Home Heating Costs: Options for the Winter of 2005-2006

Natural gas has long been a clean inexpensive heating fuel for many southeastern homeowners. Rates for residential customers have been slowly inching upward for several years but signs of more dramatic change appeared even before hurricanes Katrina and Rita damaged the Gulf Coast supply and distribution network. In addition to its uses as a fuel and feedstock for many industrial processes, natural gas has become a fuel of choice for electric power plants. Advanced natural gas plants are nearly twice as efficient as conventional coal-fired plants; they require much less expensive equipment to meet environmental regulations; and they have the lowest greenhouse gas emissions of any fossil fuel. Thus, natural gas will most likely continue to be a popular energy source that will be relatively "clean" but no longer inexpensive.

How much will it cost this winter? The simple answer is "more" and in some cases "a lot more". This should lead many homeowners to look to other alternatives, such as heat pumps, wood heat, propane, and even electric space heaters. This paper will compare these alternatives at current prices. Although an exact value for an individual home is difficult to predict, estimates of heating requirements can be made for typical homes in the southeast. Homeowners can then estimate fuel requirements based on "nearly equivalent" home types and then compare the costs for different fuels and equipment efficiency levels.

Table 1 provides the description of four homes (two different sizes and two different construction types) and the resulting heating requirement in MBtu/h[1] at the outdoor design temperature for Tuscaloosa, AL. "Typical" construction reflects practices used in the last 10 years that meet insulation requirements but exercise no effort to maximize efficiency beyond minimum code requirements. Efficient construction practices go beyond this by placing the ductwork inside the conditioned space and extensively sealing the structure with caulk and low leakage windows and doors. Insulation levels are approximately 50% above minimum recommendations, including walls made with 2×6-inch studs rather than the conventional 2×4-inch stud wall.

Table 1. Heating Requirement @ 20ºF Outdoor Temperature for Four Homes

Home Size	2000 ft^2	4000 ft^2	2000 ft^2	4000 ft^2
Construction	Typical	Typical	Efficient	Efficient
Stories	1	2	1	2
Roof Insulation	8-inch	8-inch	12-inch	12-inch
Wall Insulation	3.5 inch	3.5 inch	5.5 inch	5.5 inch
Windows	Double	Double	Double, Tight	Double, Tight
Duct	In Attic	In Attic	Below Ceiling	Below Ceiling
Seal/Caulk	Obvious Cracks	Obvious Cracks	Extensive	Extensive
Slab Insulation	1 inch × 24 inch	1 inch × 24 inch	2 inch × 48 inch	2 inch × 48 inch
Window/Wall Area	30%	30%	30%	30%
Heating Requirement	**54 MBtu/h** [1]	**96 MBtu/h** [1]	**32 MBtu/h** [1]	**51 MBtu/h** [1]

[1] A British Thermal Unit (Btu) is a small amount of energy. Thus, MBtu (Btu×1000) is a common unit of measure.

The heating season in the southeast is typically 4 to 6 months (2900 to 4300 hours) in duration and the heating equipment will normally operate 20 to 30% of the time (600 to 1200 hours). The comparative estimates discussed here will use an average operation time (900 hours) multiplied by the heating requirement for the four homes (in MBtu per hour) to arrive at an annual heating requirement in MBtu. This will match the required annual **output** of the heating equipment. The fuel requirement (and costs) will be this output divided by the equipment efficiency or COP.

Natural Gas

Natural gas furnace efficiencies (AFUE = annual fuel utilization efficiency) range from 78% to 95%. Additionally, they consume a small amount of electricity to operate the indoor fan and in some cases, a blower to provide combustion air to the burners. A common unit of measure for natural gas is the ccf (100 cubic feet) and a product of average quality provides approximately 100 MBtus (100,000 Btus) when burned. A furnace with an efficiency of 80% will deliver 80 MBtus to the home if 1 ccf (≈100 MBtus) is burned. The current cost of a ccf of natural gas in Alabama is approximately $1.85. The exact cost is more complicated since the rates structure includes a base monthly charge, taxes (4%), and has a declining block structure (the more you use the cheaper it gets). More precise costs can be determined using the spreadsheet *ALResUtilBillCalc.xls* available through the Mechanical Engineering Department at the University of Alabama.

Propane

Propane furnaces are similar to natural gas furnaces except that the fuel is delivered in bulk quantities of liquid. The unit of measure for propane is a gallon which provides 91.5 MBtus (91,500 Btus) when burned. Current propane costs are $2.35 per gallon in Tuscaloosa. Electrical costs are also incurred due to the fan motors.

Electric Furnaces

Electric furnaces are heating elements that convert electrical energy directly to heat and are 100% efficient. Space heaters also fall into this category. Traditionally, electric heat has been much more expensive than natural gas. However, the primary source of electrical energy in the southeast is coal, which has remained relatively stable in cost. Nuclear and hydroelectricity are also significant and also have moderated the increased cost at natural gas fired plants. The unit of electrical energy is a kilowatt-hour (kWh) which provides 3.41 MBtu (3412 Btus) when converted to heat. Currently the average cost is 8¢ per kWh. However, electrical rates are more complex since they also include a base monthly charge, taxes (4%), a declining block rate, an energy cost recovery (ECR) factor, and lower rates in the winter, fall, and spring. The spreadsheet *ALResUtilBillCalc.xls* also computes average electrical energy costs.

