Understanding LEED Unmet Load Hours in HAP 4.5

Introduction

HAP v4.5 includes important changes in the way "unmet load hours" are compiled for the "Section 1.3 - Advisory Messages" portion of the LEED EA Credit 1 Summary Report. This e-Help explains the fundamental principles and procedures involved with compiling LEED unmet load hours in HAP v4.5. A companion e-Help titled "Reducing LEED Unmet Load Hours in HAP v4.5" describes a systematic procedure for efficiently reducing eliminating those hours.

Background

The Performance Rating Method defined in Appendix G of ASHRAE Standard 90.1-2007 specifies in section G3.1.2.2 that cooling and heating unmet load hours be determined and shall not exceed certain limits. Further, Standard 90.1-2007 contains a formal definition of the term "unmet load hour" which was not present in previous editions of the Standard:

> *unmet load hour: an hour in which one or more zones is outside the thermostat setpoint range.*

This definition appears to be formulated in a strict physical sense. That is, any deficiency in the cooling or heating capacity of an HVAC system will manifest itself as zone air temperatures that are too hot or too cold versus the thermostat operating range. While this definition is simple and clear, some thought is required when applying this to energy simulation programs. That is because a simulation program creates a virtual representation of the building that is a simplification of reality. Specifically, nearly all programs decouple the air side and equipment side simulations and feedback between the two simulations, if it exists, is imperfect. As a result Carrier believes proper implementation of the LEED unmet load hour concept requires looking at problems both in the air side simulation and the equipment side simulation. If both parts of the decoupled simulation are not considered, the intent of the unmet load hour requirements in G3.1.2.2 are not met.

In HAP v4.5 this will mean LEED unmet load hours appearing on the LEED EA Credit 1 Summary report must be diagnosed by investigating problems indicated both on the Zone Temperature Report for air systems (indicating air-side problems) and on the Unmet Load Reports for air system and plants (indicating equipment-side problems).

Derivation Procedure

To aid in explaining the procedure for deriving LEED unmet load hours, consider a simple example:

> *The HVAC system for a small building is a VAV rooftop unit which provides air to VAV/RH terminals serving five zones. A hot water boiler serves the reheat coils in the VAV boxes. The cooling thermostat setpoint is 76 F, the heating thermostat setpoint is 70 F and the thermostat throttling range is 2 F.*

The derivation procedure can be thought of as assembling a large spreadsheet of system and equipment performance data and then distilling the LEED unmet load hours from this data. The spreadsheet contains one column for each of the 8,760 hours in a standard year. Figure 1 illustrates a tiny segment of this spreadsheet containing 11 hours from one summer day. One group of rows in the spreadsheet contains air temperature data for the zones in the building. This data is obtained from the air-side simulations. In the example in Figure 1 there are 5 rows for the five VAV zones. A second group of rows contains data for each equipment unit such as DX cooling, DX heat pump, combustion heater, and electric heating devices, and chilled water, hot water and steam plants.

The data in these rows indicate whether the equipment capacity is sufficient to meet the cooling or heating demand each hour. In the example in Figure 1 there is one row for the rooftop DX cooling equipment and one row for the hot water boiler plant.

Using this spreadsheet concept, the derivation procedure performed automatically by the software is as follows:

1. Collect Zone Air Temperature Data

   First, HAP collects zone air temperature results from the air-side simulations and places the values in the zone air temperature cells in the spreadsheet. Sample results are shown in Figure 1.

   Then HAP evaluates the temperatures to identify which are inside and outside the thermostat operating range. In our example temperatures above 78 F (setpoint of 76 F plus 2 F range) or below 68 F (setpoint of 70 F minus 2 F range) are out of range. As a practical matter HAP uses a 0.1 F tolerance, so any temperature 78.1 F and above, or 67.9 F and below in our

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example will be identified as an unmet load condition. In Figure 1 out of range hours are color coded as orange, and those in range are color coded as green.

