Large Split VRF Systems in Multifamily Buildings

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Introduction

NYSERDA and HPD convened a meeting of subject matter experts on September 25, 2024, at the NYSERDA office in NYC, NY. The purpose of the convening was to discuss whether the large split Variable Refrigerant Flow (VRF) system deserves its status as the system of choice for multifamily buildings in NYS, both for new construction and for retrofits.

Emerging information indicates that large split VRF systems use far more energy and far more refrigerant than other systems, such as residential split heat pumps or room heat pumps. Research also shows that large split VRF systems are more leak-prone, result in challenges for owners wishing to bill tenants for cooling, are harder and more costly to maintain, raise loss-of-heating/cooling risks for more dwelling units when equipment goes down, and cost as much or more to install than other equipment types.

Subject matter experts came together to review these findings, hear thoughts and emerging data from the group, discuss other available options, and see if there is any consensus on whether large split VRF heat pumps should be a first choice for multifamily buildings. The following is a report created by the convening planning committee to summarize the discussion and findings from the convening. In this report, the term large split VRF systems references systems that serve more than one dwelling unit per single system.

Large split VRF systems have gained popularity in recent years as the most common solution for heating and cooling multifamily buildings. This may be in large part because commercial technology is more familiar to the design and engineering community. However, studies have raised concerns about their high energy use, high refrigerant leak risk, high maintenance costs, and high installation costs, specifically for multifamily buildings.

Key Issues with Large Split VRF Systems

1. **Measurably High Energy Consumption**
    - **Studies that show low efficiency:** Multiple studies that show unusually high energy use for large split VRF systems, including one study showing 77% higher energy use than residential split systems[1], a second study showing extremely low annual heating efficiency of 1.2-2.0 COP[2], and a third study confirming this low efficiency with measurements of 1.4-1.75 COP[3].
    - **Known reasons for higher energy use than residential use, including but not limited to:**
        - **11%-17% lower rated efficiency[1]**
        - **Long pipe lengths:** Extended pipe lengths will result in significant energy losses and reduced system performance.

        - **Continuous refrigerant flow:** Large split VRF systems typically maintain some continuous refrigerant flow, even when individual units are not in use, contributing to energy waste.

2. **Environmental Impact**
    - **Refrigerant usage:** Large split VRF systems use a significantly higher amount of refrigerant: 60% more refrigerant per rated ton of heating/cooling than split systems, and over 100% more refrigerant per rated ton of heating/cooling than packaged room heat pumps. This will contribute to higher greenhouse gas emissions if leaked.
    - **Leak risks:** The complex network of hidden pipes and fittings in large split VRF systems increases the risk of refrigerant leaks, and presents challenges to finding and fixing these leaks, further exacerbating leak concerns.
    - **Alternative refrigerants:** In 2020, Congress passed the American Innovation and Manufacturing (AIM) Act that will require the phase-out of R-410A, which has been the industry standard most heat pumps. On January 1, 2025, new standards for manufacturing with refrigerants will go into effect. Designers will need to seek equipment with newer, low GWP refrigerants, which tend to be more flammable, which may be very challenging, especially for large split VRF systems due to long refrigerant runs.
3. **Maintenance Challenges**
    - **Complex systems:** Large split VRF systems are intricate, invasive, and require specialized knowledge for installation and maintenance.
    - **Difficult troubleshooting:** Identifying and resolving issues can be time-consuming and costly, especially for leaks in hard-to-reach areas.
        - Of particular concern is the case of a large split VRF installation in a low-income, multifamily complex that was entirely abandoned due to refrigerant leaks that could not be found or repaired.
    - **High maintenance costs:** The complexity of large split VRF systems presents a risk of higher maintenance costs over the long term.
4. **Other**
    a. **High installation cost** of large split VRF systems was noted in the group.
    b. **Disappointing performance** of three pipe (heat recovery) large split VRF systems was noted in the group.

Alternative Solutions

At the end of the meeting, there was a clear consensus from the group that large split VRF heat pump systems should not be the default system of choice for new or retrofit multifamily buildings. Given the drawbacks of large split VRF systems, industry experts are advocating for alternative solutions:

- **Residential split systems** These systems offer greater energy efficiency, lower maintenance costs, and easier installation. However, there seems to be a reluctance to use these systems when heating and cooling costs must be split.
- **Air-to-water heat pumps** These systems provide flexibility and can be integrated with various elements in existing heating and cooling technologies. Most are factory-charged systems, reducing the risk of leaks.
- **Small-packaged heat pumps** Compact and efficient, these systems are well-suited for individual units and have been found to offer good efficiency, low risk of refrigerant leak, and ready maintenance that can even be done off site. Many packaged heat pumps already use next-gen refrigerants. This allows minimal loss of heating or cooling in occupied buildings. Additionally, these systems can be wired for owner-paid heating and resident-paid cooling. However, wall penetrations make these systems less appealing for retrofits that do not have existing sleeves.

Are there alternatives for large split VRF heat pumps in all situations?

The convening group collectively discussed whether there are alternatives available that are appropriate for multifamily new construction and retrofits. The general consensus was that there are currently alternatives for all new construction buildings. Split systems offer flexibility for the location of the outdoor units. For example, in high-rise buildings, the outdoor units can be placed on each floor, concealed behind louvres on recessed balconies—a practice that is already commonly implemented in many other countries. Additionally, small-packaged heat pumps can easily be integrated into facades to minimize air leakage. Air to water heat pumps offer yet another alternative.

The group recognized that in some instances existing high-rise multifamily buildings might have fewer options due to long line lengths that residential split systems cannot provide. Nonetheless, the group recommended that all other options still be evaluated for such buildings before large split VRF systems are considered, as it is highly unlikely that any of the available other options (residential split systems, packaged heat pumps, or air-to-water systems) would not offer a solution to virtually any building.

Conclusion

By carefully evaluating the factors discussed in this report, industry stakeholders can make informed decisions that prioritize energy efficiency, environmental sustainability, and cost-effectiveness. It is crucial to move away from the default choice of large split systems and explore alternative solutions that can deliver both measurably lower energy use and risk of refrigerant leaks.

References

1. Taitem Engineering. (2021, January). *Choosing air source heat pumps for multifamily buildings.* NYSERDA Multifamily Building Solutions Network.
2. Lee, J., Im, P., Munk, J. D., Malhotra, M., Kim, M.-S., & Song, Y.-H. (2018). Comparison evaluations of VRF and RTU systems performance on flexible research platform. *Hindawi, 2018*, 7867128. https://doi.org/10.1155/2018/7867128
3. Southard, L. E. (2014). *Performance of the HVAC systems at the ASHRAE headquarters building* (Master's thesis). Oklahoma State University.