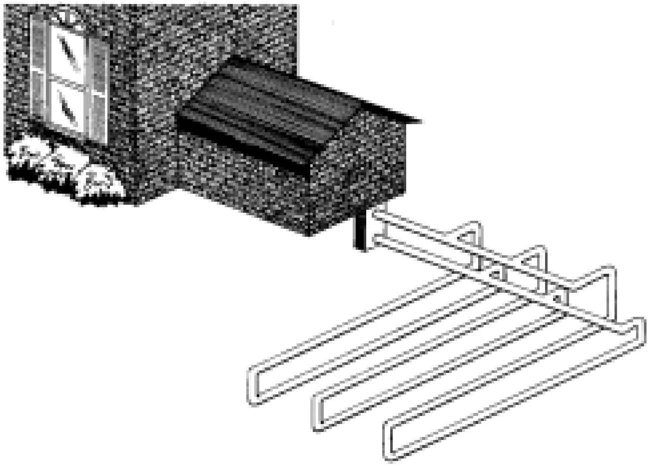
Geothermal Heat Pumps

Using the Earth to Heat and Cool Buildings

A heat pump—like an air conditioner or refrigerator—moves heat from one place to another. In the summer, a geothermal heat pump (GHP) operating in a cooling mode lowers indoor temperatures by transferring heat from inside a building to the ground outside or below it. Unlike an air conditioner, though, a heat pump's process can be reversed. In the winter, a GHP extracts heat from the ground and transfers it inside. Also, the GHP can use waste heat from summer air-conditioning to provide virtually free hot-water heating. The energy value of the heat moved is typically more than three times the electricity used in the transfer process. GHPs are efficient and require no backup heat because the earth stays at a relatively moderate temperature throughout the year.

A GHP system has three major components: a ground loop (buried piping system), the heat pump itself (inside the house), and a heating and cooling distribution system.

There are two main types of GHP systems. The earth-coupled (or closed-loop) GHP uses sealed horizontal or vertical pipes as heat exchangers through which water, or water and antifreeze, transfer heat to or from the ground. The second type, the water-source (or open-loop) GHP, pumps water from a well or other source to the heat exchanger, then back to the source. Because of their versatility, earth-coupled systems dominate the GHP market.



A typical geothermal heat pump system

Typical loop installations for the earth-coupled systems are expected to work for 50 years.

More than 400,000 GHPs are operating in homes, schools, and commercial buildings in the United States. They are adaptable to virtually any kind of building; the Federal government has installed nearly 10,000 GHPs.

The world's largest installation of geothermal heat pumps is in Fort Polk, Louisiana. The project was funded by $18.9 million in private capital, with no investment by the Federal government except for procurement and administrative costs. The improvements will be paid over 20 years by the energy and cost savings resulting from the retrofit.

In one study of all residential heating, cooling, and water-heating systems, the U.S. Environmental Protection Agency concluded that (1) GHPs can reduce energy consumption and related emissions by 23%–44% in comparison to air-source heat pumps, (2) GHPs generally have lower carbon dioxide emissions than conventional equipment, and (3) GHPs have the lowest annual operating costs of all conventional technologies, as well as competitive life-cycle costs.

What are the opportunities?

- GHPs operate in all climates, but they are more cost effective in applications that require cooling and that need a significant amount of space or water heating.
- The primary markets for GHPs include new homes, apartments, schools, and commercial buildings, plus existing homes and buildings without access to natural gas.
- In addition to energy savings, many building owners factor in other benefits, such as reduced heating, ventilating, and air-conditioning maintenance costs and the opportunity to eliminate conventional systems. For example, the Austin Independent School District has installed GHPs in more than 50 schools to benefit from energy savings, low noise, and low maintenance.
- Many utilities offer special rates to customers with GHP systems.

Renewable Energy Technologies for Federal Facilities

U.S. Department of Energy

Office of Energy Efficiency and Renewable Energy

What are the important terms?

Energy-Efficiency Ratio (EER)—a value representing the relative electrical efficiency of cooling equipment in the cooling season. Calculated by dividing cooling capacity (in British thermal units per hour [Btu/h]) by the power input (in watts or W) under a given set of rating conditions. The higher the EER, the less electricity the equipment uses to cool the same amount of air. A unit with an EER of 7 costs about twice as much to operate as one with an EER of 14.

Coefficient of Performance (COP)— the ratio of heat energy delivered or extracted to the work supplied to operate the equipment. For heat pumps in the heating mode, COP is the total heating capacity provided (Btu)—including the circulating fans—divided by the total electrical energy input (watt-hours [Wh] x 3.414). The higher the COP, the more efficient the heat pump.

Seasonal Energy-Efficiency Ratio (SEER)—the ratio of total seasonal cooling requirement (Btu) to total seasonal energy used (Wh). The higher the SEER, the more energy efficient the system.

What is required?

- The economics are best when a ground-loop piping system is installed while a building is under construction, using an open-loop system or closed loops in ponds or lakes.
- The climate, property layout, and geologic conditions will determine the geometry of the ground-loop piping system. Piping may be arranged as coils buried horizontally, as a single well, or as a series of vertical wells.
- GHPs are a viable heating and cooling option in areas where stringent air emissions standards are difficult to meet using conventional systems.

What does it cost?

A residential GHP system is more expensive to install than a conventional heating system. It is most cost effective when operated year-round for both heating and cooling. In such cases, the incremental payback period can be as short as 3–5 years.

For commercial buildings, GHP systems can be the lowest first-cost option when an open-loop design is used or when the GHP is competing with conventional systems. In most other situations, GHP systems also have lower life-cycle costs than conventional systems when energy and maintenance costs are taken into consideration.

The Federal Energy Management Program (FEMP), part of the U.S. Department of Energy, has awarded five contracts to furnish technology-specific GHP energy savings performance contracting (ESPC) services to Federal agencies throughout the United States. For more information and a list of the contractors, see http://www.eren.doe.gov/femp/financing/ghp.html.

For More Information

For additional information on geothermal heat pumps, contact:

Geothermal Heat Pump Consortium, Inc. (GHPC)
701 Pennsylvania Avenue, NW
Washington, DC 20004-2696
202-508-5500 or
800-ALL-4-GEO (255-4436)
http://www.ghpc.org/

International Ground-Source Heat Pump Association
490 Cordell South
Stillwater, OK 74078
405-744-5175 or
800-626-4747
http://www.igshpa.okstate.edu

For additional information on geothermal Super ESPCs, contact:

Doug Culbreth
FEMP Regional Service Office
211 Ellwood Drive
Raleigh, NC 27609
919-782-5238

For GHP design assistance, contact:

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Oak Ridge National Laboratory
1 Bethel Valley Road
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To inquire about renewables design assistance available through FEMP, contact:

Nancy Carlisle
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1617 Cole Boulevard
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