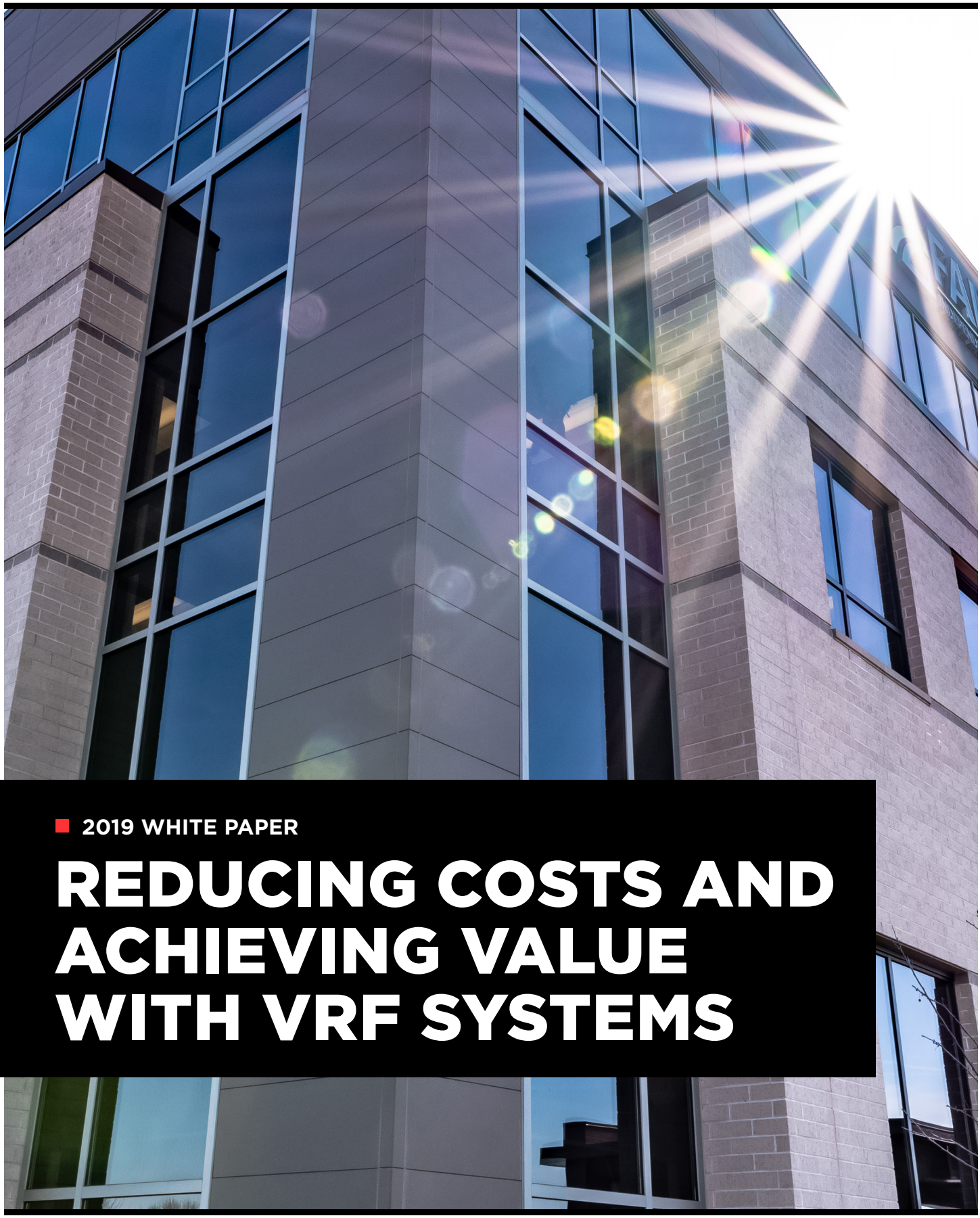


2019 WHITE PAPER

REDUCING COSTS AND ACHIEVING VALUE WITH VRF SYSTEMS

INTRODUCTION

Variable Refrigerant Flow (VRF) zoning systems solve many challenges associated with commercial construction and facility management.

VRF zoning systems contribute to sustainable buildings as they rely solely on electricity to deliver energy-efficient performance. This benefits cities, states and building owners looking to reduce carbon emissions and deal with rising energy costs.

