
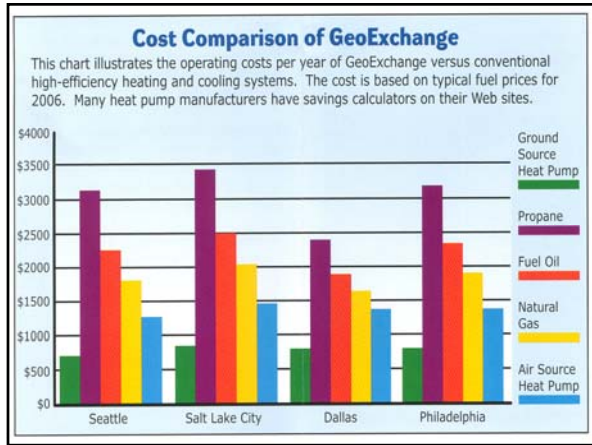
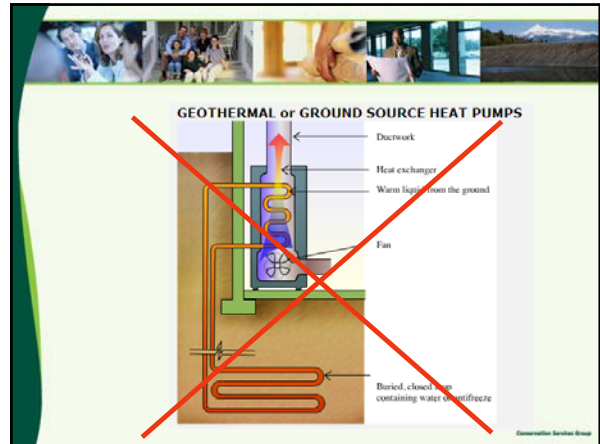


Myths and Realities of Ground Source Heat Pumps

NE HERS Alliance
1/10/2009

Bruce Harley
Technical Director
Conservation Services Group

DO IT Naturally

Advantages of GeoExchange

GeoExchange systems are self-contained. The heat pump unit is housed entirely inside and connected to the ground loop buried outside. The unique flexibility of ground source heat pumps allow them to be used for residential and commercial buildings around the world from North America to Australia. They are quiet, pollution free and do not detract from the surrounding landscape.

- Savings**—Geothermal systems can cut your home or business heating and cooling costs by 50 percent and provide hot water for free or at a substantial savings.
- Durability**—Ground source heat pumps last longer than conventional systems because they are protected from harsh outdoor weather. The heat pump unit is housed indoors and the loop is underground.
- Low Maintenance**—Geothermal systems have fewer mechanical components, making them more reliable and less prone to failure. The ground loop has an expected life of over 50 years and requires no maintenance.
- Cleanliness**—Geothermal systems work toward the preservation of the environment by minimizing present environmental problems like acid rain, air pollution and the destruction of the ozone layer.
- Low Noise**—Ground source heat pumps have no exposed, noisy outside units. The unit operates quietly to satisfy your needs without disturbing you or your neighbors.
- Conservation**—Geothermal systems work with the environment by using the earth's moderate ground temperature to heat your home or business in the winter and to cool it in the summer.
- Flexibility**—Geothermal systems can be adapted for residential, institutional and commercial buildings anywhere. They can be placed in both new buildings or used for retrofits of existing buildings.
- Health**—Geothermal systems keep indoor air cleaner and free of pollens, outdoor pollutants, mold spores and other allergens. Good indoor air quality is a priority with us. Consider geothermal.

GeoExchange:
Space conditioning that is energy smart, financially sound and environmentally friendly.

YOU CAN STOP BUYING OIL OR GAS TO HEAT YOUR HOME NOW!

No one needs to tell you the price of oil and natural gas is shooting through the roof. Just look at your last fuel bill. And both aren't going down, EVER. There are predictions for home heating oil to top \$4 a gallon - THIS SEASON. Keeping up with your home heating bills isn't easy.

There is a solution. And best of all it's "green"

Here's an opportunity to **save money** heating and cooling your home with a **pure, renewable energy source** you already own right in your backyard!

