Comparing Fuel Costs of Heating and Cooling Systems

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Introduction

One of the most common questions posed to energy specialists at Engineering Extension asks for a comparison between costs to operate different heating and cooling systems. It might be a comparison of a furnace to a heat pump, a regular furnace to a high-efficiency furnace, or a wood burning stove to a pellet stove.

There are two components to cost, the initial cost to purchase and install the system, and the ongoing fuel cost. In general, higher efficiency equipment costs more initially but saves operating costs. To determine the purchase price, get bids from one or more contractors. Be certain bids include all costs to make the system fully functional including duct work, thermostats, and chimneys. This fact sheet will help you compare the cost of fuel for several types of heating and cooling systems.

Annual cost of delivering heating and cooling to a home depends on cost of the fuel, how efficiently the system converts the fuel source into heating or cooling energy, and the quantity of heating and cooling required. The following section, "Estimating the cost of heating or cooling", allows you to estimate the cost of one million Btus for several fuels and system types. However, if you want to compare annual estimated costs for two or more fuels, then you will also need to estimate the heating load of your home. This process is explained in "Estimating annual costs" on page 7.

What is the price of fuel?

Fuel prices vary between suppliers, may change seasonally, and are affected by world events. To estimate fuel costs, you can either contact your local utility or supplier or you can use past billings.

To estimate natural gas costs from your utility bill, divide the monthly charge by the consumption, usually measured in MCF. The cost should be between $3 and $12 per MCF. Use a winter bill so meter charges are spread out over several units of gas. If your bill shows gas consumption in CCF, you will need to multiply the gas cost by 10 to get it in $ per MCF.

To obtain an average $ per kilowatt hour (kWh), divide the total monthly cost by the consumption in kWh. Use a mid-winter bill if you want to estimate heating costs and a mid-summer bill if you want to estimate cooling costs. The cost for electricity in Kansas varies from $.04 to $.15 per kWh.

Propane, fuel oil, wood, and pellets are sold in simple units and should be easy to determine.

Estimating the cost of heating or cooling

If you just want to compare operating costs of different systems, you can use Tables 1 through 7 to directly determine the cost of delivering one million Btus (MBTUs) of heating and Table 8 for one MBTU of cooling. For example, you could compare the cost of delivering one MBTU to your home from a high-efficiency natural gas furnace to the cost of

delivering one MBTU from wood in a modern wood stove. There are several measures of system efficiency. A brief explanation is provided in the description of the tables.

Table 1 is for natural gas furnaces and boilers. There are three efficiency levels and gas prices range from $5 to $15 per thousand cubic feet (MCF). If your furnace was installed before about 1985, use the "older equipment" column. If you have a modern but normal-efficiency unit, use the 78 percent column. The last column is for high-efficiency (condensing) equipment.

Tables 2 and 3 are similar to Table 1, but are for propane and fuel oil, respectively.

Modern natural gas, propane, and fuel oil furnaces and boilers receive an annual fuel-utilization efficiency (AFUE) rating. Older units were not rated but an assumed performance of 65 percent is reasonable.

Table 1. Natural gas heating costs — $ per MBTU delivered for three appliance efficiencies.

	Furnace or boiler efficiency		
Gas price $/MCF.	65% (low) older equipment	AFUE = 78% (average) current minimum	AFUE = 95% high efficiency
$5.00	$7.69	$6.41	$5.26
$5.50	$8.46	$7.05	$5.79
$6.00	$9.23	$7.69	$6.32
$6.50	$10.00	$8.33	$6.84
$7.00	$10.77	$8.97	$7.37
$7.50	$11.54	$9.62	$7.89
$8.00	$12.31	$10.26	$8.42
$8.50	$13.08	$10.90	$8.95
$9.00	$13.85	$11.54	$9.47
$9.50	$14.62	$12.18	$10.00
$10.00	$15.38	$12.82	$10.53
$10.50	$16.15	$13.46	$11.05
$11.00	$16.92	$14.10	$11.58
$11.50	$17.69	$14.74	$12.11
$12.00	$18.46	$15.38	$12.63
$12.50	$19.23	$16.03	$13.16
$13.00	$20.00	$16.67	$13.68
$13.50	$20.77	$17.31	$14.21
$14.00	$21.54	$17.95	$14.74
$14.50	$22.31	$18.59	$15.26
$15.00	$23.08	$19.23	$15.79

Table 2. Propane heating costs — $ per MBTU delivered for three appliance efficiencies.

