At ASHRAE Headquarters, Geothermal and VRF Go Head to Head

It's fitting that when ASHRAE headquarters in Atlanta was renovated in 2008, the building became a living laboratory for exploration of commercial building performance and state-of-the-art HVAC technology.

Aside from a stand-alone ventilation system, the facility uses two separate HVAC systems that serve similar spaces. A variable refrigerant flow (VRF) system provides heating and cooling to the building's first floor, while a geothermal (or ground-source heat pump/GSHP) system serves the second floor. For two full years, data from dozens of sensors and metering devices were gathered to compare the actual – not rated – efficiency of the two systems.

Due to differences in ventilation, occupancy and floor space the loads on the VRF and GSHP weren't identical, but the data were normalized in order to show a true side-by-side performance comparison of the two modern systems.

Results

Despite both GSHP and VRF being considered "high efficiency" systems, the performance difference between the two was quite dramatic.

During the summer, the GSHP system used about 20 percent less energy than the VRF system, and roughly 60 percent less energy in the winter and shoulder seasons while maintaining similar zone temperatures

After removing variables, the GSHP system consumed 1.5 kWh/ft^2 per year, while the VRF system consumed 2.7 kWh/ft^2 per year. Over the course of a year, the VRF system used *nearly twice as much energy* as GSHP system used. See *Figure 1*

The average system heating COP of the GSHP system was 3.3±0.2, and the average system cooling EER was 14.2+2.0/-1.6. In contrast, the VRF system's heating COP was 2.0±0.1, and the average system cooling EER was 8.5±0.4.

Other findings

While efficiency ratings of both systems were lower than that listed in the manufacturers' catalog, the published data for the VRF system in particular could be very misleading. The following graphs compare the measured to published data for both systems.

