# Effect of Supply Temperature Control on Energy Efficiency for Small Equipment Shelters

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## SUMMARY

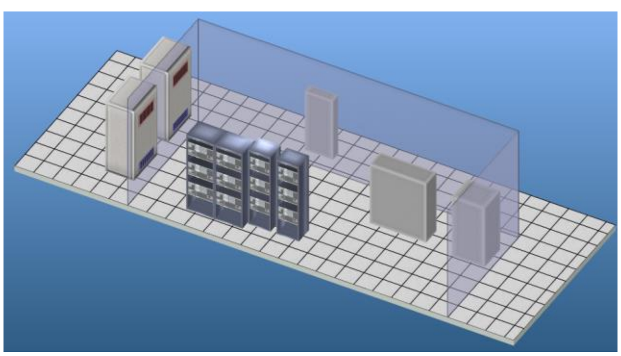
The effect of supply air temperature control for HVAC systems have on energy efficiency for typical small telecom shelter is studied. Two options for indoor sensor studied: (1) traditional placement on wall between HVAC units, averaging shelter temperature, and (2) in the geometric center of equipment intake. This study covers 4 typical shelter layouts, each with different heat loads (4, 8, and 12kW) are studied for representative climates across continental US. For each scenario, a computational fluid dynamic (CFD) model is used to establish required HVAC capacity in the order to determine annual energy consumption. Results are compared across headload, layout, climate, and sensor placement.

## INTRODUCTION

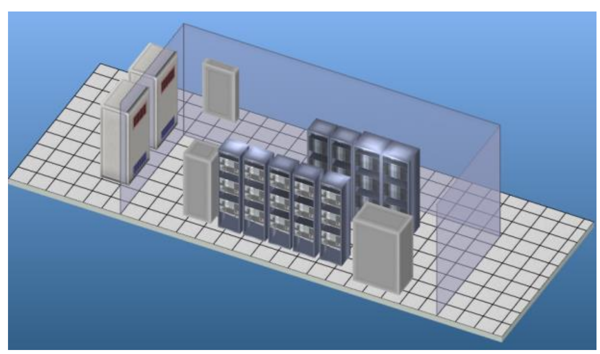
For traditional HVAC systems, supply air temperature control was not a possibility since the HVAC will short cycle without precise capacity control. With the advent of variable speed compressors, supply air temperature control became a possibility where the exact required temperature can be supplied to the equipment. For supply air temperature control, controlling temperature sensor would be placed where the shelter equipment intake is to precise control the equipment intake temperature to avoid overcooling/overheating of the equipment. This paper studies the efficiency advantage for supply air temperature control.

## METHODOLOGY

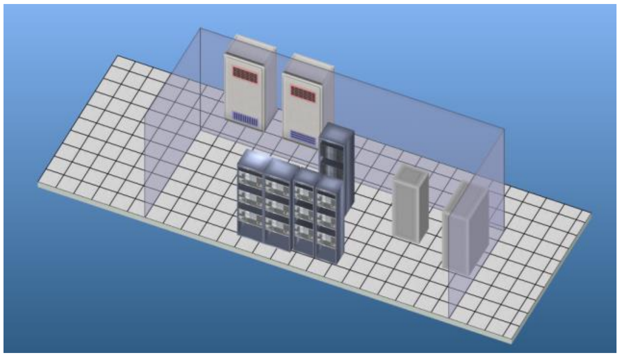
A set of 4 typical small telecom shelter layout is studied. Each of the layout is loaded into CFD model along with information on rack location, heat load, HVAC placement, along with non-load generating equipment such as battery banks. See below for list of layouts.