		July 16										
		0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
VAV Zone 1		79.1	78.5	77.9	77.5	77.4	77.5	77.6	77.7	77.8	77.7	77.4
VAV Zone 2		78.7	78.2	77.7	77.3	77.2	77.3	77.4	77.5	77.6	77.5	77.1
VAV Zone 3		80.0	79.5	78.7	78.0	77.8	77.8	77.9	78.1	78.3	78.0	77.6
VAV Zone 4		77.7	77.4	77.3	77.2	77.0	77.2	77.4	77.6	77.7	77.5	77.1
VAV Zone 5		77.4	77.1	76.9	76.8	76.7	76.9	77.1	77.3	77.3	76.8	76.4
RTU DX Cooling		OK	OK	OK	OK	OK	OK	OK	Def	Def	OK	OK
HW Plant		OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Cooling Unmet		1	1	1	0	0	0	0	1	1	0	0
Heating Unmet		0	0	0	0	0	0	0	0	0	0	0

Figure 1. Excerpt from Spreadsheet Illustrating LEED Unmet Load Hour Derivation Process

2. Collect Equipment Capacity Data

Next, HAP collects equipment capacity data from the equipment-side simulations. For each equipment operating hour, HAP identifies whether the equipment capacity is sufficient to meet the demand or is deficient. As a practical matter HAP uses a 0.5% tolerance. Any hour in which the demand exceeds capacity by 0.5% or more is identified as an unmet load condition. In Figure 1, cells in which equipment capacity is deficient ("Def") by 0.5% or more are color coded orange, and those for which capacity is sufficient ("OK") are color coded green.

3. Identify LEED Unmet Loads for Each Hour

Once all the zone air temperature and equipment capacity data is assembled for the year, HAP scans the data to distill the LEED unmet load hours.

Any hour in which one or more zones is above the cooling range (greater than or equal to 78.1 F in our example), or one or more cooling equipment units has deficient capacity is assigned 1 cooling unmet load hour. In Figure 1, hour 0800 has three zones above the cooling range. By the Standard 90.1 definition this counts as 1 cooling unmet load hour, not 3 unmet hours. The unmet load tally is shown at the bottom of the spreadsheet in Figure 1.

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Any hour in which one or more zones is below the heating range (less than or equal to 67.9 F in our example), or one or more heating equipment units has deficient capacity is assigned 1 heating unmet load hour. Because Figure 1 shows an example for a summer day, no heating unmet load hours appear.

4. Count Annual Unmet Load Hours

   Finally, the total annual cooling unmet load hours are determined by summing the values in the "Cooling Unmet" row of the spreadsheet. The total annual heating unmet load hours are determined by summing the values in the "Heating Unmet" row of the spreadsheet. These annual sums are the values shown in the "Section 1.3 - Advisory Messages" section of the LEED EA Credit 1 Summary report.

Notes

Please note the following about the LEED Unmet Load Hour derivation:

a. A particular hour of the year can count as no more than 1 cooling unmet load hour and 1 heating unmet load hour.

b. HAP tallies a cooling unmet load hour if the air temperature in one or more zones is above the cooling thermostat range or one or more DX cooling units or chilled water plants is deficient in capacity versus the cooling demand.

c. HAP tallies a heating unmet load hour if the air temperature in one or more zones is below the heating thermostat range or one or more DX heat pump, combustion heater or electric heater units or hot water plant or steam plant is deficient in capacity versus the heating demand.

d. In HAP v4.5 the derivation procedure described above is used for both the LEED NC-2.2 and LEED 2009 versions of the LEED EA Credit 1 Summary Report. LEED NC-2.2 references ASHRAE Standard 90.1-2004 which did not define the term "unmet load hour". The addition of a definition for "unmet load hour" in the 2007 edition of the standard is assumed to represent the intent both for 2007 and prior versions of the standard. Therefore the same derivation procedure is used for both versions of the LEED report.

e. The air system Zone Temperature and Unmet Load reports, and the plant Unmet Load reports show statistics derived from the same raw material used for distilling LEED Unmet Load Hours. However, the derivation and use of the data on these reports is different from the LEED Unmet Load Hour data. These three reports, which existed long before USGBC or LEED existed, are intended to help users diagnose modeling problems. As a result they show ***bulk*** statistics - the total numbers of zone-hours when temperatures are in and out of range, and total number of equipment-hours when capacity is sufficient and deficient. Except in the simplest cases, such as a building with one zone and one equipment unit, the sum of unmet loads and zone temperature hours shown on these reports will be larger than the LEED unmet load hours reported on the LEED EA Credit 1 Summary. That is because the unmet load hours on the LEED report count no more than 1 cooling unmet hour and 1 heating unmet hour for each particular hour of the year. The Zone Temperature and Unmet Load reports display all hours, regardless of whether they coincide during the same hour of the year.

Need more help?
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