

## **Geothermal Systems – How It Works**

Home and Commercial Building Owners in virtually every region throughout the world are enjoying a high level of comfort and significantly reducing their energy use today with geexchange (geothermal) heating and cooling.

This marvelous technology relies on the Earth's natural thermal energy, a renewable resource, to heat or cool a commercial building, house or multi-family dwelling. The only additional energy geexchange systems require is the small amount of electricity they employ to concentrate what Mother Nature provides and then to circulate high-quality heating and cooling throughout the building or home.

Building & Home owners who use geexchange systems give them superior ratings because of their ability to deliver comfortably warm air, even on the coldest winter days, and because of their extraordinarily low operating costs. As an additional benefit, geexchange systems can provide inexpensive hot water, either to supplement or replace entirely the output of a conventional, domestic water heater.

Geexchange heating and cooling is cost effective because it uses energy so efficiently. This makes it very environmentally friendly, too. For these reasons, federal agencies like the Environmental Protection Agency, National Research Council of Canada and the US Department of Energy, as well as state agencies like the California Energy Commission, endorse it.

Owners of geexchange systems can relax and enjoy high-quality heating and cooling year after year. Geexchange systems work on a different principle than an ordinary furnace/air conditioning system, and they require little maintenance or attention from owners. Furnaces must create heat by burning a fuel--typically natural gas, propane, or fuel oil. With geexchange systems, there's no need to create heat, hence no need for chemical combustion. Instead, the Earth's natural heat is collected in winter through a series of pipes, called a loop, installed below the surface of the ground or submersed in a pond or lake. Fluid circulating in the loop carries this heat to the building or home. An indoor geexchange system then uses electrically-driven compressors and heat exchangers in a vapor compression cycle--the same principle employed in a refrigerator--to concentrate the Earth's energy and release it inside the dwelling at a higher temperature. In typical systems, duct fans and/or hydronic systems distribute the heat to various rooms.

In summer, the process is reversed in order to cool the building or home. Excess heat is drawn from the inside of the building, expelled to the loop, and absorbed by the Earth. Geexchange systems provide cooling in the same way that a refrigerator keeps its contents cool--by drawing heat from the interior, not by injecting cold air.

Geexchange systems do the work that ordinarily requires two appliances, a furnace and an air conditioner. They can be located indoors because there's no need to exchange heat with the outdoor air. They run so quietly people don't even realize they're on. They're also compact in size. Typically, they are installed in a mechanical room, basement or attic, and some are small enough to fit into a closet. The indoor location also means the equipment is protected from mechanical breakdowns that could result from exposure to harsh weather conditions.

Geexchange works differently than conventional heat pumps that use the outdoor air as their heat source or heat sink. Geexchange systems don't have to work as hard (which means they use less energy) because they draw heat from a source whose temperature is moderate. The temperature of the ground or groundwater a few feet beneath the Earth's surface remains relatively constant throughout the year, even though the outdoor air temperature may fluctuate greatly with the change of seasons. At a depth of approximately six to eight feet, for example, the temperature of soil in most of the world's regions remains

stable between 40 F and 70 F. This is why well water drawn from below ground tastes so cool even on the hottest summer days.

In winter, it's much easier to capture heat from the soil at a moderate 50 degree F. than from the atmosphere when the air temperature is below zero. This is also why geexchange systems encounter no difficulty blowing comfortably warm air through a ventilation system, even when the outdoor air temperature is extremely cold.

Conversely, in summer, the relatively cool ground absorbs a building's waste heat more readily than the warm outdoor air.

Studies show that approximately 70 percent of the energy used in a geexchange heating and cooling system is renewable energy from the ground. The remainder is clean, electrical energy which is employed to concentrate heat and transport it from one location to another. In winter, the ground soaks up solar energy and provides a barrier to cold air. In summer, the ground heats up more slowly than the outside air.

### **Making Hot Water**

Geexchange systems can also provide all or part of a building's hot water. This can be highly economical, especially if the building already has a geexchange system, hence a ground loop, in place.

One economical way to obtain a portion of domestic hot water is through the addition of a desuperheater to the geexchange unit. A desuperheater is a small, auxiliary heat exchanger that uses superheated gases from the heat pump's compressor to heat water. This hot water then circulates through a pipe to the building's water heater tank. In summer, when the geexchange system is in the cooling mode, the desuperheater merely uses excess heat that would otherwise be expelled to the loop. When the geexchange unit is running frequently, owners can obtain all of their hot water in this manner virtually for free. A conventional water heater meets building hot water needs in winter if the desuperheater isn't producing enough, and in spring and fall when the geexchange system may not be operating at all.

