

Air-to-Air Heat Pumps for Space Conditioning

When it comes to electrifying space heating, heat pumps stand out due to their mature technology, high market awareness, and high efficiency.

Heat pumps are an effective way to heat and cool homes and buildings while also saving on operating costs and reducing greenhouse gas emissions. A heat pump transfers, rather than generates, heat from a variety of sources. Heat pump technology can be categorized by the heat source (air, ground, or water) and by the medium through which they distribute that heat (air or water). Heat pumps for building applications commonly fall into three main categories: Air source, ground source and water source. This factsheet will

focus on air-to-air heat pumps because they are the most common due to the variety of configurations and styles that make them well-suited for a broad range of applications.

With technological advancements greatly improving this type of heating and cooling, **4,334,479** heat pumps are being installed across the U.S. Historically, cold weather performance has been an issue for air source heat pumps. Both energy efficiency and heating capacity have been significantly lower in colder conditions. However, in recent years, manufacturers have made great progress in advancing cold-climate heat pump technology. Today, product availability for key air-to-air heat pump (ASHP) product types is robust, and both technology optimization and product diversity are expected to improve further.



Credit: Bennington College

	Air Distribution	Water Distribution
Air Source	 Air-to-Air (Splits, VRF, PTHP, RTU)	 Air-to-Water (Reverse cycle chiller, Hybrid VRF)
Ground Source	 Ground-to-Air (GSHP with forced air distribution)	 Ground-to-Water (GSHP with hydronic distribution)
Water Source	 Water-to-Air (WSHP)	 Water-to-Water (WSHP)



Split Air Source Heat Pump System

(includes “Mini-splits”)

KEY FACTS

Heating/Cooling Capacities: Range from approximately 1-5 tons.

Building Types: All building types but most common in homes and small commercial buildings.

Availability: Widely available and commonly installed, including cold-climate models.

Configuration: Available in both a more traditional ducted configuration (i.e., centrally ducted) as well as a wide variety of ductless configurations (often referred to as mini-splits). Split systems can be designed as single- or multi-zone, with the ability to mix and match ducted and ductless indoor units for the unique needs of the home or building.

Benefits: Available in cold climate models. They are typically easier to install than some other types of space conditioning systems. They also can be small in size and flexibility for zoning or heating and cooling individual rooms.



Ductless Indoor Units

1-Way Cassette



4-Way Cassette



Ceiling Suspended



Wall Mounted



Floor Standing



Ducted Indoor Units

Compact Ducted
(low, medium static pressure)

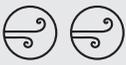


Centrally Ducted
(high static pressure)



All ductless and ducted images credit: Daikin

	Building Type Applicability					Vintage Applicability		Cold Climate Performance Availability
	Single Family	Multifamily	Small Commercial	Large Commercial	Institutional	New Construction	Retrofit	
Split Air Source Heat Pumps (Ducted and Ductless)	✓	✓	✓	✓	✓	high	high	high



