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Fuel Cost Comparison

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A relative cost comparison chart showing heating values for fuels and biomass can be helpful in deciding what type of fuel is the most cost effective to use. The chart is arranged so the prices of each fuel are easy to compare. The cost to deliver a given amount of heat based upon a specific heating efficiency is in the same column. For example, if the price of No. 2 fuel oil is $3.45 per gallon, the equivalent cost is 12 cents per kilowatt-hour (kwh) for electricity, $301.68 per ton for coal, $11.93 per bushel for hard red spring wheat, $27.43 per hundredweight for sunflower seed and $10.87 per bushel of corn.

In a typical heating appliance, the burners (Figure 1) release heat from the fuel source, and a heat exchanger (Figure 2) is used to transfer that heat to a delivery device, such as the heating ducts in a home or hot-water piping

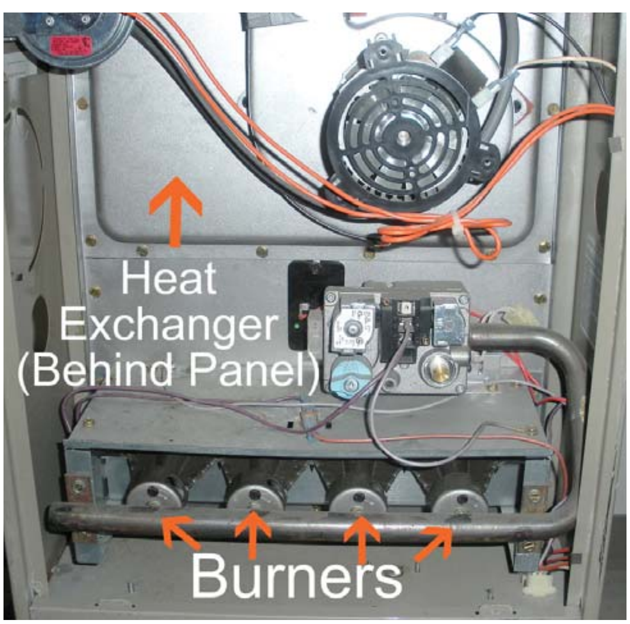
Heating efficiencies vary depending on the type, quality and condition of the burner and the heat exchanger. Some of the newer natural gas and propane heating appliances have efficiencies that are well above 90 percent. Also, if burners are not maintained properly, they may operate at 70 to 75 percent efficiency, and the heat exchanger may have an efficiency of only 75 to 80 percent, reducing the overall heating efficiency to only 50 to 60 percent. If a heating appliance is operating at 50 percent efficiency, $50 of every $100 spent on fuel simply is wasted.

Burner efficiency is controlled by adjusting the air-to-fuel ratio and the fuel injection system to allow for efficient combustion. If inefficient combustion occurs, soot may build up on the heat exchanger and insulate it, so more heat will go up the chimney and less will move through the heat exchanger. Inefficient combustion also produces more carbon monoxide.

For maximum efficiency, efficient combustion along with maximum heat transfer through the heat exchanger must occur. Heating contractors and service technicians have equipment to test combustion efficiency and remove soot from heat exchangers. Heating equipment inspections by competent service technicians will help make heating equipment safer. Cracks in heat exchangers that allow carbon monoxide to escape from the burner into living space must be repaired or replaced immediately.

As energy costs rise, more efficient ways to provide heat become more attractive, even though they may have a higher initial cost. Heat pumps that extract heat from the air have been in use for a number of years. Extracting heat from the earth with heat pumps is a newer and more efficient method.

