VRF Heat Pumps In The Real World

Wide temperature swings, submetering deficiencies, bloated carbon footprint … these are but three of the problems tackled in two contrasting projects in the Northwest.

By Marcia Karr

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FIGURE 1. The Little DeSchutes Lodge, a senior living facility in Oregon, employed VRF technology, which brought utility costs down to $37 per unit.

How is variable refrigerant flow (VRF) working for you? We asked a number of people that question and summarized the findings from two typical facilities here.

The first case is a new construction, multi-family, low-income housing project. The second was a very poorly functioning office building that needed to be remodeled without displacing the workers. Both design teams had their work cut out for them. Both facility owners were exceptionally progressive in their energy demands.

THE LITTLE DESCHUTES LODGE

The Little Deschutes Lodge is an affordable housing project for seniors in La Pine, OR. It is a 28,000-sq-ft, 26-unit complex with on-site laundry, a community room, community dining with kitchen, a reading room, and two computer centers.

For affordable housing to be viable, operating and maintenance costs need to be as low as possible so property owners can hedge against rising costs for utilities, operations, and maintenance. And because most affordable housing is sponsored and/or developed by non-profits, the owners need to be able to cover all of their operating expenses, including debt coverage, so they do not lose money.

Having a very energy-efficient HVAC system can go a long way to help achieve these goals. This is especially important in light of the fact that property owners can only raise rents to the extent that the area median income (AMI) of the county increases on a per-centage basis.

Even with its generous amenities and features, the total monthly gas and electric bills for the facility came to only $37 per month per apartment. With a ground-source VRF heat pump system, the facility is nearly net-zero energy.

The Little Deschutes Lodge's energy use intensity (EUI) score is only 29 kBtu/sq-ft/yr, compared to about 70 kBtu/sq-ft/yr for an av-erage dorm unit, as The Little Deschutes Lodge calculated using Energy Star's Portfolio Manager. This project has a Portfolio Manager score of 95, modeled as a dorm. A high score like this means this facility performs much better than the national average for this type of building.

A PROGRESSIVE DESIGN TO MEET THE OWNER'S NEEDS

The facility owner, Pacific Crest Affordable Housing LLC, had the following requests:

- A design that provided clean, comfortable amenities at the lowest operating cost;
- Low utility bills and low maintenance expenses;
- Reduced energy consumption that would pay back for the life of the facility.

VRF seemed like the right way to go to deliver these outcomes. Even though VRF has a relatively higher first cost over other tech-nologies, the whole building cost is relatively untouched. Because VRF is so efficient, electrical first costs are lower. And the structural and architectural costs are lower because VRF is lighter and takes up less space.

When selecting ground source VRF for the Little Deschutes Lodge, the owner and the design team had to consider some temperature issues. The outside air temperatures in La Pine range from a record low of -40°F to a record high of 104°F, with design temperatures between 18°F and 82°F. Because the actual outside air temperature can be colder than the temperature at which an air source heat pump can operate (-20°F), the decision was made to go with ground source VRF so that auxiliary electric strip heat would not be needed.

The design team created a distinctive facility with direct hard costs of only about $115/sq ft — an exceptional value for a new facility with geothermal that exemplifies the financial value of VRF. The mechanical system for the Little Deschutes Lodge was designed by SOLARC Architecture and Engineering Inc., in Portland, OR.

TRENCHING

The ground-source system necessitated the added cost for trenching, specifically 28 horizontal trenches, each approximately 150 ft long; the header piping is buried at a depth of 6 ft and the trench piping is buried at a maximum depth of 9 ft. There are 600 ft of 1-in. pipe per trench, with four pipes spaced evenly in a 3-ft-wide trench. The trenches are spaced 12 ft on center. The overall area of the piping field is approximately 50,000 sq ft.

HEAT PUMPS AND VENTILATORS

The equipment needed for this facility included:

- Four heat pumps (Mitsubishi City-Multi PQRY P96TGMU, 8 tons each) to serve the apartments, office, reading, and fitness rooms;
- One Florida heat pump (ES-070, 6-tons) to serve the community room and kitchen;
- One 300-cfm ERV to serve the community room and kitchen;
- One 800-cfm ERV to serve the rest of the building.

DUCTED FAN COILS

The mechanical code has a requirement for maximum refrigeration per space. If each room were designed with a ductless fan coil, and that fan coil leaked so all of the refrigerant in the system leaked into the room, the allowable refrigerant levels may be exceeded. To eliminate the possibility of exceeding acceptable refrigeration limits, the apartments in this facility are supplied with ducted fan coils to increase the volume of space per fan coil. Ductless fan coils are in the larger common spaces.

WATER-HEATING COMPONENTS

One of the most economical methods for generating hot water is with a desuperheater. The Little Deschutes Lodge design includes a potable hot water storage tank sized to allow a desuperheater to preheat the hot water. The VRF system can also provide a booster heater to heat water to 160°F.

Because this project is located in an area that sees a lot of sunshine, the design also includes a solar thermal system that is thermally connected to the ground loop to take advantage of solar energy whenever possible.

