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Water-To-Air Heat Pumps

J. Robert Cusick
Area Housing Specialist

Most information on heat pumps discuss at length the air-to-air machine. Some may list other heat pump types. But seldom does a heat pump author delve into these alternative types with anything other than an honorable mention. And, with good reason. The national heat pump market is for air-to-air units.* Hundreds-of-thousands of air-to-air systems will be sold this year because of the air-to-air system's universal heat source/heat sink—AIR. But for some, especially non-

*See Home Economics Guide Sheet GH5259, "Air-To-Air Heat Pumps"

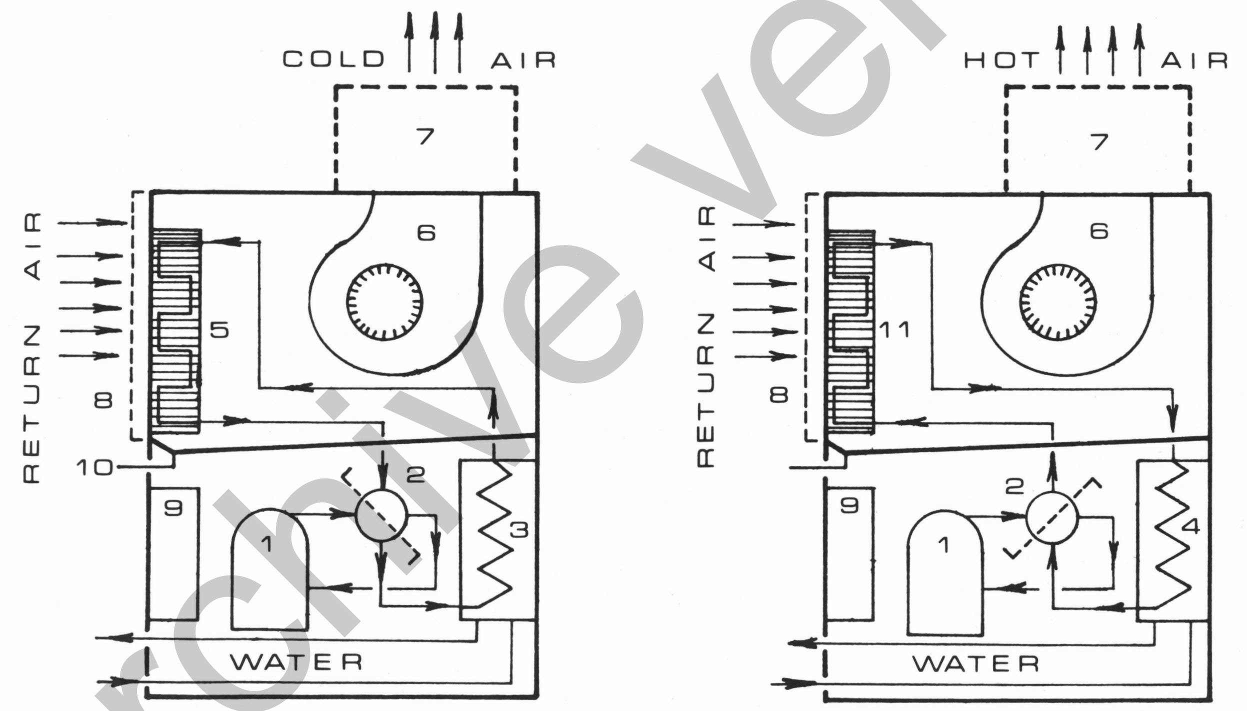


Figure 1—Schematic of Packaged Water-To-Air Heat Pump

Cooling cycle

Heating cycle—refrigerant flow is reversed; condenser coil now becomes "chiller" coil.

1. COMPRESSOR
2. REVERSING VALVE
3. CONDENSER COIL
4. CHILLER COIL
5. EVAPORATOR COIL
6. BLOWER
7. BACK-UP HEAT SECT.
8. FILTER
9. CONTROL BOX
10. CONDENSATE DRAIN
11. CONDENSER COIL

urban and rural, the water-source heat pump presents a very attractive option. There might even be hope on the horizon for the urbanite.

