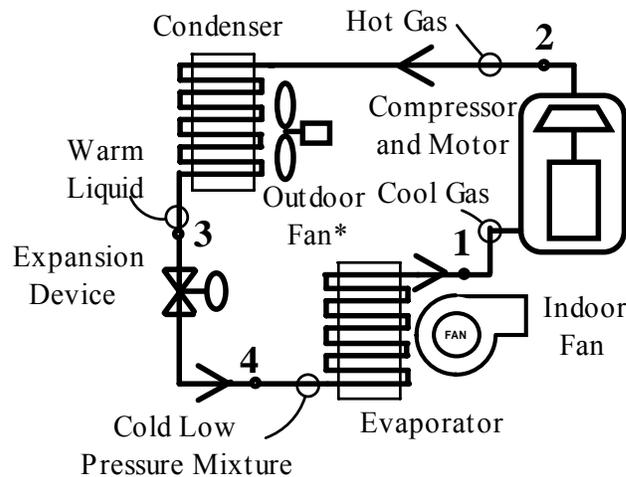


How Air-Conditioners and Heat Pumps Work

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An air-conditioner consists of several primary components as shown in Figure 1:

- A compressor that is driven by an electric motor (typically located outdoors)
- A condenser (or outdoor) coil with tubing and many fins to transfer heat to the air
- An outdoor fan to circulate air over the hot condenser fins and tubing
- An expansion device (usually located indoors) to lower system pressure
- An evaporator (or indoor) coil with tubing and many fins to cool the 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



* In water cooled or "geothermal" systems, a pump is used rather than an outdoor fan.

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 ($\approx 45^{\circ}\text{F}$). 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 tubing inside the condenser. Outdoor air circulated by the fan cools the refrigerant and causes it to return to a liquid (condense). Even though the air may be warm ($80\text{-}100^{\circ}\text{F}$) it is cooler than the hot refrigerant ($100\text{-}160^{\circ}\text{F}$). In some cases, water can be used to cool the hot refrigerant if higher efficiency is needed.
- 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 Pumps Heats

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 condenser. Thus, the heat pump will act like the air-conditioner described in the previous page. Note the valve permits the refrigerant to travel from the indoor coil to the compressor in cooling and from the outdoor coil to the compressor in heating.

