GEOTHERMAL HEAT PUMP UTILIZATION IN THE UNITED STATES

John W. Lund, Research Associate
Geo-Heat Center

Introduction

Air source heat pumps have been used for many years, but due to the constant temperature of ground water, water source heat pumps became popular in the 1970s. This was promoted in part by the National Water Well Association of Dublin, Ohio. Due to cheap drilling methods, earth coupled closed loop heat pump systems gained in popularity in the 1980s. The latter consist of either vertical or horizontal installations of a closed loop heat exchanger. The vertical installation normally uses a 4-inch diameter hole, in which two one-inch diameter plastic pipes are placed and grouted. Drilling and piping costs are around $2.50 per foot. A rule of thumb is to use 100 to 150 foot of hole for each 12,000 Btu/hr peak load required. Since most residences require around 3 tons of cooling or heating load, up to 450 feet may be required. The national average is 150 to 200 feet per bore. Water with ethylene glycol is circulated in the system. In areas where drilling is difficult or expensive, horizontal closed loops are used; buried four to five feet below the surface. These loops are generally longer than the vertical loops, and use extensive surface land area. In some states, ponds are used as the heat source or heat sink. The pipes are placed on the bottom of the pond, which are generally at least eight feet deep. The Internationsl Ground Source Heat Pump Association, located on the Oklahoma State University Campus at Stillwater, is the main promoter of earth coupled systems.

Recent developments in earth coupled systems use a refrigerant, rather than water/antifreeze, that is circulated through the buried pipes. This system extends the refrigerant loop of the heat pump into the ground, eliminating the heat exchanger and circulation pump between the water/antifreeze loop and the refrigerant loop. The buried copper pipes become a giant evaporator in winter and a condenser in summer. The buried pipes, are placed in 1¼ inch diameter holes, typically 60 feet deep. It normally takes three such holes for each ton (12,000 Btu) of heat pump capacity. Preliminary tests indicate the net effect is a 15 to 20% efficiency gain over water/antifreeze system. (Popular Science, June 1988).

Ground water and earth coupled systems (vertical configuration) depended upon the average ground water temperature. The temperature of the ground and ground water below 100 feet is controlled by the geothermal gradient and thus are considered geothermal. The horizontal earth coupled and surface pond systems are influenced by solar radiation due to their shallow placement. Only data for the former two are considered, and only the ground water systems are used to determine ground water pumping usage. Generally three gallon per minute per ton of heating or cooling load is required. A typical value for a residential location of 3 tons is 8 gpm with a temperature drop of 10 °F.

When calculating energy use, load factors are considered for the heating mode only, since this extracts heat from the earth. In determining the approximate annual energy use, a load factor of 0.10 is used for the southern states with ground water temperature above 60°F; a factor of 0.20 used for the central states, and 0.30 for the northern states where the ground water temperature is below 50°F (See Figure 1). In the southern states, cooling loads control the size of the system, whereas in the northern states heating is the controlling factor. The heating loads for various sites in the U.S. using this procedure are listed in Table 1.