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2 General Modeling Procedures

2.1 General Requirements for Data from the User

2.1.1 General

Users must provide valid data for all descriptors that are designated as *compulsory* in Appendix A and that apply to parts of the building that must be modeled.

2.1.2 Requirement for Complete Building Description

Complete descriptions of the building envelope, mechanical, service water heating, and electrical systems for the project are required.

2.1.3 Building Envelope Descriptions

The user shall provide accurate descriptions for all building envelope assemblies including exterior walls, windows, doors, roofs, underground walls and floors. The user shall provide data for all of the required descriptors listed in Appendix A that correspond with these assemblies. However, the following exceptions apply:

- Any envelope assembly that covers less than 1% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the next most similar assembly of that type.
- Exterior surfaces whose azimuth orientation and tilt differ by no more than 45º and are otherwise the same may be described as a single surface or described using multipliers. This specification would permit a circular form to be described as an octagon.

2.1.4 Space Use Classification

The user must designate space use classifications that best match the uses for which the building or individual spaces within the building are being designed or used. Depending on purpose, space use classifications determine the default or prescribed occupant density, receptacle power, service water heating, minimum outdoor ventilation air, operating schedule, and lighting assumptions used in the rating analysis. They also determine the lighting power and other characteristics of the baseline building.

The user must specify the space use classifications using either the *building area* or *space-by-space* categories but may not combine the two types of classification within a single analysis. The building area method assigns assumptions based on average values that occur within typical buildings of the designated type. The building area method is recommended for use when detailed space planning information is unavailable. More than one building area category may be used in a building if it is a mixeduse facility.

The space-by-space method requires space-by-space entry of floor area and space use designations. The space-by-space method can be used whenever design information is available with the necessary detail.

Both the *building area* and *space-by-space* choices are consistent with the baseline standards supported in COMNET and are listed in Appendix B. COMNET provides a single list of *building area* and *space-by-space* classifications so that when a model is specified by a user, it can be analyzed for multiple purposes.

2.1.5 Treatment of Building Descriptors Not Fully Addressed By This Document

The goal for this document is to provide input and rating rules covering a full range of energy-related features encountered in commercial buildings. However, this goal is unlikely to ever be achieved due to the large number of features that must be covered and the continuous evolution of building materials and technologies. Where descriptors need to be used that are not addressed completely (or are not addressed at all) in this manual, users are expected to employ these inputs using their judgment consistent with accepted design and construction practice. Any uncertainty regarding appropriate modeling assumptions must be resolved so that the impact is conservatively assessed; for example, so as to make it less likely rather than more likely that percent savings will be higher.

2.2 Thermal Blocks, HVAC Zones and Space Functions

2.2.1 Definitions

A *thermal block* is a space or collection of spaces within a building having sufficiently similar space conditioning requirements so that those conditions could be maintained with a single thermal control device. A thermal block is a thermal and not a geometric concept: spaces need not be contiguous to be combined within a single thermal block.

An *HVAC zone* is a physical space within the building that has its own thermostat and zonal system for maintaining thermal comfort. HVAC zones are identified on the HVAC plans. HVAC zones should not be split between thermal blocks, but a thermal block may include more than one HVAC zone.

A *space function* is a sub-component of a thermal zone that has specific baseline lighting requirements and for which there are associated defaults for outside air ventilation, occupancy, receptacle loads, and hot water consumption. An *HVAC zone* may contain more than one *space function*. Appendix B has a list of the space functions that may be used with the COMNET rating method.

Figure 2.2.1-1 [1] shows the hierarchy of *space functions*, *HVAC zones* and *thermal blocks*.