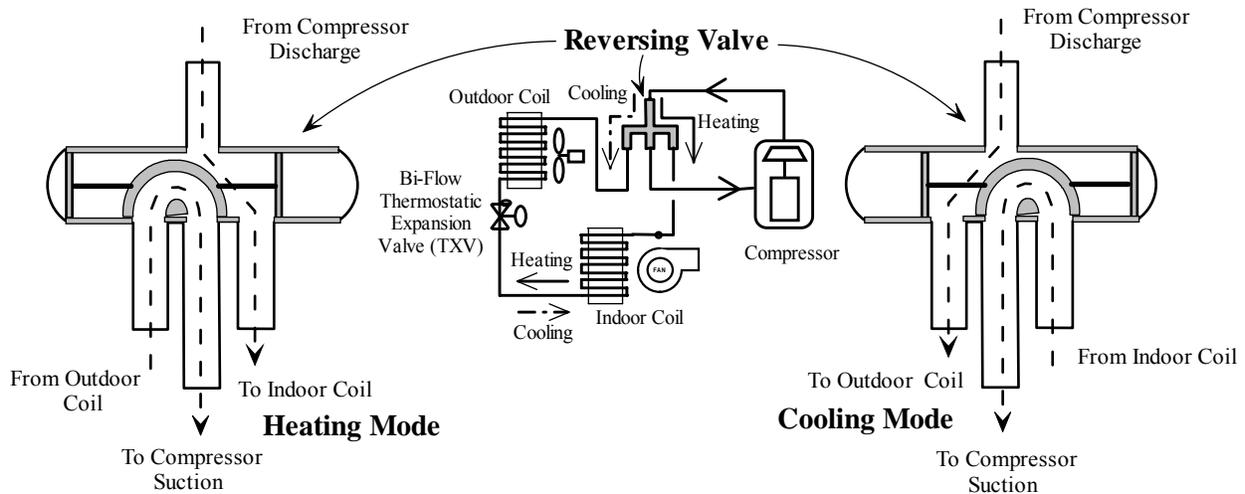


Figure 2

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 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 evaporator coil at a low temperature. Because the temperature is so low, heat can be transferred from the outside air to the refrigerant inside the evaporator. However, this process is not very effective when outdoor temperatures are low (<30 - 40°F). Therefore, backup heat is often used. The recent natural gas price increase makes electric resistance a more attractive choice for backup heat. Again if higher efficiency is needed, water can be used rather than outdoor air in both heating and cooling modes. If the water loop is connected to a properly size ground coil, the heating efficiency is exceptionally high compared to conventional systems.

Figure 3 is a closer representation of the layout of a typical “split-system” heat pump. An air conditioner is identical in exterior appearance since the only significant difference is the relatively small reversing valve. Some heat pumps and air-conditioners are arranged in a single package, which usually located on the exterior of a building or in a wall penetration. Ductwork for distributing the indoor air is non-existent or is routed through the wall or roof.

Finally Figures 4 and 5 are provided to demonstrate 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 a modified 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. As shown in Figure 5, a 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.

