Approach- unmet load hours

Below I have explained my approach to dealing with unmet load hours, which has never failed me and no LEED reviewer has ever questioned. It includes info on Baseline auto-sizing since the two are often related. As a general guideline, unmet load hours are a control issue rather than a capacity issue. When capacity is an issue, I find that it's with the Baseline model. In dealing with these cases, I have come to the conclusion that G3.1.2.2 and G3.1.2.8 are at odds with each other in many cases. If I correctly auto-size the flows off a 20 F delta T but still have too many unmet load hours, how can I reduce the hours without increasing air flow? It's pointless to increase coil capacity without delivering more air to the zone. So, my basic approach is to get the right controls in place and then target the remaining trouble zones with increased air flow. I feel this finds a balance between G3.1.2.2 and G3.1.2.8.

The magnitude of hours is important. If you're in the thousands for a given system, ensure you've selected the right system type according to eQUEST's definition. For example, a recent project utilized chilled water fan coil units (two-way valves) with electric heat. They were constant volume, variable temperature, single zone, with no central air handler. I had to change the system type from "fan coil" to "single zone reheat" to get the correct behavior. An air-cooled heat pump is a PSZ whereas a GSHP is a PVVT (but also single-zone). So, sometimes a little research is required to ensure you and eQUEST define the system the same way.

Assuming the system type is correct…

1) For Baseline systems with auto-sized flows and capacities, start with the correct air flows by ensuring the G3.1.2.8 requirement is in place:

a. For every zone, define the heating & cooling "Indoor Design Temperature" under Zone Properties/Basic Specifications. These are not the same as the hourly T-stat settings, but some would argue that they should be set the same for the Baseline. So, if occupied heating = 70 F at the T-stat, make that the indoor heating design temperature, too. Spreadsheet view makes this process quick. Do not make the heating & cooling design temps the same; there should be at least a two-degree difference to ensure (somewhat) stable operation.

i. If applicable, apply G3.1.3.13 for Baseline Systems 5 & 7 under Zone/Air Flow/Minimum Flow. Note that this is different than "Min Design Flow". For all Baseline system types, leave the Min Design Flow blank to allow the system to auto-size off the 20 F delta T requirement. For Systems 5 & 7, the Minimum Flow will override the Min Design Flow if the Min Design Flow is less than 0.4 CFM/sf.

ii. Ensure the Baseline ventilation is the same as the Proposed ventilation per G3.1.2.5. This requires specifying a CFM, not a percentage of supply air. It can be done at the zone or system level, but specifying at the zone level will ensure a more apples-to-apples comparison if zone-level heating or cooling is involved. It will also ensure the zone SA never falls below the OA requirement.

b. At the system level, under Cooling/Coil Cap Control, set the "Zone Entering Min Supply Temp" to be 20 F lower than the zone "Indoor Design Cooling Temperature". Repeat for the heating coil, setting the "Zone Entering Max Supply Temp" 20 F greater than the heating Indoor Design Temperature.

c. For mechanical or storage spaces, or anywhere there's a difference in control temperature or space load, there will probably need to be a separate system. See if G3.1.1 a) through d) apply to your project and proceed accordingly. Steps 1a) and 1b) still apply, but with different temperatures.

2) For all multi-zone systems, VAV in particular, go through every zone and set the Throttle Range to at least 4 R (4 – 6 R). This is a reasonable range for stable system operation.

a. NOTE: When adjusting the Throttle Range, you are, in effect, defining how eQUEST counts unmet load hours. Increasing the Throttle Range is the same as decreasing the counter's sensitivity. It should not be abused, however, and the value should be reasonable. For a large, multi-zone VAV system, 4 – 6 R is reasonable. For smaller/single-zone systems, 0.2 – 3.0 R is probably more reasonable.

3) Next, adjust the system fan, heating, and cooling schedules to reflect a morning warm-up period. Going from a 85 F night setting to a 75 F occupied setting cannot be done in one hour. This transition probably needs two to four hours, adjusting the thermostat a few degrees at a time. Heat pumps are particularly sensitive to T-stat fluctuations and probably need to make the transition in two-degree increments; water-cooled equipment may be able to make the transition a little more aggressively.

a. Use a schedule to lock out OA during the warm-up period unless simulating an overnight flush-out. The DOE2.2 documentation indicates how to do this.

b. If the design calls for fans to remain off during unoccupied hours, good luck. In many climates the zone temps will drift to the extent that they will be difficult to bring under control within a few hours. It is advisable to define some sort of setback temp and allow the fans to cycle so that there is a ceiling/floor to the zone temps (Baseline fans must cycle at night). Naturally, the larger the delta T between occupied/unoccupied, the longer the transition period required. This is compounded by systems which are relatively slow responders. Again, the shift in hourly T-stat setting needs to be reasonable for the system type & capacity, maybe 2-4 F.

c. For VAV or VAVVT, use schedules to deliver 100% flow and heating/cooling supply air temperature during the warm-up. This may already be accounted for by the type of thermostat, but a schedule will provide additional assurance. Again, one can read the DOE2.2 documentation to figure out how to do this.

