GEO CONNECTIONS

ASHP VS GSHP

MAKING AN APPLES TO APPLES COMPARISON

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IN THE REAL WORLD,

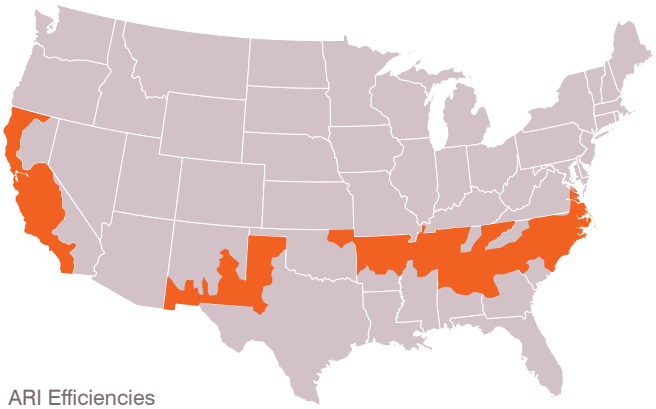
ASHP efficiencies can vary from rated by as much as 22% in cooling and 50% in heating.

In many areas, it can be difficult to make the case for a ground source heat pump (GSHP) over an air source heat pump (ASHP). The nameplate efficiencies of ASHPs combined with their lower cost of installation make them an extremely attractive alternative for the energy (and cost) conscious building owner. As a geothermal system designer, or geothermal system salesman, the case you always have to make is one based on long term cost projections. In order to succeed in that argument, you need to be sure that you are making an apples to apples comparison of the operating cost of each system based on the installed location.

ASHRAE research has shown that in the real world, air source heat pump (ASHP) efficiencies can vary from rated by as much as 22% in cooling and 50% in heating. It isn't that rated efficiencies are wrong - it's just that they aren't meant to model actual equipment performance. They are meant to offer a baseline for comparing one ASHP to another ASHP.

Location Matters

For air source equipment, the ARI rating system used to determine published efficiencies is based on operation in the relatively mild weather of Climate Zone IV. The original intent of the rating system was not to generically predict operating efficiencies for any place in the country, but instead to develop a performance baseline for quick Air Source to Air Source equipment comparisons.



ARI Efficiencies assume operation in Climate Zone IV.

That only leaves a little bit of the country unaccounted for... just the grey area plus Alaska and Hawaii.

In practice, advocates of air source equipment and, much to their own detriment, geothermal system designers have treated these reported efficiencies as gospel. But if we stop to think about how heat pumps work (air and ground source alike), we realize that their efficiencies are inherently dependent on the temperatures of their sources/sinks. So, if we take a heat pump rated based on the temperatures of the Texas panhandle and install it in Maine, we can not expect the same efficiency.

For GSHP system designers, most of the available programs (such as LoopLink) account for the effect of varying entering water temperatures, pumping energy, supplemental heat operation, etc. on overall system efficiency. But because those programs don't model air-source equipment in a similar manner, estimated values of their efficiencies are needed to make operating cost comparisons.

If designers simply use published HSPF and SEER values for long term cost projections, air source equipment is given an unrealistic advantage. To combat this problem and provide home/building owners with a more accurate projection of the long term cost of operation for ASHP vs. GSHP, we need to turn to the good people of ASHRAE.

HEAT PUMPS ÜBER ALLES

According to the EPA heat pumps in any form will save energy and reduce emissions. Here is how things stacks up.

ASHRAE Research Makes Oranges Look Like Apples

In the June 2004 issue of ASHRAE Transactions, "Climate Impacts on Heating Seasonal Performance Factor (HSPF) and Seasonal Energy Efficiency Ratio (SEER) for Air Source Heat Pumps" was published (Fairey, P., D.S. Parker, B. Wilcox and M. Lombardi). This document was made available on the heels of research that showed how much ASHP performance depends on climate and it provides us with the tools necessary to:

- Adjust rated ASHP efficiency based on Outdoor Air Temperatures (OAT in °F)
- Compare ASHP operating cost to GSHP operating cost more accurately.

The great thing about the research was that they condensed everything down into two equations that you can use to account for the variation in ASHP performance according to the outdoor design temperatures for a given location. The equations are fairly simple to apply but they get even easier with software. This article was actually started right after we built these equations into LoopLink's Operating Cost Analysis. Below, you can see the equations and procedure for making the adjustments.

