Geothermal Clinic

A Primer of the Basics of the Geothermal Application

Chapter One:
What is Geothermal?

When we first start to take a look at geothermal it is important to realize that geothermal is not the same for everyone. In Europe, geothermal technology has focused on the use of **direct source**. The term direct source means that we are actually using the energy from the Earth in the way of heat, by either drilling or tapping into a surface source of energy. The closest way to imagine direct source is to think of drilling into magma or siphoning off the energy from Old Faithful in Yosemite National Park for use. Although this is a valid source of energy it is not what we do here.

When we talk about geothermal here we are always referring to **indirect source**, otherwise known as passive geothermal. Passive geothermal is the term given to an indirect usage of the Earth's constant temperature. The indirect usage of the Earths energy through a geothermal exchange happens when we exchange one heat for another by either accepting or rejecting heat into the ground by using an exchanger.

Chapter Two:
How Does Geothermal Work?

Geothermal systems pump heat…it is a heat pump that moves heat from one place to another. It operates the same way as a traditional heat pump, being that the compressor squeezes gas and the by product is either heat or cooling. The huge advantage that a geothermal heat pump has over a conventional unit is the medium that it uses for the exchange.

In a traditional heat pump the unit uses the outside air to affect the exchange. This means that in the summer when it is 90 degrees and the humidity is up, the unit is trying to move the heat inside your home to the outside air which is hot. In the winter the unit is trying to remove the cold from inside your house and exchange it with the cold that is outside. This method of moving or exchanging temperature is neither efficient or in expensive to operate.

A geothermal heat pump uses the constant temperature of the earth, which is 55 degrees, to effect the same exchange and is a much more efficient and cost effective medium with which to exchange temperature. An engineer, when given a specific set of parameters, can design a very efficient machine that performs well. This is the geothermal advantage.

Chapter Three:
Types of Exchange

Now that we know that geothermal is exchanging or moving heat from one place to another, we can talk about the many different ways to accomplish that goal, and how to determine if the method you have selected is the appropriate one for your project. One last note before we go on is that no one method of exchange is any more efficient than any other. The amount of efficiency that your system delivers is a function of the design not the geothermal system.

When we talk about exchangers there are really only two types, and a multitude of variations of the major two.

1. Open Loop

The most common form of open loop geothermal system is also known as a "pump and dump" system. The geothermal exchange is made by a direct exchange with water, meaning that water is pumped through the heating and air unit and BTU's are either extracted or rejected and the used water is "dumped" or discarded back into the aquifer.

A pump and dump can also be utilized by using raw surface water from a pond with enough area to accept or reject the BTU's directly. The minimum size is generally considered to be 1 acre in surface area and at least 8 feet deep.

2. Closed Loop

The second type of exchange is called a closed loop. This means that the exchanger really is operating as a giant radiator. Once the loop(s) are assembled, the fluid inside the loop is continuously circulated, making it a closed system. Closed loops can be constructed either vertically or horizontally depending on the ground area available. From an efficiency standpoint, closed loops have what is called the "pendulum" effect.

Closed loops can also be constructed in ponds and in some cases storm water retention areas if large enough, and even streams and lakes. The State of Minnesota is called the "Land of 1,000 Lakes" and it is no coincidence that there are a large number of closed loop lake systems in operation there.

An off shoot of a closed loop system is called DX, which is short for Direct Exchange. This method of moving heat uses no exchanger or middle man to effect the change on the gas from the compressor. Copper tubing is inserted directly into the ground and the gas is pumped through the tubing, making a direct exchange. This particular option, though while effective, is not typically used in our area due to a high acid content in our soil.

3. Standing Column

This exchange method is a marriage of the two types of exchanges, open and closed loop, in a specific application. Standing column is used when a water well is constructed in rock to a depth of 400' and deeper. These wells typically have both a low yield and a low water table, but the thermal conductivity of the rock, however, is very high. The water from the well is extracted, pumped through the geothermal unit, and is deposited into the bottom of that very same well. The rock's thermal conductivity adjusts the temperature of the water inside the well prior to it being pumped through the unit again. These systems also have temperature sensors on the incoming water and if it is either too hot or too cold the water is "bled" off until a base temperature is achieved. These systems work very well but are specific to deep rock well areas of the Country.

Chapter Four:
Costs and Applications

Every region of the country has an accepted method of accomplishing a geothermal exchange. How each region arrives at their preferred method is based purely on economics and efficiency of installation. Here on the Delmarva Peninsula, the water table is high and plentiful and lot sizes are usually small. Open and closed loop systems work best within these parameters.