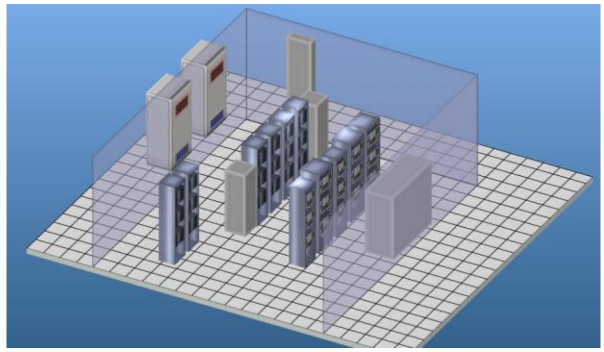


**Layout 1**



**Layout 2**

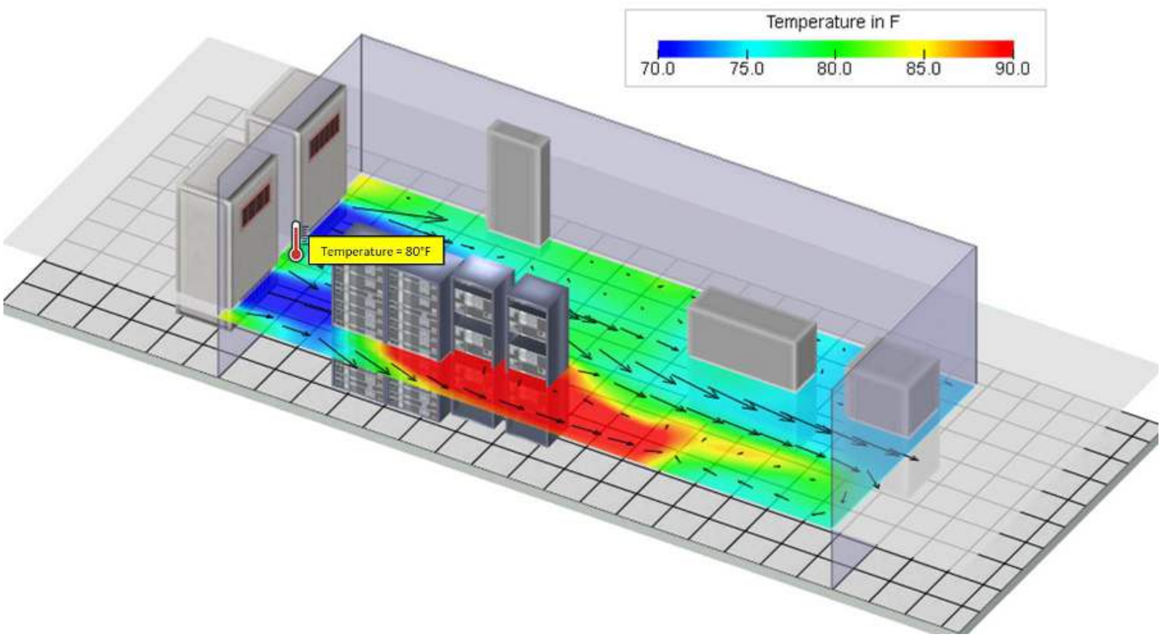




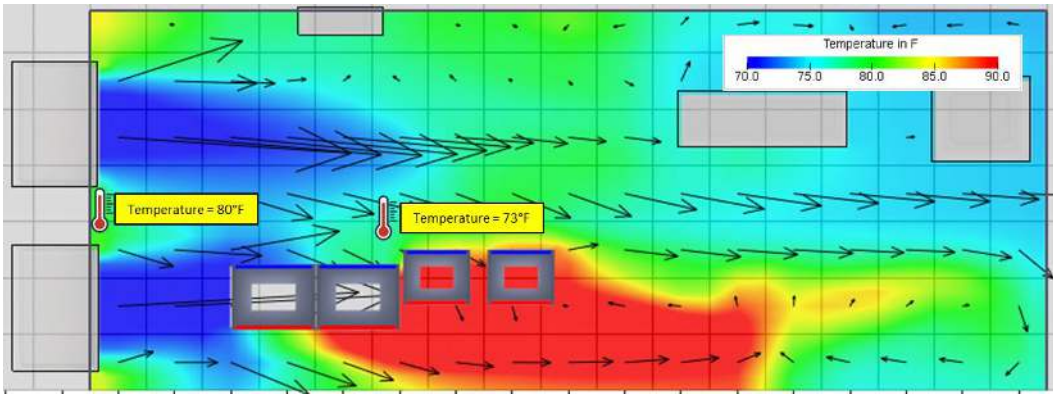
**Layout 3** **Layout 4**

With each of the 4 layouts, CFD models are run at 4, 8, or 12kW heatload. For each of these heat load, the HVAC unit's supply temperature is determined in the order to reach 80°F stable at the designated temperature sensor placement.

In the sample scenario below, when a controlling temperature sensor is placed in the middle of the HVAC units, a total of 1400CFM supply air at 69F is required to maintain stable 80°F at the sensor location.




**CFD Model, Layout 1, Sensor placement between HVAC units**




**Temperature Distribution, Layout 1, Sensor placement between HVAC units**

For each set of required return/supply temperature and air volume, the required HVAC capacity required for cooling equipment, without external load, is calculated.

In order to determine the annual energy consumption, additional cooling requirement is calculated based on the climate location.