HOW TO APPLY ASHRAE EQUATIONS

HSPF EQUATIONS

1) $Diff = a + b * OAT + c * OAT^2 + d * Rated\ HSPF$
2) $Adj.\ HSPF = [1-(Diff)] * Rated\ HSPF$

HSPF COEFFICIENTS

Rated HSPF < 8.5	Rated HSPF => 8.5
a = 0.1392	a = 0.1041
b = -0.00846	b = -0.008862
c = -0.000107	c = -0.0001153
d = 0.0228	d = 0.02817

EXAMPLE VARIABLES

OAT = -11°F Rated HSPF = 8

EXAMPLE PROBLEM

Use Equation 1 to find your adjusted difference (Diff). Find values for the constants a, b, c and d in the HSPF Coefficients table.

$$Diff = a + b * (-11°F) + c *(-11°F)^2 + d * (8)$$

Diff = 0.40171

Use Equation 2 and your answer from Equation 1 to calculate your Adjusted HSPF (Adj. HSPF).

$$Adj.\ HSPF = [1-(Diff)] * (8)$$

Adj. HSPF = 4.79

SEER EQUATIONS

1) $Diff = a + b * OAT + c *\ Rated\ SEER$
2) $Adj.\ SEER = [1-(Diff)] * Rated\ SEER$

SEER COEFFICIENTS

Rated SEER < 13.5	Rated SEER => 13.5
a = -0.5655	a = -0.5864
b = 0.005414	b = 0.005668
c = 0.01039	c = 0.01029

EXAMPLE VARIABLES

OAT = 85°F Rated SEER = 20

EXAMPLE PROBLEM

Use Equation 1 to find your adjusted difference (Diff). Find values for the constants a, b and c in the SEER Coefficients table.

$$Diff = a + b * (85°F) + c * (20)$$

Diff = 0.10118

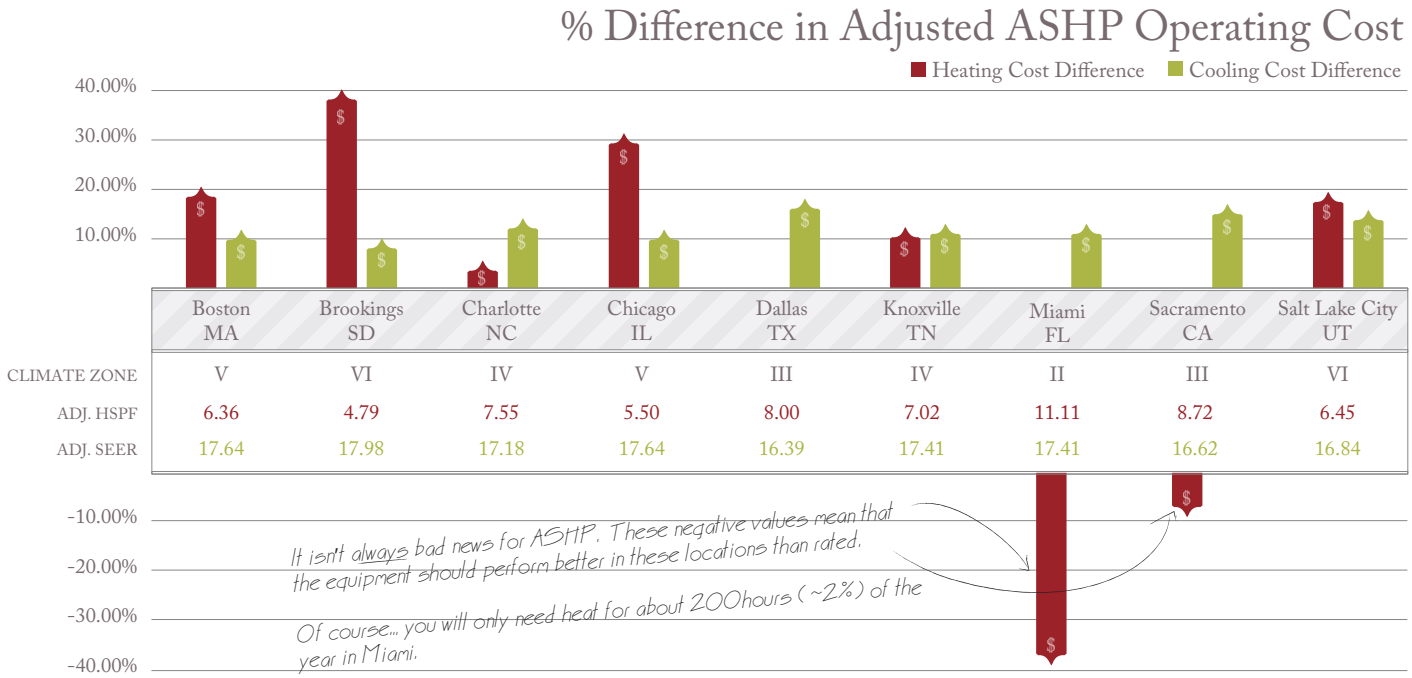
Use Equation 2 and your answer from Equation 1 to calculate your Adjusted SEER (Adj. SEER).

$$Adj.\ SEER = [1-(Diff)] * (20)$$

Adj. SEER = 17.98

ASHRAE Equations Applied

Using the outlined procedures, we created the following reference table/graph to show how nominal HSPF and SEER ratings will vary when adjusted for operating conditions by project location. The values in the table assume that the nominal ratings for the ASHP were HSPF=8.0 in heating and SEER=20 in cooling.