A plentiful supply of water that is easily obtained by drilling can make open loop systems a prime consideration. Because the exchange is done with water, and it only takes 3 gallons per minute per ton to do the exchange, they can be cheaper to install initially.
The major controlling factors regarding risk with an open loop geothermal system, though, are the quality of the water being used and the aquifer hydraulics that effect the ability of the recharge well to accept water. Mineral content and pH, and in the case of raw water, the organic content, can have an adverse effect on the performance of the unit as well as fouling and maintenance issues.

Because drilling on the peninsula is relatively inexpensive, the other option for us is the vertical closed loop. Vertical loops can be placed on a small footprint and because we recirculate the contained fluid, the assumed risks associated with an open loop do not occur. Maintenance requirements for a closed loop system are the most minimal of all the systems.

Again, open or closed loop systems are going to be the best choices for this area. You may ask why horizontal systems were not also included in that list. Excavating into the water table to a depth of six to eight feet is going to be problematic, excavation costs can be much higher than that of drilling, and installing a horizontal system will always consume much more of a footprint than most lots will allow.

If you are a DIY, have access to equipment and the land available, then other types or forms of exchange systems may be better for you and your project.

Costs

On the Peninsula, vertical loops are typically installed for $6.00 a foot, with the depth being 200 feet per ton, or $1,200.00 per ton of loop installed. The amount of money to connect and manifold the exchanger and connect it to your unit with anti-freeze included is generally $1.50 per foot of drilling.

That means that the cost of constructing and installing a closed loop heat exchanger is $1,500.00 per ton of load.

The costs associated with drilling the water wells for a pump and dump on the Peninsula are $1,200.00 for the first fifty feet of drilling and $8.00 per foot for every foot past fifty. What adds to the cost of an open loop system is the gallons per minute we need to pump in order to satisfy the tonnage of the load at a rate of 3 gallons per minute. What makes the pump and dump look so attractive at first blush is the need for a private domestic water supply in rural areas. The point being that if the home needs a water supply well anyway, if we just up size the pumping equipment and add a return well we can get inexpensive geothermal exchange. While this is true in theory the water quality and aquifer characteristics should be discussed prior to starting the project.

Chapter Five:
Design

Now that we have discussed the exchangers, we need to talk about design. The design for your home is the design that your HVAC contractor comes up with to effectively heat and cool your home. The contractor will visit your home or review your prints and conduct what is called a Manual J calculation. This calculation is the tool used to determine what the actual heating and cooling load is for a specific house. This calculation takes into account the specifics of your home's envelope. A home's envelope is the outer shell, the part of your home that is responsible for keeping you hot or cool. It is a measurement of your homes insulation values and the heat gain or loss and the infiltration rate of your home. This is step one of the process, and if mistakes are made here, they will amplify later into poor performance of your system. New homes are a little more resilient to these mistakes but when we look at retro-fitting an older home these mistakes can be catastrophic.

For a new home, the process merely involves a comprehensive review of your home's blueprints and an application of that data to the software. It is important to note here that no two homes are alike. The "rule of thumb" should never be applied to a geothermal system, or any system for that matter.

In an existing home, with special emphasis given to older homes or homes with balloon frame construction, the procedure is very different. For an existing home there are rarely prints that exist. The building codes have certainly changed and improved since the home was built. Many times the home has been added onto or changed and modified since new. In this case a comprehensive audit of the home is required to ensure that the correct values are used.

Step one should be an energy audit of your home.
An energy audit should include:

1. thermal imaging
2. insulation verification
3. window analysis
4. infiltration report
5. blower door testing
6. house orientation on the lot
7. a comprehensive report in writing with recommendations for improvements

After you have received the report it is important to note that the best money that can be spent on a home is on envelope improvements.

Following the steps to improvement in the report will do several things to help you. By making your envelope better and/or improving the insulation values or reducing infiltration it is not uncommon to reduce a home's heating and air conditioning load by a full ton, if not two, depending on the homes condition. The money spent on envelope improvements is a savings that is realized before any other work is done. By reducing the load you are reducing the amount of money needed to be spent on equipment as well as constructing the exchanger. The second benefit is that it will cost less money to operate given that you have reduced the load.

It is also true that if you have a leaky house you need to heat and cool it as inexpensively as possible. Sometimes, a home cannot be improved or the cost to do so does not fit the budget. An example would be homes that are governed by historic district regulations or homes that were purchased for aesthetic reasons that trump efficiency, like my 100 year old farmhouse.

Chapter Six:
Comfort, Costs and Design Philosophy

In the old days of heat pump installation, the mantra was that you size the load for cooling and let the heat take care of itself. For fossil fuel it was oversized for heating to make up for leaky distribution systems and no one ever complained about being too hot. The amount of money that it cost to operate these systems, when sized using gross rules of thumb, were complained about frequently.