	Furnace or boiler efficiency		
Propane price $/gal.	65% (low) older equipment	AFUE = 78% (average) current minimum	AFUE = 95% high efficiency
$0.60	$10.14	$8.24	$6.94
$0.65	$10.99	$8.93	$7.52
$0.70	$11.83	$9.62	$8.10
$0.75	$12.68	$10.30	$8.68
$0.80	$13.52	$10.99	$9.25
$0.85	$14.37	$11.68	$9.83
$0.90	$15.22	$12.36	$10.41
$0.95	$16.06	$13.05	$10.99
$1.00	$16.91	$13.74	$11.57
$1.05	$17.75	$14.42	$12.15
$1.10	$18.60	$15.11	$12.72
$1.15	$19.44	$15.80	$13.30
$1.20	$20.29	$16.48	$13.88
$1.25	$21.13	$17.17	$14.46
$1.30	$21.98	$17.86	$15.04
$1.35	$22.82	$18.54	$15.62
$1.40	$23.67	$19.23	$16.19
$1.45	$24.51	$19.92	$16.77
$1.50	$25.36	$20.60	$17.35
$1.55	$26.20	$21.29	$17.93
$1.60	$27.05	$21.98	$18.51

Table 3. Fuel oil heating costs — $ per MBTU delivered for three appliance efficiencies.

	Furnace or boiler efficiency		
Oil price $/gallon	65% (low) older equipment	AFUE = 78% (average) current minimum	AFUE = 86% high efficiency
$0.70	$7.76	$6.47	$5.87
$0.75	$8.32	$6.93	$6.29
$0.80	$8.87	$7.39	$6.71
$0.85	$9.43	$7.86	$7.13
$0.90	$9.98	$8.32	$7.55
$0.95	$10.54	$8.78	$7.96
$1.00	$11.09	$9.24	$8.38
$1.05	$11.65	$9.71	$8.80
$1.10	$12.20	$10.17	$9.22
$1.15	$12.76	$10.63	$9.64
$1.20	$13.31	$11.09	$10.06
$1.25	$13.87	$11.55	$10.48
$1.30	$14.42	$12.02	$10.90
$1.35	$14.97	$12.48	$11.32
$1.40	$15.53	$12.94	$11.74
$1.45	$16.08	$13.40	$12.16
$1.50	$16.64	$13.87	$12.58
$1.55	$17.19	$14.33	$12.99
$1.60	$17.75	$14.79	$13.41
$1.65	$18.30	$15.25	$13.83
$1.70	$18.86	$15.71	$14.25

Table 4 is for electric heat. The price per MBTU for electric resistance heat includes both baseboard and central resistance heating systems. Sections for air-source heat pumps, ground-water heat pumps, and ground-loop heat pumps are provided and each contains three performance levels.

Air-source heat pumps are the most common heat pump. They have an inside blower and coil with an outside compressor and coil, and look like a conventional air conditioner. Use an air-source heat pump heating seasonal performance factor (HSPF) of 5 for older heat pumps, 6.8 for an average-performance unit, and 9.4 if you have or plan to buy a superior-performance unit.

Ground-loop and ground-water are both geothermal heat pump systems. A ground-loop heat pump, Figure 1, circulates water through buried piping loop. Coefficient of performance (COP) is the measure of performance for geothermal heat pumps. A COP of 3.1 would be appropriate for an older or low-performance system; a COP of 3.5 is representative of average equipment sold today; and a system with a COP of 4.2 would represent superior performance.