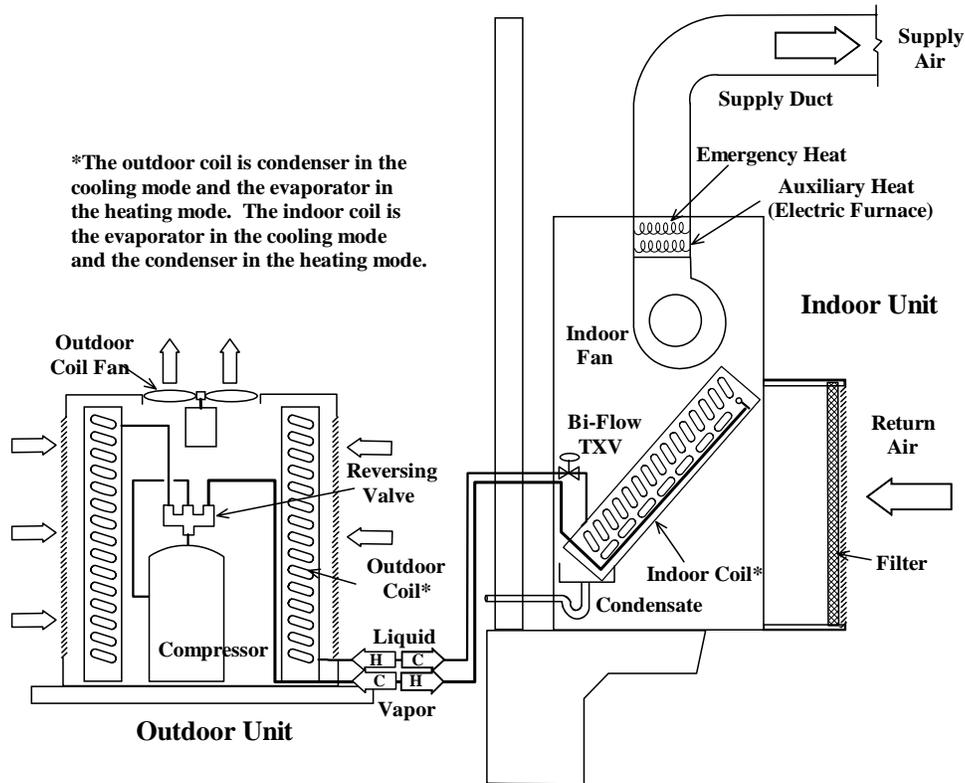


Figure 3. Split-System Heat Pump

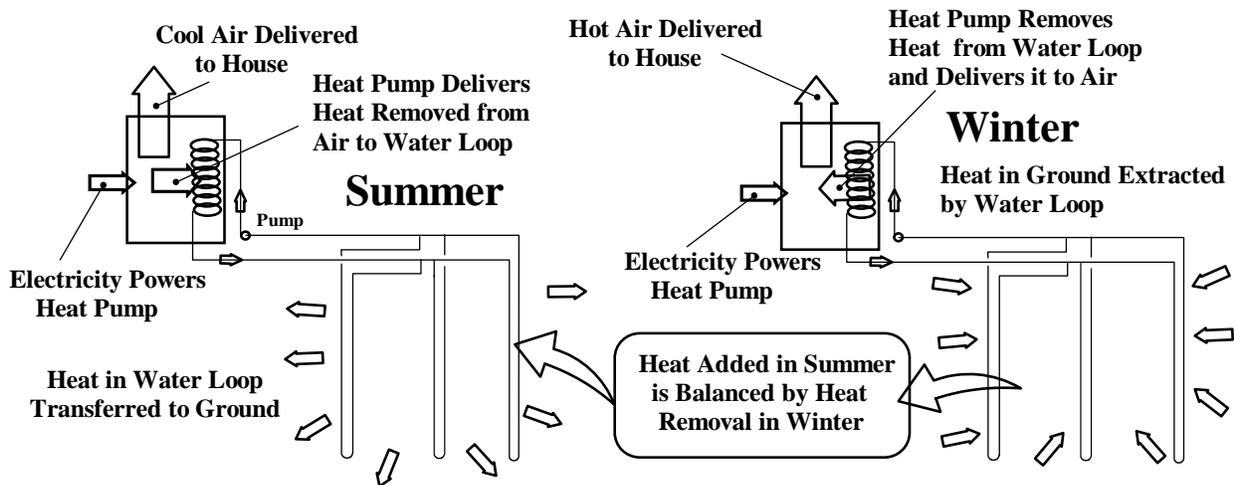


Figure 4 Ground Source "Geothermal" Heat Pump System

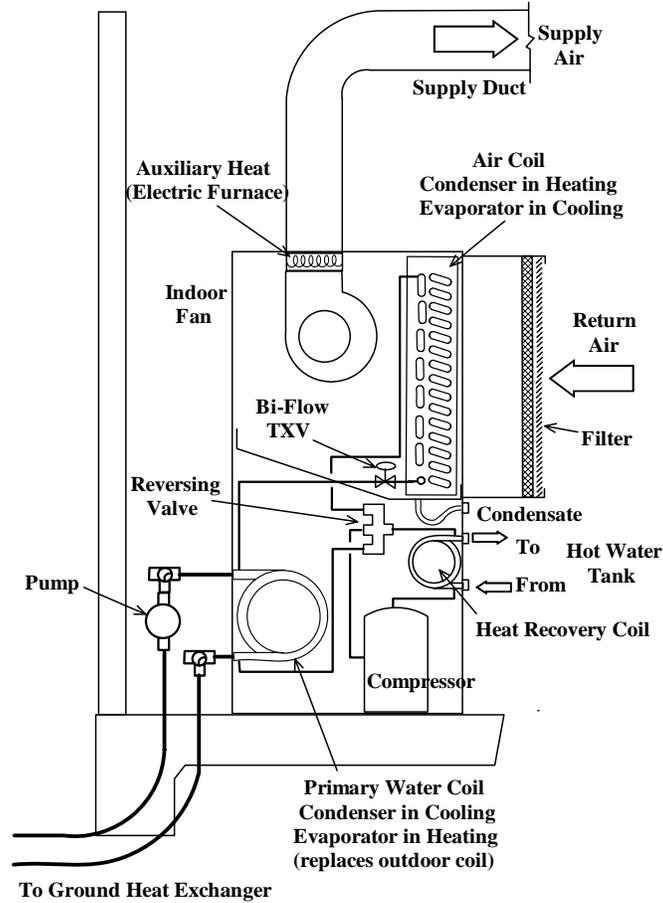


Figure 5. Ground Source "Geothermal" Heat Pump Unit

Reference:

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