Ground Source Heat Pumps

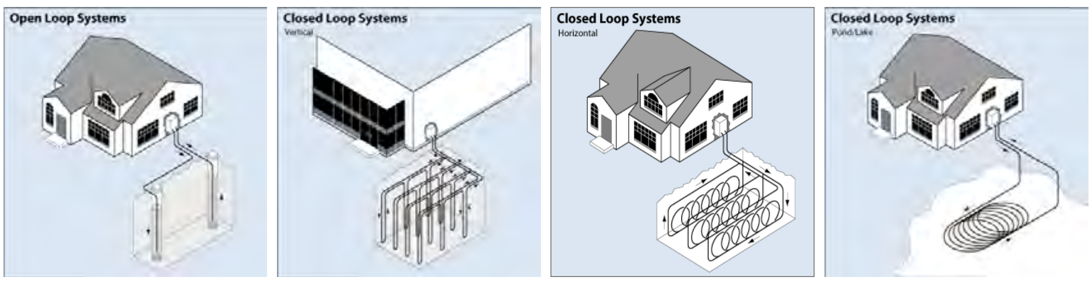
[STRATEGY]

Brief Description

The term ground source heat pumps (also known as GSHPS, geothermal heat pumps, ground-coupled heat pumps, and GeoExchange systems) refers to a family of systems that meet heating, and cooling needs using heat transfer between the earth and the indoor air. High efficiencies are achieved with GSHPs because they take advantage of relatively constant ground or water temperatures.

Applications[1]

GSHPs are generally most effective in buildings with both heating and cooling systems, and can be used in more extreme climatic conditions than air-source heat pumps. Open loop systems uses well or surface body water as the heat exchange fluid that is pumped to the heat exchanger at the building and then discharged to the well or surface water. Closed loop systems pump fluid through pipes buried in the ground or in a water source to the heat exchanger. Heat transfer takes place between the fluid enclosed in the pipes and the surrounding area that the pipes are set in. Vertical closed loop systems can be installed virtually anywhere, where the other systems depend more on the soil conditions and available land.



(a) Open Loop | (b) Closed Loop – Horizontal | (c) Closed Loop – Pond/Lake | (d) Closed Loop – Vertical

Design Notes[2]

Vertical Closed Loop: Large commercial buildings often use vertical systems because a large amount of loop length is usually required. Vertical loops are also used where the soil is too shallow for trenching. For a vertical system, holes (approximately four inches in diameter) are drilled about 20 feet apart and 100–400 feet deep. Into these holes go two pipes that are connected at the bottom with a U-bend to form a loop. The vertical loops are connected with horizontal pipe, placed in trenches, and connected to the heat pump in the building.

Horizontal Closed Loop: This type of installation is generally most effective for smaller buildings where sufficient land is available. It requires trenches at least four

[1] Source: U.S. DOE Energy Savers www.energysavers.gov

[2] Adapted from U.S. DOE Energy Savers: Types of Geothermal Heat Pump Systems. Accessed August 2010 at http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12650

feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-foot wide trench. The Slinky™ method of looping pipe allows more pipe in a shorter trench, which cuts down on installation costs and makes horizontal installation possible in areas it would not be with conventional horizontal applications.

Pond/Lake: The site needs a water source that meets minimum volume, depth, and quality criteria. A supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing.

Open Loop: This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.

System Efficiency Recommendations[3]

