E3T Energy Efficiency Emerging Technologies

WASHINGTON STATE UNIVERSITY EXTENSION ENERGY PROGRAM

EMERGING TECHNOLOGIES SHOWCASE WEBINAR:

VARIABLE REFRIGERANT FLOW (VRF)

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Question and Answer session [with additions]

Q: Does 20-30% higher cost include dedicated outside air system?

A: Yes, this is for the mechanical system as a whole. That is part of the cost. [Also, as people are getting more comfortable with the technology, the prices are coming down.]

Q: The temperature fluctuation for a typical system is modulated by cycling, rather than continuous modulation e.g. Variable Air Volume (VAV). Is this correct?

A: The zonal temperature control slide illustrates temperature fluctuations resulting from equipment that only has on/off capability. For these systems, the compressor cycles on and off, causing fluctuations in the room temperature.

Most VAV systems have single-speed compressors. However, there may be multiple compressors that can minimize the temperature fluctuations. For example, instead of having a 50-ton compressor switching off and on, there may be five 10-ton units that are staged on and off. The temperature fluctuations can be minimized even more with a variable speed compressor; so VRF technology gives you the flattest temperature curve. Variable speed control could also prolong the life of the compressor since ramping up the compressor is easier on the equipment than constant cycling with hard starts.

Q: Is there a Coefficient of Performance (COP) rating for these units, similar to heat pumps?

A: For VRF systems less than 65,000 Btu/h, the Heating Seasonal Performance Factor, or HSPF, is used to rate heating performance. For VRF systems greater than or equal to 65,000 Btu/h, Coefficient of Performance, or COP's, are used to rate heating performance. A directory of AHRI ratings can be found at: http://www.ahridirectory.org/ahridirectory/pages/vrf/VRFDirectory.pdf. This directory includes heating and cooling capacities, as well as the Energy Efficiency Ratio, or EER, and the Integrated Energy Efficiency Ratio, or IEER.

Minimum performance is defined by ASHRAE 90.1, 2010, which have been adopted by the Department of Energy, the Consortium for Energy Efficiency and Energy STAR.

Q: How effective are the filtration systems of the ductless heat pump?

A: The DHP are only coming in with a MERV 8 at this time. If you need to get a better MERV rating on your equipment , there is an option to put a filter module on the ducted models, which will get better filtration.

Q: In cold climates, can a VRF building recover from an extended outage?

A: It depends on the system; some manufacturers offer a 'low ambient' model, which delivers 90% nominal capacity at 0°F, with a COP of 2.6. All equipment performance varies with outside air temperature. For example, heating capacity and performance drops as the outside air temperature gets colder. You need to make sure you're sizing your equipment for that condition. In lab testing, VRF systems without extra "low ambient' features, have performed very well at ambient temperatures down to -20°F. So, if the power outage is during a cold spell, VRF systems should recover better than air-source heat pumps. Also, due to the variable speed capability, VRF systems sized for extreme outside air temperatures won't operate at full capacity when it's not at peak design conditions .

If the question is about the control system recovering after an extended electrical outage, or if the system can reset and recover satisfactorily – the answer depends on the manufacturer. Some have the ability to be reset remotely.

Q: Have you seen VRF systems operate effectively without backup heat?

A: VRF systems are tested down to 17° F, some systems have 90% capacity down to 0° F. Manufacturers vary, but in general VRF systems show very good low ambient performance.

Q: Can an economizer be implemented with a dedicated outside air system?

A: The Mercy Corps building in Portland, OR was designed for the dedicated outside air system (DOAS) to perform as an economizer with demand controlled ventilation. Air-side economizers are required by most codes, but some have exceptions for VRF heat recovery systems.

However, air-side economizers may be counterproductive to energy savings with VRF since the ability to save energy with internal/external heat recovery is lost.

Q: Can the zone thermostat be set to auto changeover without an oscillation between heating and cooling?

A: To understand that, first an explanation how an older thermostat deadband works. If a thermostat is set for heating at 70° F and cooling at 75° F, in heating mode, the temperature will be around 70° F. As it warms up during the day, no heating or cooling occurs as the temperature goes through the deadband, between 70° and 75° F. When the space temperature reaches 75° F, the system changes to cooling mode and tries to maintain 75° F. If it gets cooler in the evening, the space temperature will float through the deadband, and change to heating mode if it drops below 70° F.

