"GOT BALANCE" IN YOUR GEOTHERMAL SYSTEM?: HOW IT REALLY WORKS

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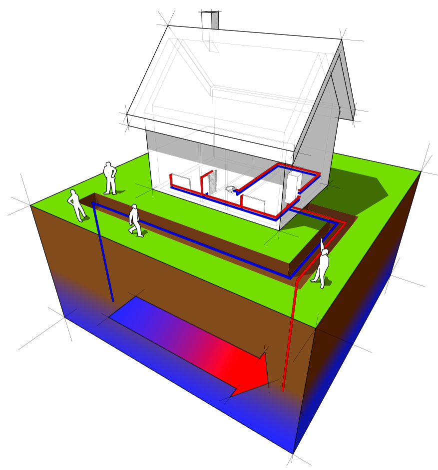
I am an architect and have read a lot of great articles[1], both long and short, that describe in easy-to-understand terms how heating and cooling a building can be accomplished using ground-sourced geothermal systems. So, I thought I had a basic understanding of how these systems worked; however, in the last six months, I have worked closely with our engineers on a number of these designs, and I learned that I had it completely wrong. Don't make the same mistake I did!



Common geothermal systems use a closed loop[2] of plastic pipe either inserted in deep, dry "wells," typically hundreds of feet deep or placed underground in some other manner to bring the pipe in contact with deep soil and rock. The purpose of these loops is to move water through the pipes to extract heat energy, known as the "heat of extraction," from the surrounding soils in order to heat a building, or to transfer heat, the "heat of rejection," to the ground to cool a building. Many articles contain a statement that geothermal systems are more efficient than conventional air-cooled systems because, unlike the air, the ground temperature 20 to 30 feet down *stays at a constant temperature year round*[3]. This statement is accurate…until you start operating a geothermal system!

Does the heat really go away? The simple answer is no. Once a geothermal system begins to operate, the ground temperature is no longer constant. For example, during the summer months, water pumped through the wells cools as heat moves into the cooler soil and/or rock. While the earth has a great capacity to absorb heat, the movement of the heat away from the well is at a slow, specific rate based on the characteristics of the soil and rock. Engineers must take this into account during design of the systems. Specialized software, such as Geothermal Design Studio's GLD 2010 package models this movement. These models use a heat transfer rating for different soil or rock formations and simulate the movement of heat and the temperature of the ground.

While the heat begins to move away, it doesn't go very far in a single summer; rather, it stays concentrated near the well. In a properly designed system, the ground temperature surrounding the well may rise by 30 to 45 oF (or more) between spring and fall! But this can be a good thing; in the fall, when heating is required, the

1 See the article in Architect magazine (April 2011) http://www.architectmagazine.com/geothermal-systems/going-underground.aspx or the short primer on BuildingGreen.com (September 2007) http://www.buildinggreen.com/auth/article.cfm/2007/8/30/Ground-Source-Heat-Pumps-Tapping-the-Earth-s-Mass/

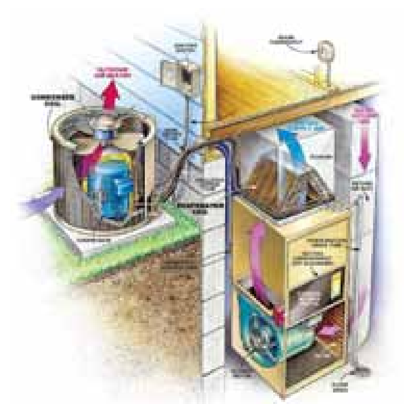
2 There are also open-loop systems, but closed loop are more common so are the focus of this explanation.

3 The ground temperature tends to be an average of the winter and summer temperature of the region, because the ground is a reasonably good insulator and energy moves through it slowly. That is why foundations don't freeze when placed three feet below the surface in areas that experience quite cold winters and hot summers.

ground is warmer, making it efficient to reverse the process and heat the building with the stored thermal energy from the earth. In the winter, the system takes heat from the ground and moves it back into the building.

Pretty cool, right? But, it shows the fallacy of the "earth as a constant thermal reservoir." What the earth really is in these systems is a big storage battery. In the summer, heat goes in, and in the winter, it is taken out. Once you understand this concept, you begin to see a problem that is often encountered with geothermal systems.

In a climate where buildings require as much heating in the winter as cooling in the summer—a balance of heating and cooling loads—an equal amount of heat goes into the earth in the summer as comes out in the winter. In these cases, the system will work indefinitely to heat and cool a building. But what about places that have warm climates[4], where heating and cooling loads are unbalanced? Each year, less heat will be drawn out in the winter than is put in the soil in the summer. The heat stays in the ground around the wells. While it does move slowly away, each year the ground gets warmer because the winter season does not cool it off enough. The system is unbalanced. After a few years, the system will become inefficient; eventually it will be too hot to operate and will no longer cool the building[5].



This problem doesn't mean that geothermal systems won't work in these climates. With integrated design, it is possible to use this excess heat to meet another energy demand, for example producing hot water needed in the building. Sometimes it is necessary to add an air-cooled device, something like the standard air conditioner coil that sits outside most houses or a commercial cooling tower, which runs when the outside air is not too hot but the building still needs cooling. Of course, the reverse problem occurs in northern climates where a lot of heating and little cooling is required. There, we add an alternative heating source to balance the system, such as a solar heating component or simply a gas or electric heater.

So what is the danger in misunderstanding the fundamentals of a ground-source geothermal system? Buying an unbalanced system.

In the short term, such a system will look fantastic in an energy model and perform adequately at startup. But in a matter of time, the energy savings will diminish steadily, undermining the natural efficiency of the system that attracted the owner to begin with.

So as I've learned, it's important to ask, "Got Balance?"

4 In the U.S., this is pretty much anywhere in the southern half of the country.

5 More wells can be added so the temperature rise is so slow it wouldn't be noticeable, but this usually costs too much to be lifecycle cost effective.