Figure 1. Burners



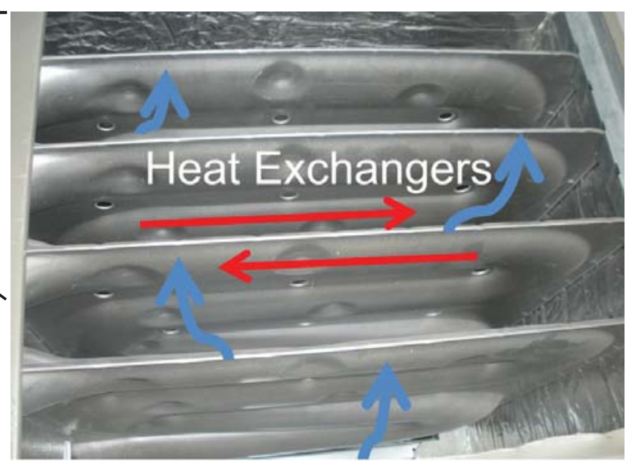


Figure 2. Heat exchangers

The efficiency of air-source heat pumps varies widely. As the outside air temperature goes down, the efficiency of the heat pump decreases to less than 100 percent near 0 degrees Fahrenheit. Throughout the entire heating season, the air-source heat pump usually will show a significant cost advantage over electric-resistance heating in more moderate climates, and during the summer it also can be converted to an air conditioner.

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Fuel Cost Comparison Chart

Percent Efficiency	Fuel Type	Equivalent Price of Each Fuel						
100%	Electric Resistance kWh	0.04	0.05	0.06	0.07	0.08	0.09	0.10
200%	Heat pump (Air Source) kWh	0.08	0.10	0.12	0.14	0.16	0.18	0.20
350%	Heat pump (Earth Source) kWh	0.14	0.18	0.21	0.25	0.28	0.32	0.35
92%	Natural Gas $/Therm High Efficiency	1.08	1.35	1.62	1.89	2.16	2.43	2.70
75%	Natural Gas $/Therm Low Efficiency	0.88	1.10	1.32	1.54	1.76	1.98	2.20
70%	#1 Fuel Oil or Diesel Fuel $/Gal.	1.11	1.38	1.66	1.94	2.22	2.49	2.77
70%	#2 Fuel Oil or Diesel Fuel $/Gal.	1.15	1.44	1.72	2.01	2.30	2.58	2.87
75%	Propane $/Gal.	0.81	1.01	1.21	1.42	1.62	1.82	2.02
92%	Propane $/Gal. High Efficiency	0.99	1.24	1.49	1.74	1.98	2.23	2.48
75%	Methanol $/Gal.	0.57	0.71	0.85	1.00	1.14	1.28	1.42
75%	Ethyl Alcohol 160 Proof $/Gal.	0.59	0.74	0.89	1.03	1.18	1.33	1.48
75%	Ethyl Alcohol 180 Proof $/Gal.	0.66	0.83	1.00	1.16	1.33	1.50	1.66
75%	Ethyl Alcohol 200 Proof $/Gal.	0.74	0.92	1.11	1.29	1.48	1.66	1.85
75%	Gasohol (90/10) $/Gal.	1.06	1.33	1.59	1.86	2.13	2.39	2.66
75%	Gasoline Unleaded $/Gal.	1.09	1.36	1.63	1.91	2.18	2.45	2.72
70%	Vegetable Oil or Biodiesel $/Gal.	1.07	1.33	1.60	1.87	2.13	2.40	2.67
65%	Sunflower Oil Meal $/Ton	137.12	171.40	205.68	239.96	274.24	308.52	342.80
65%	Sunflower Hulls $/Ton	123.41	154.26	185.11	215.96	246.82	277.67	308.52
65%	Sunflower Seeds $/Cwt.	9.14	11.43	13.72	16.00	18.29	20.57	22.86
65%	Shelled Corn $/Bushel	3.63	4.53	5.44	6.34	7.25	8.15	9.06
65%	HRS Wheat (Grain) $/Bushel	3.98	4.97	5.96	6.96	7.95	8.95	9.94
65%	Barley (Grain) $/Bushel	3.00	3.75	4.50	5.25	6.00	6.75	7.50
65%	Wheat and Barley Straw $/Ton	114.27	142.84	171.41	199.98	228.54	257.11	285.68
50%	Wood (Air Tight Stove) $/64 cft (½ standard cord) 65% Wood and 35% Air	60.45	75.57	90.68	105.80	120.91	136.03	151.14
65%	Coal (lignite) $/Ton	100.56	125.70	150.84	175.98	201.12	226.26	251.40

