HVAC

Air source heat pumps are worth a close look

by ian shapiro

- Lower carbon emissions, installed costs, drive interest.
- Better technology has boosted efficiency.
- Following best practices is key to getting top performance.

We may be seeing the beginning of the end of the use of fossil fuels to heat buildings. A push to electrify buildings to reduce carbon emissions, along with increasing availability of renewably-generated electricity, is combining with a drop in installed cost to form a perfect storm in demand for heat pump systems. There are three types of heat pumps: air-to-air, water source, and geothermal. In particular, air source heat pumps are seeing the most rapid growth.

Drivers of growth

Part of the growth of heat pumps is related to avoiding carbon emissions, because heat pumps do not burn fossil fuels for heat production. In addition, when electricity is provided by on-site photovoltaics, or is purchased from renewable sources, the technology's carbon emission avoidance impact is magnified.

Nationally, heat pump shipments are outstripping shipments of fossil fuel systems, as reported by AHRI. Shipments of heat pumps have grown by about 50 percent over the past seven years, whereas natural gas boilers and furnaces have grown by about 30 to 35 percent, and oil boilers and furnaces have dropped dramatically, by 30 to 50 percent.

Heat pumps are also starting to displace natural gas as the heating system of choice, especially for new high-performance buildings. For example, in one state's energy program for new buildings, there were virtually no heat pumps before 2008. Between 2010 and 2015, more than 20 percent of new buildings had heat pumps in them. And in the past two years, more than 50 percent of new buildings have installed heat pumps. The vast majority of these heat pumps are air source heat pumps,

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with just a small number of ground source heat pumps.

State and utility energy programs are promoting heat pumps as a way to reduce carbon emissions, and are offering rebates and tax credits. New York State, for example, just introduced a rebate for air source heat pumps. Also, some localities are increasingly reluctant to invest in infrastructure for fossil fuels, such as gas pipelines. The concern is that such infrastructure will become stranded assets as the United States increasingly transitions away from fossil fuels. In these cases, heat pumps are promoted as one way to relieve pressure on demand for fossil fuels such as natural gas. This is the case in Tompkins County, N.Y., home of Cornell University, where there is a moratorium on the use of natural gas in new buildings in parts of the county, and where the local utility has obtained permission from the state Public Service Commission to allow a competitive solicitation to reduce the use of natural gas. As a result, there has been rapid growth in the number of heat pump installations in the county, from just a few installations a few years ago, to nearly 1,000 installations in the last couple of years.

Another driver of growth is reduced installation cost. A recent study for Tompkins County found that installed costs have come down from $10 per square foot to $6 per square foot for smaller air source heat pumps. Costs are likely dropping due to several factors, including increased demand (larger volumes), increased contractor experience, increased familiarity among architects and engineers, ease of design, and increasing recognition of the ease of installation. Interestingly, larger air source heat pumps have not yet seen a drop in price, with installed costs in the $20 to $30 per square foot range, unchanged from a few years ago.

The Tompkins County study found that smaller air source heat pumps cost about the same as traditional fossil fuel heating systems combined with traditional air conditioning systems.

All types of buildings are seeing an increase in the use of heat pumps. Larger commercial and institutional buildings are mostly seeing the larger variable refrigerant flow (VRF) heat pumps, which can each contain a larger number of indoor fan coils of different kinds (wall-mounted, ceiling-mounted, floor-mounted, ducted, and more). Small commercial buildings are primarily seeing smaller air source heat pumps.

Comparing large and small heat pumps

Both VRF systems and smaller air source heat pumps have variable speed compressors and fans, with a roughly 3:1 turndown ratio (ratio of maximum to minimum speed), so the "variable" designation really applies to both large and small systems. But there are important differences.

Generally, VRF systems are in the 3-14 ton range, while smaller systems are in the 1.5-4 ton range. The tonnage refers to the nominal cooling capacity

of the outdoor unit. VRF systems are typically 3-phase electrical, whereas smaller heat pumps are typically single-phase. VRF systems have the capacity to operate simultaneously in heating and cooling, recovering heat from cooling zones and delivering it to heating zones, and so save energy if simultaneous operation is needed. In buildings with multiple tenants, smaller systems can each be assigned to different tenants, which facilitates attributing the electrical load (and metering) to specific tenants. Refrigerant leaks are also easier to find in smaller systems.

Smaller systems have slightly higher rated efficiencies, in the 10-11 HSPF range (heating seasonal performance factor), peaking just over 11. VRF systems have rated efficiencies in the 8-11 HSPF range, peaking just under 11.

The installed cost of smaller systems is significantly lower than the installed cost of VRF systems, per square foot of building.

