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VARIABLE REFRIGERANT FLOW (VRF): A LEADING ENERGY EFFICIENT HVAC SYSTEM

Written By Gibran Michel, Associate and Senior Mechanical Designer

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Variable Refrigerant Flow (VRF) A Leading Energy Efficient HVAC System

Variable refrigerant flow (VRF) is a type of air-conditioning system that adjusts refrigerant flow to different areas of a building as needed, based on heating or cooling demand, instead of distributing large quantities of refrigerant at all times. This technique creates practical zoning, giving occupants the ability to adjust their space to the preferred comfort level. For schools, hotels, and offices, the flexibility and efficiency of the VRF system makes it an up-and-coming choice for both new and old commercial buildings.

Although VRF systems have been installed in numerous applications throughout Texas for several years, it is still a relatively new technology for the U.S. Introduced over two decades ago in Japan and since maintaining a large presence in European markets, VRF has started to become a preferred HVAC solution for commercial building owners that are looking to renovate or build. Like other HVAC options, VRF systems have their advantages and disadvantages that are dependent on many factors including a building's age, type, location and the project budget. By taking a deeper look into the capabilities of VRF, owners can determine if a VRF system can be of benefit to their building project.

Advantages of the VRF system:

Energy Efficiency

According to the U.S. Energy Information Administration, about 39 percent of total U.S. energy consumption in 2017 was consumed by the residential and commercial sectors[1]. As companies are beginning to pursue energy efficient HVAC choices, VRF systems are an option to meet their environmental objectives. The VRF system has a variable speed compressor that can adjust throughout the day as the building's heating/cooling load changes. In other words, it can put the refrigerant where it is needed, when it is needed. Unlike conventional direct expansion (DX) equipment that brings the compressor(s) on and off as the thermostat calls for heating/cooling (i.e. full capacity, two stage, or multi-stage, depending on the tonnage of the equipment), VRF compressors can vary the speed from as little as 4 percent up to 100 percent, and anywhere in between. Doing this allows the system to have part load efficiency ratings (EER) well into the 20s and 30s, which is more than double of any other system on the market. According to a report by the General Services Administration, VRF systems can achieve 30 percent and higher HVAC energy cost savings relative to both older, inefficient systems and conventional compliant systems[2].

Depending on the type of VRF system used, it can have the capacity to remove heat from one area and transfer it to other parts of the building, and can also be utilized for domestic water heating. Known as heat recovery, this is an optional component that can be added to VRF in order to further increase energy efficiency and ensure that electric heat does not need to be used as a heating supplement.

1 (2018, May 3). Frequently Asked Questions: How Much Energy is Consumed in U.S. Residential and Commercial Buildings. Retrieved from https://www.eia.gov/tools/faqs/faq.php?id=86&t=1

2 Thornton, B., & Wagner, A. (2012, December). Variable Refrigerant Flow Systems. Retrieved from https://www.gsa.gov/cdnstatic/GPG_Variable_Refrigerant_Flow_12-2012.pdf

Flexibility

VRF systems have several indoor unit types to choose from, including ceiling mounted, wall mounted, low profile ducted, high static ducted, floors, residential style air handlers, and more. Depending on the type of building, VRF systems allow owners and users the ability to have multiple types of indoor units all on the same system that work together effortlessly. Used in the right application, this can allow for higher ceilings and open floor plan concepts.

VRF systems also allow for flexibility in how much ductwork is used. The reduction in overall ductwork versus conventional HVAC systems can be staggering. While it can still be utilized, some units need little to no ductwork which makes this an ideal option for older buildings that may not currently have much ductwork.

Exterior Equipment Space

The VRF system utilizes heat pump condensing units that range in size from 1.5 tons up to 18 tons. Once systems go beyond 18 tons, the condensing units can begin to be paired together up to 54 tons, totaling three condensing units. The footprint and weight of a VRF 54-ton set of condensing units is considerably less than a packaged rooftop unit or air-cooled chiller of that tonnage.

Renovations

Many older buildings have low ceilings that were once installed to conceal ductwork and other related air conditioning systems. With VRF, these ceilings can be raised, and buildings can be brought back to their original aesthetic. For owners that have an existing chilled water system with central air handlers, the VRF system condensing units can replace the equipment at the central plant and connect to the existing air handlers by replacing the chilled/heating water coils with direct expansion coils.

