How Ground/Water Source Heat Pumps Work

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A water source air-conditioner or heat pump is a variation of a traditional air source heat pump that can be linked to the ground, ground water, or lakes to provide higher levels of efficiency than conventional air-conditioners and heat pumps. The explanation that follows first describes how a cooling-only water source air-conditioner works. A description of a heat pump (heating and cooling) will follow. Note a similar document, "How Air-conditioners and Heat Pumps Work", is also available.

The cooling-only unit consists of several primary components as shown in Figure 1:

- A compressor that is driven by an electric motor (typically located indoors)
- A condenser coil with tubing for water flow and tubing for refrigerant flow.
- A circulation pump that moves water through the condenser coil and outdoor water loop.
- An expansion device (usually located indoors) that lowers system pressure.
- An evaporator (or indoor) coil with tubing and many fins that cools and dehumidifies air.
- An indoor fan to circulate air over the cold evaporator tubing and fins
- A refrigerant fluid to operate at the needed pressures and temperatures
- Outdoor water loop (discussed in more detail later).

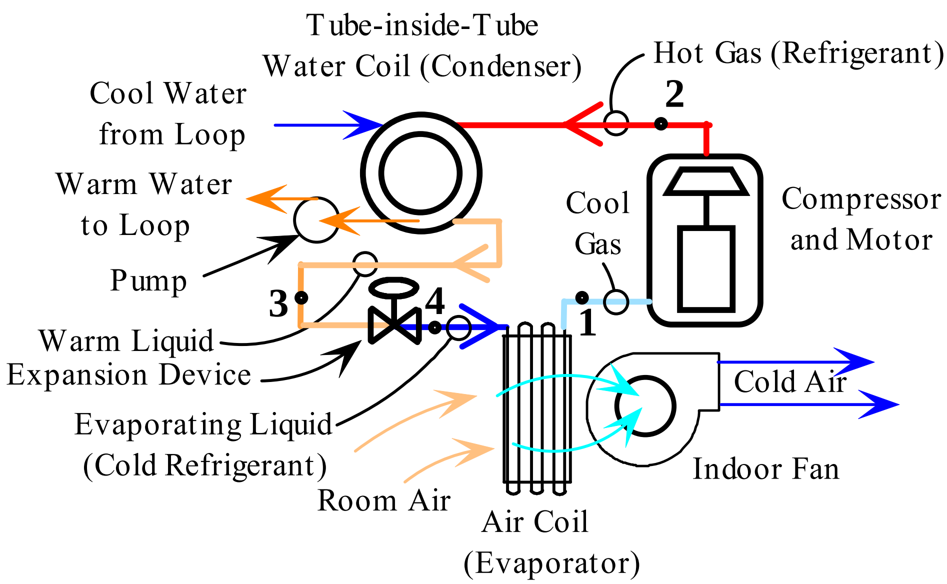

Figure 1

- The compressor "sucks" the refrigerant from point 4 through tubing in the evaporator coil. This action causes the liquid refrigerant to "evaporate" and become cold (≈45ºF). The evaporating refrigerant inside the tubes cools the air being circulated over the outside of the tubes and fins by the indoor fan.

- In order to move the refrigerant from point 1 to point 2, it must be raised to a higher pressure by the "compressor". The compressing causes the refrigerant to become hot (a similar effect occurs with an air compressor and this can be verified by quickly and carefully touching the discharge line).
- The hot refrigerant is sent through the outside tubing of a tub-inside-tube water coil condenser. Water is circulated by the pump through the inside tube and cools the refrigerant and causes it to return to a liquid (condense). The water is typically 50ºF to 90ºF and is cooler than the hot refrigerant (90ºF to140ºF).
- The warm liquid leaving the condenser (point 3) passes through an expansion device which lowers the refrigerant pressure before it returns to point 4 to repeat the cycle.

How a Heat Pump is Different

A heat pump is merely an air-conditioner with one extra valve that allows the condenser (hot coil) and evaporator (cold coil) to reverse places in the winter. Figure 2 shows close-ups of this "reversing" valve and where it is located in the heat pump system. In the cooling mode, the valve slides to a position that permits the hot gas from the compressor to flow through the top port to the left bottom port to the water coil. Thus, the heat pump will act like the air-conditioner described in the previous page. The valve also permits the refrigerant to travel from the indoor air coil to the compressor in cooling and from the water coil to the compressor in heating.