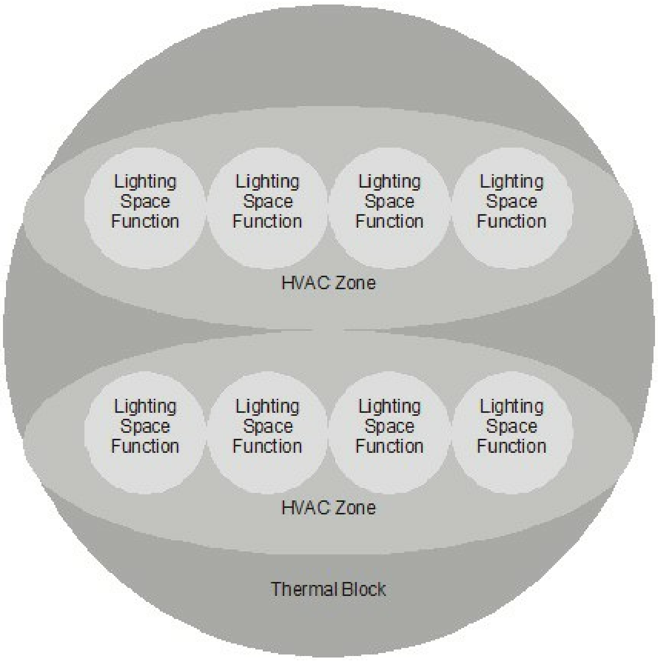

Figure 2.2.1-1: *"Hierarchy of Space Functions, HVAC Zones and Thermal Blocks"*
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2.2.2 General Guidance

Thermal blocks and the HVAC zones and space functions that they contain are user inputs; they are not automatically generated by COMNET accredited software. This section provides some general rules and guidance on how to effectively define the thermal blocks. Albert Einstein once said "everything should be made as simple as possible, but no simpler" and that is the challenge when creating thermal blocks[1]. The energy simulation model should include as few thermal blocks as possible, but as many as are needed. Breaking a building into thermal blocks is a step of the energy modeling process that requires considerable judgment.

Because of differences in the capabilities and limitations of various simulation tools and the extreme variety in size and complexity of buildings to which the *rating method* may be applied, a rigid set of rules for defining thermal blocks is not possible. Some exercise of user judgment will be required in most cases to determine the most appropriate way to subdivide and model a building.

Defining appropriate thermal blocks will save time for the user and will help to ensure accurate results. However, regardless of how the user chooses to subdivide the rated building, for most purposes, identical subdivisions will be used in modeling the baseline building. It is difficult to predict what impact a faulty decision would have on percent savings, but there is little doubt that the impact on proposed design energy use could be significant.

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1. "On the Method of Theoretical Physics" The Herbert Spencer Lecture, delivered at Oxford (10 June 1933); also published in Philosophy of Science, Vol. 1, No. 2 (April 1934), pp. 163-169.

2.2.3 Number of Thermal Blocks

In general, the smaller the number of thermal blocks that are defined, the lower the user's effort will be to create the building description. However, if too few thermal blocks are defined, simulation results are likely to be less accurate. In order to simplify ratings, users should define as few thermal blocks as possible, consistent with the other guidance in this section. Normally, the number of thermal blocks in a building should not exceed the number of HVAC zones in the building.

2.2.4 Space Use Classification Considerations

Thermal blocks may contain up to ten different space use classifications, provided the spaces have similar space conditioning requirements. If the building area method is used, each thermal block must be assigned to one and only one building area category. For space classifications that are combined in a single thermal block, the spaces must meet all of the following conditions:

- Use the same operating schedule.
- Use the same space temperature schedule.
- Have similar internal load power densities. Combined lighting, receptacle, and process equipment power densities that differ by no more than 2.0 W/ft² or a factor of two may be considered similar.
- Have similar occupant densities. Occupant densities (i.e., densities represented in floor area per occupant [under peak design conditions]) that differ by no more than a factor of three may be considered similar.

2.2.5 Envelope Load Considerations

Thermal blocks shall consist of spaces having similar envelope loads; for example, thermal loads from solar heat gains and conductive heat losses from roofs. In general, spaces close to the perimeter of the building should be in separate thermal blocks from interior spaces. The following guidance shall be applied in combining HVAC zones into thermal blocks:

- Exterior and interior spaces shall not be combined in the same thermal block, except as permitted below.