Unlike a ground-loop system that circulates water in a piping system, a ground-water heat pump, Figure 2, draws water from a well, extracts heat from the water in the winter or rejects heat to it in the summer, and then discharges the water, typically to another well. The heat pump is normally located inside, but there will be one or two wells associated with its operation. Ground-water heat pumps also use COP as a measure of performance with a COP of 3.2 for an older or low-performance system, 4.1 for average performance, and 4.7 for superior performance. In many cases, the same equipment is used for both ground-loop and ground-water systems. They are rated with different COPs because of the differences between ground-loop and ground-water temperatures.

Table 4. Electric heating costs — $ per MBTU delivered for several appliances and performance levels.

	Electric resistance	Air-source heat pump performance			Ground-loop heat pump performance			Ground-water heat pump performance		
Electricity $/kWh	Electric resistance	HSPF=5.0 (low) older equipment	HSPF=6.8 (average) current minimum	HSPF=9.4 (superior)	COP=3.1 (low)	COP=3.5 (average)	COP=4.2 (superior)	COP=3.6 (low)	COP=4.1 (average)	COP=4.7 (superior)
$0.040	$11.73	$8.00	$5.88	$4.26	$4.21	$3.74	$3.11	$3.54	$3.10	$2.70
$0.045	$13.20	$9.00	$6.62	$4.79	$4.74	$4.21	$3.49	$3.98	$3.49	$3.04
$0.050	$14.66	$10.00	$7.35	$5.32	$5.26	$4.67	$3.88	$4.42	$3.88	$3.38
$0.055	$16.13	$11.00	$8.09	$5.85	$5.79	$5.14	$4.27	$4.87	$4.26	$3.72
$0.060	$17.60	$12.00	$8.82	$6.38	$6.32	$5.61	$4.66	$5.31	$4.65	$4.05
$0.065	$19.06	$13.00	$9.56	$6.91	$6.84	$6.07	$5.05	$5.75	$5.04	$4.39
$0.070	$20.53	$14.00	$10.29	$7.45	$7.37	$6.54	$5.43	$6.19	$5.43	$4.73
$0.075	$21.99	$15.00	$11.03	$7.98	$7.89	$7.01	$5.82	$6.64	$5.81	$5.07
$0.080	$23.46	$16.00	$11.76	$8.51	$8.42	$7.48	$6.21	$7.08	$6.20	$5.41
$0.085	$24.93	$17.00	$12.50	$9.04	$8.95	$7.94	$6.60	$7.52	$6.59	$5.74
$0.090	$26.39	$18.00	$13.24	$9.57	$9.47	$8.41	$6.99	$7.96	$6.98	$6.08
$0.095	$27.86	$19.00	$13.97	$10.11	$10.00	$8.88	$7.38	$8.41	$7.36	$6.42
$0.100	$29.33	$20.00	$14.71	$10.64	$10.53	$9.35	$7.76	$8.85	$7.75	$6.76
$0.105	$30.79	$21.00	$15.44	$11.17	$11.05	$9.81	$8.15	$9.29	$8.14	$7.09
$0.110	$32.26	$22.00	$16.18	$11.70	$11.58	$10.28	$8.54	$9.73	$8.53	$7.43
$0.115	$33.72	$23.00	$16.91	$12.23	$12.11	$10.75	$8.93	$10.18	$8.91	$7.77
$0.120	$35.19	$24.00	$17.65	$12.77	$12.63	$11.21	$9.32	$10.62	$9.30	$8.11
$0.125	$36.66	$25.00	$18.38	$13.30	$13.16	$11.68	$9.70	$11.06	$9.69	$8.45
$0.130	$38.12	$26.00	$19.12	$13.83	$13.68	$12.15	$10.09	$11.50	$10.08	$8.78
$0.135	$39.59	$27.00	$19.85	$14.36	$14.21	$12.62	$10.48	$11.95	$10.47	$9.12
$0.140	$41.06	$28.00	$20.59	$14.89	$14.74	$13.08	$10.87	$12.39	$10.85	$9.46