VRF systems maintain set points specific to occupant usage and individual zone requirements. This reduces the likelihood of hot and cold "trouble" spots.

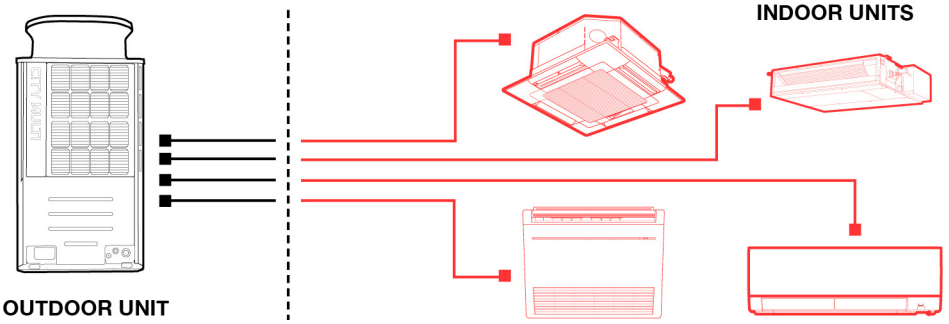
VRF systems are more compact and require less ductwork than conventional equipment. Additionally, they require fewer alterations to building facades. This smaller footprint makes them ideal for owners and developers looking to maintain the integrity of historical buildings or create rooftop entertainment spaces. The low operating sound levels mean the equipment will not disturb guests as they enjoy rooftop amenities.

These benefits drive the growing popularity of VRF systems. Lesser-known, however, are the benefits related to cost reduction or avoidance with VRF systems versus conventional systems. This White Paper addresses the mislabeling of VRF systems as "expensive" and explains how building owners can realize cost savings and create competitive advantages throughout the system's life cycle.

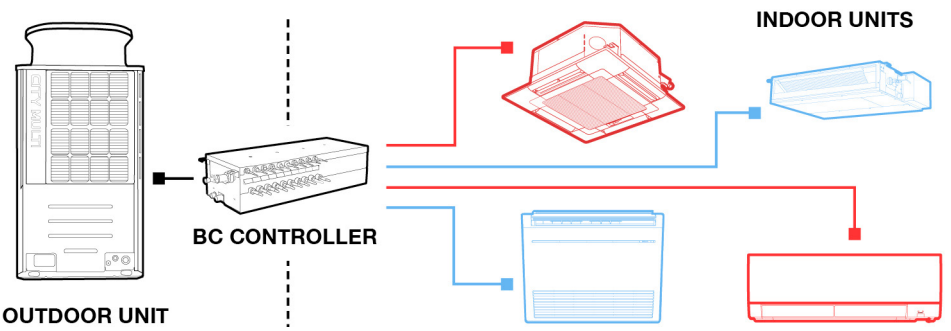
LET'S START WITH AN OVERVIEW

VRF systems provide personalized heating and cooling to **multiple zones in a building by cycling refrigerant between an outdoor unit (air-source or water-source) and indoor units in each zone via refrigerant lines**. Indoor units are available in ductless or ducted styles to match the zone's requirements or limitations. In moderate climates, HVAC contractors typically install VRF heat-pump systems. In hotels, office buildings and any facility where some zones will require heating while others require cooling, HVAC contractors will install a heat-recovery VRF system that uses a branch circuit (BC) controller to provide simultaneous heating and cooling.

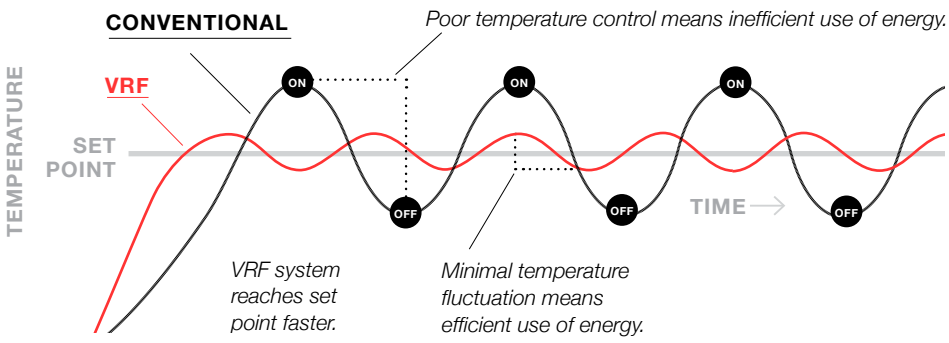
HEATING OR COOLING



SIMULTANEOUS HEATING AND COOLING



While sized to meet design temperatures, each VRF outdoor unit has an INVERTER-driven compressor enabling the system to vary capacity to match the current load. The majority of operation is during partial-load conditions, saving money by reducing **energy consumption by up to 40%** compared to conventional, fixed-capacity systems. Variable capacity enables VRF systems to precisely maintain set points without the noisy and energy-intensive start/stop cycles of conventional systems.



