A4162

How to Compare Heating Fuels

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After the first shot of cold winter weather when the energy bill arrives, we often grumble about the cost and wonder if there is a less expensive option. It's not easy to compare different fuels because they contain different amounts of energy and are measured in different units. The thermal efficiency of the associated heating appliance may also be different.

To compare energy types, it is necessary to first determine the amount of heat needed or the amount of heat that is distributed in the building after flue (chimney) losses—the usable heat. To determine the usable energy for heating, you will need three pieces of information: the fuel cost (not including fixed costs such as tank rental or meter fees), the amount of energy purchased for at least one year (preferably 2 years), and the thermal efficiency of the heating appliance. The fuel cost and amount of energy purchased can be determined from energy bills, or you can call your supplier for a summary. The thermal efficiency is usually on the nameplate of the appliance. If it isn't, you can contact the manufacturer of the appliance, or, if the nameplate lists the input Btu/hr and output Btu/hr (as in figure 1), you can calculate the thermal efficiency yourself using this equation:

$$\text{Appliance efficiency} = \frac{\text{output Btu}}{\text{input Btu}}$$

If you have a heating appliance older than 20 years, it may have lost some of its nameplate efficiency due to aging and should be de-rated by 2% to 5% depending on its condition.

The usable energy is measured in Btu (British Thermal Units—the amount of energy required to increase the temperature of one pound of water by one degree Fahrenheit) and is determined using the following equation:

$$\text{Usable energy (Btu)} = \text{units of energy purchased} \times \text{energy content per unit} \times (\text{appliance efficiency} - \text{\% de-rated (optional)})$$

The energy content can be determined from table 1 for common fuel types, or you can contact your energy supplier.

FIGURE 1. **The input and output listed on an appliance nameplate such as this one can be used to calculate thermal efficiency.**

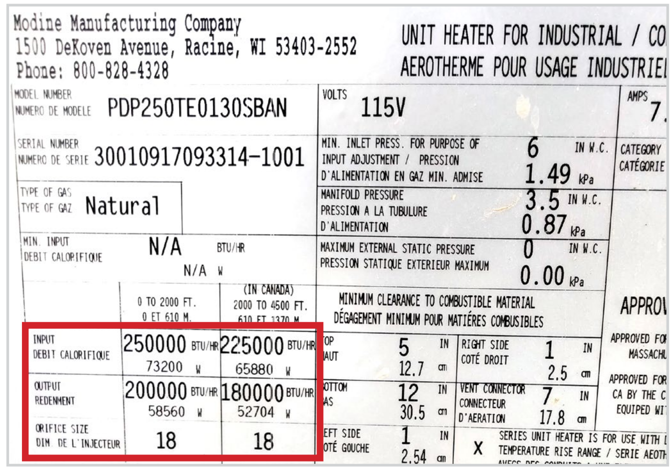

TABLE 1. **Typical energy content of fuels.**

Fuel type	Unit of sale	Energy content (Btu/unit)
Natural gas	therm	100,000 Btu/therm
LP gas (propane)	gallon	91,600 Btu/gallon
Heating oil	gallon	138,000 Btu/gallon
Electric	kWh	3413 Btu/kWh
Coal	ton	28,000,000 Btu/ton
Hardwood (oak, maple, beech)	full cord	25,000,000 Btu/cord
Mixed wood (soft and hard)	full cord	22,000,000 Btu/cord
Wood pellets	pound	8,000 Btu/pound
Green wood chips	ton	8,000,000 Btu/ton

Example calculation

A greenhouse uses 2456 gallons of heating oil to heat the greenhouse during the cold months of the year (from February to May) using a 25-year-old furnace with a nameplate input of 300,000 Btu/hr and output of 240,000 Btu/hr. Due to the age, the efficiency will be de-rated by 3%. What is the usable energy?

First we will calculate the appliance efficiency as follows:

$$\text{Efficiency} = \frac{\text{output energy}}{\text{input energy}}$$

$$= \frac{240{,}000 \text{ Btu/hr}}{300{,}000 \text{ Btu/hr}}$$

$$= .80$$

Then we calculate the usable energy:

$$\text{Usable energy} = 2456 \text{ gallons/yr} \times 138{,}000 \text{ Btu/gallon} \times (0.80 \text{ efficiency} - 0.03 \text{ de-rated}) = 260{,}974{,}560 \text{ Btu/yr}$$

If the greenhouse were heated with LP gas instead of heating oil, how much LP gas would be used? A new high-efficiency unit heater with a nameplate efficiency of 93% would be purchased.

Solving the equation above for the units of energy purchased:

$$\text{Units of energy purchased} = \frac{\text{usable energy}}{\text{energy content per unit} \times \text{appliance efficiency}}$$

$$\text{Units of energy purchased} = \frac{260{,}974{,}560 \text{ Btu}}{91{,}600 \text{ Btu/gallon} \times 0.93}$$

$$= 3064 \text{ gallons of LP gas}$$

The calculation shows that it would take more units of LP gas than heating oil to heat the greenhouse, but it's the total cost that matters, not the amount of fuel.

$$\text{Total fuel cost} = \text{unit cost} \times \text{amount used}$$

The price of heating oil is $2.49 per gallon, and the cost of LP gas is $1.59 per gallon.

$$\text{Heating oil cost} = \$2.49\text{/gallon} \times 2456 \text{ gallons/yr} = \$6115\text{/yr}$$

$$\text{LP gas cost} = \$1.59\text{/gallon} \times 3064 \text{ gallons/yr} = \$4872\text{/yr}$$

Heating the greenhouse with LP gas would cost $1243 less per year than heating with heating oil. The cost savings could be used to pay for a new LP gas appliance to switch fuel types. A new high-efficiency unit heater (93% efficiency), with approximately the same output of energy, sells for $3750 installed. Is this a worthwhile investment? A quick way to see if an investment is worth further consideration is to calculate the simple payback. Simple payback is the number of years it will take to pay back the investment cost using the annual savings.