Variable Refrigerant Flow (VRF) Systems

KEY FACTS

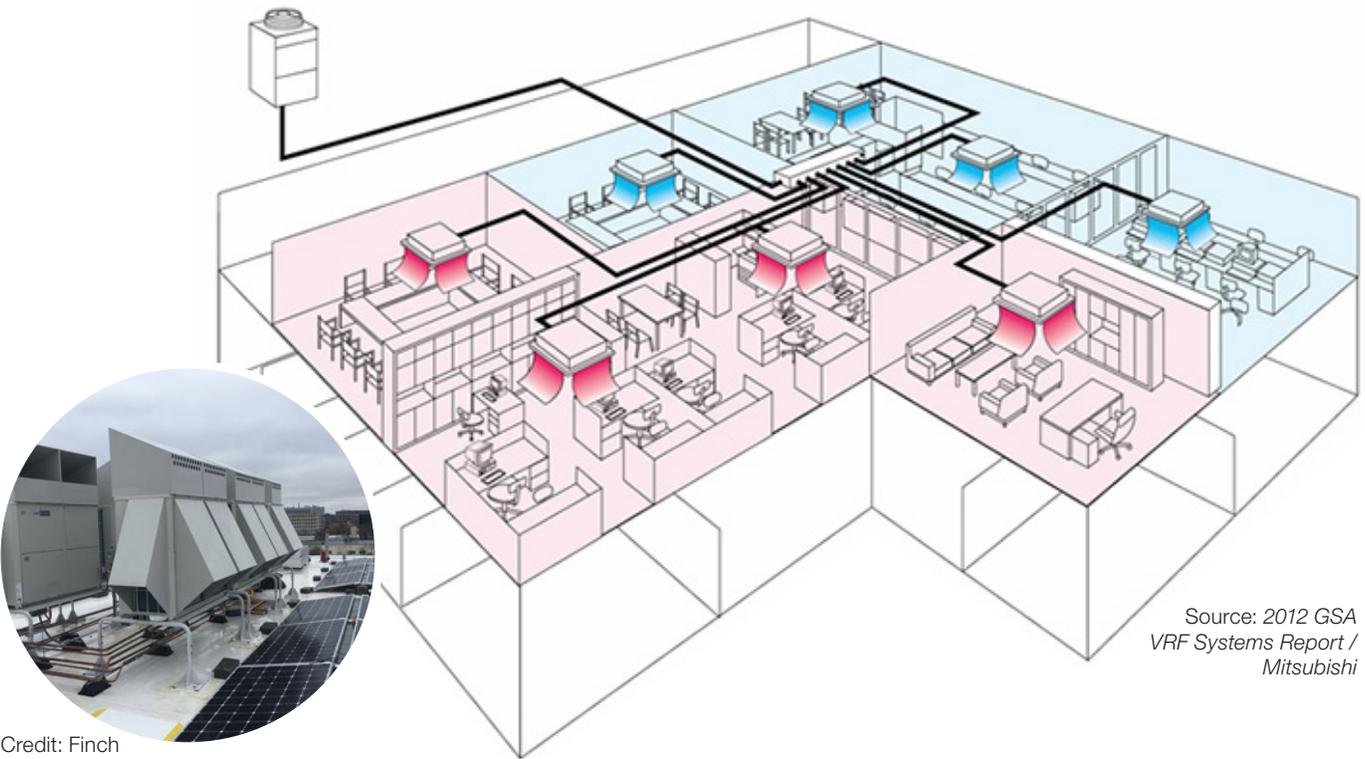
Heating/Cooling Capacities: Range from approximately 5-60 tons.

Building Types: Commercial, multifamily, institutional. Best fit for larger buildings because of ability to attain high efficiencies by minimizing the overall energy demands associated with simultaneous heating and cooling from deep floor plates.

Availability: Perfected technology, widely available, commonly used.

Configuration: Current VRF systems use large volumes of conventional high global warming potential (GWP) refrigerants, which can significantly reduce the greenhouse gas (GHG) savings relative to other electric options. The outdoor unit is connected to the indoor units by refrigerant lines, and each indoor unit can be individually controlled to provide heating or cooling as needed. The system uses a heat pump cycle to transfer heat from the outdoor air to the indoor spaces, allowing for efficient heating even in cold temperatures.

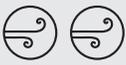
Benefits: The system can provide simultaneous heating and cooling to different areas of a building. These systems circulate the minimum amount of refrigerant needed for each individual zone to satisfy the building load. Since there are no ducts, this eliminates the energy waste.



Credit: Finch Cambridge Housing Complex

Source: 2012 GSA VRF Systems Report / Mitsubishi

	Building Type Applicability					Vintage Applicability		Cold Climate Performance Availability
	Single Family	Multifamily	Small Commercial	Large Commercial	Institutional	New Construction	Retrofit	
Variable Refrigerant Flow (VRF) Multi-Split Heat Pump		✓	✓	✓	✓	high	medium	high



Packaged Terminal Heat Pump (PTHP) Systems

KEY FACTS

Heating/Cooling Capacities: Range from approximately 1-2 tons.

Building Types: Commercial, multifamily, hospitality, education, institutional. Best for buildings with small or partitioned floor plates because, as perimeter-sited systems, they cannot condition the interior core of the building.

Availability: While limited, a few manufacturers now have cold-climate PTHP lines that offer high-efficiency heat pump operation at temperatures below freezing. Broadly available across the United States besides in cold climate areas.

Configuration: PTHPs are single packaged units installed in metal sleeves typically located below windows in living spaces and bedrooms. PTHPs heat and cool spaces using refrigerant and incorporate back-up heating mode, typically electric resistance heat, for lowest winter temperatures. They are packaged systems and require proper insulation to seal the envelope.

Benefits: PTHPs offer substantial efficiency savings over today's packaged terminal air conditioners (PTACs) that rely on electric resistance heating. Retrofit-ready units can replace an existing building's gas and/or electric PTAC.



