Firewood Ratings and Info

based on data from: U.S. Forest Products Laboratory (and numerous other sources)

Compiled by Bob Ferrari of Flue Season in Redding, CA
Shared with the NCSG Discussion List in October 2008

Species	Relative Heat	Easy to Burn	Easy to Split	Heavy Smoke ?	Throw Sparks ?	General Rating	Aroma	Weight of Seasoned Cord-lbs	Heat Producd per Cord M Btu
Hardwoods	.								
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Black Ash	Med	Yes/Fair	Yes	No	No/Few	Excel	Minim	2,992	19.1
White Ash	High	Yes/Fair	Yes	No	No/Few	Excel	Minim	3,689	23.6
Red Oak	High	Yes/Poor	No	No	No/Few	Excel	Fair	3,757	24.0
White Oak	High	Yes	No	No	No	Excel	.	4,012	25.7
Beech	High	Yes/Poor	Yes	No	No/Few	Excel	Minim	3,757	24.0
Blue Beech	High	Yes/Poor	Yes	No	No/Few	Excel	Minim	3,890	26.8
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White Birch	Med	Yes/Good	Yes	No	No/Mod	Excel	Minim	3,179	20.3
Grey Birch	Med	Yes/Good	Yes	No	No/Mod	Poor	Minim	3,179	20.3
YellowBirch	High	Yes/Good	Yes	No	No/Mod	Excel	Minim	3,689	23.6
Paper Birch	Med	Yes/Good	Yes	No	No/Mod	Excel	Minim	3,179	20.3
Black Birch	High	Yes/Good	Yes	No	No/Mod	Excel	Minim	3,890	26.8
Hickory	High	Yes/Fair	Bad	No	No/Mod	Excel	Good	4,327	27.7
HardMaple	High	Yes	Bad	No	No	Excel	.	.	.
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Pecan	High	Yes	Yes	No	No	Excel	.	.	.
Dogwood	High	Yes	Yes	No	No	Excel	.	.	.
Red or Soft Maple	Med	Yes	No	No	No	Good	.	2,924	18.7
Cherry	Med	Yes/Poor	Yes	No	No/Few	Good	Excel	3,120	20.0
BlackCherry	Med	Yes/Poor	Yes	No	No/Few	Good	Excel	2,880	19.9
Walnut	Med	Yes	Yes	No	No	Good	.	.	.
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White Elm	Med	Med/Fair	No	Med	No/None	Fair	Fair	3,052	19.5
AmericanElm	Med	Med/Fair	No	Med	No/None	Fair	Fair	3,052	19.5

Sycamore	Med	Med	No	Med	No	Fair	.	.	.
Gum	Med	Med	No	Med	No	Fair	.	.	.
Aspen	Low	Yes	Yes	Med	No	Fair	.	2,295	14.7
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Basswood	Low	Yes	Yes	Med	No	Fair	.	2,108	13.5
Cottonwood	Low	Yes	Yes	Med	No	Fair	.	2,108	13.5
Chestnut	Low	Yes	Yes	Med	Yes	Poor	.	.	.
Apple	High	Poor	.	.	Few	Med	Excel	4,140	26.5
Hemlock	Low	.	.	.	Many	Fair	Good	2,482	15.9
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BlackLocust	High	Poor	.	.	None	Good	Minim	3,890	26.8
Sugar Maple	High	Poor	No	.	Few	Good	Good	3,757	24.0
Eastern Hornbeam	High	.	.	.	.	Excel	.	4,267	27.3
Hackberry	Med	.	.	.	.	.	.	3,247	20.8
Boxelder	Low	.	.	.	.	.	.	2,797	17.9
Butternut	Low	.	.	.	.	Poor	.	2,100	14.5
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Softwoods	.								
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Yellow Poplar	Low	Yes	Yes	Med	Yes	Poor	.	.	.
Southern Yellow Pine	High/ Low	Yes	Yes	Yes	No/Mod	Good	Good	.	.
Douglas Fir	High	Yes	Yes	Yes	No	Good	.	.	.
Cypress	Med	Med	Yes	Med	No	Fair	.	.	.
Redwood	Med	Med	Yes	Med	No	Fair	.	.	.
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White Cedar	Med/ Low	Yes/Exc	Yes	Med	Some	Good	Excel	1,913	12.2
Western Red Cedar	Med/ Low	Yes/Exc	Yes	Med	Yes/Many	Good	Excel	.	.
Eastern Red Cedar	Med/ Low	Yes/Exc	Yes	Med	Yes/Many	Good	Excel	.	.
Eastern White Pine	Low	Med/Exc	Yes	Med	No/Mod	Fair	Good	2,236	14.3
Western White Pine	Low	Med/Exc	Yes	Med	No/Mod	Fair	Good	2,236	14.3
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Sugar Pine	Low	Med/Exc	Yes	Med	No/Mod	Fair	Good	.	.
Ponderosa Pine	Low	Med/Exc	Yes	Med	No/Mod	Fair	Good	2,380	15.2
Tamarack	Med	Yes	Yes	Med	Yes	Fair	.	3,247	20.8
Larch	Med	Yes	Yes	Med	Yes	Fair	.	.	.
Spruce	Low	Yes	Yes	Med	Yes	Poor	.	2,100	14.5
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Black Spruce	Low	.	.	.	.	.	.	2,482	15.9
Jack Pine	Low	.	.	.	.	.	.	2,669	17.1
Norway Pine	Low	.	.	.	.	Fair	.	2,669	17.1
Pitch Pine	Low	.	.	.	.	Fair	.	2,669	17.1
Balsam Fir	Low	.	.	.	.	Poor	.	2,236	14.3
Willow	Low	.	.	.	.	Poor	.	2,100	14.5
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Coals	.							one ton	per ton
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Anthracite	High	No	N/A	.	No	Good	Good	2,000	25.4
Bituminous Hi-Volat	Med	Med	N/A	.	No	Med	Fair	2,000	22.0
Bituminous Lo-Volat	Med	Yes	N/A	.	No	Med	Fair	2,000	28.6
Lignite	Low	Yes	N/A	.	No	Poor	Poor	2,000	13.8
Charcoal	High	Yes	N/A	.	No	Poor	Poor	2,000	26.0

