Steven Winter Associates, Inc.

Study: Oversizing VRF Systems Will Cost You in Equipment *and* Energy

Installing oversized variable refrigerant flow (VRF) systems based on inflated loads dramatically reduced efficiency.

In a DOE-sponsored study, SWA monitored VRF systems in two new high-rise apartment buildings in New York City:

Building 1, a 26-story affordable Passive House

Building 2, a 24-story market rate building

During the summer of 2023, the VRF systems in Building 1 used ***six times less*** electricity per sq.ft. than Building 2. While Building 1 has a more efficient enclosure, this cannot explain the discrepancy in cooling electricity. Instead, proper VRF sizing seems to be the key difference.

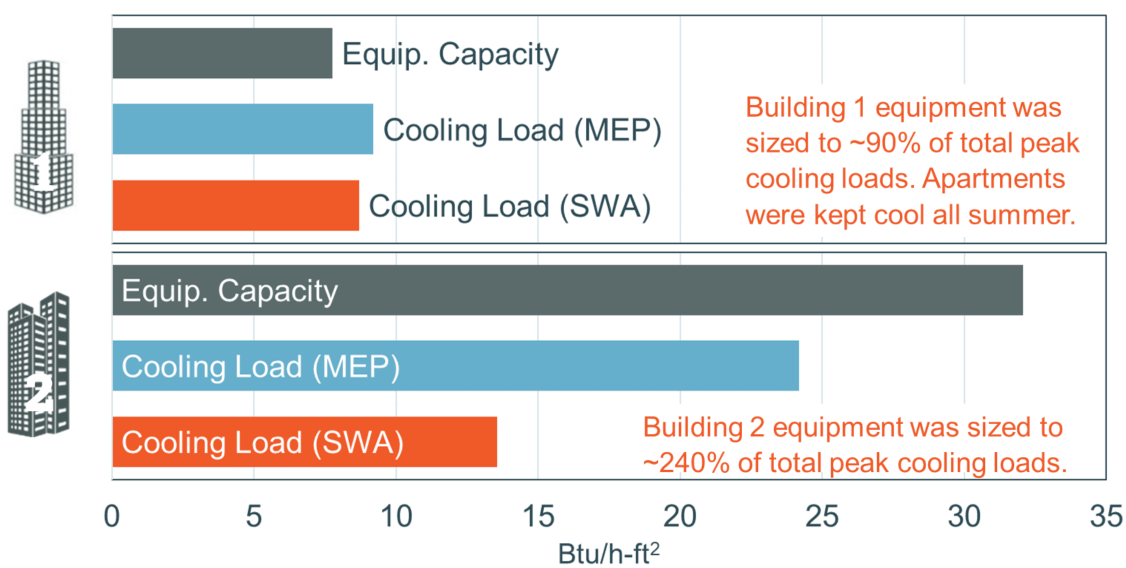
Different assumptions about cooling loads lead to drastically different equipment capacities.

Oversizing starts with poor design load calculations. SWA reproduced room-by-room design loads[1] for both buildings. In Building 1, SWA's cooling loads matched the MEP designer's loads remarkably well. In Building 2, the MEP designers' loads were ***70-75% higher*** than SWA's calculated loads.[2]

Designers for Building 1 specified VRF cooling capacity[3] roughly 10% lower than the sum of all apartment design loads to account for diversity: not all apartments experience peak cooling at the same time.

In Building 2, on the other hand, designers specified capacity 33% higher than the already inflated loads.

VRF Cooling Loads and Capacity



[1] Cooling loads were the driver for sizing in both buildings. SWA used ASHRAE residential load factor methods from 2017 Handbook of Fundamentals.

[2] The biggest discrepancy was internal gains.

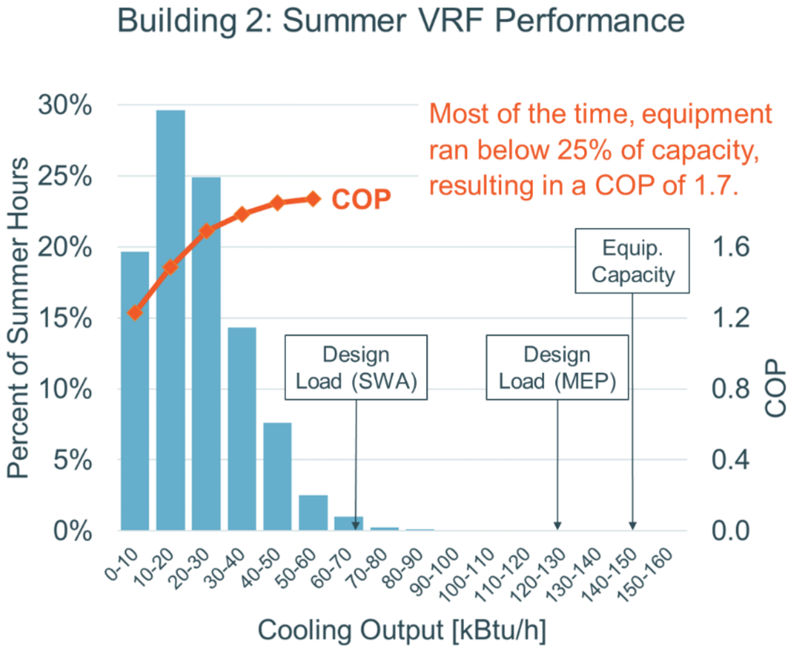
[3] Outdoor unit capacity at design conditions.

Both buildings were comfortably cool all summer – even during heat waves.

At Building 2, SWA measured heating and cooling output as well as COP for three VRF systems.[4] The maximum cooling output was very close to SWA's calculated peak loads – indicating our load calculation method was sound.

Cooling output was ***much less*** than the designer's predicted peak loads. In fact, the maximum cooling output was ***less than half*** of the designer's loads for 99.8% of the summer. These inflated design loads just don't match real world conditions.

Unfortunately, SWA couldn't get cooling output for Building A, but we did get electricity use. The cooling electricity was ***six times lower*** in Building 1 – where systems were right sized.[5]



Oversizing has real costs.

HVAC designers understandably want to provide ample heating and cooling capacity. But this conservative approach has real world costs. Bigger equipment obviously costs more; in Building 2, the VRF manufacturer said ***proper sizing would have saved 24%*** in equipment costs.

Oversizing also hits efficiency. VRF systems are only "variable" to a point. When these particular systems run below 33% of max capacity COP drops dramatically, and these systems were almost always below this point.

Key Takeaways

There is no need to inflate design loads or add safety factors. Calculations per ASHRAE or ACCA Manual J accurately predict peak load.

VRF equipment sized using these reasonable loads resulted in much better efficiency.

Both buildings were comfortable all summer: whether VRF was sized to 90% of apartment peak loads (Building 1) or 240% of peak loads (Building 2).

Significant savings can be found in up-front equipment costs AND operating energy.

[4] SWA was unable to measure output (and therefore COP) at Building 1 due to system configuration. COP values do not include electricity used by indoor units.

[5] Cooling electricity normalized per apartment floor area