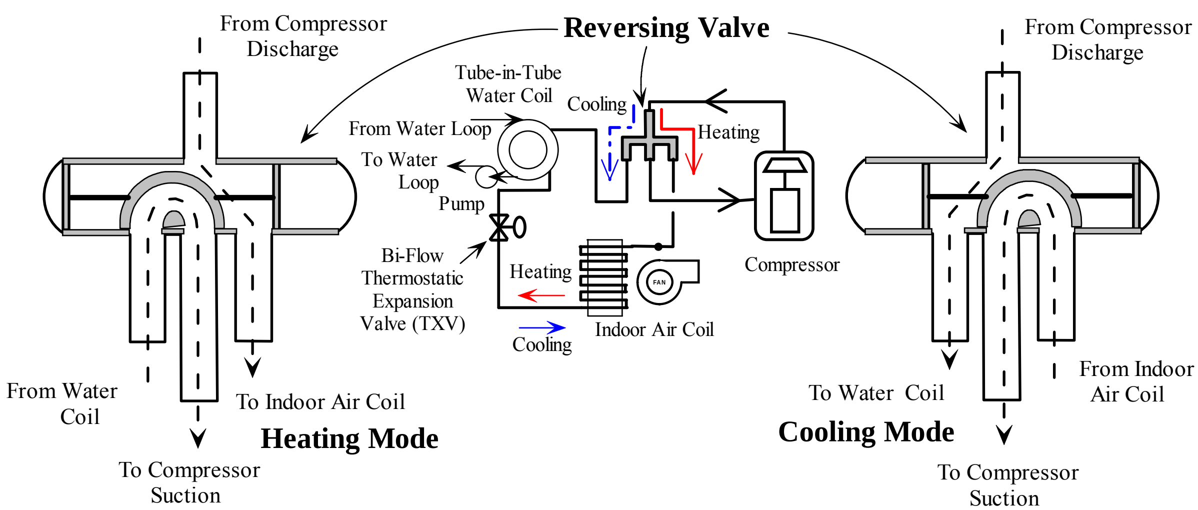

Figure 2

In the heating mode the reversing valve slides to a position that routes the hot refrigerant from the compressor through the top port to the indoor air coil (which is now the condenser) through the right bottom port of the reversing valve. Thus the air circulated by the indoor fan will be heated. After passing through the expansion device, the refrigerant enters the outdoor coil at a low temperature. Because the temperature of the refrigerant is low, heat can be transferred from the water to the refrigerant inside the evaporator. The advantage of using water from a ground or lake loop is that backup heat is often unnecessary. If the water loop is connected to a properly size ground or lake coil, the heating efficiency is exceptionally high compared to conventional systems.

Figure 3 shows the components of a ground source or geothermal heat pump (GHPs). These systems incorporate a piping loop buried in the ground, which is considerably warmer than the outdoor air in the winter. Water is circulated through the loops and the water source heat pump removes the heat from the water as it circulates through the low temperature water coil inside the home. Since the low temperature coil is relatively warm (it is in contact with the water being circulated through the ground), the COP of a GHP is much higher. GHPs can have COPs above 4.0 when the loops are with a good connection between the ground and piping loop. GHPs also provide high efficiency in the cooling season.

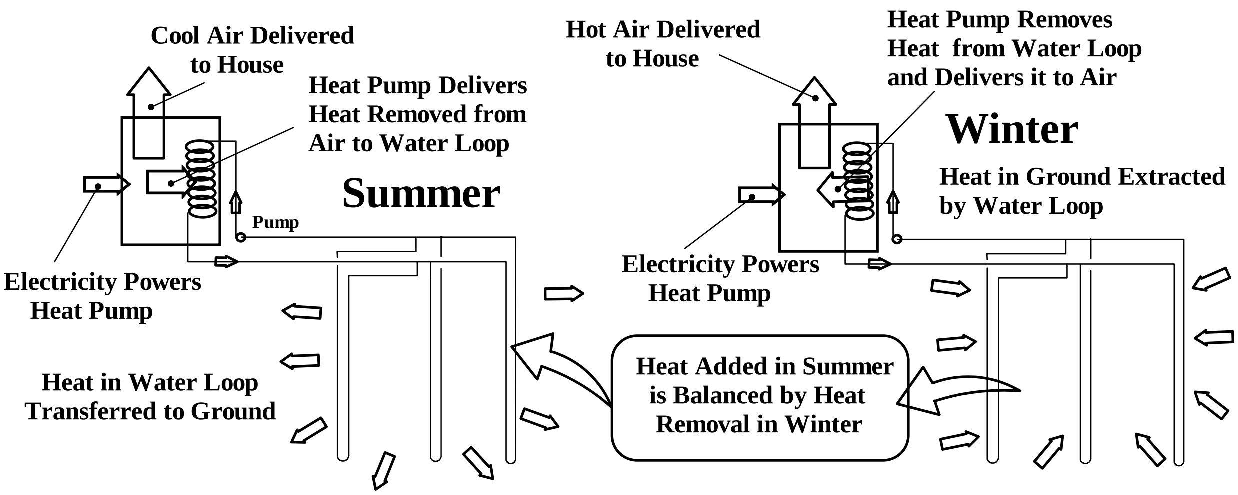

Figure 3 – Ground Source Heat Pump (Closed Loop type)

Figure 4 depicts a heat pump system that uses a coil submerged in a lake to replace the ground loop. These coils are typically less expensive to install than ground loops and the system can be even more efficient in cooling than a system with a ground coil if lake is more than 30 feet deep. However, even deep lakes are colder in the winter than the ground, so the ground coil system performs slightly better in heating.