Disadvantages of the VRF system:

Initial Cost

Although popular in other parts of the world, VRF is still generally new to the U.S., and even newer to North Texas. These systems may cost more upfront compared to conventional HVAC options. While the initial cost may be more expensive, VRF systems can reduce energy costs over time and have a long-term savings effect, and the installation cost per ton is comparable to chilled/heating water systems. Like any project, once the reduction in building electrical requirements, structural supports, and ceiling space are considered, the impact of the implementation of a VRF system to the overall project cost can be reduced.

Outside Air Requirements

The typical VRF systems are not intended to be used for applications where a high amount of outside air is required. In these applications, a separate outside air unit would be needed to condition the required amount of outside air and deliver that air to the intended spaces.

Condensate Piping

Having multiple indoor units will also require condensate – liquid formed by condensation – to be drained from each one. Depending on the applications of the units, finding places to dispose of condensate can become complex and require planning ahead of time.

A Unique Approach to Staying Cool

VRF continues to grow in popularity in North Texas and surrounding areas due to its multiple benefits including energy efficiency, capabilities of an improved zoning layout, and user comfort. As Variable Refrigerant Flow systems become more common, initial installation costs will decrease, making it even more likely that VRF will be the optimal system to use on both new and old buildings. Check out the project features below to see some of the recent VRF projects BHB has worked on, and how the system benefited each building in a unique way.

University United Methodist Church: A New Addition to an Old Classic

Located just a few blocks from Texas Christian University, University United Methodist Church preserves a piece of Fort Worth history and gives the modern neighborhood some classic charm with its white building and red-roof trim. Founded over 100 years ago, the congregation's main sanctuary was built in 1949 – and is still being used for worship today.

With a building that is nearly 70 years old, deterioration and aging of the HVAC system comes with the territory. The sanctuary originally had a chilled water system with an air-cooled chiller and a hot water boiler – both of which were starting to fail. When the church staff decided it was time to update the heating and cooling in the sanctuary, they enlisted the help of Baird, Hampton & Brown to find the option that would best benefit the building while also reducing operating costs. Unlike most older buildings built in the early 20th century, University UMC's existing HVAC system had ductwork, which meant that it could be reused when installing the new system. Although using little to no ductwork is often a benefit of using VRF, there was different reasoning and other benefits for why VRF was ultimately chosen for the sanctuary.

"We needed to provide both heating and cooling, and if we used a conventional split system we would have to provide a lot of electric heat, but the church didn't have enough electrical capacity," stated Les Brown, Senior Associate and Senior Mechanical Engineer at BHB. "We decided to go with VRF because it has higher efficiency and uses a heat pump to provide heat during low, outdoor temperatures."

While a conventional heat pump can efficiently heat a building with an outdoor temperature of 30 to 40 degrees, it requires electric heat as backup. The VRF straight heat pump, however, can provide heating at even lower outdoor temperatures without requiring any electric help. This option not only lowers operating costs for the church and negates the use of electric, but the outdoor VRF unit is also much quieter than a conventional system. The choice to go with VRF also simplified the sanctuary's heating and cooling equipment requirements. Instead of having a chiller and boiler each with their own pumping systems, they now have two split systems, each with one outdoor condensing unit and one indoor air handler unit. Unlike the VRF heat recovery option, the University UMC sanctuary utilizes straight heating or cooling, meaning one indoor unit is connected to one outdoor unit to provide comfortable heating throughout the building.

"VRF heat pumps are very efficient and reduce operating costs," said Brown. "It allowed us to heat the sanctuary without any electric heat, and that was the main benefit for this building."

Just like the building itself, the reasons for implementing a VRF system in the 69-year old sanctuary are unique due to its age and electrical parameters. The project was successfully completed in August 2018, and just like before, the building continues to provide a place of worship for University United Methodist Church.

The Sinclair Building: A Modern Twist to a Historic Structure

In the heart of downtown Fort Worth, the Sinclair Building is hard to miss. Located just steps from Sundance Square, its distinct geometric patterns and exquisite art-deco design are a small piece of early 20th century history that seems to slow time down in this modern "hustle and bustle" era. Built in 1929, the Recorded Texas Historic Landmark is about to become one of the most technologically advanced hotels in the world, while also being restored to its original ambiance and dramatic elements designed over 89 years ago.

With the project set to be complete in 2019, the building will become simply known as The Sinclair, a Marriott Autograph Collection hotel. BHB has been providing MEP engineering services for this project since 2014, and every aspect has been thoughtfully planned and coordinated so that the hotel will be considered an "intelligent building." The old office building will soon be a 164-room upscale hotel to create a one-of-a-kind experience for guests, including Power over Ethernet (POE), which is the process of carrying electrical power through network cables, that will enable lighting, video analytics, and more. With these renovations, BHB's scope of work includes replacing the building's traditional chilled and heating system with a VRF system due to several different benefits and factors. Back when the original HVAC system was added to the building, the ceilings were lowered and the windows were covered up to add the ductwork, making the interior dark and almost cave-like. Because a VRF system doesn't require as much space as a traditional unit, the original floor-to-ceiling heights have been brought back and the ornate windows on the lobby level are now restored. An added benefit is that VRF is the most energy efficient system on the market, and since energy conservation is a requirement in part with the building's renovations, the choice was clear.

