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From advocacy to action: geothermal heat pumps

IN HIS 2004 doctoral research at the University of Washington, Jon Agnone said, "Social movements do matter, sometimes. Politicians are responsive, but this happens by going to the streets, not by schmoozing elected officials." Agnone analyzed the impact of environmental protests on the propensity of Congress to introduce pro-environmental legislation. He found that public opinion alone had little impact on the passage of pro-environmental legislation. The overwhelming majority of environmental laws passed during congressional election years (with nearly 80% of pro-environmental legislation introduced in Congress by Democrats). Most Americans allow our salaries to drive our standards. Only when we see something happen within our personal reality do we accept change.

"It is difficult to get a man to understand something when his salary depends on him not understanding it." Upton Sinclair, committed to reversing social injustice in Chicago's meat-packing industry, made this observation in 1906 in his novel *The Jungle*. Does your paycheck depend on you doing what is right with respect to environmental concerns, or does it depend on optimizing the bottom line? Fortunately, you don't have to make a compromise if you take the time to understand technology that is at once cost effective and sustainable.

It starts by looking in the mirror. Alice Walker, author of *The Color Purple*, observed, "It's essential that we understand that taking care of the planet will be done as we take care of ourselves. You know that you can't really make much of a difference in things until you change yourself." This medicine is difficult to swallow, especially for me as I face client after client who refuses to acknowledge that energy efficiency, comfort, and safety are as affordable as the granite countertop upgrade. Like Al Gore in his recent documentary *An Inconvenient Truth*, I may deliver a very convincing and exceedingly accessible portrait of a planet cooking itself to death, yet no one seems to understand his or her personal responsibility. No single raindrop accepts responsibility for the flood.

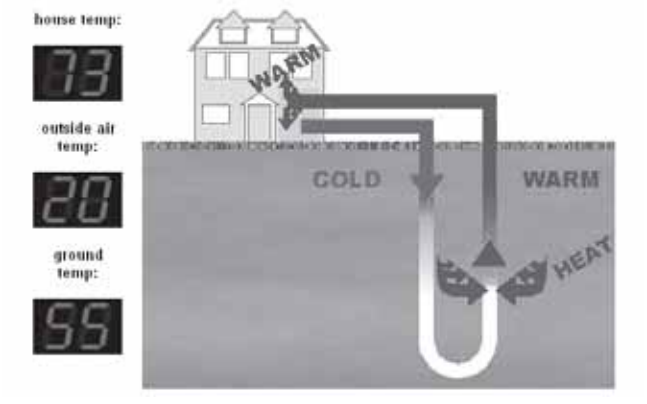

image www.groundloop.com

A simple depiction of the geo heat exchange process.

There are certain measures we can adopt now in order to achieve sustainable design and building in our lifetime: for example, geothermal heat pump technology, incorporating the structure deeply with the land. Such systems are cost-effective and environmentally sound—tools you or your clients can implement now.

"We don't have geothermal heat where I live." This is the first objection I hear when proposing a geothermal heat pump to clients, and it's simply not true. There is geothermal heat even if you live on a polar ice cap. Ground source heat pumps can use any ground temperature heat source, including water in frozen lakes. They use the same technology as air source heat pumps, but they are two to three times more efficient, quiet, and emit no combustion gases. One water-to-air unit can generate heating, air conditioning, and domestic hot water. Since there is no internal combustion of fossil fuels, the units are independent of gas prices, do not contribute to indoor air pollution, and do not produce carbon dioxide or other global warming gases. While geothermal units are more expensive to purchase, the cost difference is paid back over time through lower energy bills and federal, state, or local energy credits. If the geothermal ground loop is integrated into the site construction process, some geothermal heat pump installations are only slightly more expensive than high efficiency air-source heat pumps.

The key to geothermal heat pump efficiency lies in the constant temperature of the ground just below the surface. Below frost depth, the ground temperature remains at 50º to 55ºF, increasing one degree for every 100 ft. of depth. A traditional air-source heat pump works hard to create heat from cold winter air temperatures or cool from hot summer air temperatures (both of which can vary). A ground-source heat pump uses a renewable heat source (the ground) at a constant temperature that is warmer than outside air temperatures in the winter and cooler than outside air temperatures in the summer. By circulating water in a closed loop (similar to your car's radiator system), the heat pump transfers heat from the house to the ground in cooling mode and vice-versa in heating mode. The ground's enormous mass provides a constant source of 50-degree heat in the house.

"How does the heat pump make hot air or water, or cold air, from a constant ground temperature?" This is

A horizontal loop being installed.

photos Al Wallace

A manifold of loops joins to go into the house.

the next question I get. You already have a heat pump in your home—your refrigerator. If you put your hand behind it, you'll feel the heat that has been pumped from the fridge's inside. This is how the geothermal heat pump moves heat to and from a house and the earth. In summer, the heat pump extracts heat from the conditioned space and sends it out to the earth loop to warm the relatively cool ground, or pond, if it's an aqua loop. (An added benefit of cooling with a heat pump is that the extracted heat can be used to generate domestic hot water at little additional cost throughout the cooling summer months. There's something very satisfying about removing heat from where you don't want it and putting that very heat where you do want it.)