A common misconception in geothermal is that the we cannot cover 100% of the heating load and still be comfortable in cooling in regard to the units running long enough to remove the humidity. With today's modern equipment utilizing two stage operation, this simply is not true. Two stage equipment means that to cover the whole heating load, the unit can run at full capacity and deliver heat in the winter, and in the summer it runs at low speed longer to remove the humidity and ensure comfort. This means that there is no need for electric resistance heat or what is referenced as stage three.

The cost of installing a system that covers 100% of the load is another consideration. When we look at a design for a given home it is based on the combination of degree days, bin data, the results of the Manual J calculation, installer philosophy and installer experience. When you receive an estimate for a system, the design is the most important aspect of the estimate. The design will dictate the comfort level you will experience in the home, as well as your wallet.

No matter how many estimates you obtain, each contractor supplying an estimate should include a copy of their design to ensure that you understand what the design parameters are, and what the estimated cost of operation will be. If we need a pick-up truck for a specific job we would never call three different dealers and tell them I need a quote on a pick-up, we would be specific. It needs to be a dually, it needs to be 4 wheel drive, it needs to be fuel efficient. All three of those pick-ups are very different yet they are all pick-ups.

If we get and solicit three different estimates for geothermal, I can guarantee that they will all be different in regard to design philosophy. One of them will use rule of thumb which will put your comfort at risk. One of them will design for cooling which will put your wallet at risk during the heating season. One of them will show you the costs for a 100% heat design with a break out of design days and the cost to install. None of these is correct yet all of them are an estimate for geothermal, and the costs will vary by thousands.

The professional I would hope to hire would be a blend of all three. A design that started as a rule of thumb, progressed to an energy audit, that was compared to the cooling load, that was then up sized to 100% heating load. From the 100% heating load coverage I would expect to see how a reduction in the heating load covered by geothermal, when offset by the cost to operate the stage three electric heat for a given number of days per year, really impacted my costs.

For example:

On an Energy Star rated home for 100% heating that requires a 5 ton unit, backing down the size of the unit to cover 80% of the load indicates that a four ton unit could be installed. That means that I save 1,000.00 to 1,200.00 dollars on the cost of the unit, I save 1,500.00 on the exchanger, and I save money on duct work. Now we have saved 3,000.00 on the install by going with a 4 ton system. The design will identify how many days a year the stage three heat will operate to cover the 20% load not covered by the geothermal. We then can take the cost of our electric and multiply to get the cost of running the stage three per year. For example, it may cost us 150.00 to operate the stage three heat per year. It will take us 20 years at 150.00 per year to get to 3,000.00 that the extra ton would have cost.

All of this is a choice. It is how we choose to spend our money. Nothing more, nothing less. It is important that the contractor explain and discuss this philosophy with you so that you understand how you are spending your money and why. This is the only way to compare estimates.

You will also be faced with estimates for different tonnages for the same house. Ask the installer to explain to you how he got to the tonnage they are recommending via the Manual J. In a field of three estimates one is wrong, one is right, and one will let you choose how to spend your money.

Chapter Seven:
Anyone Can “Do” Geothermal

While it is true that many of us have the skills to do many different things, geothermal installation should not be done by just anyone. In today's world of specializations, we all have migrated to our chosen fields of expertise. While geothermal is a branch of the heating and air conditioning world, not all HVAC contractors have the specialized training to install geothermal. This is truly an area where the rules of air to air heat pumps should be avoided, not embraced. It takes a contractor that has committed their time to obtain the specific knowledge and credentials to do geothermal professionally. A license in the HVAC field or years of air to air experience does not insure your geothermal project will have a happy outcome.

The International governing agency for geothermal is the International Ground Source Heat Pump Association. They offer licensing, credentials and certifications for anyone involved in geothermal. If your contractor has this specific training and a pedigree of happy geothermal customers for you to contact, the likelihood that your project will be successful and meet your expectations is very high.

We have spent a lot of time talking about the HVAC portion of geothermal, and scant little on the exchanger contractor/driller. Everything we have said about the HVAC contractor should also be applied to the driller. Ask for the driller’s credentials and licensure in regard to geothermal. Ask for a list of happy customers or business partners. Just because they are drillers does not ensure that they have any additional training or expertise in regard to geothermal.

Resource Links

www.weberwelldrilling.com

www.weberwelldrilling.com/kit.pdf

http://www.igshpa.okstate.edu/

http://forum.geoexchange.org/

http://www.geoexchange.org/

http://www.greenbuildingtalk.com/

http://www.climatemaster.com/

http://www.bosch-climate.us/

http://www.waterfurnace.com/

http://thefifthfuel.com/index.php