Like the air-to-air heat pump, the water-source heat pump has been around a long time. The pump has been secluded to the point that even professional HVAC (Heating, Ventilating, Air Conditioning) tradesmen in parts of the country are unable to converse on the subject due to lack of understanding of this remarkable machine. Even today, distributors and sales representatives of companies manufacturing the machine are reluctant to discuss the water-to-air heat pump. The obvious question is why? If a device is that good, why is it relatively unknown?

A brief "fact-finding tour" into the annals of heat pump technology led to some answers. This task grew out of the need to select equipment for installation in a solar research house, then in the design stages. Outgrowth of the literature search was the conviction that, at least in terms of the solar research project, a water-to-air heat pump was the *only* logical choice. The machine was purchased and installed with its performance in large part responsible for this work.

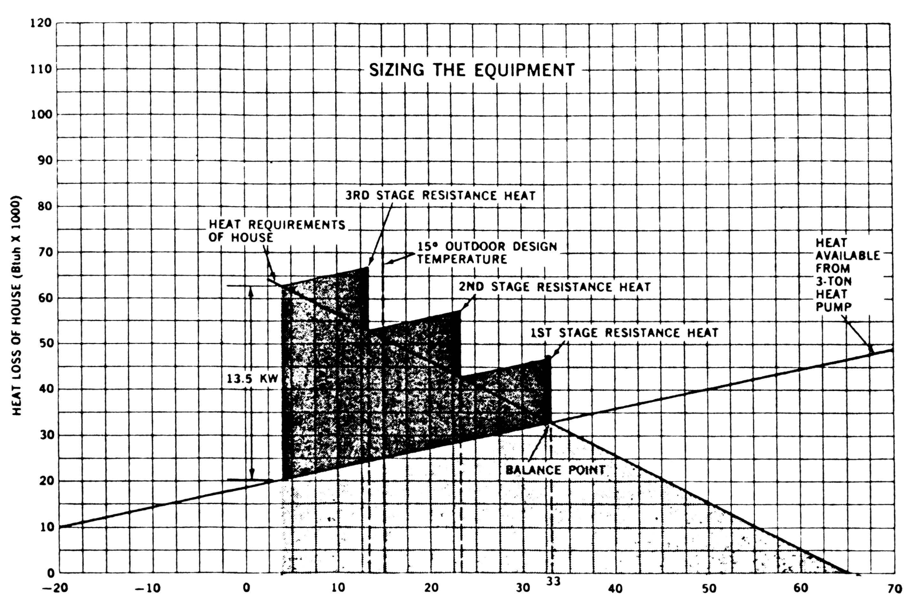
Water, The Key Ingredient

Used first in California, the water-source heat pump provides highly efficient cooling in the summer and inexpensive heat in the winter. South Florida has hundreds of thousands of units installed. The Pacific Northwest, at times thought to posses a limitless supply of cheap hydroelectric power, embraced the water-source heat pump while the rest of the country turned to fossil fuel heat.

A key geological ingredient possessed by these sectors of the United States, the ingredient that made the water-to-air heat pump so attractive, was water. Cheap, abundant water. Because most of the early systems were of the open-loop type (that is, after use, the water was not recycled but was wasted), the first generation water-to-air heat pumps acquired a reputation for being efficient but wasteful and potentially expensive to operate. The original water-to-air heat pump needed a readily available, relatively warm and inexpensive source to remain competitive. The fact that the early water-to-air heat pumps were not as successful as air-to-air pumps was NEVER due to their dependability.

Figure 2—Equipment Sizing Graph, Air-To-Air System

As outdoor temperature (horizontal axis) decreases, heat loss of house (vertical axis) increases as indicated by rise of "heat requirements of house" line. Conversely, as outdoor temperature rises, heat output from hypothetical 3-ton heat pump also rises. The intersection of these two lines represents the "balance point" which in this case occurs at 33°F. Above (to the right) of the balance point, the heat pump can supply the total heating needs of the house. Below (to the left of) the balance point, electric resistance heat supplements the heat pump. This supplementary or back-up heat is usually activated (and de-activated) in 5-10 KW "stages". The house in this example will have 13.5 KW of back-up heat, 80% of its total heating needs. In a more severe climate 100% back-up is customary.



