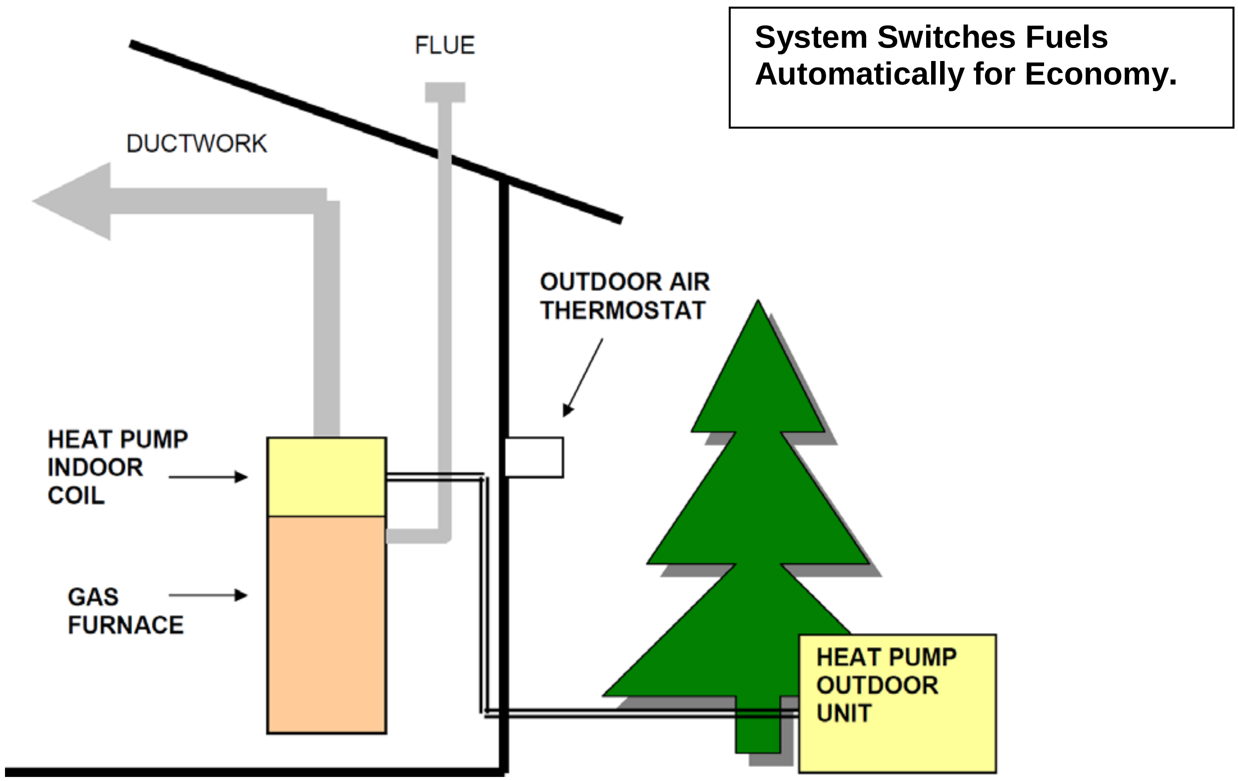
White Paper #30

Hybrid (Dual Fuel) - Gas Heat and Air Source Heat Pump



What is an Air-Source Heat Pump?

A heat pump is a modified air conditioning system with additional devices in the refrigerant plumbing to redirect the flow of refrigerant on command. When the roles of outdoor and indoor coils are reversed, heat can be pumped inside. With this modification, the same equipment can be used to cool a house in summer and also heat it in winter. An "air source" heat pump is so-named because it gets its heat from the outdoor air. Other variations of heat pumps include water-source, ground-source, and water-to-water heat pumps; each of the designations refers to the source utilized (where heat is absorbed in winter and where heat is released in summer).

For air-source heat pumps, the heating efficiency varies directly as the difference between indoor and outdoor temperatures. In mild winter weather, such as 40 degrees F, an air-source heat pump exhibits excellent efficiency, but the efficiency drops off quickly in colder weather. Heating efficiency of heat pumps is rated in terms of the ***Coefficient of Performance*** (COP). This is a unitless measure of heat output to heat input, with higher numbers meaning higher efficiency.