"We want to bring the ambiance of an early 20th century building back to what it was before, and the VRF system is helping us do that," stated Gibran Michel, Associate and Senior Mechanical Designer at BHB.

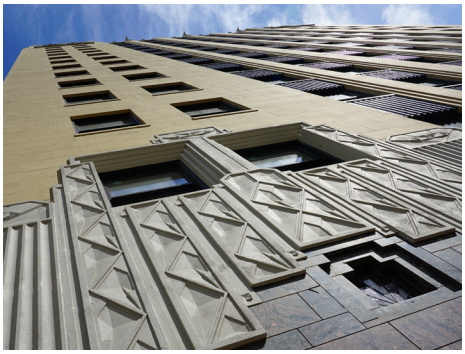
Sinclair has multiple systems in place, including VRF, that will be controlled from one platform – allowing the technology throughout the building to be easily monitored. The disparate systems all work together in order to create a unique and individualized experience for each guest.

"The VRF system can communicate with the other controls in the building that make it intelligent. So, in essence, a hotel room's AC unit will respond to the person who walks in the room and automatically know what setpoint temperature they are looking for," said Michel.

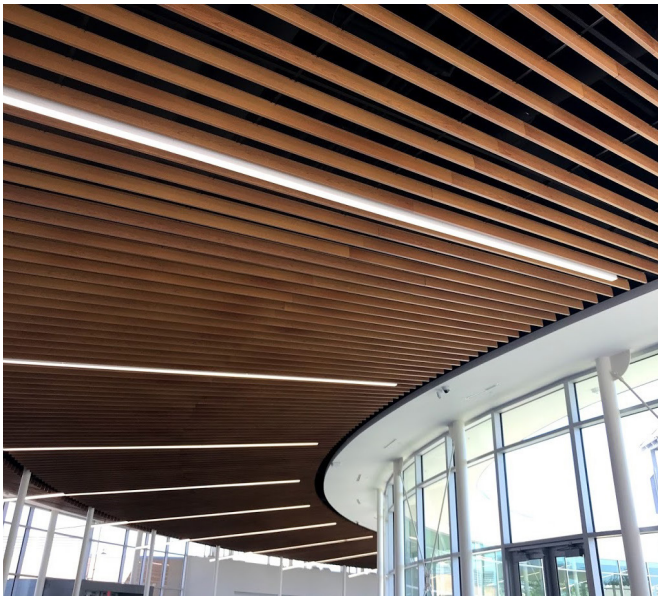
In fact, the hotel will recognize recurring guests and know their preferred settings such as what their ideal room temperature is, what shows they like to watch, and how bright or dim they like the lights – features seeming so futuristic that are now a reality. The Sinclair Building is BHB's largest VRF project. With more than 200 interior units, the system has a heat recovery feature that allows refrigerant to be exchanged to different indoor units so that one can be cooled, while another can be heated. Unlike most systems that have outdoor units on the roof of a building, Sinclair's units are located on mezzanines in the alley to create space for a rooftop bar.

"This will be the first building in America that has this type of smart technology system," said Michel.

By blending aspects of two separate centuries, the Sinclair Building is in a category of its own and will set precedents for not just boutique hotels, but the future of "intelligent buildings." What was once a structure that lost its stylish look and feel, the Sinclair Building is now restored to its original decadence with a modern twist that Fort Worth residents and visitors can enjoy.



Sellers & Campbell Union: VRF Addition to a Campus with Multiple HVAC Systems



All Saints' Episcopal School (ASES) in Fort Worth, Texas is a college preparatory day school with an impressive 147-acre campus that serves students ages 3 to 18. Since 2000, Baird, Hampton & Brown has provided mechanical, electrical, and plumbing engineering services for ASES, with projects including new classroom buildings, a performance center, gymnasium, stadium press box, chapel expansion and most recently, the addition of a student union that connects the Early Childhood Center, Lower, Middle, and Upper schools.