Weight and Heat content figures are based on seasoned wood at 20% moisture content, and 85 cu ft of wood per cord. A "cord" of wood is defined as a stack 4 feet high, 4 feet thick and 8 feet long. (A cord has about 85 cu ft of wood and not 128, because of the air spaces between the pieces). "Face cords" are often sold. These are amounts of wood that are still 4 feet high and 8 feet long, but of a lesser depth than 4 feet. Commonly, wood for sale is cut to 16 inches long, and stacked as a face cord. This is 1/3 of an actual cord, and it is also called a "rank" or "rick" or "stove cord" or "fireplace cord".

For more technical information on the amount of heat in wood, and how it is measured and calculated, see Amount of Energy in Wood.

In general, softwoods light and burn easily and quickly with a hot fire which tends to make a lot of sparks.

Hardwoods are usually harder to start but burn more evenly and quite a bit longer.

Regarding Seasoning of Wood

Freshly cut wood has a very high moisture content. As much as 60% (or more) of the weight of a tree is water. At least some of this water must be removed before trying to use it as a fuel wood. See Amount of Energy in Wood, for a discussion of why that is necessary. Several bad results can occur from burning wood that is not fully dried to below 25% moisture content. (Such wood is referred to as "green" wood). As that discussion mentions, the effective available heat is MUCH less, not just because there is less wood fibers in each pound of wood put in the woodburner, but that a good percentage of that heat must be used to evaporate all that water before those wood fibers can burn. Another VERY important consequence of burning green wood is that the presence of all that moisture tends to keep "putting out" the fire, and therefore making it burn very poorly, which tends to produce a lot of creosote and pollution. **Don't Do It!**

Generally, the way this drying is accomplished is by **"seasoning"** it. Firewood is cut to length and then seasoned (dried) in a stack, with air being able to get to it, for **at least 9 months** before burning. The natural 60%-70% moisture content must be reduced to about 20% to burn well. The wood cells don't lose much moisture through the bark; the moisture is most effectively removed through the cut cells at the ends of each piece.

That's why logs which have lain in the woods for years may still have a lot of moisture and may not burn well (unless cut and dried.) We have heard of people cutting up these downed trees and immediately putting them in a woodburner! And the wood burns poorly! Now you know why!

OK! So, sometimes, it turns out to be NECESSARY to burn some green wood. Which species would be best under those conditions? It turns out that the desirability is NOT the same as for seasoned wood! While they are living, various species of trees have different moisture contents. If you suitably dry them all, that difference rather disappears. But, while still green, it becomes significant.

It is possible to correlate both the heat-content of the wood fibers and the green moisture content to form a table of desirability for those situations when green wood must be burned.

Species	Excess Moisture to dry weight	GREEN ranking	SEASONED ranking
Ash	15%	1	8
Beech	17%	2	4
Black Locust	17%	3	1
Red Spruce	18%	4	16
Shagbark Hickory	19%	5	2
Sugar Maple	21%	6	5
Norway Pine	19%	7	14
Tamarack	21%	8	10
Black Cherry	22%	9	11
Yellow Birch	23%	10	7
White Birch	24%	11	12

Red Maple	24%	12	9
White Oak	25%	13	3
Silver Maple	27%	14	13
Red Oak	31%	15	6
White Pine	31%	16	21
White Elm	35%	17	15
Basswood	38%	18	22
Aspen	40%	19	19
Butternut	41%	20	18
Balsam Fir	44%	21	20
Hemlock	44%	22	17

Excess moisture is that percentage above the desirable 20% seasoned moisture content.