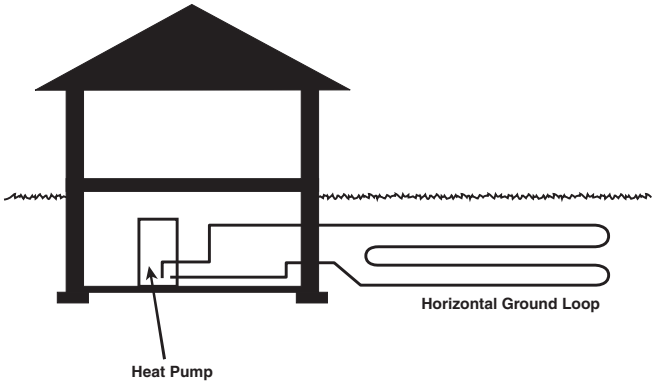

Figure 2. Ground-loop heat pump.

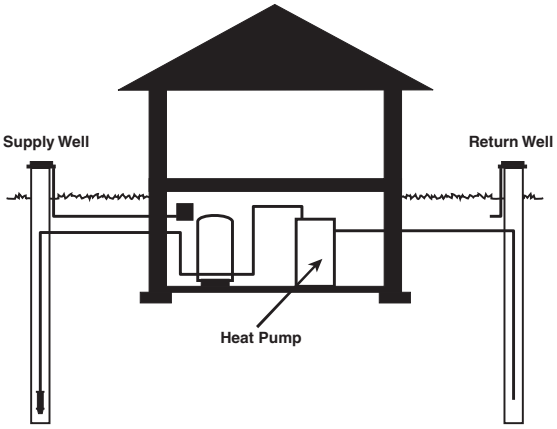

Figure 1. Ground-water heat pump.

Table 5 is used to estimate the cost per MBTU for unvented kerosene heaters. They are 100 percent efficient because all of the heat is delivered to the home. If you are using a vented kerosene appliance, use Table 3.

Table 5. Kerosene heating costs — $ per million MBTU delivered.

Unvented kerosene heater	
Kerosene price $/gallon	Unvented equipment
$1.00	$7.56
$1.10	$8.31
$1.20	$9.07
$1.30	$9.83
$1.40	$10.58
$1.50	$11.34
$1.60	$12.09
$1.70	$12.85
$1.80	$13.61
$1.90	$14.36
$2.00	$15.12
$2.10	$15.87
$2.20	$16.63
$2.30	$17.38
$2.40	$18.14
$2.50	$18.90
$2.60	$19.65
$2.70	$20.41
$2.80	$21.16
$2.90	$21.92
$3.00	$22.68

Estimate the cost of delivered heating energy

Example: Compare the cost of heat from a propane furnace to the cost of heat from an air-source heat pump.

First, you will need to know the cost of both fuels and efficiencies of the systems. Follow this example to learn how to use Tables 1 through 8.

Table 2 is for propane appliances. Assuming you have an old propane furnace, the efficiency will be about 65%. If you pay $.90 per gallon for propane, the cost per million Btus (MBTUs) will be $15.22.

Table 4 is for electric appliances. Compare this to the cost of heating with an average-efficiency, air-source heat pump with electricity costing $.07 per kilowatt hour (kWh). The cost per MBTU will be about $10.29.

Delivered heat from the heat pump costs about two-thirds that of propane.

Table 6 will allow you to estimate the cost per MBTU for several wood heating appliances. The specie of wood, cost per cord, and appliance efficiency are all important to getting an accurate estimate. The efficiency ratings provided are typical but may vary between manufacturers. Several common wood species are listed with cord costs ranging from $80 to $140. There are sections of the table for open fireplaces; pre-1980 wood stoves; masonry heaters; and post-1980, EPA-certified wood stoves. For more details on solid-fuel heating appliances, obtain a copy of *Solid-Fuel Heating Appliances* online at *www.engext.ksu.edu/*. Look under publications.

Table 6. Wood heating costs — $ per million BTU for several wood species, heating appliance efficiencies, and cord wood costs.