STREAMLINED MAINTENANCE

Once per quarter, clean coils, check electrical connections, check the refrigerant charge, inspect refrigerant lines and wash reusable filters, which last up to 10 years.

ELIMINATE COMPLEXITY

VRF systems reduce or eliminate requirements for belt changes, boiler analysis, chiller maintenance, cooling towers, filter replacements, pump seals, strainer cleaning, water treatment and 10-year overhauls.

COST AVOIDANCE WITH VRF SYSTEMS

The first opportunities to reduce costs with VRF systems emerge during mechanical design. HVAC specifiers can help developers and building owners look beyond the mechanical bid to demonstrate how VRF systems allow them to avoid costs associated with alternatives such as PTACs and Variable Air Volume (VAV) systems. The complexities of HVAC systems dictate requirements that impact the developer's first cost and total cost. For example, VRF systems allow developers to eliminate PTAC sleeves and limit wall penetrations and louver openings. VRF Systems are modular, typically requiring less design time, and are also easier to install than conventional systems. These benefits contribute to a more efficient process and provide labor cost savings.

MAXIMIZE SPACE: SMALLER PLENUMS

While VAV systems require large duct runs to move conditioned air, VRF systems utilize small-diameter piping to move conditioned refrigerant This allows for smaller plenums with reduction of space between floors. Rooms appear more spacious and **architects can demonstrate how to reduce construction costs** by, for example, designing shorter buildings with the same amount of usable space. In some applications, smaller plenums will allow developers to **increase usable space** with additional floors. Taller spaces may also provide opportunities to add windows for increased natural lighting.

MINIMIZE MECHANICAL ROOMS

VRF equipment is compact compared to conventional HVAC units and is distributed rather than centralized. **This reduces space requirements for mechanical rooms.**

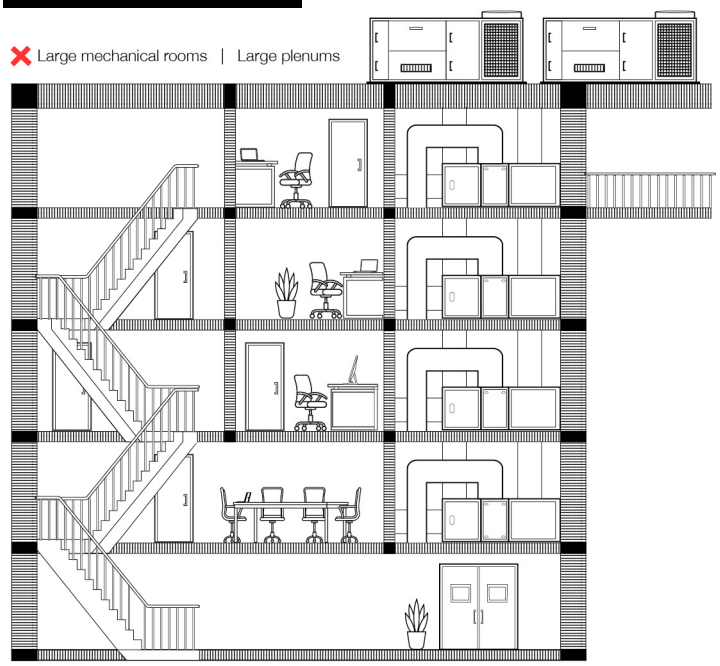
SPEND LESS ON STRUCTURAL SUPPORT

At an average weight of 70 pounds per ton for an outdoor unit, **VRF equipment is up to 30% lighter than alternatives** such as chilled water systems. This reduces requirements for structural steel and lintel beams.

