

RESIDENTIAL GEOTHERMAL HEAT EXCHANGE SYSTEMS

Provided by the Rowan University Clean Energy Team

Introduction:

It is nearly impossible to live an entire day without mentioning, noting or feeling the temperature within the workplace, school or personal home. Years ago scientific fact has proven that soil temperature as little as six feet below the surface of the earth is perhaps the calmest, non-fluctuating temperature on earth. To some, six feet down may not sound like the most promising group of words, but many Americans judge different. The Environmental Protection Agency claims ground heat exchange systems are the most energy efficient, environmentally clean, and cost-effective space conditioning systems available [1]. The installation of a ground heat pump accomplishes ground heat exchange.

What is a Heat Pump?

A heat pump transfers heat from one position to another. A refrigerator is a heat pump. A refrigerator, utilizing mechanical work, transfers heat away from the cool food enclosure to the surrounding air. Consequently, a refrigerator also acts as a heater warming the living space around the unit. For this reason conventional air-conditioning cooling systems are situated so heat pulled from an interior space is transferred to the surrounding air outside the home. If this were not the case, no noticeable change in temperature would result. A ground heat pump operates in the same manner as the above described products, but deposits its end heat into the most abundant resources on earth, soil and rock. Furthermore, a ground heat pump has the added bonus of being able to run in the opposite direction. This allows the system to heat rather than cool.

How does a Ground Heat Pump Work?

A ground heat pump takes advantage of the determinable constant temperature below the surface. A typical ground temperature profile trend can be referenced in **Figure 1**. As depth increases ground temperature becomes increasing more constant. During cold winter months a temperature warmer than outside ambient air temperature will always occur below the surface. The opposite is true for summer months. The heating and cooling energy made available by the ground can be harnessed in a plethora of varying designs. The most common being a Closed Loop System (CLS).

The CLS consists of three main components, a heat exchanger, piping, and heat transfer medium. The heat exchanger installed inside or outside the home serves as the heat transfer station from home to ground or ground to home. Connected to the exchanger, a network of piping, run throughout the local ground, serves as a heat distribution block for the heat absorbing or giving soil. Closed loop system piping comes in two typical varieties,

those with vertical piping and those with horizontal piping as illustrated in **Figure 2**.

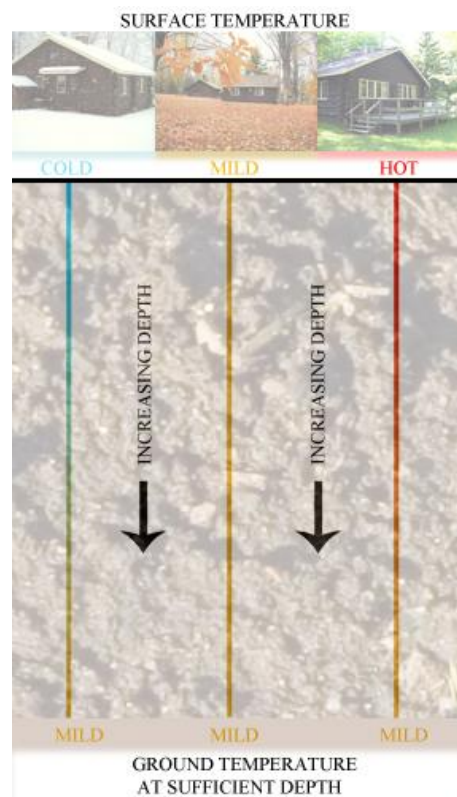


Figure 1: Relationship between surface and ground temperature.

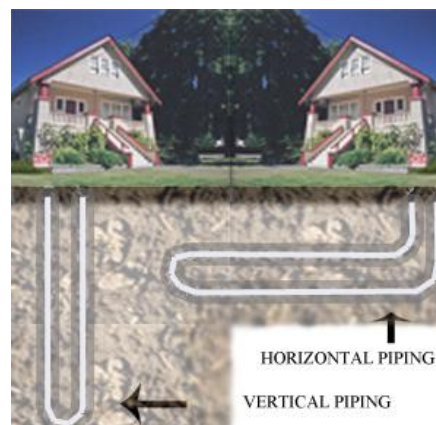


Figure 2: Horizontal and vertical piping layouts.