Because geexchange systems heat water so efficiently, many manufacturers today are also offering triple function geexchange systems. Triple function systems provide heating, cooling and hot water. They use a separate heat exchanger to meet all of the building's hot water needs.

### **The Earth Connection**

Once installed, the loop in a geexchange system remains out of sight beneath the Earth's surface while it works unobtrusively to tap the heating and cooling nature provides. The loop is made of a material that is extraordinarily durable but which allows heat to pass through efficiently. This is important so it doesn't retard the exchange of heat between the Earth and the fluid in the loop. Loop manufacturers typically use high-density polyethylene pipe, a tough plastic material. When installers connect sections of pipe, they heat fuse the joints. This makes the connections stronger than the pipe itself. Some loop manufacturers offer up to 50-year warranties.

The fluid in the loop is water or an environmentally safe antifreeze solution that circulates through the pipes in a closed system.

Another type of geothermal heating and cooling is Direct geexchange (DX) systems, which utilize copper piping placed underground. As refrigerant is pumped through the loop, heat is transferred directly through the copper to the earth.

To ensure good results, the piping should be installed by professionals who follow procedures established by the International Ground Source Heat Pump Association (IGSHPA). Installers should be certified by IGSHPA or be able to show equivalent training by manufacturers or other recognized authorities at a recognized institution, such as one of the

many regional geexchange training centers located throughout Canada and the United States.

The length of the loop depends upon a number of factors, including the type of loop configuration used; a building's heating and air conditioning load; soil conditions; local climate; and landscaping. Larger buildings with larger space conditioning requirements generally need larger loops than smaller ones. Buildings in climates where temperatures are extreme also generally require larger loops. A heat loss/heat gain analysis should be conducted before the loop is installed.

### **Types of Loops**

Most loops for geexchange systems are installed either horizontally or vertically in the ground, or submersed in water in a pond or lake. In most cases, the fluid runs through the loop in a closed system, but open-loop systems may be used where local codes permit. Each type of loop configuration has its own, unique advantages and disadvantages, as explained below:

**Horizontal Ground Closed Loops.** This configuration is usually the most cost effective when adequate land space is available and trenches are easy to dig. Workers use trenchers or backhoes to dig the trenches three to six feet below the ground, then lay a series of parallel plastic pipes. They backfill the trench, taking care not to allow sharp rocks or debris to damage the pipes. Fluid runs through the pipe in a closed system. A typical horizontal loop will be 400 to 600 feet long per ton of heating and cooling capacity. The pipe may be curled into a slinky shape in order to fit more of it into shorter trenches, but while this reduces the amount of land space needed it may require more pipe. Horizontal ground loops are easiest to install while a building is under construction. However, new types of digging equipment that allow horizontal boring are making it possible to retrofit geexchange systems into existing buildings with minimal disturbance to landscape. Horizontal boring machines can even allow loops to be installed under existing buildings or driveways.

**Vertical Ground Closed Loops.** This type of loop configuration is ideal for buildings where land space is insufficient to permit horizontal trenching for buildings with large heating and cooling loads, when the Earth is rocky close to the surface, or for retrofit applications where minimum disruption of the landscaping is desired. Contractors bore vertical holes in the ground 150 to 450 feet deep. Each hole contains a single loop of pipe with a U-bend at the bottom. After the pipe is inserted, the hole is grouted and backfilled. Each vertical pipe is then connected to a horizontal pipe, which is also concealed underground. The horizontal pipe then carries fluid in a closed system to and from the geexchange system. Vertical loops are generally more expensive to install, but require less piping than horizontal loops because the Earth deeper down is alternately cooler in summer and warmer in winter.

**Pond Closed Loops.** If a building or home is near a body of surface water, such as a pond or lake, this type of loop design may be the most economical. The fluid circulates through polyethylene piping in a closed system, just as it does in the ground loops. Typically, workers run the pipe to the water, then submerge long sections under water. The pipe usually coiled in a slinky shape to fit more of it into a given amount of space. Geoexchange experts recommend using a pond loop only if the water level never drops below six to eight feet at its lowest level to assure sufficient heat-transfer capability. Pond loops used in a closed system result in no adverse impacts on the aquatic system.