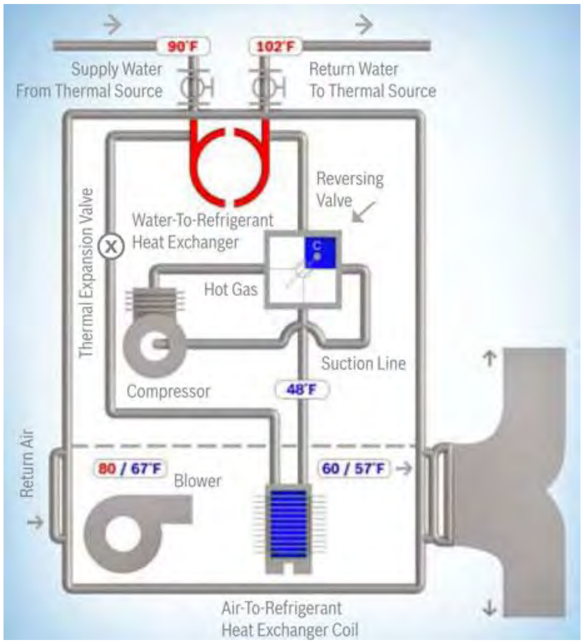
Product Type	Recommended		Best Available	
	EER[a]	COP[b]	EER[a]	COP[b]
Closed Loop	14.1 or more	3.3 or more	25.8	4.9
Open Loop	16.2 or more	3.6 or more	31.1	5.5

[a] EER is the cooling capacity (in Btu/hour) of the unit divided by its electrical input (in watts) at standard (ARI/ISO) conditions of 77°F entering water for closed-loop models and 59°F entering water for open-loop systems.
[b] COP is the heating capacity (in Btu) of the unit divided by its electrical input (also in Btu) at standard (ARI/ISO) conditions of 32°F entering water for closed-loop models and 50°F entering water for open-loop equipment.

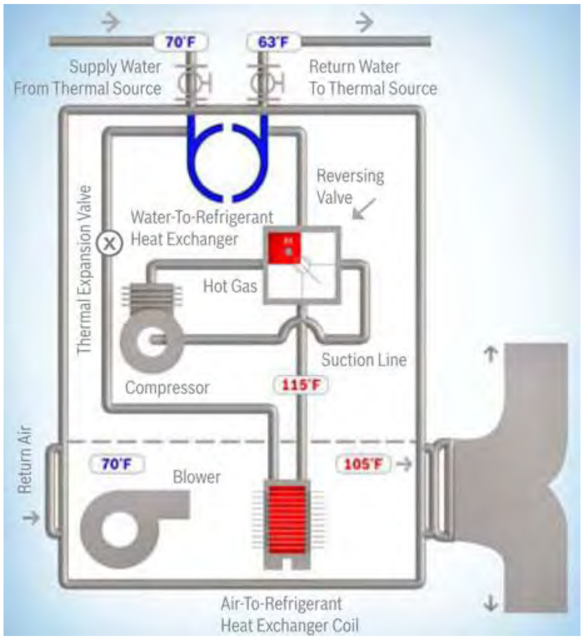
Space Considerations: The indoor requires less space than that needed by conventional HVAC systems, so the equipment rooms can be scaled down in size, freeing space for productive use.

[3]Adapted from FEMP: Energy Efficient Products - How to Buy an Energy-Efficient Ground Source Heat Pump. Accessed August 2010 at http://www1.eere.energy.gov/femp/procurement/eep_groundsource_heatpumps.html

Sample System Diagram[4]



Cooling Mode



Heating Mode

[4]Source: FHP Manufacturing www.fhp-mfg.com

Environmental Impacts

- Systems use 25–50 percent less electricity than conventional heating or cooling.
- Many systems use refrigerants with low global warming potential (e.g. R410A).

Social Benefits

- Customer satisfaction with thermal comfort can be higher because the systems operate well during extreme temperatures and offer humidity control.
- GSHPs are not susceptible to vandalism since they usually have no outdoor compressors.

Guiding Principles[5]

Optimize Energy Performance (Energy Efficiency)

- Reduce the energy use by 30 percent compared to the baseline building performance rating per ASHRAE Standard 90.1-2007.

Reduce Environmental Impact of Materials

- **Ozone Depleting Compounds**. Eliminate the use of ozone depleting compounds during and after construction where alternative environmentally preferable products are available, consistent with either the Montreal Protocol and Title VI of the Clean Air Act Amendments of 1990, or equivalent overall air quality benefits that take into account lifecycle impacts.

