Air-to-Water Heat Pumps - Homeowner Reference

Audience: this document is intended as an overview of air-to-water heat pumps for homeowners considering different types of heat pumps.

Air-to-water heat pumps (AWHPs) are a lesser known type of heat pump here in New England, but they are a common technology in other parts of the world. Like their more common cousins ducted central heat pumps and ductless mini-split heat pumps, AWHPs take thermal energy from outdoor air and boost it through vapor compression to usable heat for heating homes. This article mainly compares AWHPs with mini-split systems because these two types may be considered as alternative solutions for homes that do not have central ducting for heating and cooling.[1]

The key difference between AWHPs and ductless mini-split systems is the distribution system. Like typical boiler systems, AWHPs distribute heated water inside the home, while mini-splits distribute heated refrigerant. Unlike mini-splits, AWHPs can also be used for heating domestic hot water (DHW) by adding a desuperheater and (usually) an “indirect” hot water tank to the system if there isn’t one already.

AWHPs can tie into existing hydronic heat distribution systems (baseboards, radiators, or radiant floors), though changes are usually required to adapt to the lower temperature water supplied by the heat pump in comparison to a conventional boiler. AWHPs can also be used for cooling, though air-tight insulation of the distribution piping and separate cooling convectors with condensation drains are required to avoid water damage.

[1] There are different types of heat pumps, and the terminology can be confusing. All heat pumps for homes use electricity. If the heat pump gets energy from the air also, it would be generally called an air-source heat pump. Air-to-air, including mini-split and multi-split, and air-to-water are all types of air-source heat pumps. The most common types of heat pumps installed today are central ducted air-to-air, and ductless mini-/multi-splits. To add to the nomenclature soup, there are both ducted- and ductless mini-splits, with ductless being more common.

Advantages and Disadvantages of AWHPs

In comparison with mini-split HPs and standard fossil-fuel boilers

Advantages of AWHPs

1. AWHPs can also heat water for domestic use (e.g. laundry, dish washing, showers, etc), while other air-source heat pumps generally do not.
2. Unlike boilers, AWHPs (and all heat pumps) can be used for both heating and cooling (with additional insulation and sealing steps as described above)
3. Most AWHPs have factory-sealed refrigerant systems[2].
4. AWHPs can utilize pre-existing boilers for demand reduction or supplemental heat on the coldest hours and days of the heating season. This adds redundancy and can lower system energy costs for homeowners.
5. Some AWHPs can have the compressor and heat exchanger inside the building envelope, which makes service in winter much easier and, more importantly, means that the distribution loop doesn't require any antifreeze. No antifreeze means higher system efficiency and less maintenance.

Disadvantages of AWHPs

1. Like all heat pumps, AWHPs operate at lower distribution temperatures compared to most boilers. Therefore, some hydronic system adaptations are likely to be required to provide enough heat to meet the demand. These adaptations add to the cost of the system. Exception: Floor radiant heating systems may not require modification.
2. Like mini-split heat pumps, AWHPs operate with lower efficiency and capacity as the outside air temperature decreases. Both types extract thermal energy from the outside air, and there is less thermal energy in colder air.
3. AWHPs usually cost more to buy and install than mini-splits.
4. As of 2022, only a handful of installers in Massachusetts have experience installing AWHPs.
5. If pre-existing hydronic assets (baseboards, radiators or radiant floors) are used for heating, then separate hydronic convector units are needed for cooling, adding to cost. This is necessary to drain condensation from humid air in cooling applications. Retrofitting homes to use the same hydronic distribution system for heating and cooling is challenging and costly due to the issue of distribution piping condensation.
6. Almost all heat pumps using air as a heat source/sink have equipment located outside the building envelope. Thus, they are more prone to corrosion and other damage from exposure to the elements (snow, rain, salt spray, humidity, ambient-temperature cycling, UV light) and harder to service in winter compared to boilers.

[2] Refrigerants have a high global warming potential and there is more risk of leakage when refrigerant circulates throughout distribution systems as is the case with mini-split systems.

Configurations

AWHPs have several different configuration possibilities.

1. **Outdoor MonoBloc**, or “self-contained” AWHPs have all components in one cabinet. This includes the heat exchanger. Typically a monobloc AWHP is installed outdoors. This keeps the noise of the compressor outside of the building envelope, which leads to a quiet interior. However there is a downside to monoblocs: because there is a heat exchanger and fluid piping exposed to outdoor conditions, antifreeze is required throughout the distribution system. Antifreeze adds to the upfront cost, increases maintenance requirements, and reduces the system efficiency.
2. **Split systems** have the condenser located outside the building envelope, and the compressor and refrigerant-to-water heat exchanger inside. Because theheat exchanger is inside, these systems don’t require antifreeze. Also, because most components of the AWHP are inside, they are easier to service in winter or rainy conditions if something goes wrong.
3. **Indoor MonoBloc** - These systems require two, fairly large air ducts for supply and return of outside air. Because homes usually don’t have sufficient exterior wall area available for these large ducts, they are unlikely to be suitable in most cases. Nevertheless, in some cases these may be a workable solution.

As noted above, it’s possible to combine an AWHP with a fossil-fuel or solid-biomass boiler, creating a hybrid solution.

Resources

This link to information about air source heat pumps is helpful for heat pumps in general:
https://goclean.masscec.com/wp-content/uploads/2021/01/MassCEC_ASHP_GUIDE.pdf
AWHPs are air-source heat pumps. The article does not cover the water distribution aspect of AWHPs.

A link to an article by Brian Just giving a narrative description of his AWHP retrofit in Vermont:
https://www.greenbuildingadvisor.com/article/air-to-water-heat-pump-retrofit
Note that Brian opted not to include air conditioning, which allowed him to use lower cost panel radiators (as opposed to fan-coil units) and also presumably eliminated the need to fully insulate his plumbing lines.

A link to another article written by hydronics expert John Siegenthaler:
https://www.hpacmag.com/features/heat-pumps-in-hydronic-systems/