tech primer

Variable Refrigerant Flow (VRF) Systems

Highly efficient heat pumps for centralized electric heating and cooling in multifamily buildings.

tech overview

applicable building types
all multifamily, hotels

implementation
at equipment replacement

fast facts
- reduces GHG emissions
- improves comfort
- provides temperature and zoning control
- reduces maintenance costs
- provides both heating and cooling
- offers design flexibility

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costs & benefits*

GHG Savings

Tenant Experience Improvements

Utility Savings

Capital Costs

Maintenance Requirements

*ratings are based on system end use, see back cover for details.

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getting to know VRF systems

Variable Refrigerant Flow (VRF) is an efficient heating and cooling technology that saves energy and reduces greenhouse gas emissions while greatly improving resident comfort. VRF systems offer multifamily buildings a path to electrification.[1]

how do VRF systems work?

Variable Refrigerant Flow (VRF) is an air-source heat pump (ASHP) technology that can be used to heat and cool spaces. ASHPs are high-efficiency electric appliances that add or remove heat from an indoor space as needed. Because they transfer heat rather than generate it, ASHPs are extremely efficient.

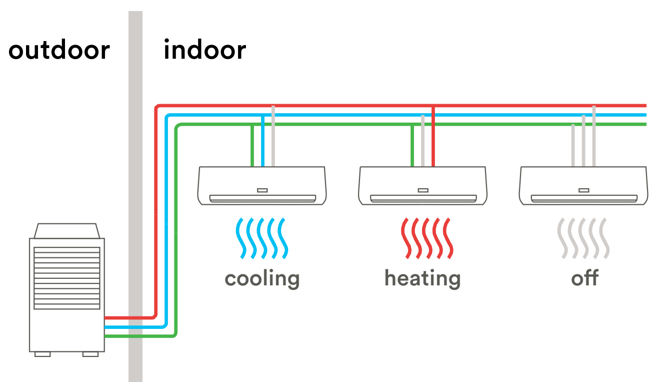
Commonly used to provide air conditioning by transferring heat from the air inside to the air outside, ASHPs can also function in reverse to provide effective heating in climates as cold as that of NYC. VRF is a type of centralized ASHP system suitable for many building types. This tech primer focuses on VRF applications for large multifamily buildings. See our *Mini-Split Tech Primer* to learn more about other ASHP options.

VRF components are modular, allowing multiple indoor units to be connected to a single outdoor unit via refrigerant lines (see Fig 1). This refrigerant piping requires minimal exterior wall penetrations compared to through-wall or packaged terminal ACs, reducing porosity that allows for heat loss or gain through the building envelope.

Outdoor units have variable speed drives that allow them to operate at the optimal rate, instead of simply at "on" or "off" functions. This reduces energy consumption and delivers greater consistency and control of interior temperature. VRF systems can be programmed with smart controls that respond to indoor and outdoor temperatures and can be adjusted to accommodate future changes to the building use or occupancy. Occupants can also adjust room temperature to their personal comfort levels using thermostatic controls on indoor units.

The VRF control system can meter individual indoor units based on refrigerant flow, enabling residents to be billed for their personal heating and cooling consumption.

Fig 1. Multiple indoor units, serving a single floor or a vertical stack, are connected to one outdoor unit via refrigerant lines. Below is a VRF system with heat recovery (see "retrofit solutions: A"), which allows different parts of the building to be heated or cooled simultaneously. This requires a third refrigerant line and additional controls.



Assess
Always consult a qualified service provider before undertaking any building upgrades.

[1]Electrification is a strategy to transition from powering building systems with fossil-fuels to electricity. Electrification is an important step towards a low-carbon future for NYC.

Coordinate Upgrades for Maximum Savings
Implementing VRF upgrades in conjunction with building envelope improvements (insulation, air-sealing, etc.) or other high-performance measures will reduce a building's heat loss and infiltration.

With an improved building envelope, it may be possible to install lower capacity VRF equipment, thereby reducing capital costs.

Plan Ahead for Success
Consider implementing a VRF system when your existing heating and cooling systems have reached the end of their useful lives, or when the building is being renovated.

Appropriate times to consider upgrading to a VRF system include when the boiler needs to be replaced, the distribution piping is leaking, or a cooling tower has failed.

how to upgrade to VRF systems

Due to the high costs of replacing heating and cooling systems, the best time to consider this upgrade is during a major renovation or at the time of equipment replacement.

retrofit solutions

There are multiple steps to retrofitting a building with a VRF system:

A Plan– When planning for a VRF system, consideration should be given to how refrigerant lines will run through the building, if and how the building should be divided into heating and cooling zones, where outdoor units will be located, and where indoor units will be installed. In buildings that require simultaneous heating and cooling, VRF offers the ability to recover heat from one side of the system and provide it to the other. Called heat recovery, this VRF option requires additional controls and refrigerant lines.