There is a complication that applies to at least some of the numerical data in the tables above. Unfortunately, two VERY different methods of describing moisture content are sometimes used. The scientific approach is to take a piece of wood and "remember" the initial weight of it. Let's say we have a piece that starts out weighing exactly one pound. If we had X-ray eyes, maybe we could see that that specific piece was actually 60% water and 40% wood fibers. A scientist would say that the initial moisture content was 60% (sounds obvious). Now, let's dry that piece, so that 5/6 of that original water evaporates. The wood fibers (originally 40% of the start) are all still there. So is water that represents 10% of the original weight of the piece of wood. So a scientist could describe this dried piece of wood as having 10% remaining moisture content.

However, think of the reality of the situation. Fifty percent of the weight of the piece of wood is now gone, evaporated as water vapor. When we actually look at the final piece of dried wood, we have no indication of all that moisture that used to be there! All we have left is wood fibers (which represents 4/5 of what we have left) and the remaining moisture (which represents the remaining 1/5 of what we have left). In practical terms, we could describe that 1/5 moisture in the piece as being 20% moisture content. Since this approach can be used with any piece of existing wood (without having to know its previous history), this is a common way used of describing the moisture content of wood.

Do you see the confusion? For our test piece, we could very correctly describe the moisture content of the dried piece as being either 10% or 20%, and either would be true. Unfortunately, some of the sources of the numerical data in the chart above did not indicate which of these two methods they used in deriving their results.

In general, we intended these charts to be of "comparative" usefulness, so a wood burner might have a general idea of which species might be better or worse. So, as long as you are not weighing all of your wood before putting it in your stove and doing rigid scientific studies, the information should be fine and you can ignore these technical comments.

If you ARE of a technical bent, there is actually yet another method that occasionally gets used. About 1980, a researcher decided to start referring to wood moisture in a piece of wood as being the percentage of the original moisture in the piece. This is a poor approach, but his reputation in the industry caused some people to adopt this system. His system would had looked at our example piece above and said that it started out with 100% moisture, and since the dried piece ended with 1/6 of that original moisture, he would have described the dried piece as having 17% moisture content.

I guess the bottom line of all this is to just realize that when anyone states a "moisture content" of a piece of wood, just remember that that number is dependent on just which system of measuring was used! And then smile, because that level of detail is pretty much irrelevant in actually using a wood stove!

Miscellaneous Wood Subjects

A number of specialty subjects might be useful to woodburners.

- Should pieces of wood be split from the top down or the bottom up? Since most people these days either buy their wood already split or they use hydraulic log-splitters, this is a somewhat irrelevant question these days. Even though old timer wood burners will adamandtly tell you one or the other, careful experimental tests have shown that there is no advantage in time or effort in splitting from either direction. It doesn't matter!
- Wood pieces should be split along "check lines", cracks that have already formed in the piece during drying. This can significantly reduce the time and effort necessary to split pieces of wood.
- There are people who believe that wood is split easiest if it is frozen. The idea is that the pieces are more brittle and will sort of shatter. Surprisingly enough, experimental tests showed very little advantage of spliting general wood. Even more surprising, if most of the wood to be split is full of knots, there is actually substantial advantage of doing that splitting them thawed and not frozen!
- There are people who insist that wood should be dried (seasoned) for at least one or two years. Experimental evidence has established that that is nearly always unnecessary, as long as the pieces of wood are cut to length and stacked. Natural airflows through the stack, and particularly through the cut cells of the pieces of wood themselves, dries them sooner than that. Experimental evidence has established that one-foot long cut pieces generally dry to acceptable levels in just two or three months. Two-foot long cut pieces take about six or seven months for similar acceptability. Four-foot long cut pieces DO require at least a year.

  Associated with this, covering the woodpile with a tarp slightly improves this, but probably not enough to make the expense of a tarp worthwhile, except in a climate where rain and very high humidity is common. Similarly, split pieces of wood tend to dry slightly faster than full diameter logs, but again by minimal amounts.

  There appears to be no value in drying firewood more than about nine months.

- If wood is stacked in four-foot or longer lengths, the drying process is greatly slowed. In other words, if wood is cut to four-foot length and stacked, for nine months, and then cut to shorter burning length just before use, it will probably not burn well because it is still to wet (green).

Technical Series

The Amount of Energy in Wood Fuel

There are a number of different values used for the energy content of wood fuels. This discussion will attempt to show the relationship between these different values.