	Wood heating appliance efficiency							
	10% — typical open fireplace				50% — typical central boiler, furnace, or pre-1980 wood stove			
Price per cord	$80	$100	$120	$140	$80	$100	$120	$140
Species								
Cottonwood	$50.63	$63.29	$75.95	$88.61	$10.13	$12.66	$15.19	$17.72
Elm, American	$40.00	$50.00	$60.00	$70.00	$8.00	$10.00	$12.00	$14.00
Hackberry	$37.74	$47.17	$56.60	$66.04	$7.55	$9.43	$11.32	$13.21
Honeylocust	$29.96	$37.45	$44.94	$52.43	$5.99	$7.49	$8.99	$10.49
Maple, Silver	$42.11	$52.63	$63.16	$73.68	$8.42	$10.53	$12.63	$14.74
Oak,Red	$32.52	$40.65	$48.78	$56.91	$6.50	$8.13	$9.76	$11.38
Osage Orange	$24.32	$30.40	$36.47	$42.55	$4.86	$6.08	$7.29	$8.51
	60% — typical masonry heater				70% — typical EPA-certified wood stoves and inserts			
Price per cord	$80	$100	$120	$140	$80	$100	$120	$140
Species								
Cottonwood	$8.44	$10.55	$12.66	$14.77	$7.23	$9.04	$10.85	$12.66
Elm, American	$6.67	$8.33	$10.00	$11.67	$5.71	$7.14	$8.57	$10.00
Hackberry	$6.29	$7.86	$9.43	$11.01	$5.39	$6.74	$8.09	$9.43
Honeylocust	$4.99	$6.24	$7.49	$8.74	$4.28	$5.35	$6.42	$7.49
Maple, Silver	$7.02	$8.77	$10.53	$12.28	$6.02	$7.52	$9.02	$10.53
Oak,Red	$5.42	$6.78	$8.13	$9.49	$4.65	$5.81	$6.97	$8.13
Osage Orange	$4.05	$5.07	$6.08	$7.09	$3.47	$4.34	$5.21	$6.08

Table 7 provides heating cost estimates for pellet- and corn-burning appliances.

Table 7. Pellet and corn heating costs — $ per MBTU.

Pellet price		Typical pellet stove	Corn price	Typical corn stove
Price per 40-pound bag	Price per ton		Price per bushel	
$2.50	$125	$9.77	$1.50	$5.05
$3.00	$150	$11.73	$2.00	$8.42
$3.50	$175	$13.68	$2.50	$11.78
$4.00	$200	$15.63	$3.00	$15.15

Table 8 will estimate the cost of providing one MBTU of cooling for air conditioners and heat pumps. A seasonal energy efficiency rating (SEER) is the performance measure for modern air conditioners and air-source heat pumps. Older units may not be rated, and a SEER of 7 is reasonable for estimating operating costs.

Table 8. Electric cooling costs — $ per MBTU cooling for several appliances and performance levels.