	Building Type Applicability					Vintage Applicability		Cold Climate Performance Availability
	Single Family	Multifamily	Small Commercial	Large Commercial	Institutional	New Construction	Retrofit	
Packaged Terminal Heat Pump (PTHP)		✓	✓		✓	medium	medium	medium



“Micro” Heat Pumps

KEY FACTS

Heating/Cooling Capacities: Range from 0.5 – 1.0 ton

Building Types: Single-family room heat/cool. Light commercial. Retrofit for multi-family

Availability: Cold climate room heat pumps are still new to the market. Therefore, heating season ratings do not yet exist. However, during the winter of 2023-2024, the New York City Housing Authority conducted a field performance test of window units in multi-family housing in New York City. This project tested Midea America and Gradient models. More models from other manufacturers are expected in 2025. ENERGY STAR and the Consortium for Energy Efficiency (CEE) are establishing specifications for window heat pumps (formally defined as room heat pumps). These new models should generally be able to deliver efficient heating performance to 17°F or lower.

Configurations: The four main configurations available include 1) Through-window, 2) Through-wall, 3) Portable, or 4) a modified mini-split arrangement. While all configurations are viable, given the existing room air-conditioner form factor, room, or window, heat pumps are drawing the most attention from the emerging modified mini-split arrangement.

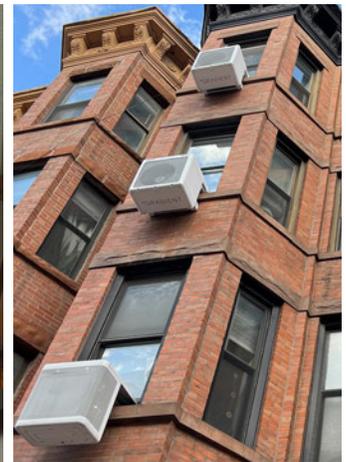
Benefits: Room heat pumps are low-capacity, pre-charged heat pumps that can be easily installed. They are designed to serve a single zone and can be a potential solution for rooms without outdoor ground space for standard outdoor compressors. They have a similar capacity to small ductless mini-splits but for less cost. Additionally, they run on 120-volt circuits, removing the added expense of adding new 240-volt lines.



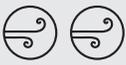
Example of through-wall model. Credit: Epocha



Example of window “saddle” unit Credit: Gradient



	Building Type Applicability					Vintage Applicability		Cold Climate Performance Availability
	Single Family	Multifamily	Small Commercial	Large Commercial	Institutional	New Construction	Retrofit	
“Micro” Heat Pumps	✓	✓	✓			low	high	medium



Packaged Rooftop Unit (RTU) Systems

KEY FACTS

Heating/Cooling Capacities: Range from approximately 3-25 tons.

Building Types: Commercial, Education, Institutional.

Availability: Widely available, very common. Manufacturers are beginning to develop heat pump units with cold climate heat pump capabilities, with the expectation that units may be available in two to three years.

Configuration: Currently, nearly all heat pump RTUs are part of either a gas pack and rely on the gas system to provide some heating or are matched with auxiliary heating provided by electric resistance coils.

Benefits: High GHG reductions compared to traditional equipment.



Credit: Trane

	Building Type Applicability					Vintage Applicability		Cold Climate Performance Availability
	Single Family	Multifamily	Small Commercial	Large Commercial	Institutional	New Construction	Retrofit	
Packaged Rooftop Unit (RTU)		✓	✓	✓	✓	high	high	low

Summary of Applicable Buildings and Climates For Different Air-to-Air Heat Pump Types

	Building Type Applicability					Vintage Applicability		Cold Climate Performance Availability
	Single Family	Multifamily	Small Commercial	Large Commercial	Institutional	New Construction	Retrofit	
Split Air Source Heat Pumps (Ducted and Ductless)	✓	✓	✓	✓	✓	high	high	high
Variable Refrigerant Flow (VRF) Multi-Split Heat Pump		✓	✓	✓	✓	high	medium	high
Packaged Terminal Heat Pump (PTHP)		✓	✓		✓	medium	medium	medium
“Micro” Heat Pumps	✓	✓	✓			low	high	medium
Packaged Rooftop Unit (RTU)		✓	✓	✓	✓	high	high	low

For more information on available air-to-air heat pump technologies, contact your local HVAC contractor/distributor and refer to DOE’s [Better Buildings’ Low Carbon Technology Strategies](#) resources.

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