A characteristic of air-source heat pumps is that as outdoor temperatures drop, the need for heating increases - meanwhile the efficiency and capacity of an air-source heat pump decreasing. Below some temperature (called the ***balance point***) the house loses heat faster than the heat pump can provide it. For this reason, and for defrosting, air-source heat pumps are equipped with back-up resistive heaters. Below some temperature, air-source heat pumps operating efficiency is equal to electric resistance heat. This characteristic curve is shown in Figure 1.

Heating with Gas or other Fuels

A common method of heating is combustion of fossil fuels, such as natural gas. The COP for combustion heating is always less than 1.0 since some of the heat is necessarily lost to the flue with products of combustion. Modern combustion heater COPs vary from 0.8 to 0.95. Older furnaces or water heaters may be as low as 0.6 COP.

Electric Resistance Heat

This source of heat is common where heat loads are low, electric prices are low, or other sources of fuel are not available. COP for electric heat is considered to be 1.0, although it is much less if the origin of that electricity is considered. At a mechanical conversion efficiency of 40% (our best power plants) the true COP of electric resistance heat is 0.4 COP. For this paper, electric heat is considered 1.0 COP.

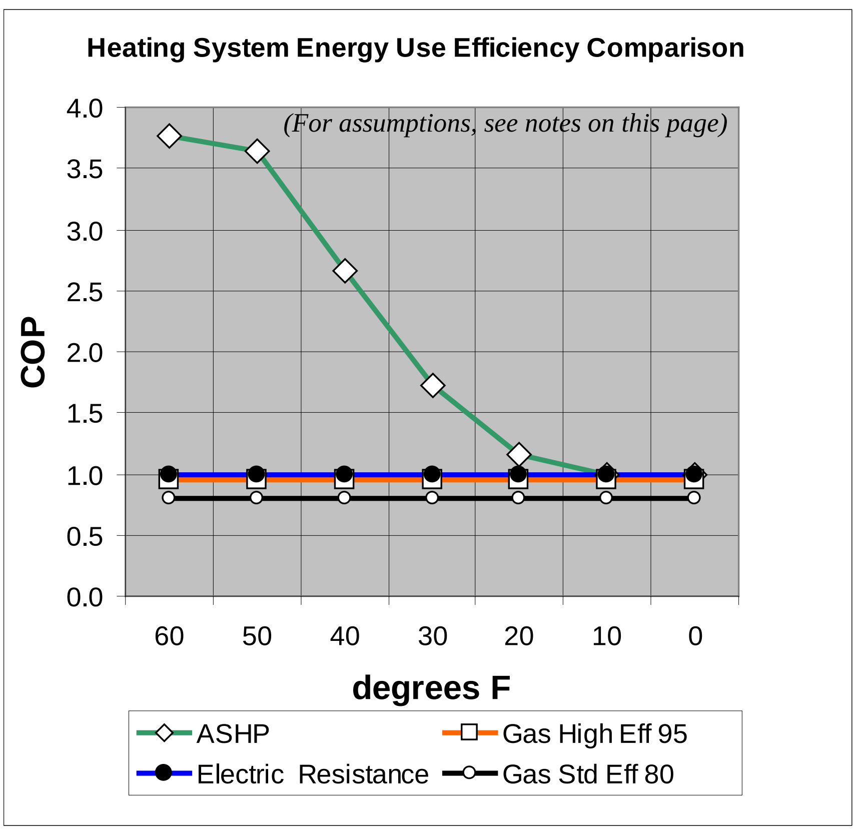


Figure 1. Heating System Efficiency Comparison

Assumptions for Charts in this Paper:

1. Heat pump efficiency HSPF 8.7, COP 3.6(47), COP 2.5(17), using mfg data for COP. Residential 2-speed selection with 2.5-ton outdoor unit and 5-ton indoor unit., Energy Star Rated
2. Weather data is for Colorado Springs Colorado
3. Assumed resistance heat operation for heat pump:
   - 0% of the time above 40 degF
   - 25% of the time at 40 degF
   - 60% of the time at 30 degF
   - 100% of the time below 30 degF0
4. Assumed energy cost: 0.0795/kWh and $23.29/MMBtu, $0.91/therm and $9.10/MMBtu
5. Standard efficiency combustion at 80%e, high efficiency at 95%e
6. Linear heat load profile with 10% load at 60 degF and 100% load at 0 degF
7. Summer air conditioning costs are not included. For homes that presently have only a heating system, the installation of a heat pump will likely increase annual electric usage by virtue of use air conditioning.