  Exception: Exterior spaces without fenestration or doors may be combined with interior spaces in the same thermal block.

- Exterior spaces having different glazed orientations shall not be combined in the same thermal block, except as permitted below.

  Exception: Exterior spaces having different glazed orientations but small effective apertures for solar heat gain (i.e., solar heat gain coefficient times fenestration area divided by zone floor area less than 10%) may be combined in a single thermal block.

  Exception: Exterior spaces having different glazed orientations but whose orientations differ by 45° or less may be combined in a single thermal block. This is not intended to prevent or discourage modeling of actual or anticipated corner zones or other actual HVAC zones which include fenestration of varying orientations in a single contiguous space.
- Spaces with envelope loads from floors and/or roofs shall only be combined within a single thermal block with spaces having similar loads from floors and/or roofs.
- Separate thermal blocks shall be created when fenestration area varies greatly. For example, a long perimeter corridor with small windows at one end, but all glass at the other should be split into two thermal blocks.

2.2.6 Conformance with HVAC Zones

Thermal blocks shall conform with the actual HVAC zoning as documented on the construction documents or the as-built drawings. "Conform with" as used here means that thermal blocks shall accurately reflect the actual floor areas of the HVAC zones (i.e., to within 5% of actual square footage), and thermal blocks and HVAC zones should share the same bounding surfaces.

2.2.7 Combining HVAC Zones

Under specific conditions, different HVAC zones may be combined into a single thermal block to reduce user input and to simplify the computer description of the building. Zone multipliers may also be used to achieve similar simplification, when this is a feature of the software. Provided all of the following conditions are met, different HVAC zones may be combined to create a single thermal block (or identical thermal blocks to which multipliers are applied):

- No more than ten different HVAC zones are included in any one thermal block.
- All the HVAC zones have similar space conditioning requirements.
- All of the zones are served by the same HVAC system or by the same kind of HVAC system. Perimeter baseboards, unit heaters or fan powered boxes (vs. straight boxes) should not be considered the “same kind” of HVAC system as zones without these features.
- All zones have similar minimum airflows (cfm/ft²) and if any have separate exhaust, this is met generally by transfer air from the HVAC zones in the thermal block.

2.2.8 Thermal Blocks in Multifamily Residential Buildings

Multifamily residential buildings, including hotel and motel occupancies, should be modeled using one thermal block per unit. Where units are thermally similar, dwelling units or hotel rooms may be combined. Corner units and units with roof or floor loads shall only be combined with units sharing these features.

2.2.9 Plenums

Plenums are spaces above the ceiling and below the floor above where lighting fixtures, pipes, ducts and other building services are often located. Plenums may or may not be used as return air plenums. Because of the leakage through the ceiling (typically suspended with lay-in panels), the temperature of the plenum tracks the temperature of the space, except that it is generally warmer because of heat stratification and heat produced by lighting fixtures located at the ceiling or in the plenum.

It is generally recommended that plenums be modeled as separate thermal blocks, but at the modeler's discretion, they may be combined with conditioned space below for modeling simplicity.

2.3 Unmet Load Hours

The Performance Rating Method and this manual use the term "unmet load hours" as a criterion for sizing equipment, for qualifying natural ventilation systems, and for other purposes. The concept of unmet load hours applies to individual thermal blocks but is summed for the building as a whole. For a thermal block, it represents the number of hours during a year when the HVAC system serving the thermal block is unable to maintain the set point temperatures for heating and/or cooling. During periods of unmet loads, the space temperature drifts above the cooling setpoint or below the heating setpoint. An unmet load hour occurs only during periods when the HVAC system is scheduled to operate. One hour with un-met loads General Modeling Procedures - Calculation Procedures Page 2-6 COMNET Manual August 2010 in one or more thermal block counts as a single un-met load hour for the building. If unmet load hours for more than one thermal block coincide (occur at the same hour), they count as only one unmet load hour for the building. Un-met load hours include periods when the space is either under cooled or under heated.