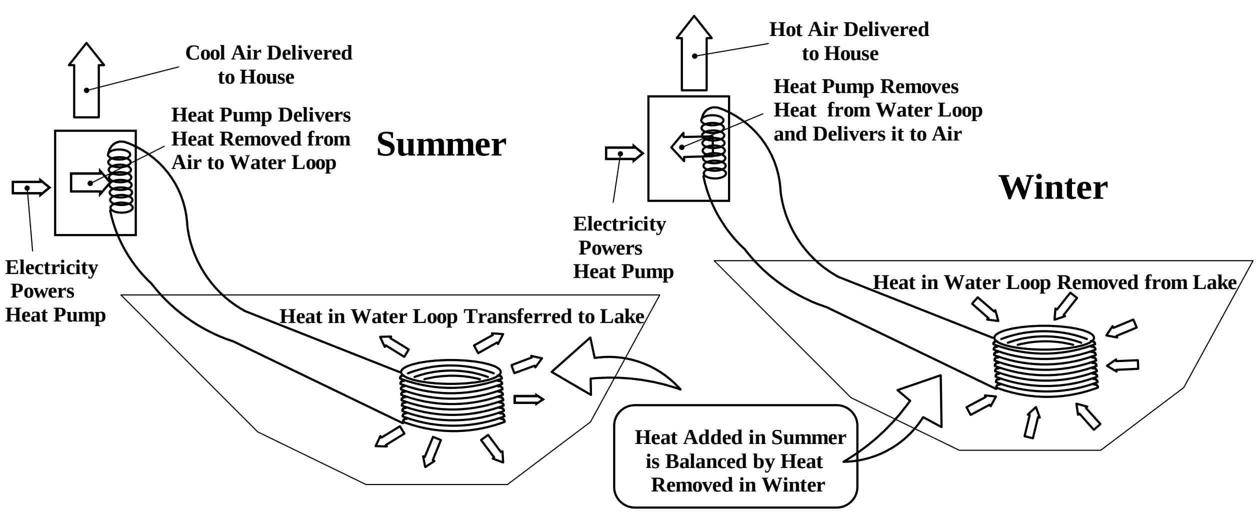

Figure 4 - Lake Source Heat Pump (Closed Loop type)

Figure 5 is a more anatomically correct diagram of a water-to-air heat pump. Note an additional heat recovery coil can also be added to heat domestic water with waste heat in the summer and with excess heating capacity in the winter.

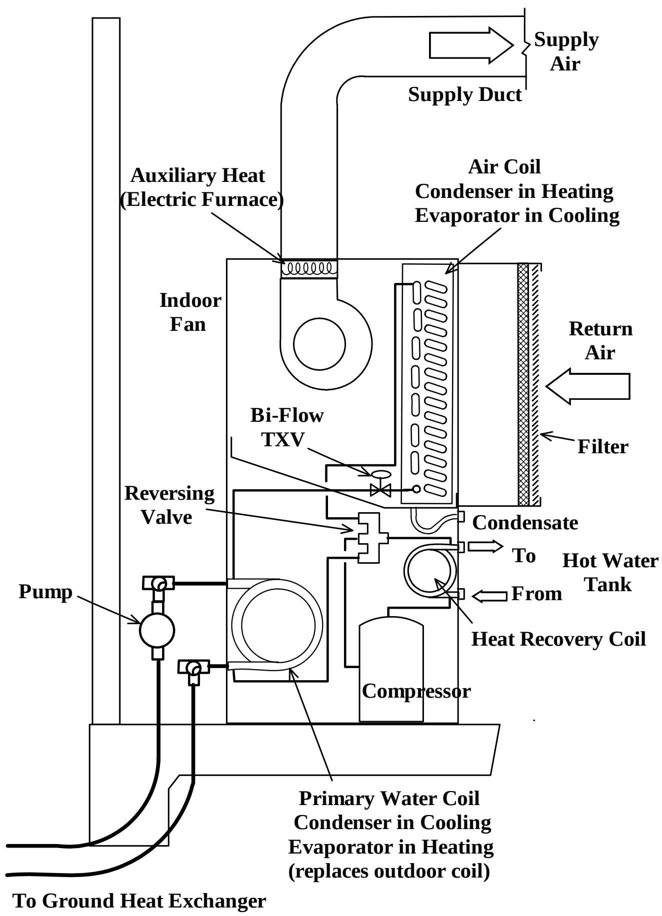

Figure 5. Ground Source "Geothermal" Heat Pump Unit

Reference:

Kavanaugh, S. P., *HVAC Simplified,* American Society of Heating, Refrigerating, and Air-Conditioning and Engineers (ASHRAE), Atlanta. www.ashrae.org