GROUND-SOURCE

Heating & Cooling Gets Better

Direct-exchange geothermal technology offers higher efficiencies than standard water-source heat pumps, and can be retrofitted even on small lots

by John Vastyan

Although they're still far from familiar, ground-source heat pumps have been installed for more than 30 years throughout the U.S. Also called geothermal heat pumps, they are recognized by the EPA and the DOE as the most efficient heating and cooling systems available today.

"Geothermal heat-pump technology offers a renewable energy solution that's right for almost any home," says Gemma Tiller, owner of Air Brokers Hvac, LLC, based in Branson, Mo. "Thermal energy is harvested from the earth and transferred into buildings by a heat pump that provides heating and cooling." Despite misconceptions about climates that are too cold, geothermal technology can be used anywhere in the U.S. and Canada, Tiller says.

A ground-source unit works like a conventional heat pump to cool a home in the summer and heat it in the winter, but is far more efficient. Conventional heat pumps use outdoor air as the heat source and heat sink. Unlike soil, air provides no reservoir of heat, is a poor conductor, and is subject to extreme temperature fluctuations, all of which defeat system efficiency: When the most heat is needed, the outside air is coldest, and the converse is true for cooling.

According to Monte Jefferson, president of Home Energy, Inc., a geothermal installations firm based in Wendell, N.C., "The key difference between an air-source heat pump — which can't heat a building efficiently when outdoor temperatures dip below 30°F — and ground-source is that the ground-source unit harvests the stable 50°F to 60°F heat of the earth, transferring this virtually endless supply of

Figure 1. Because direct-exchange technology is so efficient at collecting the heat of the earth, installations are possible even on small lots. While trenches or pits are less expensive, drilling — either vertically or at an angle — makes it possible to work around ledge or in tight quarters.

thermal energy into the home. In the summer, it transfers excess heat from inside to the earth."

Pushing Efficiency Limits

After extensive research, homeowners John and Linda Cavanaugh decided to install a geothermal heating and cooling system in their new home in coastal New Hampshire. The type of system they chose — called direct exchange — is at the cutting edge of ground-source technology and is currently offered by two leading geothermal companies, ECR Technologies and American Geothermal.

The Cavanaughs have tracked their energy use for heating, cooling, and domestic water since February 2002 with a separate electric meter. Though their system, an ECR EarthLinked heat pump, cost approximately 50 percent more up-front than conventional heating would have, they calculate that this difference has already been paid back, thanks in part to a utility rebate that helped subsidize the installation.

A direct-exchange heat pump is notably different from the typical water-source geothermal system, which exchanges the earth's thermal energy through water distributed in vast networks of plastic tubing. Direct-exchange technology accomplishes thermal transfer at much higher operational efficiencies because it eliminates one complete heat-exchange process. Also, because direct-exchange uses a much smaller "earth loop" (or "geo field"), it requires much less disruption of the property, making it ideal for retrofits (see Figure 1).

Gemma Tiller has installed various types of geo systems, but she prefers direct-exchange technology because of the higher efficiency it delivers and the greater flexibility she can offer for installation of the earth loops. "The newer technology extracts heat with little disruption to the surrounding landscape and at such high operating efficiencies that it makes payback on the investment faster than ever before," she says.

Figure 2. Rather than PEX tubing, which is used in conventional geothermal heating, direct-exchange systems use copper for a highly efficient heat transfer. (In some cases, corrosive soils may prevent installation.) Normally, the copper is protected by sand, which is installed in a slurry to ensure good coverage and optimum heat transfer. In areas where excessive groundwater might pipe away the sand, a special grout is used instead.

Installed costs are about the same for direct-exchange and water-source geo systems, though both are several thousand dollars more than a conventional air-to-air heat pump. With direct-exchange systems, however, small-diameter drilling for a geo field can achieve near "surgical" insertion of the ground loops, accomplishing the task quickly and with much less disturbance to the surrounding landscape than is the case with water-source systems.

How Direct Exchange Works

Most geothermal systems operate at ranges of 250 percent to 350 percent efficiency, notes Jody Hoffman of Hoffman Mechanical in Mechanicsburg, Pa., who has installed many types of geothermal heating and cooling systems over the last 20 years.

"That means these systems supply up to three-and-a-half units of heat for every unit of electrical energy required to operate it," Hoffman says. Direct-exchange systems perform even better, "with system efficiencies up into the 400 percent range, conservatively. Add the available options for installation of the earth field, and direct-exchange is a great choice for many existing homes."

Typical water-source geothermal systems rely on plastic piping to transfer a water-antifreeze solution through a plastic loop and an intermediate heat exchanger, where efficiency is lost.

By contrast, direct-exchange technology circulates refrigerant through highly conductive copper earth loops that are inserted into small-diameter boreholes of 50- to 100-foot depths, then embedded in sand or a protective thermal grout that enables direct transfer of energy with the earth (Figure 2).