Associated LEED Credits (NC 2009)[6]

EAc1: Optimize Energy Performance (1-19 points)

- Demonstrate a percentage improvement in energy performance compared to a baseline performance per ASHRAE/IESNA Standard 90.1-2007.

EA Credit 4: Enhanced Refrigerant Management

- Select refrigerants and HVAC&R that minimize or eliminate the emission of compounds that contribute to ozone depletion and global climate change. The building HVAC&R equipment must comply with the LEED 2009 formula, which sets a maximum threshold for the combined contributions to the ozone depletion and global warming potential.

[5] Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings www.wbdg.org/pdfs/hpsb_guidance.pdf

[6] USGBC LEED Reference Guide for Green Building Design and Construction, 2009 Edition

Product Image[7]

(a) GSHP Closed Loop Configuration

(b) GSHP Open Loop Configuration

Cost Range

Cost is variable based on loop size and heat pump size. Loop size varies based on the system type, size and geology. On average DOD Army GSHP systems have historically cost $8175 per ton of cooling[8].

Product Types

Heat pump size range categories: ½ - 5 tons, 6-10 tons, 7-25 tons
Piping material[9]: high density polyethylene, polyethylene
Closed Loop Pipe Lengths: 250-1000 feet per ton of cooling capacity
Closed Loop Vertical Borehole Depths: 200-300 feet
Closed Loop Horizontal Trenching Depths: below frost line (5-10 feet)
Open Loop Vertical Borehole/Pipe Depths: 150-500 feet depending on depth to groundwater table
Heat Transfer Fluids: Environol, Water, Methanol/Water mixture

Vendors

ClimateMaster Inc (http://www.climatemaster.com)

McQuay International (www.mcquay.com)

FHP Manufacturing (www.fhp-mfg.com)

Warranty Info

Generally 25 years for the inside components and 50+ years for the ground loop.

Code Restrictions

For open loop systems, local code requirements for groundwater wells may impact design.

[7] Source: McQuay International www.mcquay.com
[8] Office of the Secretary of Defense. 2007. Report to Congress: Ground-Source Heat pumps at Department of Defense Facilities. Accessed August 2010 at http://www.acq.osd.mil/ie/energy/library/GSHP-Report_JAN242007.pdf
[9] Geo-Heat Center. October 2005. Geothermal Direct-Use Case Studies. Oregon Institute of Technology. Accessed August 2010 at http://geoheat.oit.edu/pdf/tp115.pdf

REQUIREMENTS[10]

A. Energy Efficiency: Meet or exceed ASHRAE 90.1.

B. Indoor Environmental Quality:

1. Ventilation: Meet or exceed ASHRAE 62 and all published addenda.
2. Filtration: Meet or exceed ASHRAE 52.
3. Thermal Comfort: Meet or exceed ASHRAE 55.
4. Maintain positive pressure within the building.

EQUIPMENT

A. Ground Source Heat Pump:

FEMP Efficiency Recommendation				
Product Type	Recommended		Best Available	
	EER	COP	EER	COP
Closed Loop	14.1 or more	3.3 or more	25.8	4.9
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ACCESSORIES

A. Refrigerants:

1. Refrigerant Selection:
   a. CFC-based refrigerants are not permitted.
   b. Refrigerant shall be one of the approved alternative refrigerants based on EPA's Significant New Alternative Policy (SNAP) listing.

GROUND HEAT EXCHANGER PIPING SYSTEM[11]

A. Provide high density polyethylene pipe, fittings, and piping components for the underground portions of the ground heat exchanger. Use of polyvinylchloride (PVC) or polybutylene pipe and fittings is not permitted. [Provide high density polyethylene pipe coiled on reel, with U-

[10] Specification language modified from the Whole Building Design Guide's *Federal Green Construction Guide for Specifiers,* SECTION 23 70 00 (SECTION 15700) – CENTRAL HEATING, VENTILATING, & AIR CONDITIONING (HVAC) EQUIPMENT. Accessed August 2010 at http://www.wbdg.org/ccb/FEDGREEN/fgs_237000.doc

[11] Specification language modified from USACE/NAVFAC/EFCESA Unified Facilities Guide Specifications, SECTION 23 81 47 – WATER-LOOP AND GROUND-LOOP HEAT PUMP SYSTEMS. Accessed August 2010 at http://www.wbdg.org/ccb/DOD/UFGS/UFGS 23 81 47.pdf

bend factory installed, pipe pre-marked for depth, and U-bend connections factory tested.] Pipe coil on reel shall be factory marked to show depth graduations.