Formula used to determine values were based on the price per kWh

Comparative Cost Equation:

$$\text{Comparative Cost Fuel A} = \left[\frac{\text{Heat Value Fuel A} \times \text{Heating Efficiency Fuel A}}{\text{Heat Value Fuel B} \times \text{Heating Efficiency Fuel B}}\right] \times \text{Cost of Fuel B}$$

Fuel Cost Comparison Chart – continued

Equivalent Price of Each Fuel – continued										Energy Content
0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	3413 Btu/kWh
0.22	0.24	0.26	0.28	0.30	0.32	0.34	0.36	0.38	0.40	3413 Btu/kWh
0.39	0.42	0.46	0.49	0.53	0.56	0.60	0.63	0.67	0.70	3413 Btu/kWh
2.97	3.23	3.50	3.77	4.04	4.31	4.58	4.85	5.12	5.39	100,000 Btu/Therm
2.42	2.64	2.86	3.08	3.30	3.52	3.74	3.96	4.18	4.39	100,000 Btu/Therm
3.05	3.32	3.60	3.88	4.15	4.43	4.71	4.98	5.26	5.54	135,000 Btu/Gal.
3.16	3.45	3.73	4.02	4.31	4.59	4.88	5.17	5.46	5.74	140,000 Btu/Gal.
2.22	2.43	2.63	2.83	3.03	3.23	3.44	3.64	3.84	4.04	92,000 Btu/Gal.
2.73	2.98	3.22	3.47	3.72	3.97	4.22	4.46	4.71	4.96	92,000 Btu/Gal.
1.56	1.71	1.85	1.99	2.13	2.27	2.42	2.56	2.70	2.84	64,700 Btu/Gal.
1.62	1.77	1.92	2.07	2.22	2.36	2.51	2.66	2.81	2.95	67,200 Btu/Gal.
1.83	1.99	2.16	2.33	2.49	2.66	2.82	2.99	3.16	3.32	75,600 Btu/Gal.
2.03	2.22	2.40	2.58	2.77	2.95	3.14	3.32	3.51	3.69	84,000 Btu/Gal.
2.92	3.19	3.45	3.72	3.99	4.25	4.52	4.78	5.05	5.31	120,900 Btu/Gal.
3.00	3.27	3.54	3.81	4.09	4.36	4.63	4.90	5.18	5.45	124,000 Btu/Gal.
2.93	3.20	3.47	3.73	4.00	4.27	4.53	4.80	5.07	5.33	130,000 Btu/Gal.
377.08	411.36	445.64	479.92	514.20	548.48	582.76	617.04	651.32	685.60	9,000 Btu/lb
339.37	370.22	401.08	431.93	462.78	493.63	524.48	555.34	586.19	617.04	8,100 Btu/lb @ 8% moisture
25.15	27.43	29.72	32.00	34.29	36.58	38.86	41.15	43.43	45.72	12,000 Btu/lb @ 8% moisture
9.97	10.87	11.78	12.68	13.59	14.50	15.40	16.31	17.21	18.12	8,500 Btu/lb @ 15.5% moisture
10.93	11.93	12.92	13.92	14.91	15.90	16.90	17.89	18.89	19.88	8,700 Btu/lb @ 13.5% moisture
8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00	8,200 Btu/lb @ 12.5% moisture
314.25	342.82	371.38	399.95	428.52	457.09	485.66	514.22	542.79	571.36	7,500 Btu/lb @ 8% moisture
166.25	181.37	196.48	211.60	226.71	241.82	256.94	272.05	287.17	302.28	6,200 Btu/lb @ 20% moisture
276.54	301.68	326.82	351.96	377.10	402.24	427.38	452.52	477.66	502.80	6,600 Btu/lb @ 12% moisture

Example 1: Compare the cost of electricity at \$.04/kWh, 100% efficiency, to the cost of propane at 92,000 Btu/Gal in a 75% efficient furnace.

