GROUND-SOURCE HEAT PUMPS

Geothermal energy is heat energy captured from the earth. It is a clean energy resource that is widely available. Geothermal energy, if utilized more, would make the United States less dependent on foreign sources (i.e. oil).

The earth's heat energy can either be converted into electricity or be used directly. Utility power companies can establish plants to create electricity from the earth. Geothermal heat pumps in buildings efficiently heat and/or cool spaces. Hot water found at the earth's surface can be piped directly to building or other heating systems such as sidewalk snowmelt, milk pasteurization, and plants growing in greenhouses.

One common way to take advantage of the energy available through the earth is to use ground-source heat pumps in building applications. Using water-source heat pumps, in conjunction with the ground as a heat exchanger, results in a highly efficient system that maintains occupants' thermal comfort.

LEED APPLICATION

Leadership in Energy and Environmental Design (LEED) is a program administered by the United States Green Building Council that uses a Green Building Rating System to register and certify the world's greenest buildings. The rating system has a possible point value of 69. To become certified, a building must obtain at least 26 of the points available. Silver, gold, and platinum levels can be achieved with additional points.

One entire section of the LEED rating system focuses on energy and atmosphere. Utilizing geothermal heat pumps has the potential to gain multiple points under multiple categories. Under Credit 1 of Energy & Atmosphere, up to 10 points are possible if new construction or renovated buildings' design costs fall below the energy cost budgeted in the ASHRAE/IESNA Standard 90.1-1999. The point value assigned depends on the percent reduction in energy costs, which has the potential to increase by installing geothermal heat pump systems. Credit 2 of Energy & Atmosphere addresses renewable energy. Up to three points are possible, depending on the percentage of the building's total energy use that comes from an on-site renewable source (5%, 10%, and 20% earn one, two, and three points, respectively).

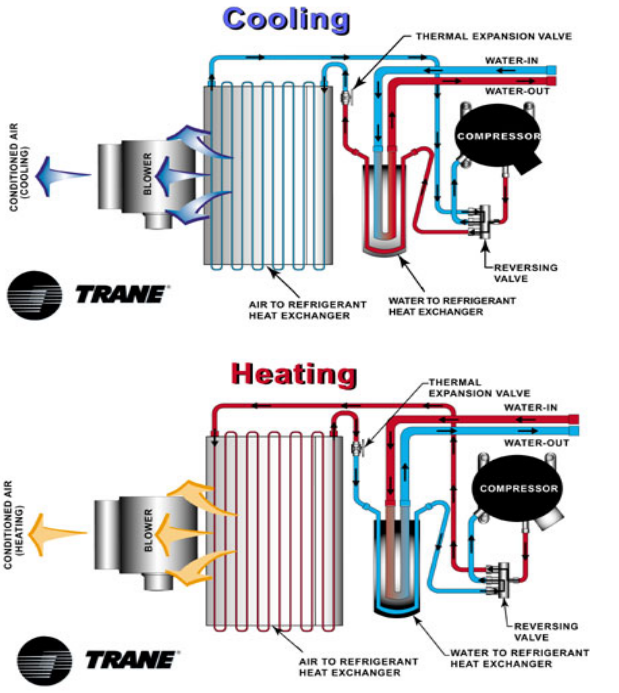

Figure 1. How water-source heat pumps work – cooling cycle and heating cycle
Taken from www.trane.com/commercial/equipment/howtheywork.asp

Ground-source heat pump systems qualify if the source used is within the property lines or if the body of water (pond-loop applications, discussed later) is also on the site. Even more points are available if the equipment selected for the heat pump system does not contain CFCs, HCFCs, or Halons (see LEED-NC, Energy & Atmosphere, Credit 4).

DESIGN/CONSTRUCTION APPLICATION

The geothermal heat pump system, as mentioned earlier, uses the ground as a heat exchanger, in either a closed- or open-loop piping system. The ground loop of a closed system is made of vertical or horizontal high-density polyethylene piping placed in the ground. Using coils of piping placed in a large body of water at least eight feet under the surface is also possible. In this case, the water is the source of heat extraction/discharge instead of the ground. For commercial applications, the most common piping arrangement is vertical wells, typically 100 to 400 feet deep. Holes are drilled, about four inches in diameter, and a piping loop with a U-bend in the bottom is placed into the well. The wells are then grout filled. A water/glycol solution circulates through the wells and then to a manifold just inside the building, where all wells combine into one main