WHAT'S THE SECRET? THIS INCREDIBLE ENERGY SOURCE IS CALLED GEOTHERMAL. IT'S REAL - IT'S NOW - AND IT WORKS!

SUMMER OPERATION

In simple terms, the earth is a giant heat storage battery. Every minute of every day the sun heats the ground and the earth retains this heat. In the Northeast United States, a few feet below the surface, the earth is about 53 degrees Fahrenheit all the time. This constant heat is the source of clean, inexhaustible energy. And once tapped, it's yours free of charge. To tap and use this energy we're proud to offer the **GeoThermal Comfort System** - a super-efficient, comfortable, reliable home heating and cooling system.

Heat Energy is removed from the house (A/C mode) via the heat exchanger and sent into the ground.

PUT MONEY IN YOUR POCKET RIGHT NOW

From the moment we install a **GeoThermal Comfort System**, you no longer buy oil, natural gas, or propane for heating. Ever. Thus, the cost to purchase and professionally install the system is financed by what you would have paid to your oil or natural gas supplier. **AND CAN INCLUDE AN IMMEDIATE PAYBACK TO YOU.** How is this possible? You've probably seen geothermal systems on TV or read about them in the papers. The technology is simple and proven. There are over 1.5 million homes and commercial buildings in the US (and more around the world) using this technology. Our teams have installed over 5,000 geothermal heating and cooling systems since 1993.

Simply compute the annual cost you pay for oil or gas. It is likely between \$4000 - \$6000 a year or more. For reference, today's average annual fuel bill for homeowners in the northeast US is \$4775. **This cost will ONLY GO UP over time which makes installing geothermal the best decision you will ever make. No BS.**


Switching to or adding GeoThermal actually costs you nothing. Seems too good to be true - But it is. This ONLY GETS BETTER - read on...

To insure affordability for every homeowner we can arrange flexible financing. Monthly payments for system purchase and professional installation are completely offset by what you would have paid your oil or natural gas supplier - and a portion can even be tax deductible. In about 5-6 years the **GS is paid off** and you actually make




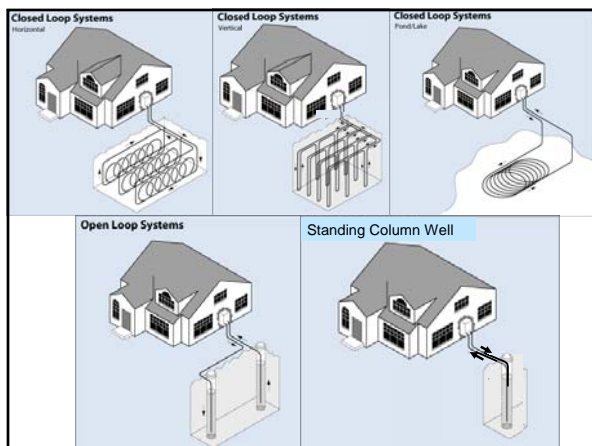
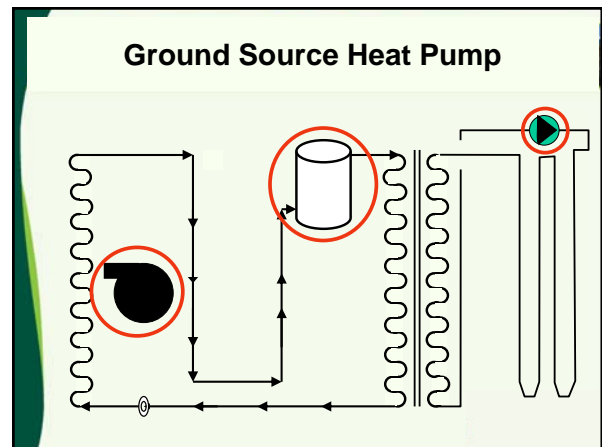
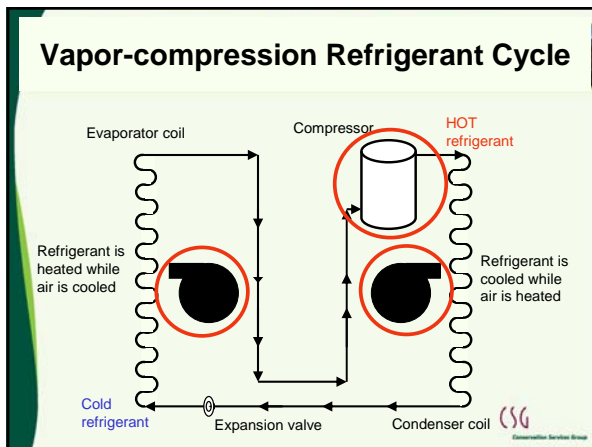