Smaller heat pump systems typically accommodate eight indoor units maximum (and sometimes the maximum is fewer than eight, for any given manufacturer). On the other hand, VRF systems support up to 12 indoor units per system. Smaller heat pump systems allow pipe lengths up to about 250 feet, whereas VRF systems allow piping up to 500 feet or more. Smaller systems allow vertical pipe lengths up to about 50 feet, whereas VRF systems can allow vertical pipe lengths over 150 feet.

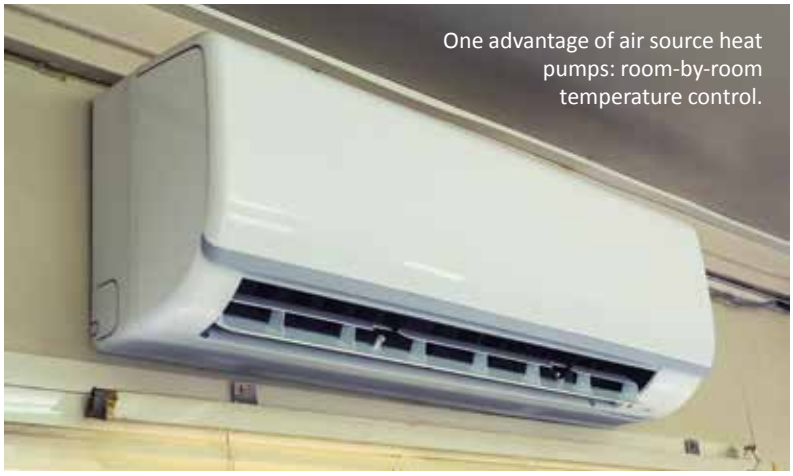
For smaller buildings, and for buildings such as multifamily buildings and hotels, the smaller systems make sense, delivering higher efficiency at lower installed cost. For larger buildings, the larger VRF systems offer larger capacities and advanced features such as heat recovery from simultaneous heating and cooling, longer pipe lengths, and more indoor units per system.

Pros and cons of heat pumps

Heat pumps are a different type of equipment, and it takes getting used to their pros and cons. Other than low carbon emissions and likely lower installation costs, air source heat pumps offer a variety of benefits. These include:

- Room-by-room temperature control, leading to better comfort.
- No requirement for a mechanical room.
- Eliminated heat losses from boilers and piping.
- No requirement for chimney or venting.
- No risk of carbon monoxide poisoning or natural gas explosion.

Air source heat pumps do bring some risks, as well. Ductless indoor units can be aesthetically unappealing to some people, in which case ducted units can be considered. If indoor units are placed in poor locations, objectionable airflow (feeling like drafts) can occur — for example, in cooling, if wall-mounted units are located above desks or in other locations where people are stationary. If condensate pans plug up, condensate will overflow and can damage indoor finishes.


One advantage of air source heat pumps: room-by-room temperature control.

Refrigerant leaks can occur, especially if piping joints are fastened poorly. However, many systems can operate for years without leaks, if installed carefully. A small study in Tompkins County, N.Y., found no refrigerant leaks reported in nine out of ten installations, including two installations that are 15 years old. Only one of the ten installations had any refrigerant leaks. A European study found that leaks average 3.5 percent per year.

Achieving high efficiency with heat pumps

The efficiency of air source heat pumps has historically been a concern, especially in colder climates, going back to their launch in the 1970s. And where electric resistance heat is used as a backup, a second concern has been over-reliance on this inefficient backup heat.

Newer air source heat pumps use variable speed compressors and variable speed fans, and operate down to temperatures below -10 F. Several studies have conclusively found that properly-sized air source heat pumps do not need backup heat.

However, a comprehensive review of recent research does show that actual efficiency can be lower than rated, likely for a variety of reasons, such as poor airflow, poor sizing (and ongoing reliance on electric resistance backup), poor refrigerant charging, and more. In order to obtain the highest possible efficiency, a variety of best practices are required in design and installation, including:

- Properly sizing heat pumps.
- Not manually setting indoor units on low fan speed.
- Not allowing the indoor units to run continuously.
- Installing outdoor units away from vegetation, fencing, or other possible obstructions to airflow. Outdoor units should be installed on stands or wall-mounted or under a roof, to minimize the risk of snow obstructing airflow.
- Following manufacturer's instructions carefully for refrigerant charging. Following best practices for making refrigerant piping joints, to minimize risk of leaks.
- Keeping indoor units clean and unobstructed. This includes cleaning filters regularly, at a minimum annually.

In the absence of such best practices, the typical air source heat pump delivers an average annual efficiency of 2.5 COP (coefficient of performance) in colder climates such as the Northeast, and slightly higher in warmer climates. With best practices, annual efficiencies approaching 3.0 COP should be possible in colder climates.

Air source heat pumps are here to stay. They offer an efficient path to buildings with low carbon emissions and come with a host of other benefits. And soon, it could cost less to install air source heat pumps than to install fossil fuel systems. ■

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