Assumptions are adjustable. Calculations available on request. Results are for comparative purposes only

Economics
The choice of heating source is not as simple as comparing heating efficiencies (COPs), because the ***cost of the fuel*** is not based on heating value. Electricity is sold in units of kilowatt hours, while natural gas is sold in units of hundreds of cubic feet or therms. Integrating this into the COP comparison is necessary for economic comparison. See Figure 2.

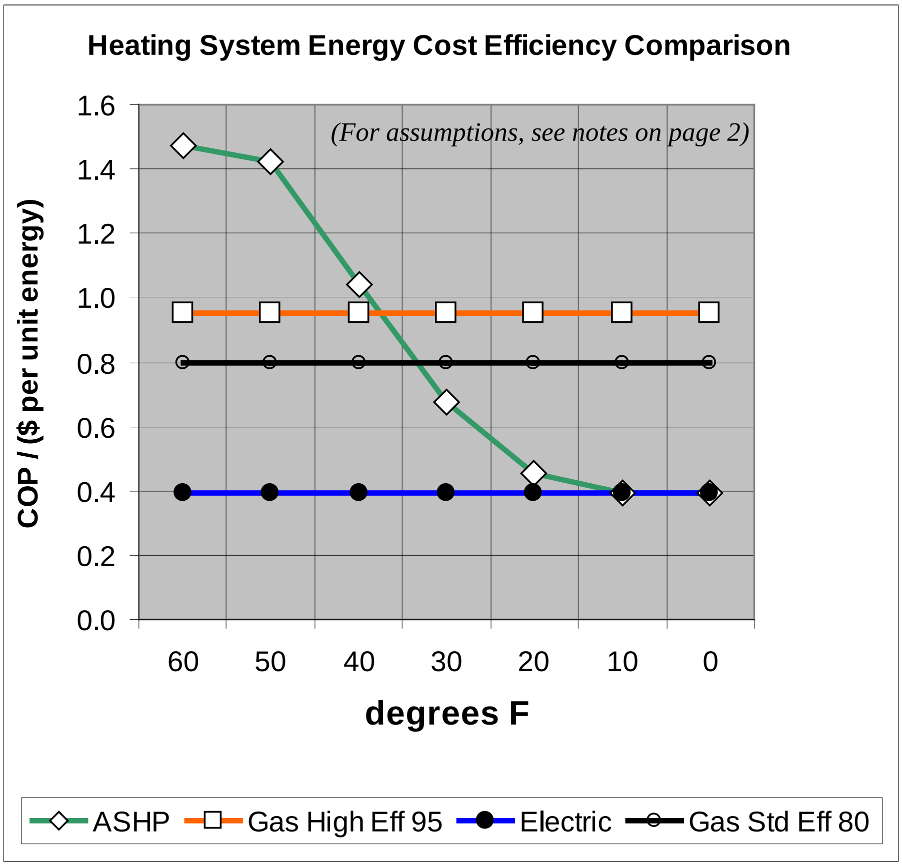


Figure 2.