Now, what we'll talk about today:

- What is a heat pump?
- What is a ground source heat pump?
- Published efficiency ratings (ISO 13256)
- Measured data on operating efficiencies
 - Past and current
- Cost and carbon


Heat pumps


- Use electricity to move heat
 - You can't do it for free!
- Move heat *from* lower temperature *to* higher
 - Using vapor-cycle refrigeration technology
 - Refrigerator, air conditioner are 1-way
 - Heat pump is reversible for heating or AC

Air vs. Ground Source Heat Pumps

- Outdoor air source:
 - Hardest to heat (or cool) when most needed
 - Typically uses electric supplementary heat - \$\$\$
- Ground source:
 - Uses ground water, or circulates antifreeze through pipes in ground
 - Ground temperature is more stable seasonally






GSHP Pros ... Cons

- Pros:**
 - Potentially more efficient
 - Operating cost savings (?) (especially cooling)
 - No outdoor unit
 - No combustion in home
- Cons:**
 - High first cost
 - More design issues
 - More installation issues
 - Less developed install/support infrastructure

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Coefficient of Performance (heating):

$$COP = \frac{\text{Energy Delivered}}{\text{Energy Purchased}}$$

- Some of the heat is “free” – some you buy
- Air source *rated* at ~ 2.3 – 3.0
 - At 47F outdoors – mild conditions
- Ground source *rated* at ~ 3.2 – 4.5
 - Different ratings for ground loop/ground water
 - ARI/ISO rating doesn't tell the whole story...

RATED EFFICIENCY OF THE “SYSTEM”

Performance Data
ARI/ASHRAE/ISO 13256-1

ASHRAE/ARI/ISO

Model	Ground Water Heat Pump				Ground Loop Heat Pump			
	Cooling 59°F		Heating 50°F	COP	Cooling 77°F		Heating 32°F	COP
	Capacity Btuh	EER Btuh/W	Capacity Btuh		Capacity Btuh	EER Btuh/W	Capacity Btuh	
GSH/V015	15,600	23.9	12,900	4.1	14,900	18.5	11,200	3.8
GSH/V018	19,000	22.7	16,000	4.1	18,300	16.7	13,200	3.6
GSH/V024	26,500	21.2	23,500	4.0	26,000	17.1	19,200	3.6
GSH/V030	31,100	21.4	27,200	4.0	30,700	16.9	22,200	3.6
GSH/V036	36,000	20.7	32,900	4.0	35,800	16.4	26,700	3.4
GSH/V042	45,400	20.3	39,000	4.0	43,300	16.0	32,700	3.7
GSH/V048	49,000	19.9	43,300	4.0	46,900	16.4	36,900	3.7
GSH/V060	59,600	17.7	58,900	3.6	59,400	14.6	48,700	3.8
GSH/V070	70,000	16.8	62,900	3.8	67,100	13.4	53,400	3.6