In a laboratory, it is possible to get about 8660 Btu/lb of wood fuel. This number is often presented as the number to use in determining outputs and efficiencies of appliances. This "high heat value" is obtained only with perfectly dry wood (0% moisture content) and only in an atmosphere of pure oxygen in a "bomb calorimeter." For laboratory use, this is a useful number and is handy for theoretical problem analysis. But for the practical world, it is unrealistic.

When wood is alive it consists primarily of water, i.e. most of its weight is actually water. After being cut to length and stacked for a year or two, the average moisture content generally drops to 20% or so. Another way of saying this is that 1.25 pounds of well seasoned wood contains 0.25 pound of water and 1.0 pound of wood fibres. You can easily see that our piece of seasoned wood has 8660 Btu per 1.25 (total) pounds or 6930 Btu/pound of actual total weight.

We now confront the problem of having 0.25 pound of water in our sample piece. It will be necessary to evaporate this water and raise its temperature to that of the flue gas temperature. There are also two other sources of water that we should consider that will also have to be heated. They are: 1) the moisture in the humidity content of the air used for combustion and excess air which is quite variable dependent on the relative humidity; and 2) the moisture produced as a by product of the combustion process. Hydrogen atoms in the wood combine with the oxygen atoms in the draft air to form water vapor. This is one of the major chemical reactions that occurs in combustion to give off energy. In wood heating, it is generally second to the carbon-to-carbon monoxide /dioxide reactions in producing energy.

The energy used in vaporizing and heating the water/water vapor exists in the water vapor as "latent heat." In principle all latent heat can be recovered to produce more usable output. Since this possibility exists, many researchers use a "high heat value (HHV)" for wood energy content that does not take latent heat into consideration. Therefore, they use the 8660 or for 20% moisture wood, 6930 figure in their calculations. In real terms, it would be necessary to have the flue gases exhaust at the temperature of the initial incoming draft air which may be near 0° Fahrenheit.

> Another approach to the situation is to account for latent heat effects. This is the so-called European system approach that was the only analysis is use (except in laboratories) up to about 1978. We at JUCA favor this approach since it comes much closer to reproducing the actual conditions of consumer use of a product. The latent heat put into the water vapors from all three sources are removed from the calculations as being not recoverable for all practical purposes.

Since about 1050 Btu are necessary to boil or evaporate a pound of water, and 1 Btu additional is necessary to raise the pound's temperature 1°F, it is possible to determine the latent heat fairly easily by knowing the total weight of water vapor given off by the fire. We had the 0.25 pound of moisture content. Add about 0.54 pound of water vapor as products of combustion. If we assume low humidity conditions that contribution is small. We now have 0.79 pounds of water vapor that started at say 60°F average temperature and was heated to say 400°F. The latent heat is then 0.79 times (1050 plus 340 temp rise) or 1098 Btu per 1.25 pound piece, or 880 Btu/pound. Therefore, the "low heat value (LHV)" of wood fuel is less than the high heat value (HHV) by this amount. The result is that the available energy in seasoned (20% moisture content) wood used in an actual usage environment (400°F flue gases) is about 6050 Btu/pound. We feel that this is the most realistic number to use for domestic wood burning as it is the number that would apply if the user weighed his wood as part of determining efficiency of his appliance.

Some charts you may run across use a figure described as an output per cord or pound of wood. This is always based on some assumption about the efficiency of the device being used. Often 50% or 40% is assumed, so that if the actual device had substantially different efficiency the figures would be wrong. Even the LHV must be slightly compensated for if the flue gas temperature is not as assumed, but these changes are relatively small and generally will not materially affect comparison results.

There are also differences in types of wood. Softwoods usually have a lot of resin content that has high energy content so their total energy content is usually higher than for hardwoods (often by about 5%). The softwoods tend to burn up faster than hardwoods and have other characteristics that reduce their attractiveness as fuel. The fact that their average density is usually lower than hardwoods means that you get less weight of wood in a cord and the extra 5% of volatile fuel will not make up for this.

For comparison sake, using LHV gives results about 8% higher that the same results using HHV. Thus, an 80% device (LHV) is 74% efficient using HHV. A 45% HHV reading is equivalent to about 49% LHV.

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It is also useful to note how these concepts apply to un-seasoned (green) wood fuel. If only seasoned a short time, 50% moisture is a realistic figure. Then a two-pound piece has one pound of wood fibers (worth 8660 Btu). There will be 1.54 pounds of water to vaporize and heat up (taking away 2200 Btu). The two-pound piece has a net available energy content of 6460 Btu or 3230 Btu/pound. This is only HALF of the available energy present when burning seasoned wood. Green wood consumes the bulk of its energy just to keep itself going, and is obviously subject to easily going out.

A freshly cut tree has even higher moisture content, often above 60%. Similar calculations show that this fresh wood has only 2000 Btu/pound of energy available. This explains why it is so difficult to burn freshly cut trees.