Locations considered are:

- Seattle WA
- Los Angeles CA
- Columbus OH
- Tampa, FL
- Phoenix, AZ

For each climate location, 8760 annual hour by hour external temperature data is loaded and at each induvial hour, the total load calculated using

$$Q_{total} = Q_{equipment} + Q_{lighting} + \Delta T * k * \left(\frac{A_{wall}}{R_{wall}} + \frac{A_{ceiling}}{R_{ceiling}} + \frac{A_{Floor}}{R_{Floor}}\right) + Q_{ventilation}$$

Where Q is the heat transferred in Btu, $\Delta$T is the dry bulb temperature difference between indoor and outdoor, k is a constant which $\approx$ 1 / ft^2 / $^\circ$ F, A is the surface area, and R is thermal resistance is the building.

At each individual hour, the HVAC's mode of operation and energy use is determined based on total cooling requirement and external temperature. For mode of operation, direct free cooling is prioritized based on given hourly outdoor temperature. Annual energy use is obtained by aggregating 8760 individual hour by hour total cooling requirement for each location.

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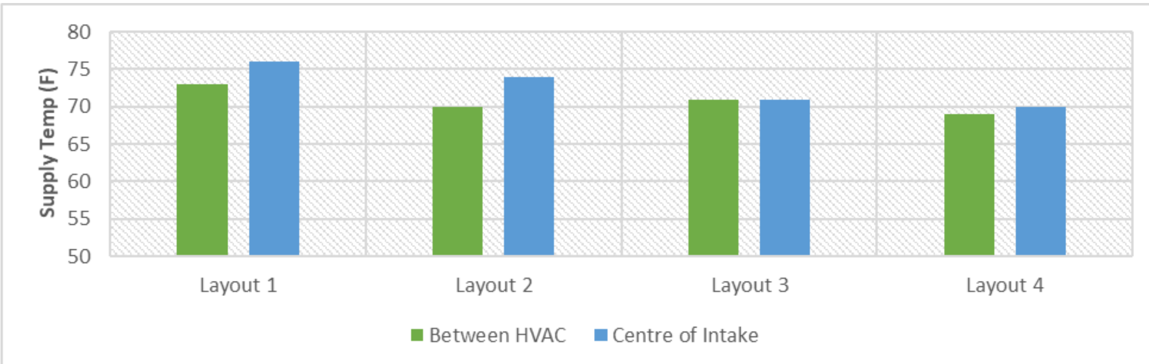
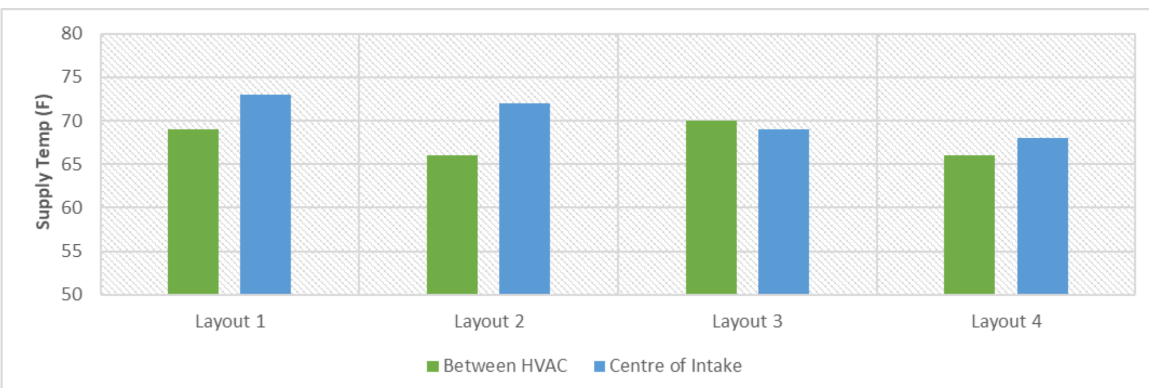
# RESULTS

Supply air temperature is modeled to maintain stable sensor temperature is shown below for sensor placement between HVAC center of equipment intake, for each equipment heat load level