300 CFM Nominal Rated Airflow

Performance capacities shown in thousands of Btu/h

EWT °F	GPM	WPD		Cooling - EAT 80/67°F						Heating - EAT 70°F								
		PSI	FT	TC	SC	Sensit Ratio	kW	HR	EER	HC	kW	HE	LAT	COP				
20	12.0	7.6	17.6	Operation Not Recommended										31.4	2.95	21.3	88.2	3.12
30	6.0	2.5	5.8	55.5	38.9	0.70	2.00	62.3	27.7	35.7	2.98	25.5	90.7	3.51				
	9.0	4.7	10.9	55.9	38.7	0.69	1.93	62.5	29.0	36.3	3.01	26.0	91.0	3.53				
	12.0	7.4	17.1	56.4	38.5	0.68	1.85	62.7	30.5	36.9	3.04	26.5	91.4	3.56				
40	6.0	2.4	5.6	53.9	38.2	0.71	2.30	61.7	23.5	40.2	3.11	31.3	94.2	3.59				
	9.0	4.6	10.6	54.3	38.0	0.70	2.21	61.8	24.6	41.0	3.11	31.3	94.2	3.59				
	12.0	7.2	16.6	54.7	37.8	0.69	2.12	61.9	25.8	41.9	3.11	31.3	94.2	3.59				
50	6.0	2.3	5.4	52.3	37.5	0.72	2.59	61.1	20.2	44.7	3.15	33.9	95.9	4.15				
	9.0	4.4	10.2	52.7	37.3	0.71	2.49	61.2	21.1	45.8	3.16	35.0	96.5	4.24				
	12.0	7.0	16.1	53.0	37.1	0.70	2.40	61.2	22.1	46.8	3.17	36.0	97.1	4.33				
60	9.0	4.3	10.1	51.7	37.0	0.73	3.07	60.3	17.2	50.5	3.20	38.1	98.2	4.40				
	12.0	7.1	16.2	52.1	36.8	0.72	2.97	60.4	18.2	51.5	3.21	39.1	98.8	4.47				
	15.0	9.9	21.3	52.5	36.6	0.71	2.87	60.5	19.2	52.5	3.22	40.1	99.4	4.54				
70	9.0	4.2	10.0	50.3	36.7	0.74	3.74	59.5	14.3	56.1	3.25	42.2	100.5	4.64				
	12.0	7.0	16.1	50.7	36.5	0.73	3.64	59.6	15.3	57.1	3.26	43.2	101.1	4.66				
	15.0	9.8	21.2	51.1	36.3	0.72	3.54	59.7	16.3	58.1	3.27	44.2	101.7	4.68				

RATED EFFICIENCY OF THE MACHINE ONLY (no fluid pump)


How can this be lower ???



What's going on?

- The old ARI 325/330 standards included a pumping allowance
- The new ARI/ASHRAE/ISO 13256-1 still includes a pumping allowance (sort of)
- BUT it rates the unit at a blower external static pressure of **0 ESP**

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And Pumping power?

- Only the pumping power required to overcome the *internal* resistance of the heat exchanger coil is included in the rating conditions.
- No allowance for external piping resistance
 - Or lift on open loop systems

