Ground Source Heat Pumps: Weighing the Value to Hospitals

Ground source heat pumps (GSHPs) are well-established systems that can economically heat and cool buildings. Hospitals are promising settings for GSHPs because of their year-round—and often round-the-clock—heating and cooling requirements.

GSHPs utilize a ground or groundwater heat exchanger, taking advantage of the relatively constant temperature of the earth just a few feet below the surface. This approach makes GSHPs far more energy efficient than conventional heat pumps, which use the outside air as the heat exchange medium and must compensate for wide seasonal variations in air temperature.

This fact sheet has been developed by the U.S. Department of Energy's Hospital Energy Alliance to assist hospital facility owners, designers, and operators in developing cost-effective GSHP applications. Information and statistics for this fact sheet were abstracted from ***Geothermal Heat Pumps***, a publication of the Federal Energy Management Program (http://www1.eere.energy.gov/femp/pdfs/26014.pdf) and the National Renewable Energy Laboratory's website on Applying Technologies, Climate-Neutral Campuses (http://www.nrel.gov/applying_technologies/climate_neutral/ground_source_heat_pumps.html). Also see http://www.energysavers.gov/.

Photo: DOE/NREL

Loop water piping underlies ground source heat pump systems, serving as an energy-efficient heat exchanger.

Considerations for Hospitals

There are two ways hospitals can use GSHPs:

- In **individual buildings**, GSHPs generally tend to be more economically feasible during construction or retrofitting of buildings that would otherwise rely primarily on electric power for heating and cooling, or where natural gas prices are high.
- **District heating and cooling applications** entail larger GSHP systems serving multiple buildings; these systems must achieve a greater temperature delta (hotter heated water, cooler chilled water) than systems for individual buildings.

GSHPs have been applied successfully in different climates and geographical zones across the United States. Like any energy-conservation project, GSHP installations must deliver sufficient annual savings to justify the initial capital investment. Energy savings will depend on the amount of heating and cooling required for the application, the efficiency of existing equipment, and the price of electricity and natural gas. The capital cost depends on the characteristics of the building heating and cooling loads, the quantity of equipment that must be installed, and the availability of geothermal resources. The feasibility of a geothermal project also is affected by policies, incentives, and regulations in effect in each region.

For commercial buildings, GSHP systems sometimes can be the lowest first-cost option when an open-loop design is used. In other situations, GSHP systems sometimes can have lower life-cycle costs than conventional systems when energy and maintenance costs are taken into consideration. While detailed estimates of costs and savings are required to determine the feasibility and payback of any given project, the following guidelines can be used to screen potential projects before deciding whether to proceed with a feasibility study.

- **Heating and cooling loads.** In general, the most promising applications for GSHPs are buildings that are maintained at reasonably comfortable temperature set points (68–78°F) for at least 40 hours per week. Since they are relatively expensive to install, GSHP systems are most likely to be cost effective with a combination of high winter heating loads and summer cooling loads.
- **Equipment to be replaced.** Potential savings in retrofit applications are significant when GSHPs replace older, less efficient equipment that is more than about 10 years old.
- **Ability to utilize waste heat.** Utilizing waste heat generated during the cooling cycle can provide hospital facilities with hot water at essentially no cost during the cooling season.
- **Maintenance costs.** GSHPs generally cost less to maintain than conventional heating and cooling equipment—savings that can sometimes mean the difference between a feasible project and an unfeasible one.

Deciding on the Right System

The main elements of a GSHP system are the heat pumps, located indoors, and the loop field, where the water-filled pipes are buried. There are two main types of GSHP systems:

- **Closed-loop** GSHPs use sealed pipes (ground loops) as heat exchangers through which water, or water and antifreeze, transfers heat to and from the ground or to and from a body of water.
- **Open-loop** GSHPs draw water up from an aquifer or a body of surface water, exchange the heat, and return the water to the aquifer or body of surface water.

Because of their versatility, closed-loop systems dominate the GSHP market. In closed-loop systems, ground loops may be oriented vertically or horizontally. While horizontal loops may be less expensive to install, commercial buildings often use vertical systems because the land area required for horizontal loops could be prohibitive. Polyethylene pipes in large vertical systems generally reach down 100 to 400 feet.

In designing a GSHP system for a particular site, engineers will consider such factors as:

- **Suitability of soil conditions.** Geotechnical conditions and soil hydrology must be evaluated for heat transfer at the site. Usually, an installer will drill an exploratory well before estimating the cost to drill a large number of wells for a GSHP field.
- **Land availability.** GSHP systems may require significant open space for wells or ground loops. The land can be used for parking or open space after the system is installed, but installation may take some time.
- **Codes and regulations.** The installation of closed-loop GSHP systems may be subject to local codes and regulations governing wells, water, and protection of water quality. Regulations affecting open-loop systems are common and variable—some requiring reinjection wells rather than surface drainage, for example. Some states require permits to use even private ponds as geothermal resources. Large installations must be carefully engineered so they do not heat up the ground or groundwater, harming micro-biota and diminishing the ability of the soil to absorb heat over time.

Because GSHP systems have relatively few moving parts, they are durable and highly reliable. The underground piping often carries warranties of 25 to 50 years, and the heat pumps often last 20 years or more. Since they usually have no outdoor compressors, GSHPs are not susceptible to vandalism. GSHP hardware requires less space than conventional HVAC systems, enabling equipment rooms to be greatly scaled down in size and freeing space for productive use.

Hospital Energy Alliance

HEA is a forum in which healthcare leaders work together with DOE, its national laboratories, and national building organizations to accelerate market adoption of advanced energy strategies and technologies.

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