Given the water source, anyone can quickly recognize the inherent advantages of this fluid as a heat source/heat sink. Ground water usually possesses an extremely uniform temperature throughout the year. Water in the range of 50-55°F (10-12.7°C) is available if the source can be tapped. On the whole, more heat can be transferred from water with a uniform temperature than from air with a temperature that is inconsistent.

The secret of the presently unexcelled performance of the water-source heat pump is the constant temperature source. It's springtime to the heat pump, all year long. (See figure 2.) There is no thermal shock brought on by the defrost cycle because a water-to-air heat pump doesn't defrost.* There's no need to shade or otherwise protect the outdoor unit from summer's heat, because the water-to-air heat pump is located in the basement or mechanical room.

Potential Problems

The water source heat pump, while an exceptional machine, is not without its share of problems. ***Water source***—Many have been and can be used. In areas of high water table (southeast and southwest Missouri), shallow wells can be driven. Fairly high volume (15-20 GPM) springs have been used: a municipal water line can be tapped; deep wells have been drilled; and reservoirs in the form of lakes or ponds can be used. The last source is perhaps least desirable for several reasons—1. lakes and ponds at times are silt laden; 2. they freeze over in the winter and even though they might be quite deep, they can be very cold at the point of heat pump intake; 3. a typical farm fishing pond is too small and too cold (or hot) to provide economic annual use in a typical residential setting; 4. the elevation change and reservoir-to-heat pump distance can significantly affect operating (pumping) costs.
Water quality—Water quality is also important not only to the heat pump's heat exchanger, but to the owner's pocketbook. Highly mineralized or acidic water can either scale up or corrode the pump's water/refrigerant coil which means costly replacement of the coil and other water contact components. Dirty or impure water is also undesirable perhaps calling for filtering or other treatment.

*See Home Economics Guide GH5257, "Heat Pumps: How They Work, How They're Rated."

Water disposal—Assuming that a source of good quality and inexpensive water exists, what about disposal of the spent water? One can hardly dump it on the ground allowing it to seek its own course. Few, if any municipalities would allow such a practice. The rural dweller may be situated so the water can be taken to the branch or a nearby reservoir, but the city dweller seldom has this option. Under acceptable geologic conditions, recharge wells can and have been used as a receptable for the discharge which upon entering the shaft is allowed to percolate into the surrounding soil.

Until recently, injection of heat pump discharge water back into Missouri's subsurface was forbidden. However, changes in the law now permit this practice, *under certain conditions*, by a single-family homeowner. Commercial installations and discharge from a multi-family housing project are still regulated or in some cases forbidden. Check with the Missouri Department of Natural Resources, Water Pollution Control Unit, South Ridge Plaza, Jefferson City, Missouri 65101, phone (314) 751-3241, for exact details.

Closed-Loop versus Open-Loop

There are several potentially expensive and wasteful characteristics of an open-loop water circulation system. A closed-loop system in which the water is recycled is much preferred. Not only does the closed-loop technique conserve water but a closed-loop storage tank can be chemically treated to soften, neutralize, or treat the impounded water, adding significantly to the life of all water contact components.

Of even greater importance with a closed-loop are the possibilities of solar assisting a water-source heat pump. A typical arrangement consists of stored water that is heated by an array of solar panels. During the heating season, the sun-warmed water is pumped through a water-to-air heat pump which extracts the heat, delivering it to the building. The beauty of the technique is that unlike a normal 35-55 degree water source, with solar assist, the water can be kept at much higher temperatures correspondingly improving the efficiency* of the heat pump.

All is well during the heating cycle with a closed loop system. But when switched to cooling, a different situation develops. In the cooling

*See Home Economics Guide Sheet GH5259, "Air-To-Air Heat Pumps"