Pipe is typically made of plastic polyethylene or copper. These materials allow efficient transfer of the carrier mediums heat to or from the overbearing soil while cycled through the ground piping. Vertical piping systems can have exchange pipes reaching depths of approximately 150 to 300 feet. Recall that as depth increases constant temperature becomes increasingly steady. This fact makes vertical piping systems much more efficient than horizontal systems. A more common system to install, the horizontal loop, typically installs within a 6 to 12 foot trench. For a geothermal system to work most efficiently an expected heating load capacity must effectively be determined. This depends on the size of the home or space to be heated. Furthermore, the sizing,

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depth, and length of pipe for each unique system depend on site specific soil and rock thermal properties. Once piping has been installed, the piping is charged with a highly thermo conductive, refrigerant, water, or other liquid medium depending on the specific system installed. During operation the medium is cycled through the pipe loop transferring heat from ground to home or home to ground.

Ground Heat Pump Efficiency:

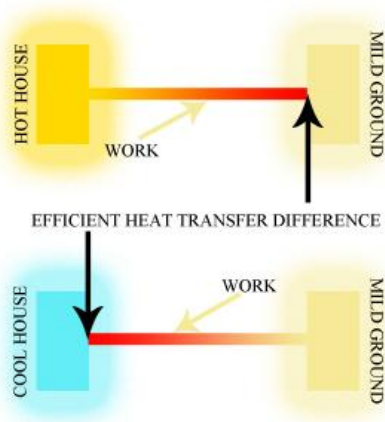


Figure 3: A diagram of efficient heat transfer methodology.

The second law of thermodynamics states that heat flows from hot to cold. System efficiency and rate of heat transfer depend on the temperature difference between heat sinks, namely the temperature inside a conditioned space versus outside air or for geothermal systems, ground. Opposing differential temperatures between surface and ground provide insight towards the GHP's excellent heat transfer and energy efficiency. All heat pumps require an input of energy termed work to increase temperature differential to allow for quick, efficient, transfer of heat. **Figure 3** shows this concept visually. A larger temperature differential results in an increasingly efficient system. Geothermal technology gains an advantage over traditional technology because ground temperature typically provides a large temperature differential. Refer back to **Figure 1** for reference. Without a temperature differential heat cannot be transferred. A traditional air conditioner trying to deposit collected heat into an already warm ambient air with little to nonexistent temperature differential will take much longer and much more energy to cool a house than a geothermal system. Since outside air temperature can fluctuate greatly from day to day the amount of work and energy and ultimate cost of running a conventional air conditioning system varies on a day to day basis. This fluctuation of operational costs can be minimized and most definitely reduced by conversion to a ground heat pump system.

Residential Geothermal Benefits:

- Green Energy
- Lower, Consistent, Cooling/Heating Costs
- Absent Noisy, Ugly, Outdoor HVAC Unit
- Lower Personal Carbon Emissions
- Supplemental Hot Water Heating Supply
- Tax Benefits

Is Geothermal For Everyone?

Ambitiously speaking, yes, it is possible for all parts of the world to benefit from the positive characteristics of geothermal heating. Everyone lives on the same earth, with the same ground. Generally, geothermal heating and cooling can be installed anywhere on earth if the piping depth requirements are met. Moderate climate conditions of the continental United States make most of our inhabitable land extremely favorable.

The US department of energy reports cost of installing geothermal system will be initially high between \$7,000 and \$9,000 for a typical residential sized home as compared to \$4000 for a traditional air conditioning or forced air heating system. Generally speaking the new installation will pay for itself between 2 to 10 years due to the significantly decreased energy use. Annual energy savings can be expected to be within the 30% to 60% range.[3]

Furthermore, if a home currently contains a conventional central air system or forced air furnace the ductwork needed to circulate the cooled or heated air throughout the house is already in place, reducing the cost of a system upgrade to geothermal immensely.

Additional Information:

This discussion performed its duty by presenting accurate but extremely general concepts relating to geothermal cooling/heating. For further learning, pricing, contractor listing, and tax benefit explanations please visit the following website: www.geoexchange.org (Geoexchange is not affiliated with Rowan University).

References

1. Georgios Florides, "Ground Heat Exchangers-A review of systems, models and applications", in Renewable Energy, Nicosia, Cyprus: Higher Institute of Technology, 2006, 17.
2. Environmental Protection Agency, "Space Conditioning: The Next Frontier," report 430-R-93-004, April 1993.
3. US D.O.E., "Selecting and Installing a geothermal heat pump system" < http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12670>