Air-to-Water Heat Pumps

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As you know, heat pumps have been around for a long time in the comfort business. When you talk about heat pumps, historically there have been three categories:

- **Air-to-Air heat pumps**
- **Water-to-Air heat pumps**
- **Water-to-Water heat pumps**

In general, heat pumps are devices that can convert low temperature heat into higher temperature heat. The low temperature medium is referred to as the "source." This is where the energy comes from to heat the building. The "source" can be the outdoor air or water from lakes, ponds or, most commonly, tubing buried in the ground. This is where the "free" heat comes from—the renewable energy source. The converted "higher temperature" energy is then released into the sink—the place that can absorb this energy—like an air handler unit that is moving cooler return air across a coil (the heat exchanger) and delivering the warmer air into the living space.

Most are familiar with the Air-to-Air heat pumps. They extract heat from outside air and have become fairly common throughout the U.S. They deliver the high temperature heat through a forced air network of duct throughout a home. This type of heat pump is classified as an Air-Source heat pump.

There are other heat pumps that extract heat by using water that is circulated through tubing which is buried in the ground. The earth heats the water circulating through a "field" of tubing and this heat is then converted by the heat pump into a higher temperature medium. If it is air, they are known as Water-to-Air heat pumps, and if the high temperature medium is water, then they are referred to as Water-to-Water heat pumps.

The newest heat pump to enter the marketplace is called Air-to-Water. It is a hydronic system that produces water temperatures of 85°F up to 130°F. It extracts heat from a renewable energy source (the outside air) and transfers it through refrigerant piping to a module. This module contains a refrigerant-to-water-plate heat exchanger that heats water that is then circulated through floor heating systems, fan coils and low temperature radiators. Because it is a heat pump, the whole cycle can be reversed and provide chilled water (45°F) for cooling. They have been in Europe for the last 10 years and continue to grow in popularity.

Why a Heat Pump?

Heat pumps are considered the most energy efficient, electrically operated heating and cooling system on the market. These modern Air-to-Water heat pumps can deliver between 3–5kWh of usable heat for every 1kWh of electricity that it uses. This equates to a Coefficient of Performance (COP) of 3–5 or 300%–500% more efficient than resistance electric heat.

The heat pump uses the renewable energy source (air) and therefore has no localized CO_2 emissions. The same system can be used for heating in the winter and cooling in the summer. Another benefit to this style heat pump is it uses an inverter technology to operate the compressor. The speed of the compressor can vary to match the actual load that the system is currently experiencing. This can provide more comfort by matching the output to the load and cycle losses are reduced, which increases the compressor's efficiency and reduces "wear and tear" on the compressor, thus extending its life cycle.

Using air instead of geothermal, you eliminate all of the expenses associated with drilling a well field and installing the tubing (anywhere from $10,000–$30,000), consuming the necessary footprint to support the well field and the operating costs of pumping the well field all year long.

Where Does the Heat Come From?

Generally speaking, the heat contained in the soil, ground water and air all started as solar energy. Basically, we are

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taking energy from the sun and using it to heat the water for the hydronic systems. During warmer weather, the ground and the air absorb this heat, and as the weather gets colder, some of this heat dissipates to the outside air.

However, the heat absorbed into the soil can take a long time to transfer back to the atmosphere, even in the dead of winter. The soil temperature in the earth is much warmer than the outside air temperature. This condition generally favors water source heat pumps because their efficiency, or thermal performance, remains high due to the warmer source water temperature. Conversely, the Air-to-Water heat pump's efficiency dips as the outside air temperature gets very cold (-5°F to10°F). However, manufacturers are continuing to improve the efficiency of the refrigerant cycle, enabling them to extract heat from these very cold temperatures while maintaining their rated efficiencies and capacities.

How the Heat Pump Does What It Does…

Refrigerant plays a major role in the successful transfer of energy from one place, where it is available, to another place that needs or wants it. The refrigerant is a chemical that has unique properties that allows it to absorb heat from low temperatures and transfer that energy to a medium operating at a higher temperature.

For this to happen, the refrigerant has to change its state from liquid to vapor and then back to liquid, and in doing so, has to undergo some pressure changes. This whole process can be referred to as the "Refrigeration Cycle" and is the starting point for the operation of all vapor-compression heat pumps. There are four components that play a major role in this cycle. Their respective names indicate their function and how they play their part in the process.

- **Evaporator**
- **Compressor**
- **Condenser**
- **Thermal expansion valve**

The Evaporator

Here we have cold liquid refrigerant enter into the evaporator. Now the pressure of this cold liquid 410A refrigerant is low, and there is a direct relationship between the refrigerant's pressure and its corresponding temperature—the lower the pressure the lower the refrigerant's temperature. The refrigerant's pressure/temperature will adjust as the "source" (air) temperature changes.

As it gets colder outside, the temperature of the liquid has to become colder so it can absorb heat from the cold air outside. As it absorbs heat from the air outside, the refrigerant evaporates or changes its state from liquid into a vapor or gas. Its temperature is still low, but warmer than when it was a liquid. This is important because the next component in line is the compressor. Liquids are not compressible, so if the refrigerant didn't evaporate into a vapor, the liquid entering the compressor would severely damage it.

Compressor

The compressor's job is just as it sounds—it compresses the low temperature vapor. This creates a large increase in both its pressure as well as its corresponding temperature as the refrigerant leaves the compressor. Another factor to consider is that the electrical energy used to compress the refrigerant by the compressor is added to the refrigerant. Now we have a high temperature vapor that contains a lot of energy ready to be utilized.

Condensor

This high-pressure, high-temperature vapor then enters the condenser and the cooler return water from the hydronic system is pumped across the exchanger. The refrigerant is hotter than the water; it transfers its energy to the cooler water, elevating the water temperature as the water goes back out to the heating system. This transfer of energy causes the refrigerant to change its state and condense back to a high pressure liquid.

Thermal Expansion Valve

The last step in this process is for the high pressure/high temperature liquid refrigerant to flow through an expansion valve (either thermal or electronic). The expansion valve controls the flow of the liquid refrigerant through its orifice, drastically reducing its pressure, and thus its temperature, so that the refrigerant is back to the cold temperature it was at the beginning of this process.

Air-to-Water Heat Pumps are starting to play a major role in renewable energy applications. Questions or comments? e-mail me at *gcarey@fiainc.com*, call me at 800-423-7187 or follow me on Twitter at *@Ask_Gcarey*. **ICM**