Example 1: Propane Cost $= \left[\dfrac{\text{92,000 Btu/Gal. x .75 Heating Efficiency}}{\text{3,413 Btu/kWh x 1.00 Heating Efficiency}} \right]$ x .04 Electricity Cost/kWh = \$.81 per Gal. Propane

Example 2: Compare the cost of natural gas at \$.81/CCF in a 92% efficient furnace to the cost of propane at 92,000 Btu/Gal in a 75% efficient furnace.

Example 2: Propane Cost $= \left[\dfrac{\text{92,000 Btu/Gal. x .75}}{\text{100,000 Btu/CCF x .92}} \right]$ x \$.81/CCF = \$.61 per Gal. Propane

Earth-source heat pumps may show a 300 to 400 percent advantage in efficiency over electric-resistance heating. These units circulate an antifreeze solution through pipes in the earth to transfer energy. Other earth-source systems draw water from one well, circulate it through a heat exchanger and discharge the water to another well. Because the heat source, earth or groundwater, is normally warmer than air and doesn't vary as much as air temperature, these units have a higher efficiency, but burying pipes in the earth or digging wells is an added expense.

Several other materials that occasionally may be considered and used as alternate fuels are listed. These are included so their economic value may be compared. These include feed grains, vegetable oil, gasoline and diesel fuel.

A comparison of heating costs needs to include capital and labor costs in addition to the cost of the energy or fuel.

If a homeowner wants to estimate annual home heating costs, the following chart may give some help. A well-insulated, 1,500-square-foot home in North Dakota will require about 80 million British thermal units (Btus) of heat during a year's time. A 3,000-square-foot well-insulated home will require about two times as much energy. An older, poorly insulated 1,500-square-foot home may require up to five times as much heat, compared with a well-insulated home. With fluctuating fuel costs, insulating foundations, walls and ceilings and sealing cracks around doors and windows, along with selecting a new heat source, is important for homeowners.

Estimated Annual Heating Cost for Selected Fuels*

Fuel Type		Heating Efficiency Percent	Fuel Cost	Energy Use Per Year for a 1,500-square-foot Home	Energy Cost for a 1,500-square-foot Home
Elec. Res.	(3413 Btu/kwh)	100%	$0.10/kwh	23,440kwh	$2,344
Elec. Res.	(Off-peak)	100%	$0.06/kwh	23,440kwh	$1,406
Propane	(92,000 Btu/gallon)	92%	$2.02/gallon	945 gallons	$1,909
Natural Gas	(100,000 Btu/therm)	92%	$.62/therm	870 therms	$539
Fuel Oil	(140,000 Btu/gallon)	70%	$2.87/gallon	816 gallons	$2,342
Vegetable Oil	(130,000 Btu/gallon)	70%	$7.00/gallon	879 gallons	$6,153
Shelled Corn	(8,500 Btu/pound)	65%	$6.00/bushel	258 bushels	$1,548
Wheat (Grain)	(8,700 Btu/pound)	65%	$8.00/bushel	236 bushels	$1,888

* **Note:** The chart includes only an estimate for fuel cost. It does not include costs for furnace equipment, installation of the equipment, fuel-handling equipment or additional energy provider charges, such as monthly service charges or delivery costs.

- This chart is based on 9,000 heating degree days (HDD) for North Dakota. The estimated annual heat use for a 1,500-square-foot well-insulated home is 80 million Btus for a heating season. This is determined from a home with the following R-values: walls, R-19; ceiling, R-38; basement walls, R-10; and including an air infiltration rate of 0.5 air changes per hour.

Heating Unit Relationships

Natural Gas

- 1 cubic foot = 1,000 Btus
- 100 cubic feet = 100,000 Btus = 1 therm

Electric

- 3,413 Btus = 1 kwh = 1,000 watts used for 1 hour
- 1 Btu is the energy needed to raise the temperature of 1 pound of water 1 degree Fahrenheit

For more information, consult the following NDSU Extension publications:

- AE-1483, "Ground Source Heat Pumps"
- AE-1375, "Corn and Biomass Stoves"

On the web: www.ndsu.edu/energy

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