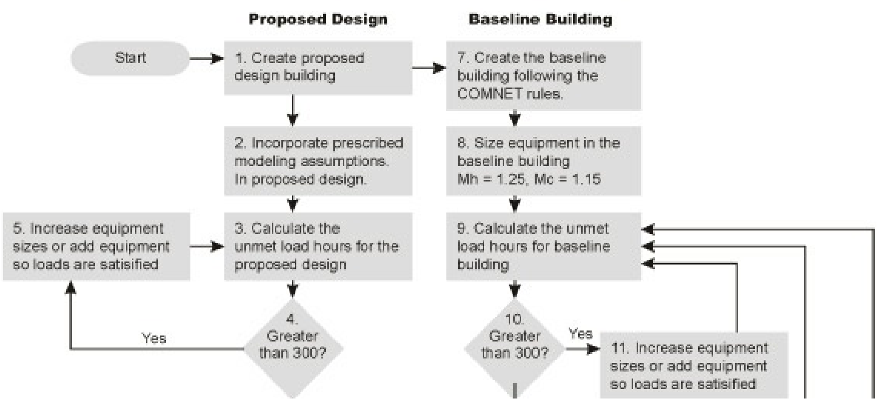
Unmet load hours can occur because fans, air flows, coils, furnaces, air conditioners or other equipment is undersized. Unmet load hours can also occur due to user errors including mismatches between the thermostat setpoint schedules and HVAC operating schedules or from other input errors, for instance, high internal gains or occupant loads. The term, as used in this manual, only addresses equipment undersizing. It is the responsibility of the user to address other causes of unmet load hours in the proposed design. There can be many reasons, but the following checklist is offered as a starting point:

- Make sure that thermostat schedules agree with schedules of HVAC system operation; occupant schedules; miscellaneous equipment schedules; outside air ventilation schedules and other schedules of operation that could affect the ability of the HVAC system to meet loads in the thermal block.
- Check to make sure that inputs for internal gains, occupants, outside air ventilation are reasonable and are consistent with the intended operation of the building.
- Examine the simulated operation of controls to determine if primary or secondary heating or cooling equipment (pumps, coils, boilers, etc.) is activated. Verify that the controls are not resetting in a way that reduces modeled capacity.

2.4 Calculation Procedures

Not applicable for Design to Earn ENERGY STAR.

The process for tax deductions and green building ratings is illustrated in Figure 2.4-1 [2]. For both of these purposes, the proposed design is compared to a baseline building and the percent savings are calculated for the proposed design relative to the baseline building.



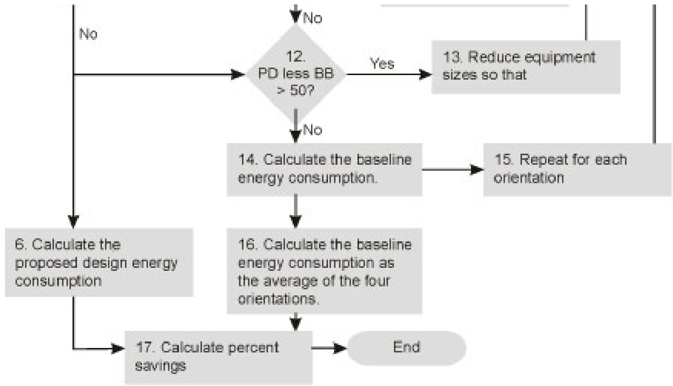


Figure 2.4-1: *"Calculation Process for Tax Deductions and Green Building Ratings"*