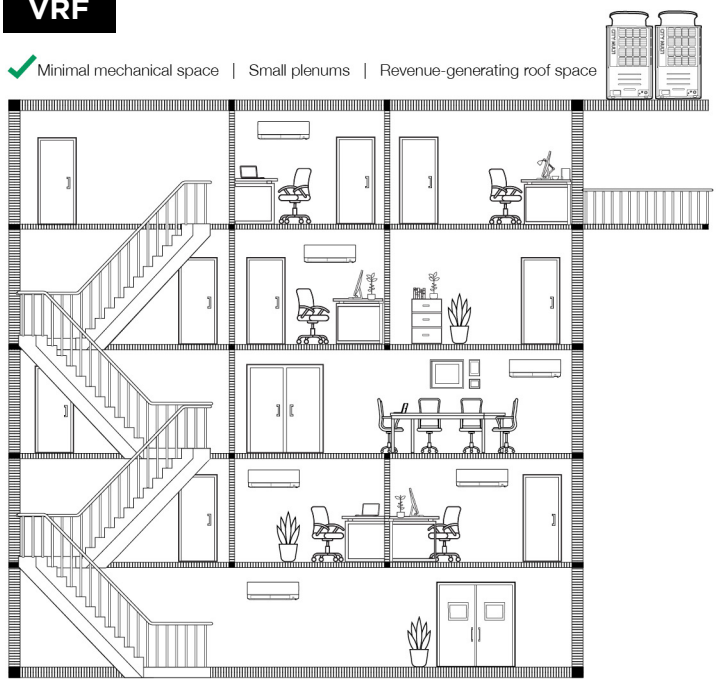
DEFER COSTS UNTIL LEASES ARE SIGNED

The design flexibility of a VRF system's modular components **mean contractors can finish out a system floor-by-floor based on tenant needs**. This allows developers to defer part of the installation costs until leases are signed.

CONVENTIONAL



VRF



CASE STUDY: NOMAD HOTEL

"Many of the existing city properties we develop are built lot line to lot line. There's no space to build a centralized plant that has cooling towers, boilers and chillers. VRF was ideal for us because we can put units on the roof that have a small footprint."

— Ryan Bean, Sydell Group

Los Angeles, CA | 14-story luxury hotel | 241 guest rooms | National Historic Landmark

READ CASE STUDY

WATCH OUR VIDEO

For additional explanation and scenarios with alternative HVAC systems, watch our video on the "Next Generation Office Building" available on YouTube.

VAV AND VRF SYSTEMS IN A NEW CONSTRUCTION OFFICE BUILDING

The following comparison based upon a 3-story, 78,000-square-foot office building in Wisconsin illustrates how the developer's **per-square-foot costs for a conventional VAV system can be higher than those for a VRF system**. This is despite the apparent premium paid for high-efficiency VRF technology if only the mechanical bid is considered.

VAV SYSTEM	COST	COST PER/SF
Equipment and Ductwork	$713k	$9.59 per/sf
Screening (350 feet)	$85k	$1.09 per/sf
Electrical	$45k	$0.58 per/sf
Structural Steel	$20k	$0.26 per/sf
Total Developer Cost	**$863k**	**$11.52 per/sf**

VRF SYSTEM	COST	COST PER/SF
Equipment and Ductwork	$810k	$10.38 per/sf
Screening (160 feet)	$55k	$0.71 per/sf
Electrical	$65k	$0.83 per/sf
Structural Steel	$10k	$0.13 per/sf
Reduced Plenum	-$78k	$-1.00 per/sf
Total Developer Cost	**$862k**	**$11.05 per/sf**

ENERGY ALLOCATION AND EFFICIENCY

If the building owner bills tenants for energy consumption, or needs to bill for usage in excess of projected consumption, energy-allocation controls applied with VRF systems provide the ability to track the energy usage of individual tenants. This solves the challenge of billing for energy consumption in facilities with multiple tenants. For office buildings where the projected energy usage and utility bills associated with each tenant are incorporated into the monthly rent, the energy efficiency of VRF systems creates opportunities to offer more competitive leases with minimal impact to profit.

To help HVAC contractors and project teams show building owners the financial impact of energy use reductions, VRF manufacturers and energy performance consultants developed analysis tools to reliably predict how a building will perform with a VRF system in comparison to existing and alternative HVAC systems. For example, the CITY MULTI® Efficiency Evaluator, developed by The Weidt Group with Mitsubishi Electric Trane HVAC US (METUS), calculates projected energy use, life cycle costs and LEED® points for a building based on multiple factors. The analysis helps building owners easily identify the efficiency-related financial benefits of installing a VRF system in a facility. This information is also useful when researching utility company incentives to offset the cost of an energy-efficiency investment.