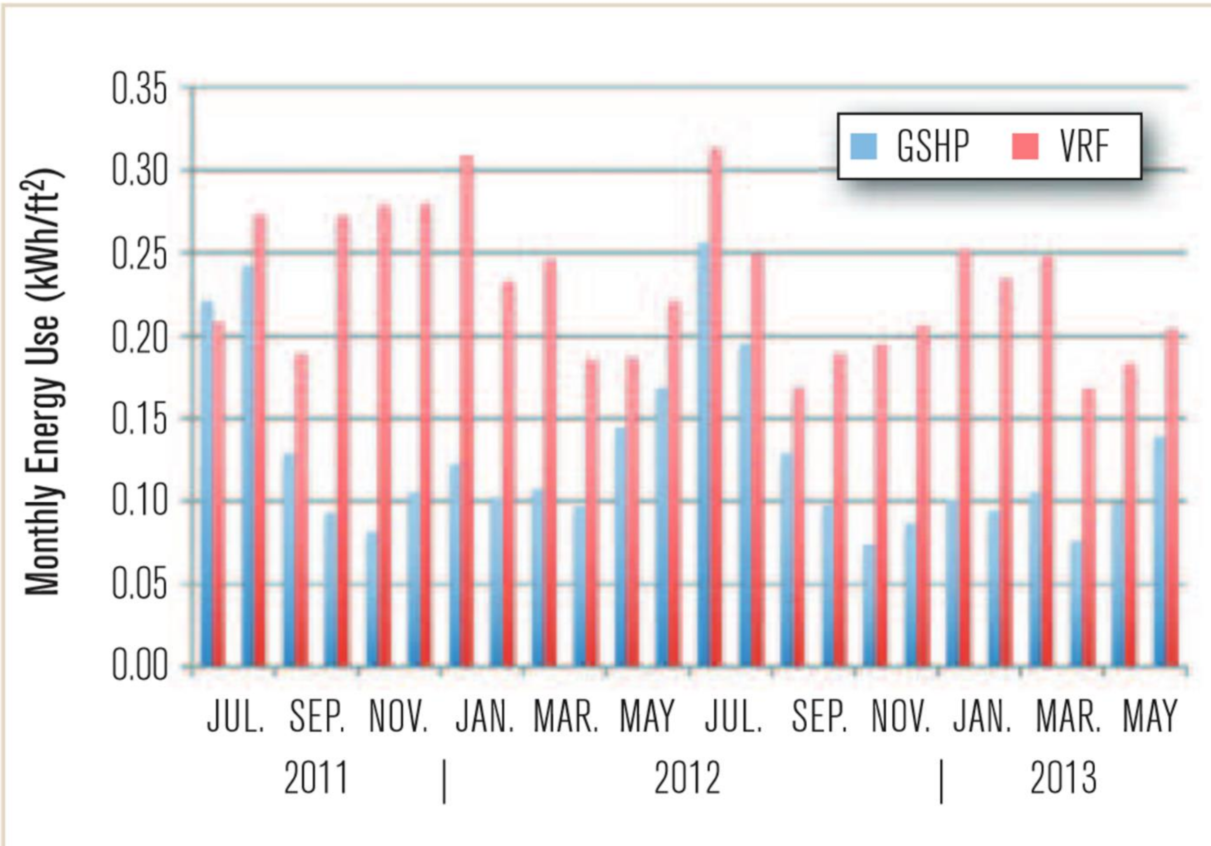
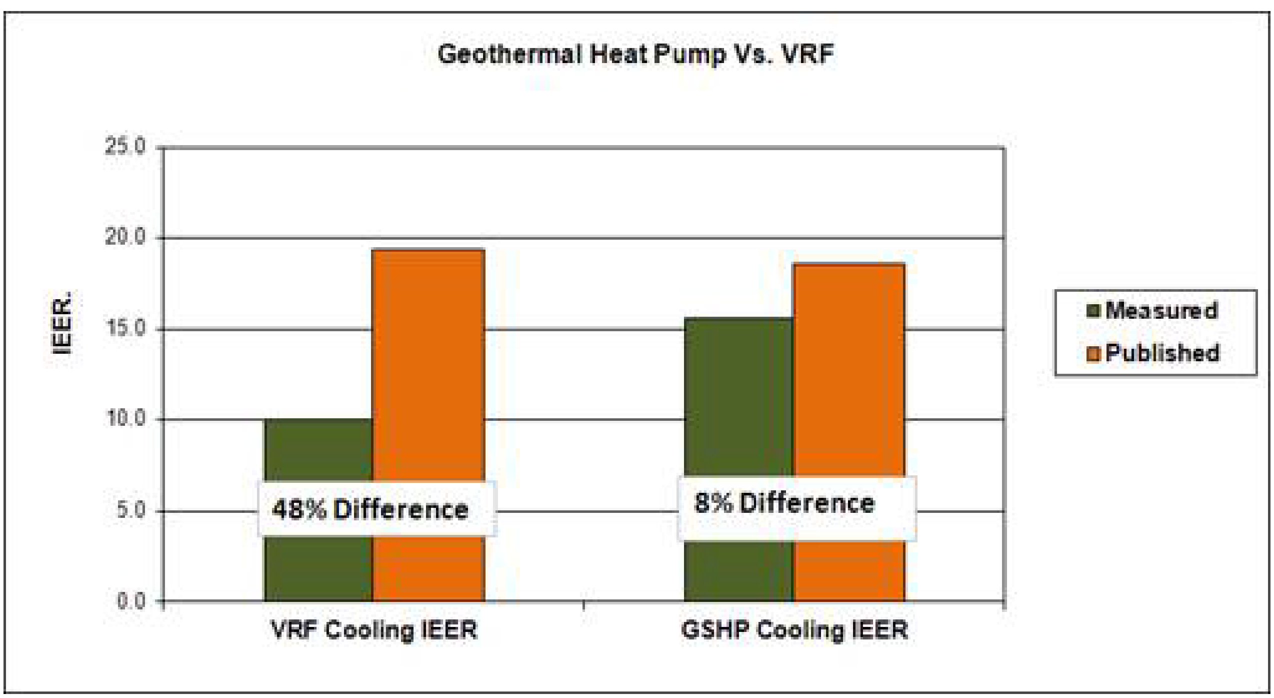
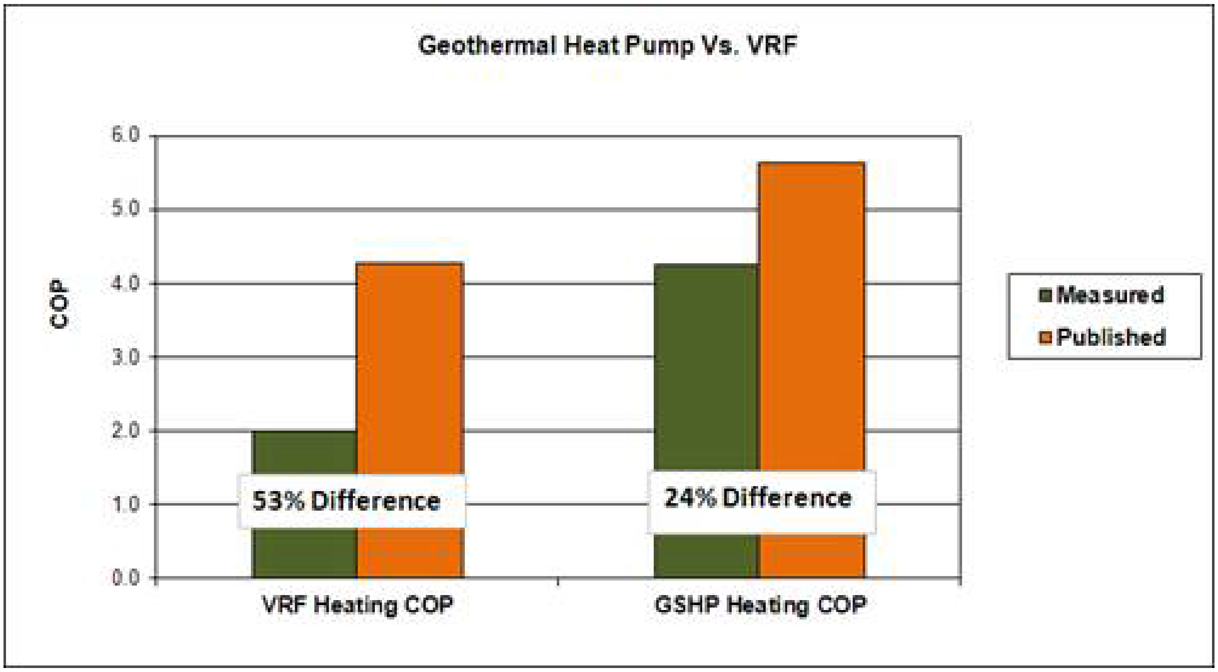


Figure 1 normalized monthly use per square foot





Note that for both heating and cooling, the VRF system's measured COPs and IEERs are roughly 50 percent less than the published data. For the water source heat pump system, the differences are significantly smaller and to be expected when system energy transfer – pump horsepower – is accounted for.

Conclusion

If the full range of outdoor temperatures seen during the study are taken into account, VRF system energy consumption is up to 80 percent higher than the water source geothermal system.

The difference is so high that even a basic boiler-cooling tower WSHP (water-source heat pump) application would be more energy efficient than VRF. Plain and simple, VRF and GSHP systems are not comparable technology and should not be considered as high-efficiency alternatives.

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