**Open Loop System.** This type of loop configuration is used less frequently, but may be employed cost-effectively if ground water is plentiful. Open loop systems, in fact, are the simplest to install and have been used successfully for decades in areas where local codes

permit. In this type of system, ground water from an aquifer is piped directly from the well to the building, where it transfers its heat to a heat pump. After it leaves the building, the water is pumped back into the same aquifer via a second well--called a discharge well--located at a suitable distance from the first. Local environmental officials should be consulted whenever an open loop system is being considered.

**Standing Column Well System.** Standing column wells, also called turbulent wells or Energy Wells<sup>TM</sup>, have become an established technology in some regions, especially the northeastern United States. Standing wells are typically six inches in diameter and may be as deep as 1500 feet. Temperate water from the bottom of the well is withdrawn, circulated through the heat pump's heat exchanger, and returned to the top of the water column in the same well. Usually, the well also serves to provide potable water. However, ground water must be plentiful for a standing well system to operate effectively. If the standing well is installed where the water table is too deep, pumping would be prohibitively costly. Under normal circumstances, the water diverted for building (potable) use is replaced by constant-temperature ground water, which makes the system act like a true open-loop system. If the well-water temperature climbs too high or drops too low, water can be "bled" from the system to allow ground water to restore the well-water temperature to the normal operating range. Permitting conditions for discharging the bleed water vary from locality to locality, but are eased by the fact that the quantities are small and the water is never treated with chemicals.

Other loop designs are also being used. In a few places, for example, home builders have installed large community loops, which are shared by all of the homes in a housing development.

### **Purchasing a System**

To ensure they receive the highest-quality equipment, system design and installation, building owners and consumers should consider the following guidelines when shopping for a geexchange system:

**Ratings and Certification:** Look for equipment that is certified by the Air-Conditioning and Refrigeration Institute (ARI), a non-profit organization that rates the performance of residential and small commercial geexchange equipment. Certified equipment carries the ARI seal.

**Warranties:** Manufacturers' terms of warranty vary. To assure a high-quality installation, seek a performance guarantee on the installed system, as opposed to coverage limited to the heat pump itself.

**Sizing:** geexchange systems that are too large waste energy and do not provide proper humidity control. Check to see that the contractor carefully determines your building's heating and cooling requirements using accepted procedures, such as those recommended by the Air Conditioning Contractors Association. The actual size of the system should be within 15 percent of the calculated load.

**System Design:** While designing a commercial or residential geexchange system is not particularly complicated, always use experienced contractors. The contractor should carefully select the size of the geexchange system, the size and design of the loop, and the type of fluid that will circulate through it. The contractor should also examine ways to use the geexchange system to provide hot water. Finally, the contractor should examine your building or home to ensure the ductwork is designed and installed properly to prevent leaks, as well as to ensure it is properly insulated and has window glazings and other energy-

efficiency features. Minimizing heating and cooling needs reduces the required size, hence the cost, of the geoechange system.

### **Sound Investment**

Geoechange is becoming the system of choice in many parts of Canada and the United States as consumers learn more about its aesthetic advantages and long-term value, and as it becomes more widely available.

Geoechange is no longer just for the affluent, a reputation it once held because typical early buyers were owners of upscale homes. They wanted the quiet comfort geoechange systems provide, and they were more than willing--and could afford--to pay the cost premium associated with early systems. This is because the extraordinarily low operating costs of geoechange systems more than make up for any higher installation costs within a few years. According to the U.S. Environmental Protection Agency, geoechange systems save building and home owners 30-70 percent in heating costs, and 20-50 percent in cooling costs, compared to conventional systems. Geoechange systems also save money in other ways. They are highly reliable, require little maintenance, and are built to last for decades. They add considerably to the value of buildings and homes.

Today, building and homeowners in all income brackets can take advantage of the benefits of geoechange heating and cooling. Initial costs have declined substantially as many more builders and heating and cooling contractors nationwide make geoechange systems available, and as innovative techniques enable the loops to be installed more quickly (often in one day) and for lower cost.

What's more, some electric utilities around the nation now have incentive programs and low-interest financing programs which can make geoechange even more affordable. Many financial institutions also now allow home buyers to qualify for larger mortgages if they purchase a house that utilizes a geoechange system. The reduction in monthly energy bills more than offsets the slightly higher mortgage payment. With such mortgages, homeowners with geoechange systems can begin saving money from day one, then go on saving year after year!

Today, the major barrier to wider use of this marvelous technology is the fact that many building developers and consumers simply aren't aware it's there.

### **A Wise Choice**

Geoechange is a smart investment for those who want a system that provides a high level of comfort and low monthly energy bills for as long as they own their buildings and homes.