CASE STUDY: 101 BEDFORD

"We didn't need shafts throughout the building to run lots of pipe or ductwork because there are no gas pipes, hot water pipes, flue pipes or chimneys. With fewer roof penetrations, there was more roof space for recreation."

— Josh Kalimi, Ener-Con Technical Services

Brooklyn, NY | 340,000-square-foot multi-family building | 351 luxury apartments | Rooftop amenities

READ CASE STUDY

REAL WORLD IMPACT

In New York City, Local Law 97 sets limits for the metric tons of CO_2 a building over 25,000-square-feet can produce per square foot. Building owners will be fined if CO_2 emissions for their facilities exceed the limits established for their category of building.

SUSTAINABILITY AND COMPETITIVE ADVANTAGES

Not all developers and building owners will immediately recognize the benefits of lower bills and overall reduced energy usage. If tenants are responsible for utility bills, some will look at the capital costs associated with VRF systems and decide there is little value in paying for an HVAC system known for its efficiency if systems with lower mechanical bids are available. Building owners will look past the mechanical bid once they comprehend the benefits of VRF systems over conventional systems. If they're still unsure of the comparative advantages relative to first cost, they should consider the indirect benefits of certified sustainable buildings. According to recent studies, potential benefits include increased rental rates, higher occupancy rates and greater tenant satisfaction and retention.

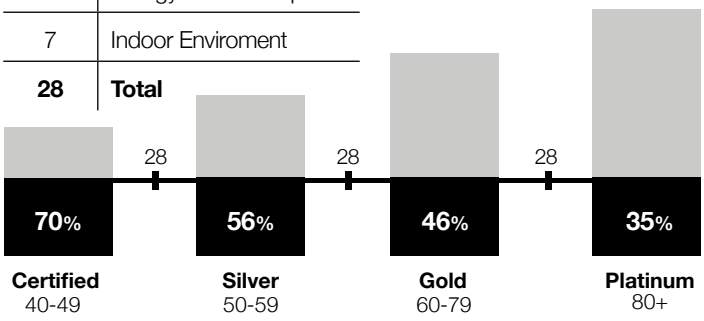
Based on 10 years of financial performance data for the **Bentall Kennedy** office building portfolio, which includes 34 million-square-feet of commercial space in the United States, a study published in the September 2015 issue of the *Journal of Portfolio Management*, showed the following:

- Higher net-effective rents: **3.7% higher** for LEED-certified properties compared to similar non-certified buildings
- Higher occupancy rates: **9.7% higher** for buildings with **ENERGY STAR®** certification compared to non-certified buildings

VRF systems contribute to the certification and marketability of high-performance buildings as "sustainable." Application of VRF technology can contribute up to 21 points in the Energy and Atmosphere category and up to 7 points in the Indoor Environment category when a building is evaluated for LEED certification. As presented earlier, VRF systems can vary capacity, reducing energy consumption and costs. This ability is especially applicable for tightly-constructed facilities certified as zero-net energy (ZNE) or passive house. Fixed-capacity systems are prone to short cycling in low-load environments.

VRF AND LEED POINTS

Points	Category
21	Energy and Atmosphere
7	Indoor Enviroment
28	**Total**



COST SAVINGS THROUGH DECARBONIZATION

In addition, the reduction in carbon dioxide (CO_2) emissions that comes with electric-powered VRF systems can help building owners keep their facilities attractive to tenants and prospective buyers. Public and private initatives toward decarbonization coupled with the cost of energy **are driving more stringent building codes and legislation.** VRF systems are uniquely positioned to help building owners meet CO_2 reduction goals while lowering utility costs. They're designed for extended life cycles providing sustainable performance well into the future.

CONCLUSION

Modern construction requirements, decarbonization efforts and rising energy costs position VRF technology as the primary heating and cooling method of the future. Total-installed-cost advantages plus the comfort and performance benefits should help developers and building owners choose VRF systems as the preferred HVAC technology of today. With more complete consideration for how VRF systems compare to conventional systems in terms of overall requirements and impact on a building, HVAC specifiers can easily explain the opportunities VRF systems create for reducing costs, avoiding costs and creating competitive advantages.