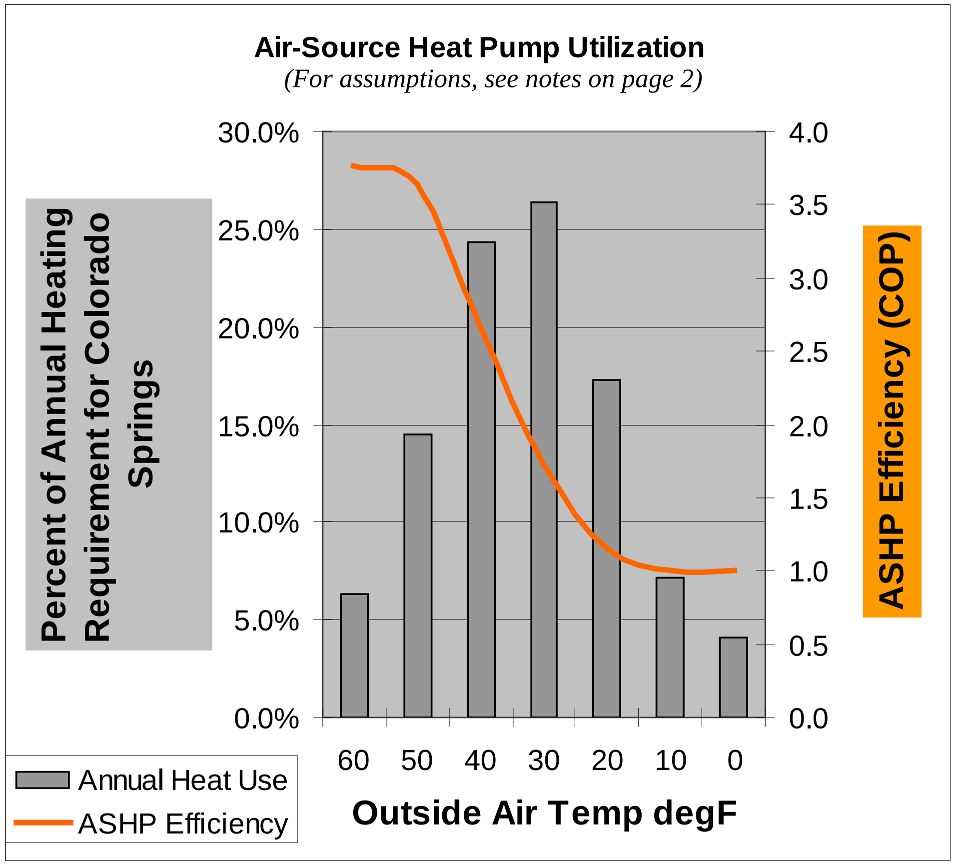
Cost of Fuel Integrated with System Energy Efficiency.

The other wild card is climate – how often is it 10 degrees F? These values vary by climate region; climate data, such as ***bin weather data***, is used to factor this in. There are also cost differences in the heating system types, but this will not be included in the discussion. Note that, equipment cost excluded, the weather does not influence the decision for combustion or electric resistance heating since the COPs are constant, but it makes a difference when considering an air-source heat pump. For example if it seldom gets below 40 degrees F a heat pump would probably be a good choice. In addition to the number of hours expected at different temperatures, the heating demand is obviously higher at the lower temperatures.

Figure 3 integrates weather predominance and percent load to show when the heating energy is spent for this climate. The air source heat pump efficiency curve is overlayed to illustrate how dynamic the evaluation is and how the 'best efficiency' answer will vary by climate region.

Figure 3.

Heat Load Distribution Related to Air Source Heat Pump Efficiency.



Savings potential for the hybrid air-source heat pump with gas heater lies in the ability to switch from electric to gas when the temperature is low enough that gas becomes more cost efficient to use.

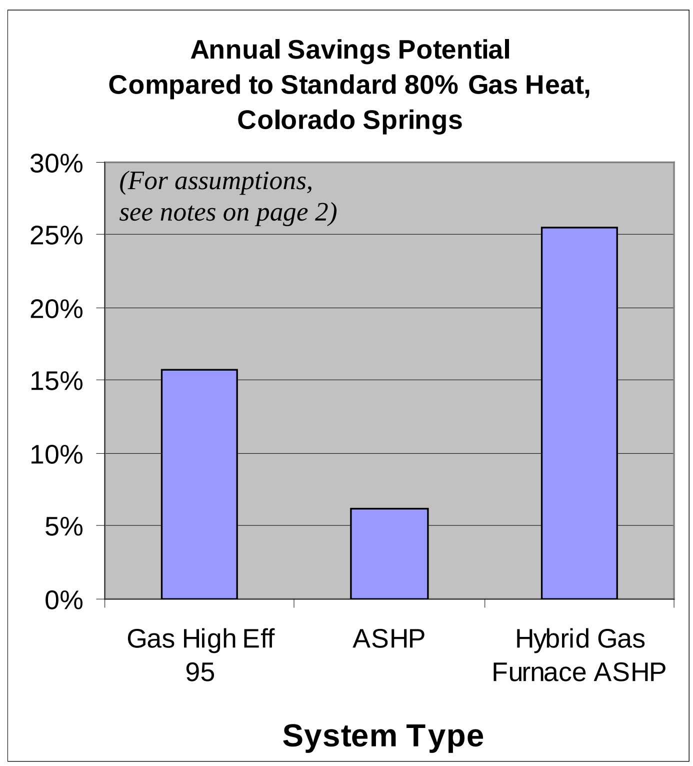


Figure 4.
Energy Cost Saving Potential Comparison

What is required?