pipe. The main pipe then connects to a pump (typically with a back-up pump), and then the main pipe gives each individual heat pump access to the ground-source loop. Each heat pump units consists of a fan, coil, compressor, heat exchanger, expansion device, and reversing valve. Air from conditioned spaces, along with required outside air, is re-circulated through the heat pumps and back into the spaces after being conditioned. Each zone has its own heat pump, and placement of the heat pump units in the building is similar to that of fan-powered mixing boxes or variable-air-volume units (see Figure 2). In the cooling mode, the reversing valve is in the cooling position. Air is drawn across the coil and the refrigerant in the heat pump unit absorbs heat from the air. Then it goes through the compressor, leaving the compressor as high-temperature vapor. After the compressor, the refrigerant goes to the water-to- refrigerant heat exchanger (this is where the ground-loop comes into the equation). The refrigerant vapor releases its heat into the ground-source loop and becomes a liquid. The refrigerant then goes through the expansion device, then back through the coil. In the heating mode, the reversing valve is in the heating position and the cycle reverses (see Figure 1).

GREEN BUILDING ISSUES

With the design and construction industry becoming more energy and environmentally conscious, more efficient ways to maintain the built environment are being sought. Geothermal heat pump systems are a viable way to achieve efficiency without sacrificing design intent or comfort and safety of occupants. One common hindrance to becoming more efficient is that more maintenance is a result. This is where geothermal heat pump systems have an advantage. Controlling each heat pump only takes one thermostat per unit; there is no equipment outdoors exposed to the elements; and the only component needing regular attention is filters. Total maintenance costs are about one-third of conventional systems.

ADDITIONAL INFO

Geothermal Heat Pump Consortium
www.geoexchange.org
U.S. Department of Energy: Energy Efficiency and Renewable Energy
www.eere.energy.gov
ASHRAE
www.ashrae.org
U.S. Green Building Council – LEED
www.usgbc.org/leed
The Trane Company
www.trane.com

This GreenBuild Tech Bulletin was developed by Betsy Price, a student at Kansas State University. As designers and builders of structural, mechanical, electrical, and plumbing systems in buildings, architectural engineers and constructors have a tremendous opportunity and responsibility to address energy and/or environmental impacts in their work.

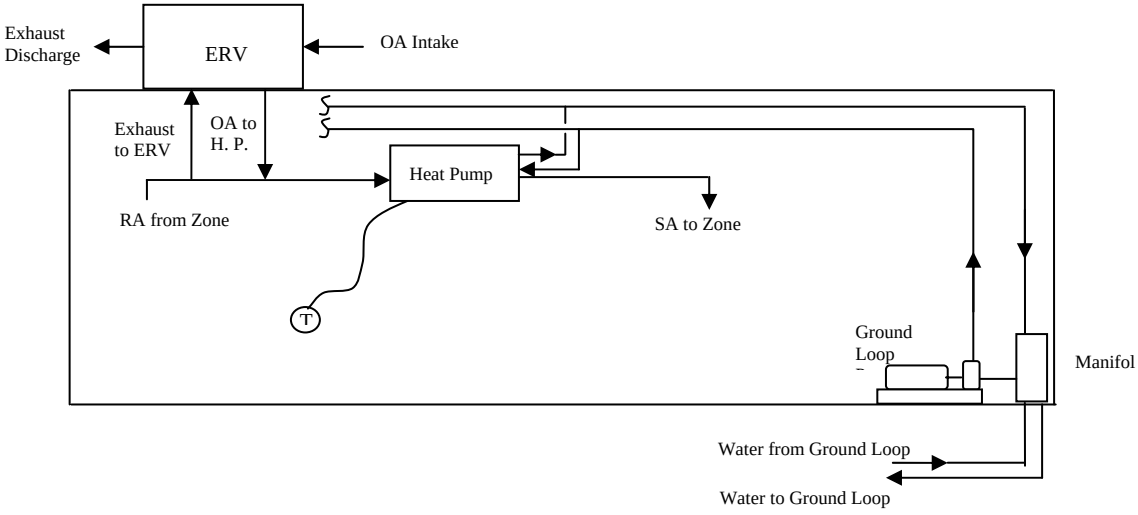

Figure 2. Typical system schematic, single-zone ground-source heat pump with energy-recovery ventilator