	Air conditioner or air-source heat pump performance			Ground-water heat pump performance			Ground-loop heat pump performance		
Electricity $/kWh	SEER = 7 (low) older equipment	SEER = 12 (average)	SEER = 15 (superior)	EER = 16 (low)	EER = 19 (average)	EER = 24 (superior)	EER = 13 (low)	EER = 16 (average)	EER = 20 (superior)
$0.040	$5.71	$4.00	$2.67	$2.61	$2.22	$1.78	$3.18	$2.62	$2.13
$0.045	$6.43	$4.50	$3.00	$2.93	$2.50	$2.00	$3.58	$2.95	$2.39
$0.050	$7.14	$5.00	$3.33	$3.26	$2.78	$2.22	$3.98	$3.28	$2.66
$0.055	$7.86	$5.50	$3.67	$3.58	$3.06	$2.44	$4.38	$3.61	$2.92
$0.060	$8.57	$6.00	$4.00	$3.91	$3.33	$2.67	$4.78	$3.94	$3.19
$0.065	$9.29	$6.50	$4.33	$4.23	$3.61	$2.89	$5.18	$4.27	$3.46
$0.070	$10.00	$7.00	$4.67	$4.56	$3.89	$3.11	$5.57	$4.59	$3.72
$0.075	$10.71	$7.50	$5.00	$4.89	$4.17	$3.33	$5.97	$4.92	$3.99
$0.080	$11.43	$8.00	$5.33	$5.21	$4.44	$3.56	$6.37	$5.25	$4.25
$0.085	$12.14	$8.50	$5.67	$5.54	$4.72	$3.78	$6.77	$5.58	$4.52
$0.090	$12.86	$9.00	$6.00	$5.86	$5.00	$4.00	$7.17	$5.91	$4.78
$0.095	$13.57	$9.50	$6.33	$6.19	$5.28	$4.22	$7.56	$6.23	$5.05
$0.100	$14.29	$10.00	$6.67	$6.51	$5.56	$4.44	$7.96	$6.56	$5.32
$0.105	$15.00	$10.50	$7.00	$6.84	$5.83	$4.67	$8.36	$6.89	$5.58
$0.110	$15.71	$11.00	$7.33	$7.17	$6.11	$4.89	$8.76	$7.22	$5.85
$0.115	$16.43	$11.50	$7.67	$7.49	$6.39	$5.11	$9.16	$7.55	$6.11
$0.120	$17.14	$12.00	$8.00	$7.82	$6.67	$5.33	$9.55	$7.87	$6.38
$0.125	$17.86	$12.50	$8.33	$8.14	$6.94	$5.56	$9.95	$8.20	$6.65
$0.130	$18.57	$13.00	$8.67	$8.47	$7.22	$5.78	$10.35	$8.53	$6.91
$0.135	$19.29	$13.50	$9.00	$8.79	$7.50	$6.00	$10.75	$8.86	$7.18
$0.140	$20.00	$14.00	$9.33	$9.12	$7.78	$6.22	$11.15	$9.19	$7.44

Estimating annual costs

Once you have determined the cost per MBTU for any fuel, you can estimate annual heating or cooling costs. It is important to remember these are estimates only; lifestyle, actual housing conditions, house configuration, and other factors can greatly influence heating and cooling costs.

Table 9[1] provides estimates of heating and cooling requirements of homes in Kansas. Three levels of home efficiency are listed. Standard practice represents homes as they have generally been constructed in Kansas, energy code compliant applies to a home that would meet modern energy codes, and energy efficient represents homes where high performance was a major design goal. There are also three climate areas listed.

Based on the type of home and location, choose the appropriate index. Multiply it by the size of your home (square feet of living space) and the cost of your fuel in $ per MBTU, then divide by 1,000 to estimate annual costs. If you live in an older, poorly insulated and weatherized home, your heating costs will be higher than those estimated by this method. To estimate savings for using higher performance equipment or other fuels, calculate the costs for each and compare.

Table 9. Annual heat and cooling indicies — 1000 Btus/square foot.

	Heating			Cooling		
	Northwest	Central	Southeast	Northwest	Central	Southeast
Current practice	50	45	40	11	13	14
Energy code compliant	36	32	29	10	11	12
Energy efficient	28	25	23	9	10	11

Estimating annual costs

Example: Estimate the annual cost of heating a 2,000-square-foot home in rural Sedgwick County. The home was built in the 1960s. The home owner is considering both propane and an air-source heat pump. Fuel costs were determined in the previous example to be $15.22 /MBTU for propane and $10.29/MBTU for a heat pump.

The heating index for the home would be 45. Annual heating costs would be

$\frac{2{,}000 \times 45 \times 15.22}{1{,}000}$ = $1,370 for propane, and

$\frac{2{,}000 \times 45 \times 10.29}{1{,}000}$ = $925 for the heat pump.

[1] Ground-Source Heat Pumps, An Efficient Choice for Residential and Commercial Use, J. Mark Hannifan, Joe E King, AIA, 1995.

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