In the winter, this process is reversed. The heat pump actually generates temperatures in the heating unit above 130°F even in the coldest installations. The 55° ground temperature is what it uses to do this. It takes heat out of the water, goes through a compressor to raise temperature further and transfers the heat to the house, then sends very cold water (say 34°) back to the ground loop, which warms it back up to 55°, etc.

A geothermal system consists of three principal components: an earth connection subsystem (ground loop), the heat pump subsystem, and a heat distribution subsystem. The ground loop is a series of polyethylene pipes buried underground (or in a body of water) that contains water mixed with ethanol to keep it from freezing. A pump circulates the water, using the same amount of energy as a 100-watt light bulb. Water circulates within the loop and moves heat from the ground to the house or vice-versa. Loops can be installed in the ground in one of four ways: vertically, horizontally, as a slinky in a trench, or in a water source such as a pond.

While some suggest an open loop system (taking water directly from and returning it to an open water source), it's not a good idea. The water's changed temperature destroys the ecology of the water source and Mother Nature retaliates by destroying the internal mechanism of the heat pump.

Ground loop piping is installed by a certified contractor. The high density black polyethylene is certified (yellow for natural gas installations), fused at all fittings, and warranted by many installers for 50 years. If planned with other utility installations, the same piping used for geothermal can be used to run water from a source to the house, saving on the cost of underground copper piping. The contractor can also purchase yellow pipe and fuse in the gas supply to the property.

The size and soil conditions of the site determine the most cost effective ground loop installation.

If the site is large enough, the ground loop is buried in horizontal loops at least six feet below the surface. For every ton (12,000 BTUs) of heating or cooling, a 200-ft.-long trench, 8 ft. deep, is dug with a backhoe and one 800-ft. length of ¾-in. polyethylene is buried in each

Al's experience with geo heat

Al says, "I have installed quite a few geo heat systems, and every client loves the technology. For example, a 2500-sq.ft. house requiring $400 of heat in January (and drafty and uncomfortable) was gutted and top-popped to two stories, with twice the square footage. The client now heats the home, guest house, hot tub, and domestic hot water with geothermal, and air conditions with geothermal in summer. The January bill with geothermal and radiant floor heating is now $150!"

Al is currently installing a geo heat pump in his own house. He is installing a combination solar hot water and geothermal system. He intends to use the added solar heat to melt ice on his driveway.

trench. (The loop is doubled back twice within the trench.) Another option is to dig a wide trench (such as the excavation for a house foundation) and lay a 1000-ft.-per-ton loop in a slinky manner. Slinky loops work best in soils that are damp or wet year round.

The ideal soil for geo systems is clay. The worst is sandy soil in a hot climate such as south Texas. When the surface soil type is unacceptable or there are heavy rock concentrations just below the surface, vertical ground loops are installed. For every one ton of heating or cooling capacity, a 200-ft.-deep well is drilled. Vertical wells are placed at least 10 ft. apart. In each well, a 400-ft. length of pipe is inserted with a U-joint fused to allow 200 ft. on each vertical leg.

Ground loop lengths are joined with a manifold consisting of ¾-in. couplings to a 1¼-in. polyethylene pipe. The two 1¼-in. pipes are buried from the ground loop, travel through or under the house foundation, and connect to the heat pump inside the house.

The heat pump takes the heat from the ground loop (for heating) or to the ground loop (for cooling) and transfers it to the heat distribution system. The heat pump consists of a high efficiency compressor and two copper heat exchange loops. The heat distribution system can move heat from the water ground loop to an air or water heating system. If one is transferring to a water heating system such as radiant floor heating, the heat pump is called a water-to-water geothermal heat pump. (These systems are not used for summer cooling, as they would create condensation on cold surfaces.) If transferring to an air system, typical of most furnace systems in this country, the heat pump is referred to as water-to-air system. Water-to-air systems can circulate hot or cold air year round. Residential hot water can be integrated into either system. The manufacturer simply installs a secondary heat exchanger that circulates water from a hot water storage tank. Within the trades, this secondary heat exchanger is referred to as a desuperheater.

Any of these options can be combined with solar hot water panels for additional heating capability . . . hmmm, maybe something to be discussed the next time I write.

For more information, see the Geothermal Heat Pump Consortium site, *www.geoexchange.org*, the Department of Energy, Energy Efficiency and Renewal Energy site, *www1.eere.energy.gov/geothermal/heatpumps.html*, and Ground Loop Inc., *www.groundloop.com*. *—Al Wallace*