For this example, the simple payback is:

$$\text{Simple payback} = \frac{\text{investment}}{\text{annual savings}}$$

$$= \frac{\$3750}{\$1243}$$

$$= 3.0 \text{ years}$$

The fuel savings from 3.0 years of operations would pay back the cost of the unit heater. Is this a good investment? The new heater has a life of 10+ years, so after 3 years there would be an extra $1243 each year for at least 7 years, which could be invested elsewhere. This would be approximately equal to getting 33% interest on a savings account. Since that rate of return is much higher than typical interest rates, buying an LP gas heater would be a very good investment.

Burning wood

Many people would like to consider cordwood or wood pellets as an alternate energy source. The energy content of wood varies with the species or mix of species and moisture content. The moisture content of wood must be less than 20% for proper combustion. A mix of hardwood species (oaks, maple, hickory, beech) will have a higher energy content than softwood species (box elder, poplar, ash), mainly because hardwood has a higher density (it is heavier per unit of volume). All wood has an energy content of about 8000 Btu per pound at a moisture content of 20%. The energy content of wood pellets will be listed on the bag and is generally about 8000 to 8200 Btu per pound.

The energy efficiency of wood combustion appliances varies greatly. Older outdoor wood boilers (hydronic heaters) may be as low as 20% efficient, while new EPA-certified units could be as high as 75% efficient. The efficiency of wood pellet appliances can range from 78% to 85% for a standard unit to over 90% for a high-efficiency unit. The best place to find efficiency values for all currently available wood-burning appliances is the EPA Burn Wise website (https://www.epa.gov/burnwise). If you are comparing an older outdoor wood boiler (manufactured prior to 2010, or one without gasification technology), an energy efficiency of 40% would be representative of the boilers on the market at that time. Smoke emissions are an indication of low efficiency. If considering switching from a fossil fuel to cordwood, the labor for refueling needs to be considered as part of the annual cost and subtracted from any estimated fuel savings.

Example

A home has used an average of 1250 gallons of LP gas for the last five winters at $1.55 per gallon with an 80%-efficient boiler. The homeowner is considering an outdoor wood boiler and cutting his own wood. A new outdoor boiler with an efficiency of 68% will cost $13,000 installed. Bulk wood sales are $250 per full cord based on a survey of online offerings in the area. The homeowner estimates his cost to cut wood at $150 per cord to cover the cost of ownership and maintenance of chainsaws, a wood splitter, and a trailer, as well as some of his time. Harvesting wood is not free, but it does provide great exercise.

Based on the above example, the results are as follows:

Annual fuel cost with LP gas	$1938
Usable energy	91,600,000 Btu
Estimated amount of hardwood	5.4 cords
Cost of hardwood	$810 (at $150/cord) to $1350 (at $250/cord)
Annual savings	$1128 to $588 per year
Investment cost	$13,000
Estimated payback	12 to 22 years

A 12-year simple payback is the equivalent of receiving an 8% interest rate on an investment, but this doesn't include maintenance or labor for refueling. Comparing the lifespan of the appliance to the simple payback is important because if the product wears out before the end of the simple payback period, then the investment won't be fully recovered.

Based on the 2018 cost of different fuel types, if you are using natural gas for heating, it will be the least expensive option provided you're using a high-efficiency heating unit. If your current natural gas or LP gas heating appliance does not have an efficiency of 90% or higher (typically vented with PVC pipe), replacing the heating appliance with a high-efficiency unit or adding wall or ceiling insulation to the building may be a better investment than switching fuel sources.

Fuel cost comparison worksheet

Type of heating fuel currently being used ____________________

1. Cost per unit of current fuel $ ____________ / ____________ (use same units shown in table 1)
2. Energy content of fuel (consult table 1) ____________
3. Amount of fuel used per year (same units as in table 1) ____________
4. Multiply lines 2 & 3 ____________ Btu/year
5. Efficiency of heating appliance
   a. From appliance nameplate ____________

   or

   b. Output Btu ____________
   c. Input Btu ____________
   d. Divide line b / line c ____________
   e. Amount to de-rate an old appliance (1% to 5%) ____________
   f. Overall efficiency (subtract line e from line a or line d ____________
6. Usable heat (multiply the results of line 4 by line 5f ____________
7. Fuel cost per year (multiply lines 1 & 3) ____________

Potential new fuel type for comparison ____________________

8. Cost per unit of "new" fuel $$ ____________ / ____________ (use same units shown in table 1)
9. Energy content of "new" fuel (consult table 1) ____________
10. Divide line 6 by line 9 ____________
11. Efficiency of the proposed new appliance ____________
12. Amount of new fuel estimated per year (divide line 10 by line 11) ____________
13. New fuel cost per year (multiply line 12 by line 8) ____________
14. Annual fuel cost saving/loss (subtract line 7 from line 13) ____________
15. Cost/investment of new fuel appliance $ ____________
16. Approximate time for payback (divide line 15 by line 14) ____________

For more information on using wood for heating visit www.wisconsinwoodenergy.org.

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