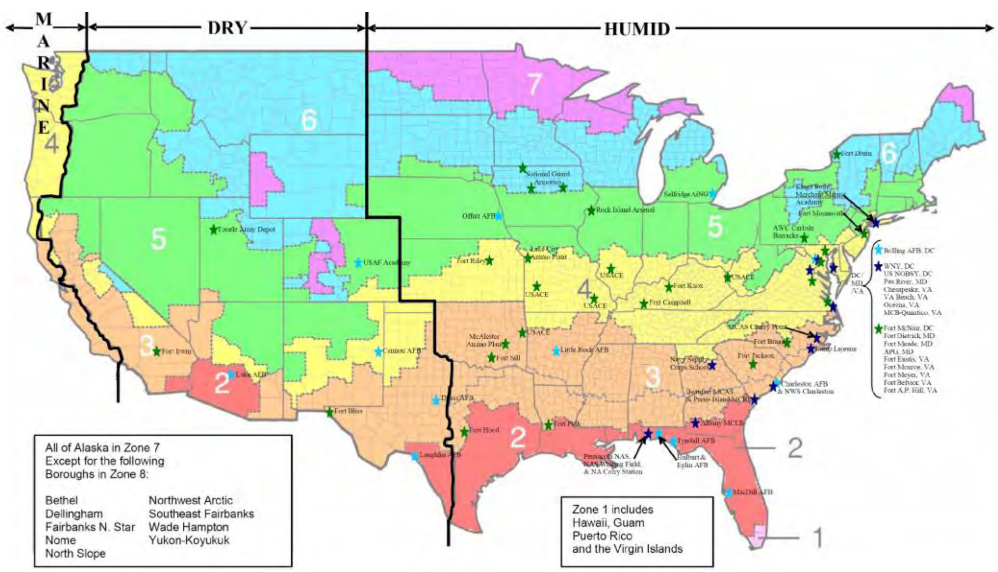
B. High Density Polyethylene Pipe - Pipe shall be manufactured from virgin high density polyethylene extrusion material in accordance with ASTM D 2513 with PE345434C or PE355434C cell classification and UV stabilizer of C, D, or E as specified in ASTM D 3350.

C. Provide ASTM D 3035 pipe with a standard dimension ratio (SDR) of 11.0 for pipe less than 32 mm (1.25 inches) diameter. Provide ASTM D 2447, Schedule 40 or ASTM D 3035 pipe with a minimum SDR of 13.5 for pipe 32 mm (1.25 inches) diameter or greater, and a minimum SDR of 17.0 for pipe 75 mm 3 inches diameter or greater. Provide ASTM D 3035 pipe in vertical bores greater than 60 m (200 feet) deep with a SDR of 11.0.

Additional detailed specification language can be found in the following separate documents:
SPECS WBDG HVAC.doc
SPECS UFGS 23 81 47.pdf

Facilities	• 264 reported projects at DOD installations as of 2007, representing over 20,000 GSHP units.
Approach	• The major building types where GSHPs are installed include: family housing, unaccompanied personnel housing, office buildings, and training facilities. • Other project have been implemented at morale and welfare, personnel support, covered storage, maintenance, medical and support, land operational, and production facilities.
Results	• Average payback for Army projects is 11.2 years.

DOD Installations DOD Installations with GSHPs Currently Installed or Planned to be Installed (2007) [12]



[12] Copied from: Office of the Secretary of Defense. 2007. Report to Congress: Ground-Source Heat pumps at Department of Defense Facilities. Accessed August 2010 at http://www.acq.osd.mil/ie/energy/library/GSHP-Report_JAN242007.pdf