Air to Water Heat Pumps

Hydronics Meets Refrigeration

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With the continued focus on electrification, there is much discussion about using heat pumps to displace fossil fuel appliances. Of course, heat pumps have been around for a long time in the HVAC industry. When discussing 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 tubing buried in the ground, and is where the "free" heat comes from, *aka* 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 ***Air-to-Air heat pumps***, especially the mini-split units. Very common throughout our market, they extract heat from outside air and deliver high temperature heat through either a forced air network of duct throughout a home, or individual cassettes mounted throughout various rooms in the house. 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 the higher temperature medium is air, this is known as a ***Water-to-Air heat pump***; if the high temperature medium is water, then it is referred to as a ***Water-to-Water heat pump***.

Another type of heat pump gaining attention in our industry is the ***Air-to-Water heat pumps***, which are similar to wall-hung boilers that can produce water temperatures from around 85°F up to 130°F. They do not burn fossil fuel, another reason they are gaining in popularity with some consumers. Instead, this unit extracts heat from the ambient air outside the home and transfers it through refrigerant piping to a module. The 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. Since it is a heat pump, the whole cycle can be reversed and provide chilled water (45°F) for cooling. Air-to-Water heat pumps have been gaining popularity in the U.S. for the last five years.

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 elec-

A Centrus Air-to-Water heat pump

tricity that it uses, which equates to a Coefficient of Performance (COP) of 300–500% more efficient than typical electrical resistance heat. By using the renewable energy source (air), this heat pump therefore has no localized CO_2 emissions, and the same system can be used for heating in the Winter and cooling in the Summer.

Another benefit to this style of heat pump is that it uses an inverter technology to operate the compressor. The heat pump can vary the speed of the compressor to match the actual load that the system is currently experiencing, then providing more comfort by matching the output to the load. As well, cycle losses are reduced, which increases the compressor's efficiency and extends its life cycle.

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

Where Does the Heat Come From?

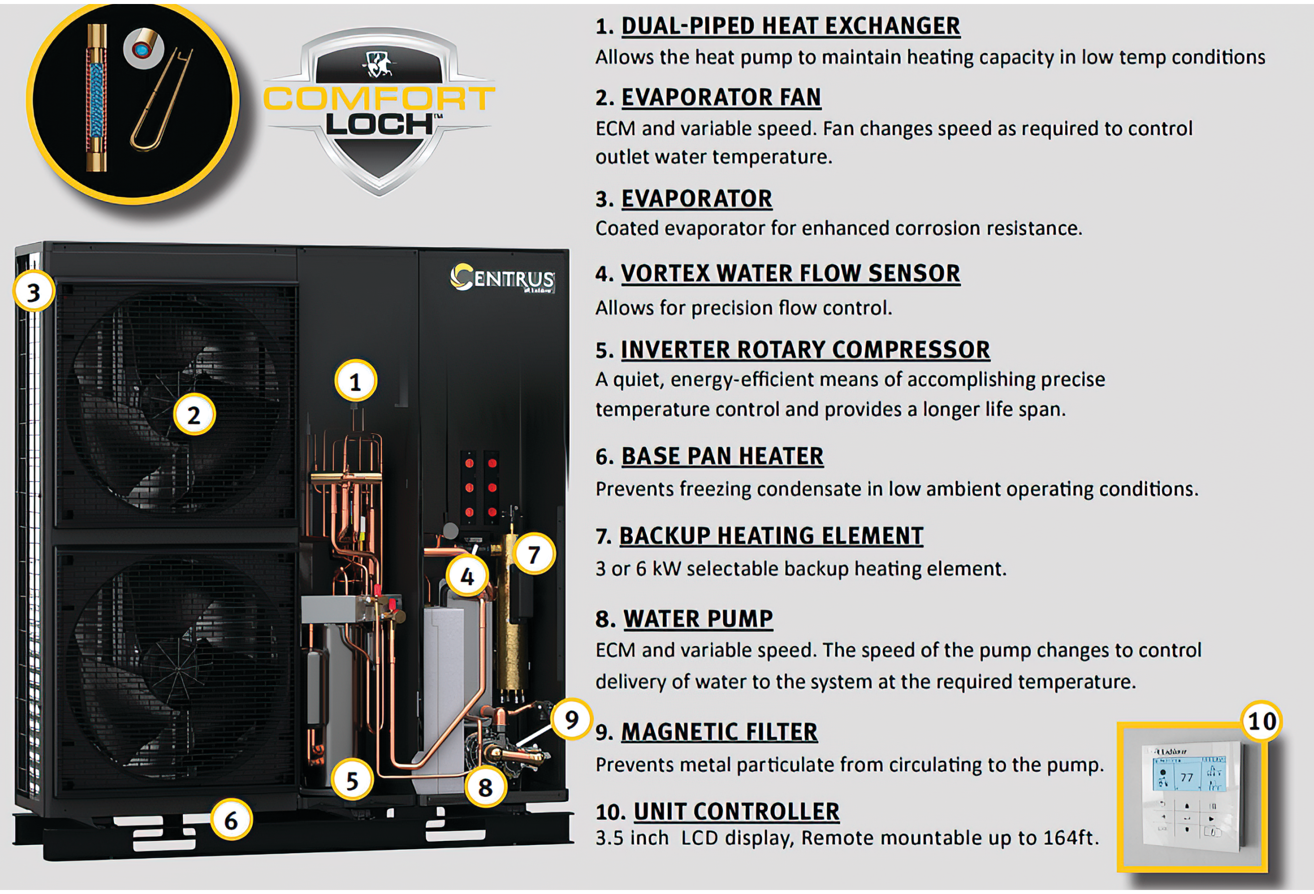
Generally speaking, the heat contained in the soil, ground water and air *all* started as solar energy. Energy is drawn from the sun and used to heat the water for the hydronic systems. During warmer weather, the ground and the air absorb this heat and as the weather gets colder, some of this heat dissipates to the outside air. However, the heat absorbed into the soil can take a long time to transfer back to the atmosphere, so even in the middle 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, whereas an Air-to-Water heat pump's output capacity drops as the outside air temperature gets colder (0°F to 25°F). Manufacturers are continuously trying to improve the efficiency of the refrigerant cycle, enabling them to extract heat from colder temperatures while maintaining their capacities.

How the Heat Pump Does What It Does

Refrigerant plays a major role in the successful transfer of energy from the place where it is available to the 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 higher temperatures. For this to happen, the refrigerant has to change its state from liquid to vapor and then back to liquid, and in doing so, undergo 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



Cutaway air source hydronic heat pump

how they play their part in the process: evaporator, compressor, condenser and thermal expansion valve.

1. **Evaporator:** Cold liquid R32 refrigerant enters the evaporator at a low pressure. There is a direct relationship between the pressure that the refrigerant is at and what its corresponding temperature is, so 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 relatively cold air outside. The key is that, as it absorbs heat from the outside air, the refrigerant evaporates or changes state 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 and since liquids aren't compressible, if the refrigerant didn't evaporate into a vapor, the liquid entering the compressor would severely damage it.
2. **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. There is then a high temperature vapor that contains a lot of energy ready to be utilized.
3. **Condenser:** 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 (being hotter than the water) transfers its energy to the cooler water, elevating the water temperature going 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.
4. **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.

As Air-to-Water Heat Pumps become more popular, they will most assuredly have a place in the renewable energy industry.

If you have any 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**