With VRF, you can set the a tighter deadband. For example, you can set the temperature to 72° F, with a deadband of 5 degrees. The 5° F deadband means 2.5° F on either side of 72° F. In the morning, the outdoor-unit goes into heating mode to maintain 72° F, plus or minus 0.4 degrees. It does that by varying the indoor-unit linear expansion valve and the speed of the indoor-unit fan to maintain 72° F. If the temp goes below 69.5° F (2.5 below 72), the system changes into heating mode, to bring the space temperature up to 72° F. As it warms up during the day, the system modulates to maintain 72° F. When the temperature rises 2.5 degrees above 72° F, the outdoor-unit changes into cooling mode. The indoor-unit fan and linear expansion value modulate to maintain 72° F.

The system won't oscillate back and forth until space temperatures change the full deadband, or 2.5 degrees on either side of the setpoint. The outdoor unit is the last stage to provide heating or cooling needed. The system will try to maximize the refrigerant effect, by varying the volumetric flow rate, before using compression heating and cooling.

Q: Are power and control wiring run to each zone fan unit along with the refrigerant?

A: VRF systems need both power and the control wiring to each indoor unit. Two wires and refrigerant piping are routed to every terminal unit.

The control wiring connects to the central VRF system controller, while there are many ways to route the power wiring.

Q: What are the refrigerant safety issues?

A: ASHRAE standard 15 is referenced by the mechanical code. It defines refrigerant exposures that can be sustained before it becomes a hazard such as asphyxiation, flammability, or toxicity. For refrigerant R410A, the limit is 25 pounds per 1,000 cubic feet, which was determined to be an acceptable exposure limit. VRF systems have more refrigerant because refrigerant is piped to every zone. If there is a small leak, potentially all of the refrigerant could leak into zone. The system needs to be designed so that the amount of refrigerant going into the smallest zone is less than the acceptable exposure limit. One inexpensive design strategy is to use transfer grilles between smaller and larger zones, which increases the effective area of the zones.

Q: Please explain the condensate issues with the Lewis County PUD example.

A: Since the ceilings were not going to be opened up, some of the zones used the wall hung indoor units, and the condensate was piped through the conditioned space. Also, the condensate pump cycling can be distracting to occupants. Condensate piping can be the biggest challenge with existing buildings, and should be thought about when a system is being laid out.

This is not just for Lewis County, but for any existing building. It's typically harder in retrofits when you have a hard ceiling or limited ceiling space. Also, piping needs to be terminated to an approved location.

Q: Lewis County PUD: how did post-retrofit actual compare to pre-retrofit actual?

A: There was no metering of the pre-retrofit, which is why they relied on modeling for comparison.

Q: Would VRF work in conjunction with swimming pools such as at hotels, etc. with the pool being the water source?

A: Yes, the technology can be used for heating pool water. It's pretty common now to use heat pump technology in pool heating systems, and a water-cooled VRF system may be a little more efficient because it doesn't cycle-on and cycle-off. A separate heat exchanger will be needed between the chlorinated pool water and the VRF system cooling water.

Q: Which energy modeling software does the best job of predicting actual performance?

A: Energy Pro was the first to include VRF systems. All of the modeling software packages are tweaking their algorithms as they're getting more data.

The current release of Energy Plus has VRF heat pump and VRF with heat recovery algorithms, which were vetted with actual field data. Currently E-quest does not have the capability to model VRF heat pumps or VRF with heat recovery. There are some post-processing techniques that allow that analysis.

Q: Does VRF have a DOE minimum efficiency standard, an Energy Star threshold, and any CEE threshold?

Yes, VRF systems have all three. Just this year, DOE adopted ASHRAE minimum standards and they're closely aligned with the CEE and Energy Star ratings. Currently the IEER rating is not in effect but should be adopted in the next year or two.

Q: Can anyone anticipate how long it will take to get VRF measures to get through the RTF?

A: While no one can estimate how long that will take, VRF systems can be incented as custom projects. The BPA emerging technology field test streamlines the process by estimating the savings in advance so that you don't have to model them. The savings have been deemed at either 1,000 kWh per ton or 1,500 kWh per ton, depending on the hours of operation of the building. So no one has to wait for RTF approval of VRF system savings – there are incentives available for them now.