Utilities: The facility must have both electric service and gas service, each with ample capacity. For some homes this is a barrier if the home was installed without air conditioning. Also, some homes may not have natural gas service available.

Furnace: The usual approach is a split system, which means an indoor and outdoor unit separated by refrigerant tubing (like central air conditioning). Inside will be a high efficiency gas furnace with an over-sized fan motor, with the indoor heat pump coil mounted on top. The heat pump outdoor unit looks just like an air conditioning unit, but is specially constructed to function in the cold weather for heating. This system now has both heat pump and gas heat capability….plus air conditioning.

Controls: A simple outdoor air thermostat makes the decision on which fuel to use. Warmer temperatures favor the heat pump, and lower temperatures favor gas. Somewhere around 40 degrees F is the likely switch point, but each system will vary a little bit. As gas and electric prices change over time, the best switch point will also vary, so squeezing every dollar out of this ***fuel switching*** system involves watching those two heat source costs in proportion. A regular science experiment!

When properly coordinated, the dual fuel system can be leveraged to get the best of both worlds, using each fuel when it is most cost advantageous to do so. See Figure 5.

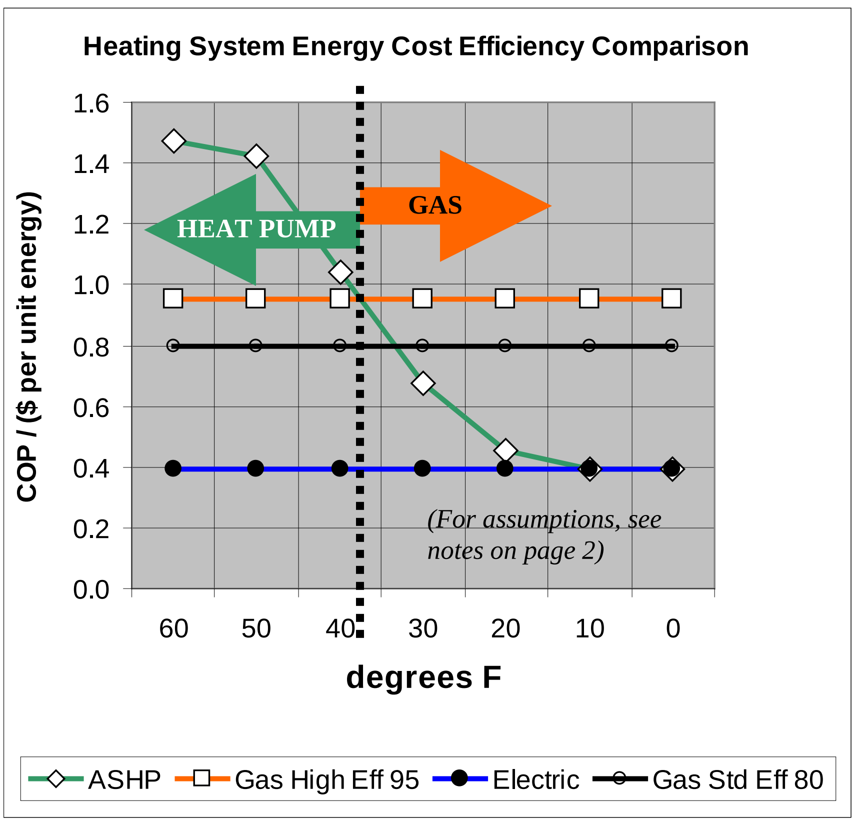


Figure 5. Fuel Switching Graph

Cost: System cost is always important; however they are not discussed in this paper. The biggest cost hurdle may be in the utility services that may/may not already be there, so look at those first.

Review: To determine the least cost of operation requires consideration of these variables:

- Energy Efficiency of Heating Systems
- Cost of Available Energy Sources
- Weather Distribution and Load Profile
- Ability to Accurately Switch Between Fuels at the Proper Time.