The refrigerant moves directly from the geo field to the unit's compressor with no stops or intermediate heat exchangers required, enabling super-efficient transfer of thermal energy. Only a small amount of electricity is needed to power the system's compressor. The rest of the heating or

Heating & Cooling Efficiency: How Direct-Exchange Geothermal Compares

This data comes from Audit, by Elite, a widely used professional energy-analysis software. The test case is a typically insulated 2,436-square-foot new home in Chicago, which has cold winters and hot, muggy summers. The home is inhabited by a family of three who are in the house 12 hours a day; the cooling load is 24,717 Btu/hr and the heating load is 43,668 Btu/hr. Also included in the calculation is the heating of all domestic hot water. The example assumes $.09 per kwh for electricity, $1.30 per therm for natural gas, $1.62 per gallon for propane, and $1.55 per gallon for fuel oil. Domestic hot-water design assumes a 60-gallon tank with 50°F entering water temperature and a tank temperature of 125°F.

System description	Total heating cost	Total cooling cost	Water heating cost	Total operating cost	Average monthly cost
Direct-exchange geothermal	$463	$135	$225	$823	$69
Closed-loop, water-source geothermal	$602	$156	$512	$1,270	$106
Air source, 12 SEER HP	$737	$193	$512	$1,441	$120
12 SEER AC w/80% nat-gas furnace	$1,301	$193	$515	$2,009	$167
12 SEER AC w/80% fuel-oil furnace	$1,421	$193	$330	$1,945	$162
12 SEER AC w/80% propane furnace	$1,733	$193	$512	$2,437	$203

cooling energy comes from the earth's temperature just below the surface (see table, above).

Load Calcs Critical

Most hvac contractors are familiar with Manual J load calculations, which are used to determine heating and cooling loads, though sadly too few perform one when sizing a system. It's a fairly complex process, but should always be done, especially in the case of geothermal systems. According to ECR, all EarthLinked installers are required to submit the Manual J load calcs with each order to ensure proper operation and maximum efficiency.

"Without a Manual J load calculation, the risk is that the system will be oversized or undersized, each presenting a different set of problems," says Tiller.

An undersized system struggles to maintain comfortable indoor temperatures and will run continuously to meet the demand for heating or cooling; this will most likely shorten the life of the system. An oversized system will run in bursts. The cooling or heating need will be met quickly, instead of gradually, setting a pattern of short cycling. It's uncomfortable for the homeowners and reduces overall system efficiency.

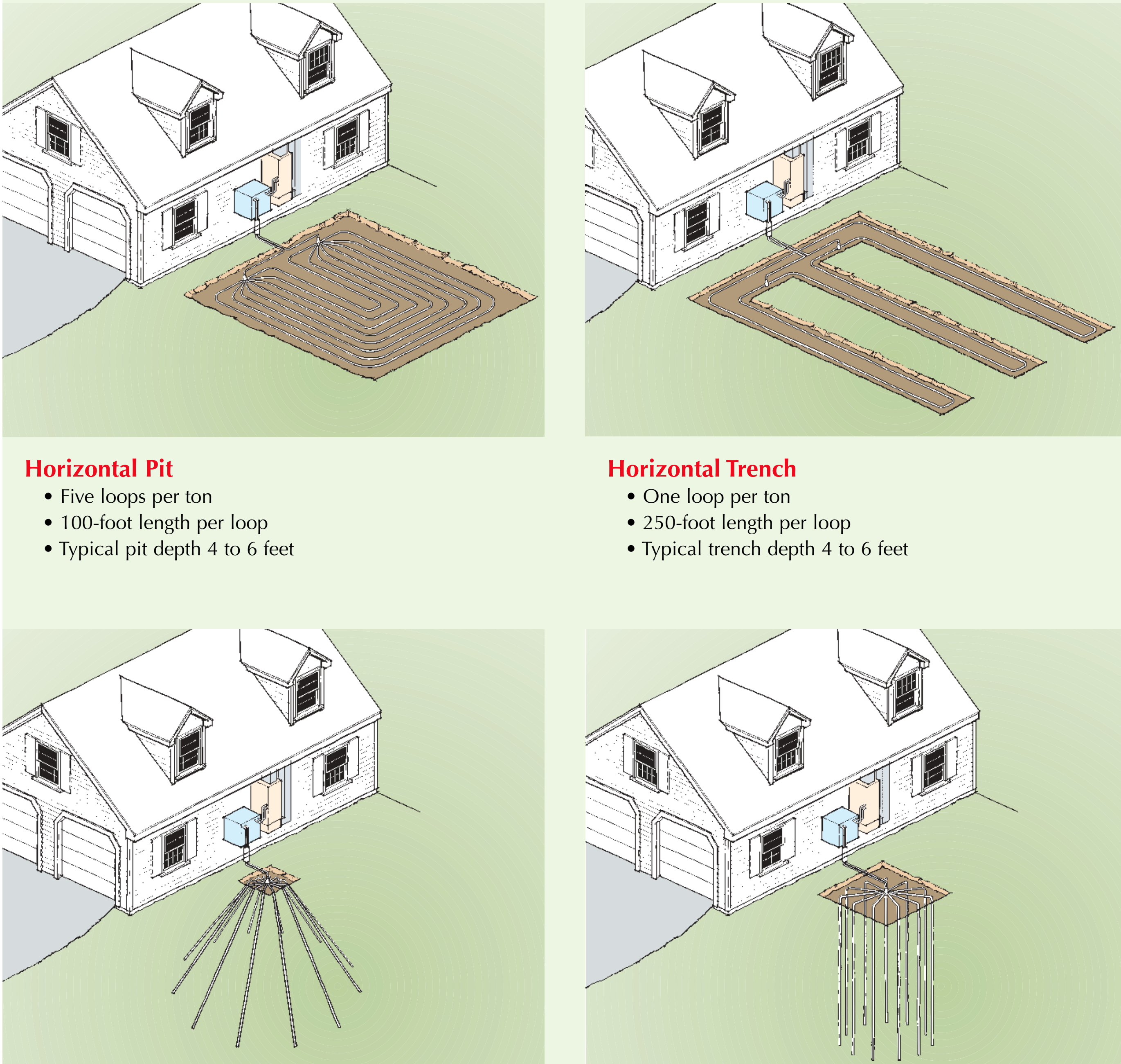
"Regardless of the type of geothermal system your customer is considering, be sure they get a Manual J load calculation as part of the deal," Tiller says. "In the case of new construction or for a building that will be substantially retrofitted, my advice is to wait until all changes have been made to the plan. By doing this, you won't run the risk of unanticipated, last-minute change orders adversely affecting the load calculation after the equipment has been sized and ordered."