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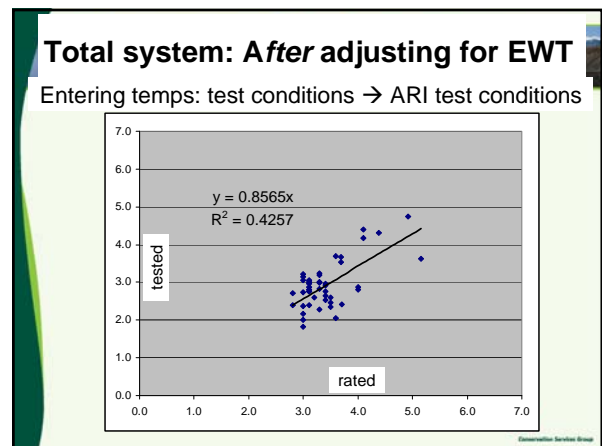
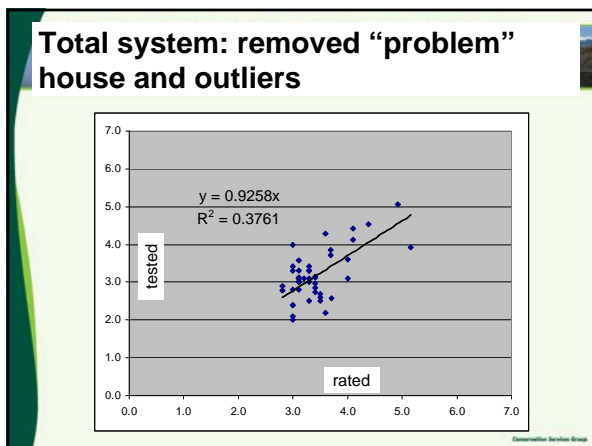
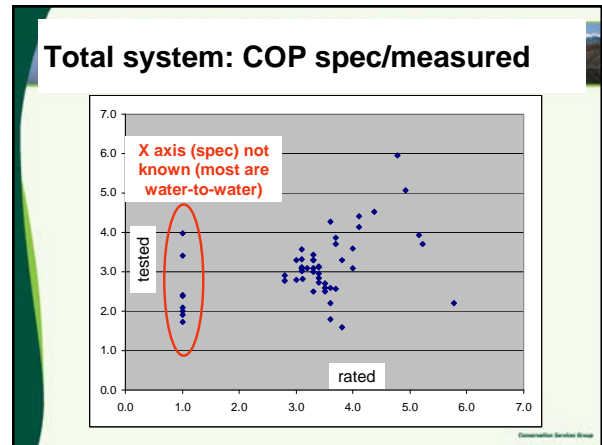
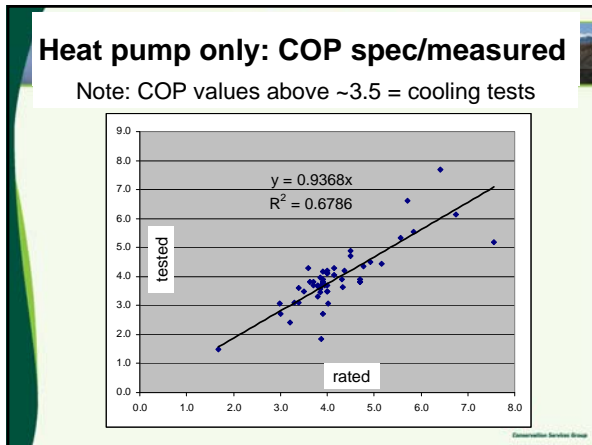
**Previous ratings under ARI 325 / 330:
(apparently otherwise identical product)**


Model	Cooling 55°F			Heating 50°F		Cooling 77°F		Heating 32°F	
	Capacity Btuh	EER Btuh/W	COP	Capacity Btuh	COP	Capacity Btuh	EER Btuh/W	Capacity Btuh	COP
GSHV015	15,600	23.9	12	3.6	4.1	14,900	18.5	1	3.5
GSHV018	19,000	22.7	16	3.6	4.1	18,300	16.7	1	3.3
GSHV024	26,500	21.2	23	3.7	4.0	26,000	17.1	1	3.3
GSHV030	31,100	21.4	27	3.5	4.0	30,700	16.9	2	3.3
GSHV036	36,000	20.7	32	3.5	4.0	35,800	16.4	2	3.2
GSHV042	45,400	20.3	39	3.7	4.0	43,300	16.0	3	3.3
GSHV048	49,000	19.9	43	3.7	4.0	48,900	16.4	3	3.3
GSHV060	59,600	17.7	58	3.5	3.8	59,400	14.6	4	3.2
GSHV070	70,000	16.8	62	3.4	3.8	67,100	13.4	5	3.1

A Look at Tested Efficiencies

- 79 Systems measured in utility programs
 - 1998-2002
 - Not "problem" calls – did include 1 home with poorly designed valve system
 - Compared with ARI 325/330 ratings
 - One-time, steady state


Machine Only		
Avg:	rated	tested
COP	3.9	3.7
EER	18.8	17.6




System Efficiencies compared to ARI

Adjusted System Performance					
	Average	Rated	Tested	% of Rated	n
Closed loop @32F	COP	3.2	2.9	91%	19
	EER	14.5	13.8	95%	8
Open loop @40F	COP	3.4	2.4	71%	21
	EER	17.2	11.6	67%	3




What Interferes with Efficiency?

- All heat pumps:
 - Low air flow
 - Over or under on refrigerant charge
 - Affects cooling more than heating on TXV systems
 - Duct leaks (not reflected in above results)
 - *Undersizing* (in cold climate; also not reflected)
 - Conservative sizing due to cost
 - Underestimating design load due to building flaws




What Interferes with GSHP Efficiency?

