Renewable Energy Technologies for Federal Facilities

FEMP
FEDERAL ENERGY MANAGEMENT PROGRAM

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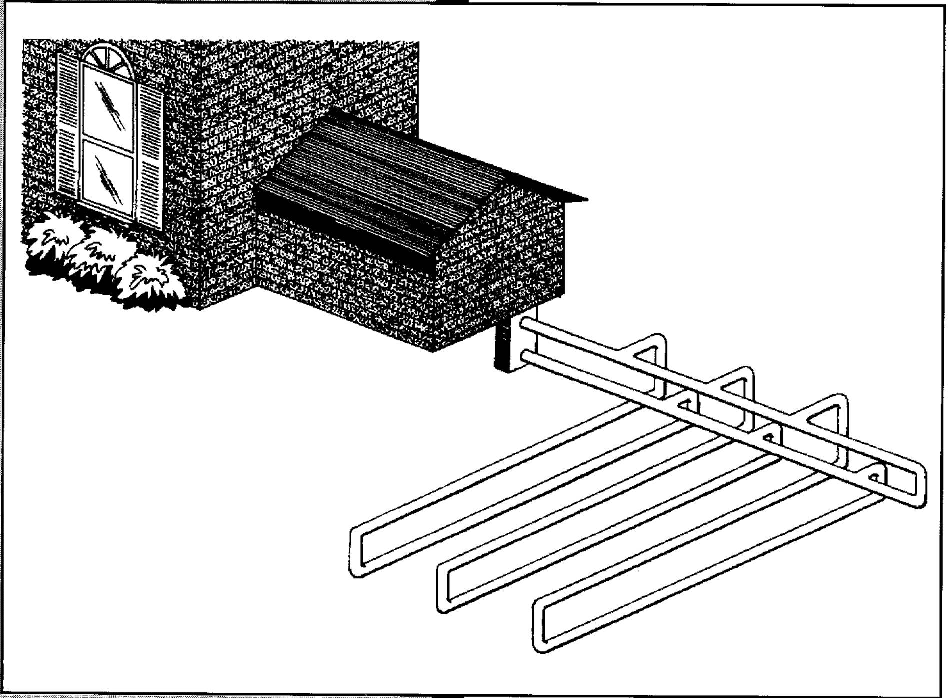
Geothermal Heat Pump

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 to the ground. 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 typical earth-coupled system

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The GHP system includes three major components: a ground loop (buried piping system), the heat pump itself (inside the house), and a heating and cooling distribution system. Furthermore, GHP systems consist of two major types. 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. Typical loop installations for the earth-coupled systems are expected to work for 50 years.

More than 200,000 GHPs are operating in homes, schools, and commercial buildings in the United States. Currently, a few major utilities, hundreds of rural electric cooperatives, and a few states provide incentives valued at as much as $3000 per residential installation. Many utilities are tailoring their demand-side management programs, particularly for large energy users such as the federal government. Negotiating with such utilities may lead to even greater funding, services including design assistance, or both, especially for nonresidential facilities. As a result, GHPs are gaining widespread popularity, causing the industry to expand annually by 10% to 20%.

In a 1993 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% compared to air-source heat pumps, (2) GHPs generally have lower CO_2 emissions than all other equipment, and (3) GHPs have the lowest annual

U.S. Department of 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 Btu/h) by the power input (in watts) 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 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 input (watt-hours × 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 (watt-hours). The higher the SEER, the more energy-efficient the system.

operating costs of all technologies, as well as competitive life-cycle costs.

What are the opportunities?

- GHPs operate in all climates, but they are more cost effective in colder regions where a large difference exists between the ambient air temperature and the ground temperature below the frost line.
- The primary markets for GHPs include new homes, apartments, schools, and commercial buildings, plus existing homes and buildings with no access to natural gas.
- In addition to energy savings, many building owners factor in other benefits such as: reduced HVAC maintenance costs and opportunity to eliminate boiler and cooling towers. For example, the Austin Independent School District has installed GHPs in more than 50 schools due to energy savings, low noise, low maintenance, and the fact that each teacher has complete control of the temperature in his or her classroom.
- Utilities may provide financial incentives to install GHPs as a demand-side management measure for strategic conservation, strategic load growth, and peak-shaving.

What is required?

- The best economics are gained by installing the ground-loop piping system when a building is under construction, using an open-loop system or closed loops in ponds or lakes.
- The exact climate, property layout, and geologic conditions will determine the geometry of the ground-loop piping system. Piping may be arranged either horizontally or as a single or 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 and 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 to 5 years.

For commercial buildings, GHP systems can be the lowest first-cost option when using an open-loop design or when competing with boiler and cooling-tower systems. In most other situations, GHP systems have lower life-cycle costs when considering energy and maintenance costs.

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