The Sellers & Campbell Union is not only unique because of its sleek, curved architecture, but it also uses a variable refrigerant flow (VRF) system to heat and cool the building, while preserving energy in the 29,600 square-foot space. The other buildings on campus utilize a mixture of Geothermal, DX rooftops and Chilled Water Systems. For this addition, Geothermal was ruled out due to a lack of available land to drill wells, the existing chilled water systems are at capacity, and DX rooftop units were deemed unsightly. Instead, the team decided to use VRF because of its higher efficiencies resulting in long-term electrical savings for the school and its ability to be flexible with the architectural design. VRF is ideal for projects with limited ceiling space due to the small size of the indoor units and the minimal amount of ductwork required. Since the student union has sloping, wood-slat ceilings, VRF was deemed the perfect complement to the design's intent.

The student union project began in 2016, and by August 2018, the building was complete and ready for the new school year. The building's VRF system consists of 29 indoor fan/coil units above the ceilings, and nine outdoor heat pump units located on the roof. VRF indoor units have ducted and ductless options, and while the student union uses both depending on the area of the building, they all work together seamlessly. Each indoor unit can individually send a signal to the outdoor unit, which then delivers the right amount of refrigerant needed. This allows heating or cooling capacity to be supplied to each unit without large variances in room temperature. Like the rest of the campus, the student union is now connected to the school's BCS (Building Control System), provided by Enviromatic Systems. This allows the owner to monitor and adjust all HVAC systems in every building from one computer.

One significant challenge on this project was how to provide the code required amount of outside air to a space that may seat up to 360 students for lunch.

"The outside air requirement is based on the maximum number of people plus square footage," said Sean Rath, Project Manager and Mechanical Designer at BHB. "The solution utilizes three dedicated 100 percent outside air units, one on each of the flat roof areas connecting the union to existing buildings. Each unit provides neutral temperature (72 degrees Fahrenheit) fresh air to the space and is capable of dehumidification to maintain the space at 50 percent RH (relative humidity). Ducting outside air to each of the 29 indoor units was not a practical option."

The system was commissioned this past August and was immediately able to reap the advantages of VRF. The system was sized for August afternoons, North Texas' hottest time of the year, but when outside temperatures are lower, the VRF system compressors and fans decrease in rate to use only the necessary amount of energy needed to properly heat or cool the space.

"VRF Systems can ramp down and save energy," said Rath. "When the VRF is at half speed, it is actually using less than half of the electricity, so there are significant energy savings at part-load conditions."

HVAC Systems Used at ASES

VRF: Adjusts refrigerant flow to different areas of a building as needed, based on heating or cooling demand

Geothermal: Provides heating or cooling by transferring heat to or from the ground.

Direct Expansion (DX) Rooftops: Cools spaces by absorbing heat from an evaporator coil.

Chilled Water: Cooled water is piped through a building via connected air handlers.

This is where the VRF's energy efficiency shines brightest. A VRF system can maintain different temperatures in various areas of the building, using the minimum amount of energy. The air flow and refrigerant flow ramp up and down to meet the exact heating or cooling load in each space.

Another added benefit of this particular VRF system is the heat recovery feature. This option allows heat that is absorbed from one space during cooling mode to be transferred to another space that is calling for heating. During this mode, the heat pump will respond to simultaneous heating and cooling calls by varying the compressor speed to pump the refrigerant through the system. A signal is then sent to a refrigerant selector box so that hot refrigerant from a space that is in cooling mode will be sent to a space that is calling for heating, instead of sending the hot refrigerant back to the condensing unit to be rejected to the atmosphere. This can be considered free heating and cooling since neither gas or electric heat is being used.

Now that the Sellers & Campbell Union is being used daily, All Saints' Episcopal School can take full advantage of a new HVAC system that will provide a comfortable environment, as well as offer maximum energy savings.

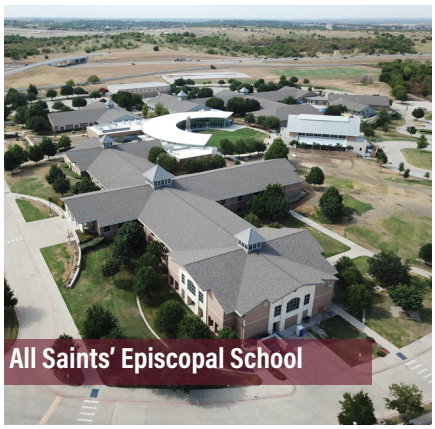
Our VRF Experience


St. Martin de Porres


Alagasco Building


Sinclair Building


Texas Masonic Retirement Center


All Saints' Episcopal School


UTA DED Technical Training Center


Richardson Fire Training Center


University United Methodist Church


Mira Vista Country Club

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