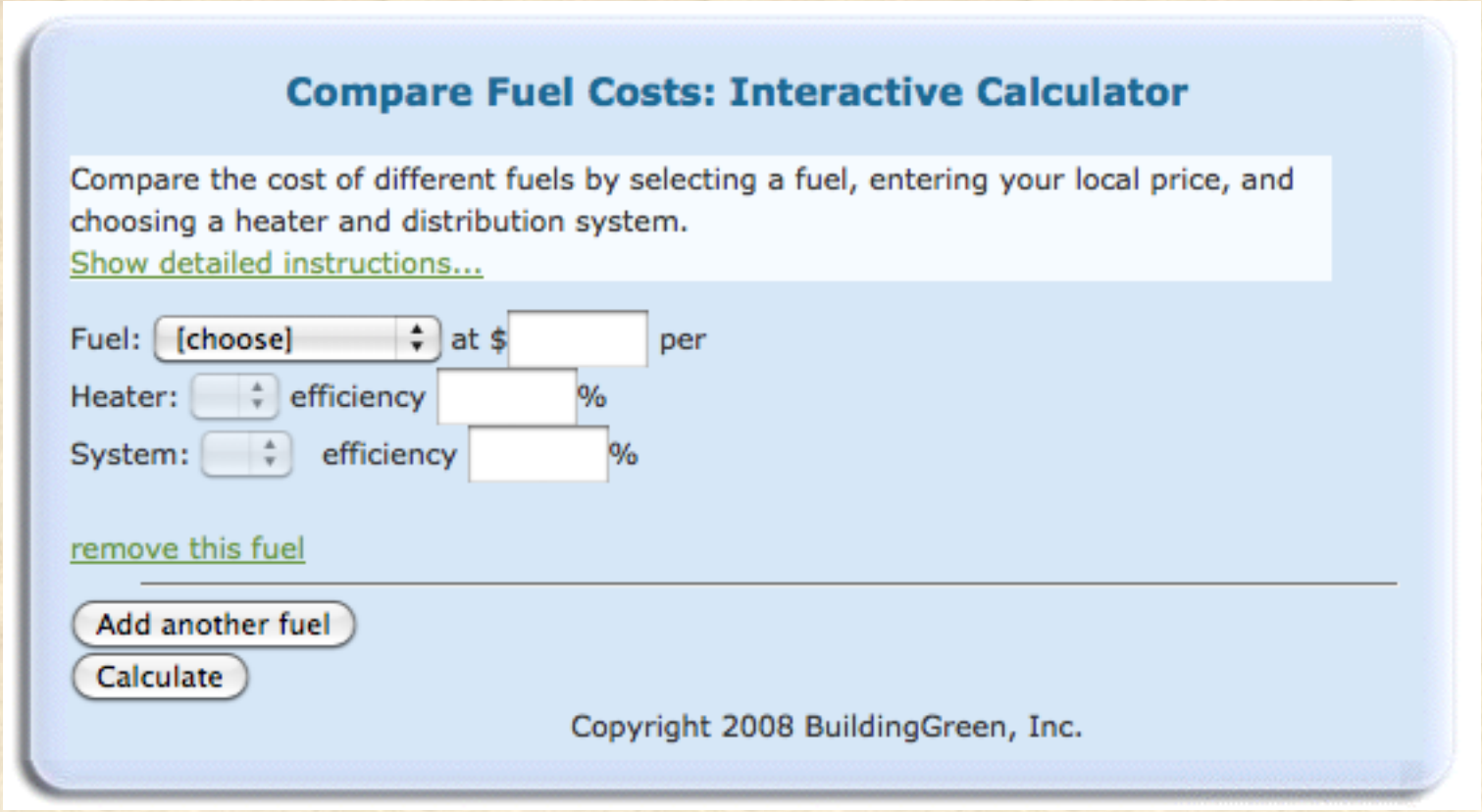




Masonry Stoves

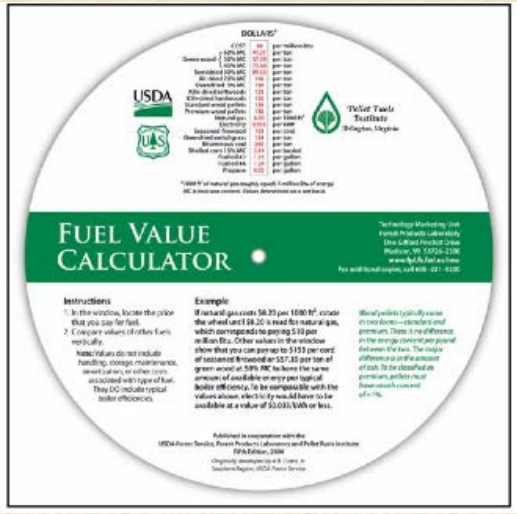
- Masonry stoves have a small, powerful firebox and a large masonry mass
- 18 and 20 hours of radiant heat from a single fuel load.
- 80 to 95% efficient

Comparing fuels



http://www.buildinggreen.com/calc/fuel_cost.cfm

Comparing fuels



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

*Wet basis.

- http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf
- Or Google “fuel value calculator Forest Service”

Comparing fuels

- Don’t just look at the fuel!
- Efficiency of consumption
- Efficiency of distribution