Evaluating the Site

After the load calc, the next step in planning a customer's installation is site evaluation, Tiller says. Evaluating the site "not only affects the type of earth loop best suited to the project, it also plays a key role in determining the overall cost of the system," she says.

Depending on the site, the hvac contractor will choose a vertical, horizontal, or diagonal earth-loop installation (Figure 3, facing page). Jefferson says the horizontal earth-loop applica-

Earth-Loop Options



Horizontal Pit
- Five loops per ton
- 100-foot length per loop
- Typical pit depth 4 to 6 feet

Horizontal Trench
- One loop per ton
- 250-foot length per loop
- Typical trench depth 4 to 6 feet

Diagonal
- One to four loops per ton
- 50- to 100-foot drilling depth
- 15- to 45-degree drilling angles
- 3-inch minimum borehole diameter

Vertical
- One to two loops per ton
- 75- to 100-foot drilling depth
- 3-inch minimum borehole diameter

Figure 3. Depending on the site, earth loops can be installed horizontally, in pits or trenches, or in vertical or diagonal boreholes.

Figure 4. Unlike standard air-source heat pumps, geothermal condensers do not require air circulation, so they can be installed in a basement or utility room, which lengthens service life.

tion is the least expensive to install, chiefly because excavating and backfilling are less expensive than drilling. But in areas where rock layers obstruct excavation, it may be necessary to drill holes for the diagonal and vertical applications. Drilling is also a viable option on small lots.

Both ECR and American Geo recommend that soils be tested for high concentrations of acids, chlorides, hydrogen sulfide, sulfates, and ammonia, all of which should be avoided because of the potential for copper corrosion.

ECR recommends that soil samples be taken with a coring tube, specifically the LaMotte model 1016 (www.lamotte.com). Your local soils engineering firm should be familiar with these tests.

Also, locations with a pH higher than 11 or lower than 6 and coastal areas with brackish water marshes, saltwater intrusion, or acidic peat bogs should be avoided unless cathodic protection is provided. ECR offers a cathodic protection system; it emits a small, self-adjusting electric current that prohibits corrosion.

Equipment Installation

Once the earth loop is in, installation of a ground-source heat pump is very similar to an air-source installation. Geothermal condensing units (the enclosure with the compressor) don't require air circulation, as do typical air-source systems, so they may be installed in a basement or utility room (Figure 4). Ductwork and the setting of equipment are comparable as well.

Typically, a geothermal system will provide service for 25 to 30 years, which is twice the life expectancy of air-source heat pumps. This is because the stable heat source prevents thermal stresses to the compressor, and the enclosed unit is out of the weather.

***John Vastyan** is a freelance journalist in Manheim, Pa., who specializes in the plumbing and mechanical, radiant heat,*

For More Information

American Geothermal
800/776-8039
www.amgeo.com

ECR Technologies
866/211-6102
www.ecrtech.com

International Ground Source Heat Pump Association
www.igshpa.okstate.edu

Geothermal Heat Pump Consortium
www.geoexchange.org