- **Water pumping power**
 - Especially wells used for domestic water supply
- Fan power of ECM blower (esp. w/small ducts)
- *Neither of these are accounted in AHRI ratings!*
- **Ground loop sizing**
 - Undersized system
 - Ground loop design mistakes


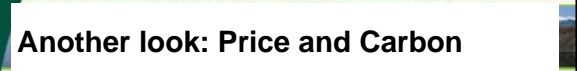
Improving GSHP Performance:

- Ensure careful design and installation
 - Adequate size (equipment & ground coupling)
 - Duct design (seal or move inside!)
 - Pumping (VFD pumps help w/ open loop (?))
- Start-up testing – actually read the meter
 - Confirm manuf's extended performance data
 - Include pump power!
- Turn off electric backup heat



Upgrade Building Shell First

- Investment in GSHP is smaller if the load is reduced dramatically
- Take advantage of programs (ENERGY STAR) and tax credits to upgrade the shell and ducts
- Consider investing MORE in building enclosure efficiency vs GSHP

Another look: Price and Carbon

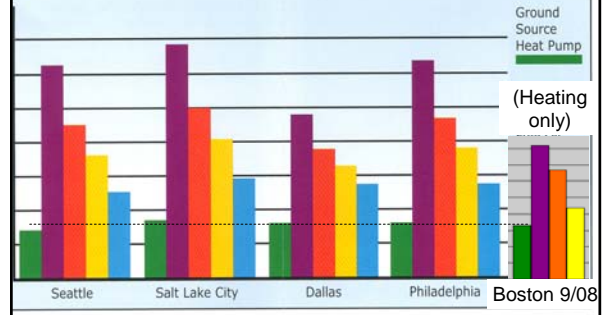
	Electric kWh	Nat Gas therm	Oil gallon	Propane gallon
Fuel rates	\$ 0.17	\$ 2.00	\$ 4.00	\$3.50
btu/unit	3,413	100,000	138,000	93,000
\$/Million btu	\$ 50	\$ 20	\$ 29	\$ 38

Another look: Price and Carbon

	Electric kWh	Nat Gas therm	Oil gallon	Propane gallon
Fuel rates	\$ 0.17	\$ 2.00	\$ 4.00	\$3.50
btu/unit	3,413	100,000	138,000	93,000
\$/Million btu	\$ 50	\$ 20	\$ 29	\$ 38
lb CO/Million btu	287	117	161	139
efficiency	300%	92%	87%	92%
\$ / Mbtu load	\$ 17	\$ 22	\$ 33	\$ 41
lb CO/ Mbtu load	96	127	185	151

Realistic Comparison of GeoExchange

This chart illustrates the operating costs per year of GeoExchange versus conventional efficiency heating and cooling systems. The cost is based on typical fuel prices for 2006. Many heat pump manufacturers have savings calculators on their Web sites.



National comparison: price & carbon

	Electric kWh	Nat Gas therm	Oil gallon	Propane gallon
Fuel rates	\$ 0.11	\$ 1.50	\$ 4.00	\$3.50
btu/unit	3,413	100,000	138,000	93,000
\$/Million btu	\$ 50	\$ 20	\$ 29	\$ 38
lb CO/Million btu	393	117	161	139
efficiency	300%	92%	87%	92%
\$ / Mbtu load	\$ 11	\$ 16	\$ 33	\$ 41
lb CO/ Mbtu load	131	127	185	151

The math

- Very dependent on utility rates
- Initial GSHP cost vs. Shell upgrades
 - The building load will ALWAYS dictate the amount of energy you need to heat or cool
 - Reduce the load and you reduce dependency on the HVAC equipment, and reduce sensitivity to energy cost increases



Conclusions....

- GSHP is not a slam dunk...
 - ... you have to do the analysis
- MUST account for fan and pump power
- Tested systems under ARI 325/330 were ~10-30% less efficient than those ratings
- AND: ISO ratings overstate efficiencies by an additional ~11% compared to old ARI

