Preliminary Screening for Project Feasibility and Applications for Geothermal Heat Pump Retrofit Projects

GHPs Should Always be Considered for Federal Sites

Geothermal or ground-source heat pumps (GHPs) are a highly efficient method of providing heating and cooling for buildings. The technology has been applied successfully in a wide variety of building types – single- and multi-family dwellings, schools, offices, department and convenience stores, hotels, post offices, and libraries among others – and in climates and geographical zones across the United States, from the deserts of Fort Irwin, California, to downtown Manhattan, and from South Texas to Northern Minnesota.

Given their energy and cost savings potential, and their wide range of applicability, GHPs should *always* be considered as a potential energy conservation retrofit for federal agency sites. However, because GHPs do not have the same history of application as other energy conservation measures, information on typical installation costs and energy cost savings are more difficult to come by. This document briefly outlines the more important factors for determining whether a given building or site is a likely candidate for a retrofit project centered on GHPs.

The feasibility of an energy conservation project depends on economics: the conservation measure must provide 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 cost of energy. 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.

Important Factors in Determining Feasibility

Detailed estimates of costs and savings are required to determine the feasibility of any given project. However, there are some guidelines that can be used to screen potential projects before deciding whether to proceed with a feasibility study.

Building function

Building function is probably the single most important factor in determining whether significant energy savings can be achieved with GHPs. In general, the most promising applications for GHP retrofits are buildings that are maintained at reasonably comfortable temperature setpoints (68 – 78°F) for at least 40 hours per week.

Equipment to be replaced

It is not usually economically feasible to replace highly efficient, recently purchased equipment. There is more potential for savings when GHPs replace older, less efficient equipment that is more than about ten years old.

Energy costs

Higher energy costs tend to improve the economics of GHP retrofit projects, but this is not always the case. For example, in a climate with significant heating requirements and high electricity rates, it may be more economical to heat with natural gas, regardless of the efficiency of the GHP.

The economics of any GHP project can be improved by utilizing the waste heat generated during the cooling cycle. For buildings with high water heating loads (e.g., residences, hotels, laundry facilities), GHPs can provide hot water at essentially no cost during the cooling season. Project economics are also improved if other energy conservation measures with relatively short paybacks are included with the installation of GHPs.

Maintenance costs

GHPs generally cost less to maintain than conventional heating and cooling equipment, and this savings can sometimes mean the difference between a feasible project and an unfeasible one.

Retrofit strategy

As with any retrofit measure, the capital cost is reduced if portions of the existing system (e.g., ductwork) can be used in the GHP system.

Geothermal Resources and GHP Systems

The type of geothermal resource that is available near the building is a primary determinant of the type of GHP system that will be most economical at any particular site.

Ground heat exchangers (or ground loops)

Heat exchange with the ground using vertical or horizontal loops may be an economical option if there is enough land area near the building to accommodate ground heat exchangers. Horizontal loops require considerably more land area than vertical-bore heat exchangers, but may be less expensive to install, depending on the types of soil and rock formations encountered in drilling.

Ground heat exchangers are an option almost anywhere and are by far the majority among currently operating GHPs. However, as the industry matures and experience in the field grows, GHPs using surface water or groundwater for heat exchange are slowly gaining prominence. These other geothermal options may be even more economical than ground-coupled systems and should be considered where they exist.

Groundwater already being pumped

Some federal sites pump groundwater to the surface, treat it, and reinject it as a part of groundwater remediation projects. Tapping into groundwater that is already being pumped to the surface could be an extremely economical approach. Typically a plate-and-frame type heat exchanger is used to transfer heat between the groundwater and a common loop serving water-source heat pumps in nearby buildings. In years after the remediation project is completed, pumping on the groundwater side of the heat exchanger can be reoptimized for the HVAC application and continued using the same supply and reinjection wells.

Stationary surface water

Where large volumes of stationary surface water are near buildings, they may be economical resources for heat exchange. A common loop to serve water-source heat pumps in a nearby building can be submerged directly into a surface water impoundment such as a reservoir, runoff retention basin, reflecting pool, pond, or lake. If the water is used for recreational or other purposes that might interfere with this approach, an on-shore pump house with a heat exchanger and protected intake from and discharge to the body of water could be considered.

Moving surface water

A large river with reliable flow and modest current could be an economical heat exchange resource for nearby buildings. An on-shore pump house with a heat exchanger and protected intake from and discharge to the river might be advisable. Issues such as historical high and low water conditions, debris flow, and commercial and recreational traffic would be serious considerations.

Wastewater streams

Large-volume, reliable, flowing wastewater streams can be used to condition a heat exchanger. Maintenance of the heat exchanger and the stability of the missions of the facilities that are the source of the wastewater would be considerations.

Groundwater

Groundwater may be an economical heat exchange resource if large quantities are available at a reasonable depth, along with an acceptable and economical means of disposal. Poor water quality might require the use of expensive heat exchanger materials, and in some formations additional maintenance and aquifer reinjection might be expensive.

Standing-column well

Standing-column-well GHP systems are similar to standard groundwater GHPs, but because water is recirculated between the well and the building, only one well may be required (larger projects may have several wells in parallel). Standing-column wells are feasible in areas with near-surface bedrock. Deep bores are drilled, creating a long standing column of water from the static water level down to the bottom of the bore. Water is recirculated from one end of the column to the other. To reduce required bore length, the system can be designed to bleed part of the water rather than reinjecting it all during peak heat rejection or extraction periods, causing water inflow to the column from the surrounding formation to cool or heat the column as needed.

Local water and well regulations

The installation of the ground-coupling system 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.

Assistance Available from FEMP

FEMP's GHP team can provide technical assistance with GHP projects. Contact:

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GHP and ESPC Information and Resources

DOE Geothermal Energy:
www.eere.energy.gov/geothermal

FEMP GHP Technology-Specific Super ESPCs:
www.eere.energy.gov/femp/financing/espc/technologies.html

FEMP GHP Resources:
www.eere.energy.gov/femp/financing/espc/ghpresources.html

FEMP GHP Core Team
www.ornl.gov/femp

Geothermal Heat Pump Consortium:
www.geoexchange.org

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

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