	Boston MA	Brookings SD	Charlotte NC	Chicago IL	Dallas TX	Knoxville TN	Miami FL	Sacramento CA	Salt Lake City UT
CLIMATE ZONE	V	VI	IV	V	III	IV	II	III	VI
ADJ. HSPF	6.36	4.79	7.55	5.50	8.00	7.02	11.11	8.72	6.45
ADJ. SEER	17.64	17.98	17.18	17.64	16.39	17.41	17.41	16.62	16.84

A Simple Case Study

In the end, the adjustment of HSPF from an 8.0 to a 6.45 or a SEER from a 20 to a 17.41 seems insignificant, but these deceptively small changes in efficiency add up a lot when the percentage of change is applied to the annual operating cost of the system. Consider the difference in estimated operating cost for an ASHP system installed in Brookings, SD when we adjust our efficiency for operating conditions versus using the rated efficiency.

For simplicity, we will only look at the difference in heating costs and we will stick with a rated HSPF of 8.0. If we assume an electric rate of $0.12/kWh and an estimated heating load of 30,000 Btu/hr. The last piece of information that we need is the design minimum OAT which in Brookings is -11°F.

Using the rated HSPF we have an estimated operating cost for the ASHP of $1,000.00 annually. If you apply the adjustment equations and use the more accurate location adjusted HSPF of 4.79, your annual operating cost jumps to about $1,700.00. That's seven hundred dollars difference- every year... and we aren't including the difference in cooling cost. The impact is significant over the short term, but compounds dramatically over the long haul.

Efficiency adjustment isn't just an issue of helping to make geothermal look financially better than air source systems. Failing to adjust the rated efficiencies of ASHPs based on location, provides your customers with incomplete information. Applying these equations may swing the economics to favor geo (or not). It is isn't important that geo win every time. The important thing is that the information you present your customers is the most accurate available, and that the heating/cooling system they select is the best fit for their budget and lifestyle now and into the future GC

PROJECTED ANNUAL HEATING COST

RATED $1,000

ADJUSTED $1,700

Location
Brookings, SD

Heating Load
30,000 Btu/hr

Electric Cost
$0.12/kWh

SIMPLY PUT...

1. Rated efficiencies are not and never have been designed for projecting long term operating costs. They simply supply a standardized reference point for assessing the merits of like systems.

2. ASHPs are not the enemy. Air source heat pumps have their place in the world and are well suited for many HVAC applications. The point of this article is that when projecting long term operating costs for air source equipment, using rated system efficiencies will result in unrealistic costs.

3. If competing against an air source heat pump for a geothermal job, the best case you can make is based on long term operating cost. Make sure that you ask whether your competitor has adjusted their efficiencies based on actual operating conditions. If not, hand the building owner (and your competitor) this document and explain why adjustment is so important.

4. Geothermal systems are also subject to efficiency variability due to operating conditions. Make sure that your design is honestly accounting for variations from rated conditions. When in doubt use software and get trained in how to use it correctly.

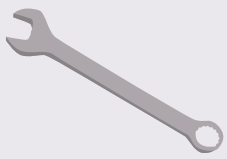
DON'T FORGET TO MENTION...

A lot of system designers and salesman stick with the straight up economics of geothermal as reason enough for the purchase but there are other advantages that should not be forgotten.

COMFORT

Geothermal systems have much better cooling and dehumidification capabilities than air source equipment because the temperature and relative humidity of the outside air don't affect heat rejection underground.

For those way up north, the geo system also offers warmer air temperatures coming through the registers than air source heat pumps during the coldest days. Again, this is because the ground temperature doesn't swing like the air temperature.



MAINTENANCE

Geo systems are simple. There aren't too many moving parts to break and the only regular maintenance item to worry about is the air filter. There is no coil exposed to grass clippings, no unit sitting outside in the elements... everything is either in the utility room or underground. This results in less maintenance and a longer service life for a geo cabinet.

HOT WATER

Geo systems are the only heating and cooling solution that can handle 100% of your spacing heating as well as some or all of your domestic hot water generation. One machine to rule them all!

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