4) With basic controls in place, identify the zones with the largest amount of unmet load hours. Look at the SS-F report to see the zones' temperature extremes and the time of year in which they are occurring. These temperatures can then be correlated back to the SS-O report to see what time of day they are occurring. In most cases, if this step is performed before step 3), it will reveal issues in the morning hours and the need to define a warm-up period. If the unmet load hours are occurring later in the day, the zone is probably not getting enough air to satisfy its loads.

a. If morning warm-up is not an issue, the next step is to ensure the eQUEST zone loads are close to what is expected. If modeling an existing design, ensure the internal zone loads are close to design values (it is assumed the envelope loads are reasonably close to design values due to fewer unknowns). If the modeler is not the mechanical engineer, the modeler should contact the engineer and compare load assumptions. For example, in an elevator equipment room with a 60 kW motor, is 100% of that load truly sensible (the eQUEST default value)? Or, is 80% of that 60 kW being used to lift the elevator and only 20% showing up as sensible load? The LS-B report is a good one to compare to the ubiquitous Trace 700 Zone CheckSum reports. Make adjustments to the model as needed. The loads will never match exactly, but they should be in the same ballpark.

b. Get rid of infiltration in interior zones if this has not already been done.

5) At this point, the zone loads should be reasonably close to design values, the Baseline air flow should be auto-sizing correctly, and there should be controls in place to provide a sufficient warm-up period. If too many unmet hours remain…

a. For the Proposed system, ensure each zone is getting the design supply air. Total supply air may have been specified at the system level, but this does not mean eQUEST is allocating the supply to each zone as it was designed. Specify the design air flow at the zone level. If this does not resolve unmet load hours, and all other parameters are correct, it is possible that the system is undersized.

It is difficult to offer more generic advice without reviewing the project in question.

b. For the Baseline system, it is time to begin applying G3.1.2.2.

i.

First, modelers need to be aware of eQUEST's sizing factors. The System Properties/Basics tab contains a Sizing Ratio field. This is an overall sizing factor which impacts the cooling capacity, heating capacity, and supply flow. The "Cool Sizing Ratio" and "Heat Sizing Ratio" on the Cooling and Heating tabs only affect the cooling and heating capacities, respectively. So, if one were to set the system sizing ratio to 1.15 and the heating sizing ratio to 1.25, the net effect is a heating capacity ratio of (1.15)(1.25) = 1.44. The heating coil would be 44% larger (and out of compliance with G3.1.2.2), and the air flow would be 15% larger. The same concept applies on the cooling side. Therefore, I am the opinion that the system sizing ratio should always be 1.0, and the cooling & heating ratios should be 1.15 and 1.25, respectively. There is no reason to deviate from these factors unless the goal is to make a complete mess of the system sizing. Furthermore, it is useless to resolve unmet hours by playing with coil capacities alone; more air must be delivered to the zone in conjunction with a larger coil capacity.

ii.

Therefore, I believe the best way to satisfy G3.1.2.2 is to begin with System Sizing Ratio = 1.0, Cool Sizing Ratio = 1.15, and Heat Sizing Ratio = 1.25. This, along with following 1a) and 1b) above will ensure the modeler is starting from the correct point. Look at the Air-Side HVAC Summary report and note the auto-sized CFM/sf for the zones showing the most unmet load hours. For those trouble zones, and only those trouble zones, begin incrementally increasing the Min Design Flow on the zones' Basic Specifications tab. If the auto-sized flow is 0.54 CFM/sf, increase it to 0.65 or 0.75 and re-simulate. Smaller zones may require larger increments to get an extra 10 or 25 CFM. Keep going until the zone's unmet load hours are eliminated or satisfactory. By increasing zone flow rather than system sizing factors, the modeler is indirectly increasing system capacity while ensuring the additional capacity reaches the trouble zones. I believe this is a better interpretation of G3.1.2.2 than blindly ratcheting up the system sizing factors.

1. NOTE: It is advisable to make multiple passes through all the trouble zones rather than tackling them all in one round - there is a relationship between adjacent zones. When the unmet hours are down to around 20 or 30 for a given zone, move on to the next one. You may notice that bringing down unmet load hours for one zone also improves the hours for its adjacent zones.

After all this, unmet load hours have always been below 300 - usually they're zero. If it doesn't work, there's something else wrong that will require a more thorough review of the project.

Thanks,