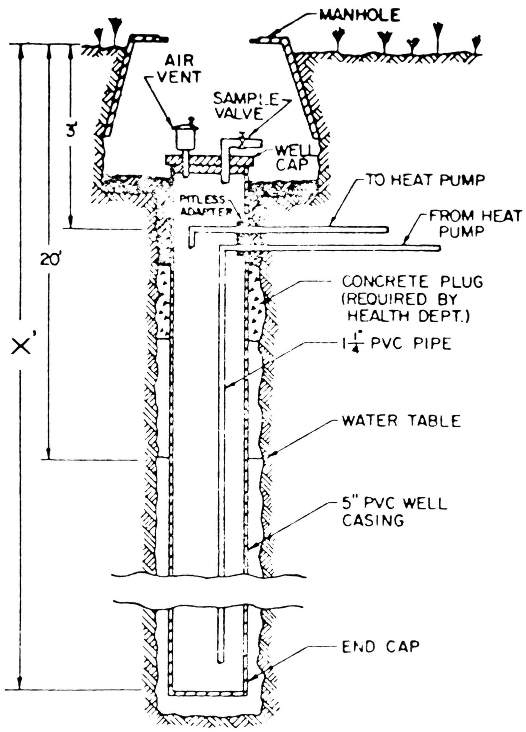


Figure 3—OSU Geo-thermal Well Design

"X" varies with climate. In Oklahoma, research indicates a depth of 100 feet of wetted pipe per ton of heat pump capacity.

mode, with refrigerant flow reversed (fig. 1), heat from the space is now being transferred to the water whose temperature will gradually rise. As the water temperature increases the efficiency of the heat pump decreases. If allowed to continue, this trend will eventually result in water that is too hot for the heat pump to use. A characteristic of the closed-loop system, this problem can be solved by installing a miniature cooling tower (fig. 3) which in a water-source heat pump system constitutes the "outdoor unit."

Geo-Thermal Heat Exchangers

The biggest obstacle to any wholesale application of a water-source heat pump rests not in the equipment, but in the water and its assorted liabilities. The acceptance of water-source heat pumps in the midwest has been lukewarm because of its anonymity and to the problems associated with water, both source and disposal. While that was the case a while ago, it's a different story today.

Since the late 1970's, the School of Technology at Oklahoma State University has been conducting extensive research into the coupling of water-source heat pumps to a variety of geo-thermal (buried) heat exchangers. OSU researchers have been investigating two approaches: 1) A vertical, "U-tube" or series of tubes (fig. 4); and, 2) A horizontal, "earth coil" of pipe buried in a trench (fig. 5). In both cases, the systems are pressurized, closed-loop, using ¾" - 2" high density polyethylene plastic pipe. The principle behind the research is to once again use the earth's thermally stable subsurface to both heat and cool habitable space while at the same time reduce operating expense.

In either the vertical or horizontal arrangement, the earth surrounding the plastic heat exchanger acts as a heat sink or source depending on the season. During the winter heating cycle, temperature of the brine circulating within the heat exchanger is cooler than the earth causing heat to flow from the earth into the brine. Heat absorbed by the brine is then removed by the water-source heat pump and delivered to the space being conditioned. In the cooling cycle, the earth surrounding the heat exchanger becomes the heat sink reversing the thermal flow.

Remarkable success is being reported by the OSU staff. According to a recent progress report, "It has been commercially demonstrated that water source heat pumps operating with water temperatures above 40°F (4.4°C) can achieve COP values of 3.0.* The 40°F. minimum temperature *can be assured* with heat pumps earth coupled to *vertical* heat exchangers."[4]

A number of obvious advantages exist in the OSU technique.

- Since it is not necessary to strike water (vertical system), the bores for the heat exchanger can be drilled on practically any site and initially charged with water from a municipal, rural, or private water system
- Once full, the water (brine) contained in the heat exchanger is cycled over and over with a small, fractional horsepower circulating pump providing substantial reduction in operating (pumping) costs
- "A positive return on investment (ROI) is assured for earthcoupled heat pumps when compared to all fuels in the U.S., except price-regulated natural gas, with payback periods ranging from one to five years, based on incremental costs of the water-source heat pump system over conventional systems."[5]

*See Home Economics Guide Sheet GH5257, "Heat Pumps: How They Work, How They're Rated."

- The system can be solar assisted (the object of current OSU research).

OSU's research has long since moved out of the lab into the real world. Over the past several years, hundreds of earth coupled, water-source heat pumps have been installed in all parts of the country with varying degrees of success. As data continues to mount, it becomes increasingly evident that the water-source heat pump's "time" is just around the corner.

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For additional heat pump information see Home Economics Guide Sheets:

GH5259, Air-To-Air Heat Pumps
GH5257, Heat Pumps: How They Work, How They're Rated

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