PUT LOW ENERGY HOUSING ON ANOTHER LINE

- The U.S. Department of Housing and Urban Development (http://portal.hud.gov/hudportal/ HUD?src=/about /mission) supports the development of affordable housing.
- The goal for residential housing should be net-zero energy, as set forth in this article produced for the U.S. Department of Energy by the National Renewable Energy Laboratory, "Moving Toward Zero Energy Homes" (http://www.nrel.gov/docs/fy04osti/35317.pdf).
- Some studies show (www.energystar.gov) that utility costs represent the single largest controllable cost in an apartment community — typically accounting for 25% to 35% of the monthly cost. Reducing energy use by 15% in a typical 250-unit master-metered community will increase net operating income and can enhance asset value by over $1 million (using a 6% capitalization rate). In a similarly sized individually metered community, these same savings may increase asset value by over $200,000 annually.

LEWIS COUNTY PUD

The Lewis County PUD in Chehalis, WA, is a two-story, 23,700-sq-ft office building originally built in the 1940s.

The HVAC system was a hodgepodge of packaged and split systems. The current energy consumption was about average, but the building occupants were uncomfortable because the building was not properly heated. Temperatures were very inconsistent throughout the spaces, moisture was not controlled and odors were a problem. The occupants of the building – a team running the publicly owned utility – needed to set an example of energy efficiency and wanted the building to be more comfortable. The new HVAC system had to meet the following criteria:

- Increase zoning for better comfort;
- Quiet operation;
- Submetering capability;
- Allow building to remain occupied during construction;
- Allow phased installation;
- Reduce carbon footprint;
- Keep hard ceilings intact;
- Provide control system that is simple and easy to operate;
- Use existing supply/return duct for DOAS with a heat recovery unit.

A PROGRESSIVE DESIGN TO MEET THE TENANTS' NEEDS

The Rice Group (Seattle) was the mechanical design firm tasked with meeting the building occupants' impressive list of requirements. The Rice Group engineer needed to provide a Class A HVAC system without disrupting the day-to-day operations or cutting into existing construction. The engineer considered HVAC systems with VAV, water-source heat pump, single-zone splits (which would have required energy inefficient auxiliary electric strip heat) and VRF. He concluded that the only system that could meet all of this customer's expectations was VRF.

VRF ADVANTAGES

When comparing the first cost for the HVAC options, VRF came in the highest. However, after considering the additional electrical, ductwork, structural and architectural implications with the other systems, as well as the disruption to work activities for the building's occupants, VRF was determined to be the best choice for this remodel. VRF is the easiest to coordinate work of the different trades in a building because the VRF system does not require large ductwork or significant structural or architectural accommodations.

The VRF system has 54 independent temperature zones with a total of 76 tons of nominal cooling capacity. Unlike a VAV system, the VRF rooftop condensing units are easily situated on the roof and did not require any structural upgrade to the building. The ductless fan coils fit into the existing spaces without needing to open up the hard ceilings. No auxiliary heat is needed, but the engineer was careful to de-rate the heating capacity to outdoor design temperature of about 20°F.

He also sized his equipment using the sum of the peaks.

The ventilation air used the existing ductwork, and a heat recovery ventilator (HRV) was added to improve efficiency. The DOAS provided the ventilation air needed for each space, and the HRV tempered this air. The engineer also equipped the heat recovery unit with demand control ventilation. Because the building has operable windows, this design also took advantage of the building code provision to allow the required ventilation to be provided naturally or mechanically.

The control system from the VRF manufacturer has optional analog and digital input/output controllers to operate other equipment such as fans and pumps. In addition to allowing for the ability to monitor and trend each heat pump for tenant billing, the sub-metering also provides information on HRV effectiveness, outside air temperature and humidity, and CO2 levels.

This project is a good example of energy code exceptions for airside economizers. This building has great potential to transfer heat from warm zones to zones that need more heat. The internal/external heat recovery capability of VRF was estimated to save 5,600 kWh/yr.

HAPPY TENANTS

The tenants are comfortable with the HVAC remodel. The contractors and building owners are happy with VRF because callbacks after turnover are minimal.

MODERN TECHNOLOGY REQUIRES SPECIFIC TRAINING

One final note: many technologies may look like older technologies, but are actually quite different and require specialized training. Many new and evolving energy efficient technologies have come to market in the last decade, and every technology has nuances. When contractors incorporate a new technology into their portfolios, they should ask the technology manufacturer to provide training in using that technology.

Just as fuel injection replaced carburetors and condensing boilers will likely replace standard efficiency hot water boilers, VRF will likely own a significant part of the HVAC market in a very short time. And just because a mechanic can work on carburetors, it does not automatically follow that the mechanic will also be able to work on fuel injectors — especially if they do not receive specific training.

New technology introduced today will continue to evolve. Therefore, training from the manufacturer should be part of the construction contract. ES

Karr is an energy engineer with the Washington State University (WSU) Energy Program. She has over 30 years of experience in commercial building design, construction, and maintenance. Her positions have included code plan reviewer, union trades manager, design/build engineer, field construction engineer, and project coordinator, HVAC/plumbing designer (commercial, institutional and residential), and project engineer. Karr has a Bachelor of Science degree in mechanical engineering and is a licensed Commercial Buildings Energy Code (NREC) Plans Examiner.

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