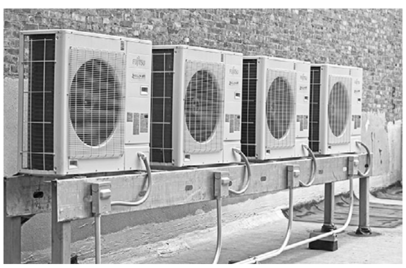


Photo: Green Star Energy Solutions, LLC

Clustered VRF outdoor units

B Determine Unit Locations– Outdoor units can be clustered together on the roof or at ground level. Indoor units can serve one room or can be ducted to serve multiple rooms.

- The placement of indoor units should avoid creating hot or cold spots in the room and ensure spaces near windows are not too cold.
- Forced air systems move air in a way that can make a room feel colder than the thermostat reads, so the placement and operation of the indoor units should not direct high-speed air onto a spot where occupants will linger, making that spot feel drafty.

C Install– Installation should be carried out by contractors with significant VRF system experience. Poor installation can result in refrigerant leaks and an underperforming system.

- Refrigerant lines must run from the outdoor unit to each indoor unit. The refrigerant can be a highly potent greenhouse gas so preventing leaks through careful installation is a top priority.
- VRF systems have maximum vertical and horizonal lengths of refrigerant piping runs. For taller buildings it may be necessary to locate outdoor units at multiple levels to service the entire height of the building.
- Condensate formed at the indoor units must be collected and piped to a drain.

Photo: Carrier Corp

VRF indoor units come in a variety of wall, ceiling, & floor mounted styles.

Design Guidelines

ASHRAE 15-2016 provides guidance on the safe design of refrigerant piping systems installed in occupied spaces based on the volume of refrigerant used in the system and the volume of the occupied space.

The refrigerant used in VRF systems is a highly potent greenhouse gas so preventing leaks through careful installation is a top priority.

Electrical Requirements

VRF systems require a 208/230V electrical service which may be available in buildings with Packaged Terminal ACs or electric resistance heaters, but may not be available in buildings with other types of heating systems.

The need for a new or upgraded electrical service should be determined early in the retrofit timeline, as it may impact the project feasibility and budget.

VRF vs Mini-Split

Centralized VRF system use only a few high capacity outdoor units, which can be installed in inconspicuous locations. Decentralized mini-split systems require many small capacity outdoor units, typically one per each indoor unit.

VRF systems require less complex maintenance and have less visual impact than mini-splits, however VRFs need long refrigerant runs, which increase the chance of leaks.

costs & benefits of VRF systems*

Greenhouse Gas (GHG) Savings

Converting a multifamily building to a VRF system can greatly reduce heating and cooling related GHG emissions, depending on the current heating and cooling system.

Tenant Experience Improvements

VRF systems dramatically improve tenant satisfaction by delivering quiet, uniform heating and cooling that can be precisely adjusted to personal comfort preferences.

Utility Savings

Although VRF systems consume significantly less energy than systems that use natural gas, fuel oil, or district steam, utility costs for operating a VRF system can be high due to the current cost of electricity. Future changes in utility costs should be considered when evaluating project feasibility.

Capital Costs

The capital costs for a VRF system conversion are very high. Installing an indoor unit in each space provides the greatest level of temperature control but comes with a high costs due to the number of indoor units, amount of refrigerant piping, and electrical work. Using one unit to serve two adjacent rooms can save money but reduces the level of control. The project cost could also be impacted if the building's electrical service needs upgrading.

Maintenance Requirements

A properly installed VRF system requires a low level of maintenance. The indoor units include air filters, which need to be periodically cleaned or replaced. Outdoor units require annual cleaning and power-washing. In order to realize maintenance savings, it is critical that a VRF system be installed properly at the outset. The system must be closely monitored for refrigerant leaks within one year of installation. Leak testing should be completed as refrigerant piping is installed, after the installation is completed, and repeated before and after the first heating season. VRF systems are technologically complex and problems will need to be addressed by a qualified contractor.

**The Costs & Benefits rating system is based on a qualitative 1 to 4 scale where 1 is lowest and 4 is highest. Green correlates to savings and improvements, orange correlates to costs and requirements. Ratings are determined by industry experts and calculated relative to the system end use, not the whole building.*

Note: Existing system assumed to be gas- fired steam boiler, steam radiators, & window ACs.

Take Action

This document is one of more than a dozen High Performance Technology Primers prepared by Building Energy Exchange and the NYC Accelerator to introduce decision-makers to solutions that can help them save energy and improve comfort in their buildings. Access the complete library of Tech Primers here:

be-exchange.org/tech-primers

NYC Accelerator is a City program that helps New Yorkers implement building energy and water efficiency upgrades to reduce carbon emissions. The NYC Accelerator provides free, individualized support for building decisionmakers to cut operating costs, meet local law compliance, access financing and boost building performance. NYC Accelerator is here to help you navigate the complexities related to local energy laws so your buildings, and our city, are more livable for all.

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This report is financed in part through the NYSERDA Cleaner, Greener Communities Program.