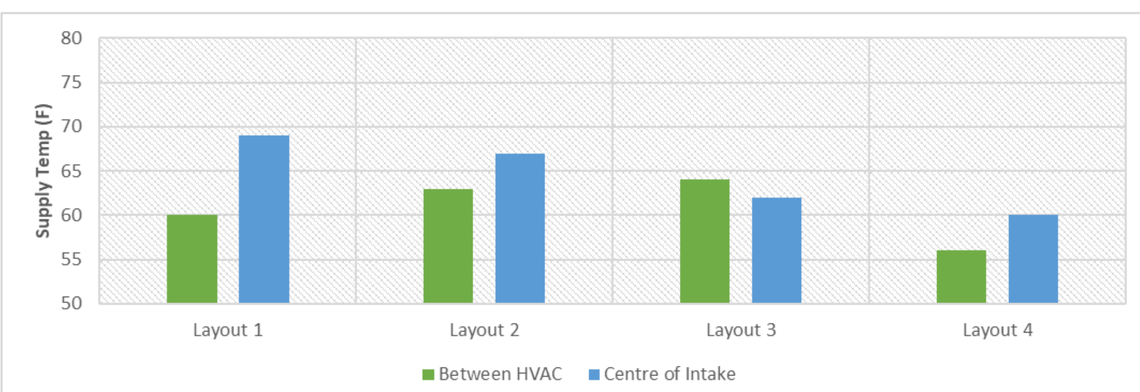
**4kW Equipment Load**



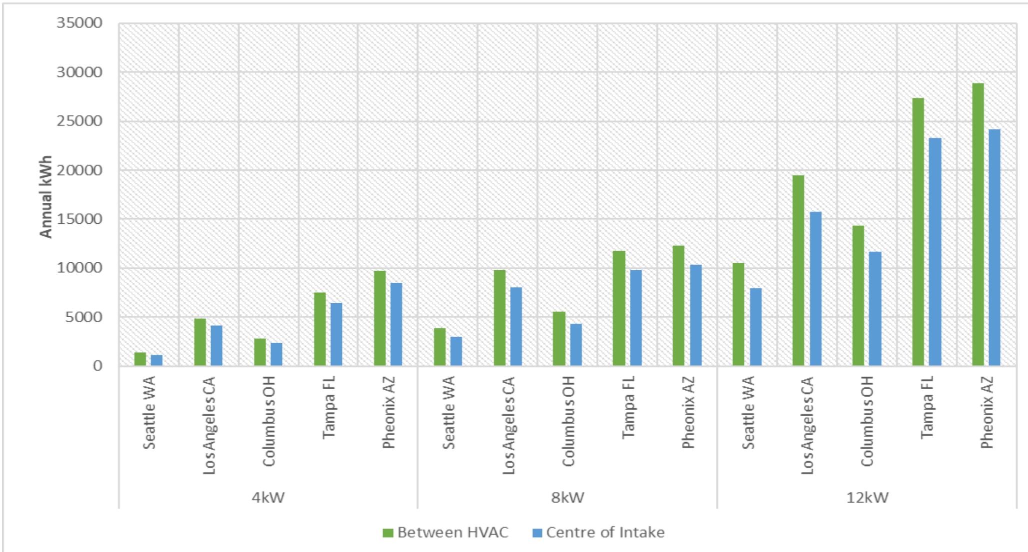

**8kW Equipment Load**



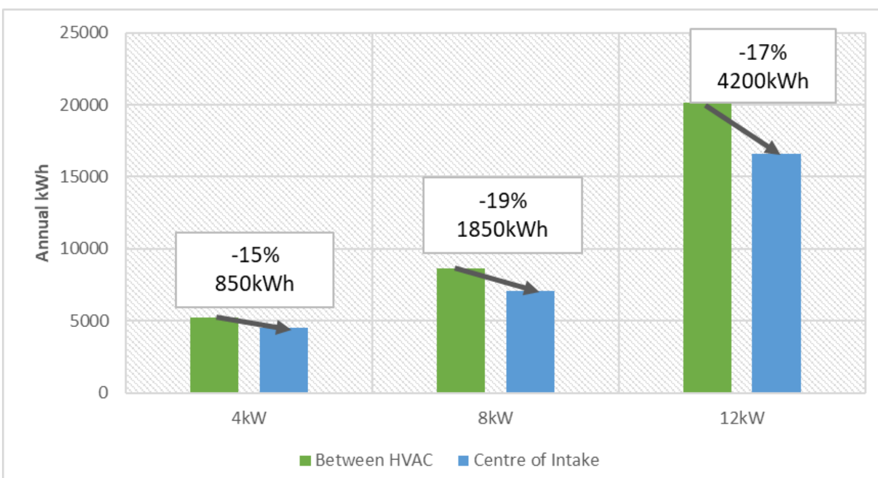

**12kW Equipment Load**



For each of the supply air temperature, an hour by hour energy analysis is done at each location below to take the external load into account.




Averaging efficiency improvement across the climate areas:




## CONCLUSION

The study results have shown an approximately 15-20% average HVAC efficiency improvement for supply air temperature control when applied to an aggregate of different climate, layout, and heatload. This can be a significant efficiency improvement for HVAC where supply air temperature control is already an option. Although the percentage saving is similar across heatload levels, priority should be given to those with higher heatload due to higher absolute improvement. Considering units with supply air temperature control often also incorporate other new technology and efficiency standard this can present substantial operating cost saving.