  - Electric baseboard radiators, the heat is produced right in the room, so the distribution is 100% efficient.
  - Hot-air furnace the distribution efficiency can be quite low
    - 60% to 65% is not uncommon.

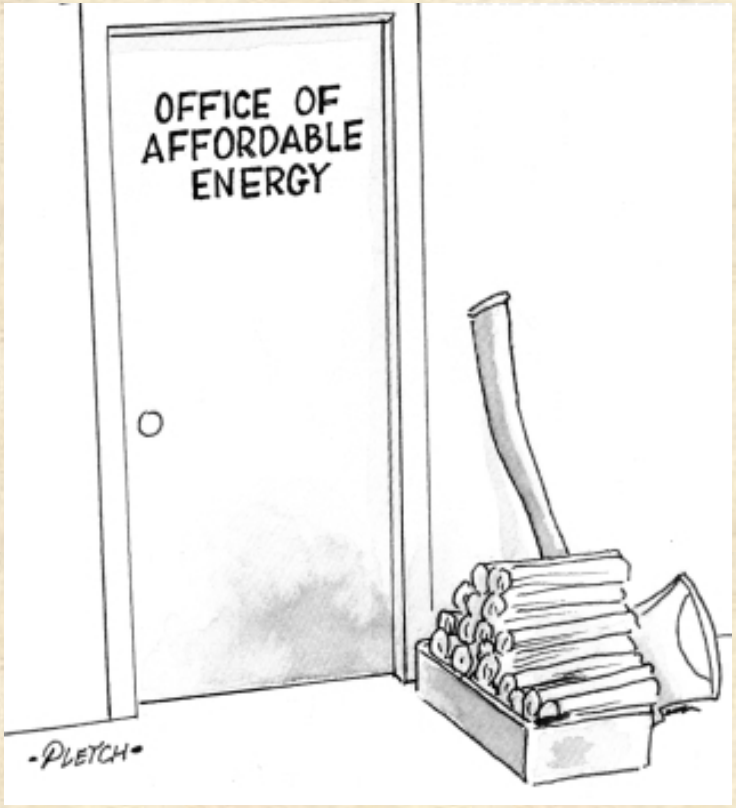
Cautions!

- Fire can be dangerous!
- Proper installation
- Proper stove maintenance
- Chimney stove pipe maintenance
- Do not move firewood

Moving Firewood

- DON'T
  - Asian longhorned beetle
  - Ash borer
  - Thousand-canker disease
  - Check with your local DOF for restrictions

Wood is the only fuel that heats twice ... first when you cut and stack it, and again when you burn it!



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