Heat Pumps

Heat pumps deliver heat to the space by removing heat from the outdoors with a low temperature coil, "pumping" the fluid inside the coil to a higher temperature with a motor-driven compressor, and releasing this heat through a second coil inside the home. This method is not particularly effective when outdoor temperatures are low and the outdoor coil tends to frost-over. During these conditions, an electric furnace is typically used as an "auxiliary" device to supplement the heat pump. The heat pump also requires two fans (one indoor, one outdoor). The measure of efficiency for a heat pump is the coefficient of performance (COP) that indicates the amount of heat provided to the home per unit of electrical energy delivered to the unit. Since the unit of measure for heat (MBtu) does not correspond to the unit of measure for electricity (kWh), heat pump heating efficiency is noted by the heating seasonal performance factor [HSPF(MBtu/kWh)=COP×3.412]. However, the field-measured HSPF values for correctly installed heat pumps range from 6.0 to 6.8 (COP = 1.8 to 2.0) in the southeast (See "Climatic Impact on HSPF and SEER for Air- Source Heat Pumps", *ASHRAE Transactions*, Vol. 110, Part 2, 2004). The unit for heat pump energy is "kWh" like the electric furnace.

Ground Source Heat Pumps (a.k.a. Geothermal Heat Pumps)

Ground source heat pumps (GSHPs) incorporate a piping loop buried in the ground, which is considerably warmer (50ºF to 70ºF) in the southeast than the outdoor air in the winter. Water is circulated through these loops and a modified heat pump removes the heat from the water as it circulates through the low temperature water coil inside the home. A compressor is used to "pump" up the fluid temperature before delivering heat to the air through an indoor coil. Since the low temperature coil is relatively warm (it is in contact with the water being circulated through the ground), the COP of a GSHP is high and "auxiliary" heat is only needed when the ground loop is inadequate or the home is poorly insulated and sealed. GSHPs can have COPs above 4.5 when the loops are installed vertically with a thermally-enhanced grout to make a good connection between the ground and piping loop. However, installation costs are typically 2 to 3 times that of conventional heat pumps and savings are often gained by reductions in ground loop quality and size. This compromises COP. The unit for GSHP energy is "kWh" like the conventional heat pump and electric furnace.

Wood Heat

Wood heating is a popular supplement that is viewed as a lower cost alternative. Results with this fuel source vary widely since the efficiency of the heating devices also varies dramatically. Open fireplaces and non-rated fireplace inserts and wood stoves can have very low efficiency with most of the heat (and a lot of smoke and creosote) going out to the chimney. EPA certified inserts and wood stoves use catalytic inserts or fireboxes with baffles and combustion air pre-heaters to meet smoke emission limits (www.woodheat.org). This results in an additional benefit of higher efficiency (60% to 80%). The unit of measure for wood is a cord (4 ft. × 4 ft. × 8 ft.). However, the most common unit of sale is a "load" in the bed of a 1/2-ton truck, which equates to approximately 1/3 cord. A cord of air-dried white oak delivers 24,000 MBtus and weighs 4300 lbs. Currently, the cost of a load of oak in central Alabama is $60 delivered ($180/cord).

Summary

Table 2 provides a summary of the estimated costs for the four homes using several different heating fuel sources and equipment. Energy efficient home construction cuts cost almost in half compared to conventional construction. In the winter of 2005-2006, properly installed heat pumps are the lowest cost option with the GSHPs being significantly lower than any other option. Wood heat with high efficiency fireplace inserts and stoves competes well with air heat pumps. Heating with natural gas is as costly as electric furnaces and space heaters. In spite of the increase in natural gas prices, it is remains less costly than propane.

Table 2. Estimated Annual (2005) Heating Cost for Four Homes in the Southeast

Home Size	2000 ft^2	4000 ft^2	2000 ft^2	4000 ft^2
Construction Type	Typical	Typical	Efficient	Efficient
Unit type	Annual Heating Cost ($US)			
80% Nat Gas Furnace	$1,155	$2,053	$684	$1,091
95% Nat Gas Furnace	$978	$1,738	$579	$923
80% Propane Furnace	$1,585	$2,817	$939	$1,497
95% Propane Furnace	$1,339	$2,381	$794	$1,265
Elec. Furnace/Space Htr.	$1,140	$2,026	$675	$1,076
Heat Pump	$633	$1,125	$375	$598
Hi Eff Heat Pump	$570	$1,013	$338	$538
GSHP	$326	$579	$193	$307
Hi Eff GSHP	$265	$471	$157	$250
Open Fireplace-Oak	$1,121	$1,992	$664	$1,058
Stove-Oak	$747	$1,328	$443	$706
Hi Eff Stove-Oak	$598	$1,062	$354	$564

Costs: Nat.Gas-$1.85/ccf, Propane-$2.35/gal, Elect.-8¢/kWh, Oak-$60/load