1. The process begins with a detailed description of the proposed design. Information is provided in enough detail to enable an estimate of annual energy use for a typical weather year. This information includes the building envelope, the lighting systems, the HVAC systems, the water heating systems and other important energy-using systems. This collection of information is referred to in this manual as *building descriptors*. A detailed presentation of the building descriptors are provided in Chapter 6.
2. Before the calculations are performed, some of the building descriptors are modified for the proposed design to incorporate *prescribed* (neutral independent) modeling assumptions. Prescribed modeling assumptions are different depending on purpose. For tax deductions, they include schedules of operation and plug loads. For green building ratings, there are few prescribed modeling assumptions.
3. The next step is to make a simulation of the *proposed* design to determine how well the heating and cooling loads are being satisfied. The indicator is *unmet load hours*, the number of hours during the year when the space temperature is below the heating set point temperature or greater than the cooling set point temperature. A large number of hours indicate that the equipment is undersized.
4. Test the number of unmet load hours and proceed only if the hours are less than 300 for the year of the simulation.
5. If the unmet load hours are greater than 300 for the year, then the baseline building simulation model is adjusted to reduce the unmet load hours to less than 300. If the problem is heating, then the size of the boiler or furnace may need to be increased. If the problem is cooling, then the size of the coils or chillers may need to be increased. These adjustments are not made automatically for the proposed buidling, but rather are specified by the modeler. See Figure 2.5.2-1 [3].
6. If the unmet load hours are less than 300, then the final simulation is performed. If no changes are made in the model, this may be the same simulation in step 3. These calculations produce the results that are compared to the baseline building, which is calculated in steps 7 through 16.
7. Create the baseline building following the rules in this manual. The baseline building has the same floor area, number of floors and spatial configuration as the proposed design; however, systems and components are modified to be in minimum compliance with the *baseline standard*. The HVAC systems for the baseline building are established according to rules in this manual and depend on the primary building activity (residential or non-residential), the floor area, the number of stories and the fuel used for heating. See Figure 6.1.2-1 [4].
8. Sizing calculations are performed for the baseline building and heating equipment is oversized by 25% and cooling equipment by 15%.
9. The next step is to make a simulation of the baseline building to determine how well the heating and cooling loads are being satisfied. This process is the same as performed for the proposed design in step 3.
10. The number of unmet load hours is then tested to see if they are greater than 300. This is not likely to occur since the heating and cooling equipment is oversized by 15% for cooling and 25% for heating in step 8.
11. If the unmet load hours are greater than 300, then equipment in the baseline building is increased so that the unmet hours are less than 300. See Figure 2.5.2-1 [3].
12. Once both the baseline building and the proposed design have unmet load hours less than 300, they are compared to confirm that the unmet load hours for the proposed design are not greater than 50 more than the baseline building.
13. If the difference in unmet hours is greater than 50, then the equipment in the baseline building is educed in size so that the difference is less than or equal to 50. See Figure 2.5.2-1 [3].
14. Once the tests on unmet load hours are satisfied, then the energy performance of the baseline building is calculated. If the tests of unmet hours are satisfied the first time through, this step is the same as step 9.
15. The baseline building is rotated 90 degrees and modeled again. This is repeated for four orientations. Each time the building is rotated the equipment is resized.
16. The baseline energy use for the baseline building is calculated as the average of the energy use for the four orientations.
17. The next step is to make a simulation of the proposed design to determine how well the heating and cooling loads are being satisfied. Finally, the percent savings are calculated. For tax deductions, only regulated energy is considered, but for green building ratings, total energy is considered.

The COMNET calculation process described above is consistent with the ASHRAE Standard 90.1 Performance Rating Method (PRM) as contained in Appendix G of the Standard.

2.5 HVAC Capacity Requirements and Sizing

Not applicable for Design to Earn ENERGY STAR.

To ensure that the simulated space-conditioning loads are adequately met, adequate capacity must be available in each of the components of the HVAC system; e.g., supply-air flow rates, cooling coils, chillers, and cooling towers. If any component of the system is incapable of adequate performance, the simulation may understate the required energy inputs for space conditioning and report unmet load hours. Adequate capacities are required in the simulations of both the proposed design and baseline building. The subsections below describe the procedures that shall be followed to ensure that both the baseline building and the rated building are simulated with adequate space-conditioning capacities.

2.5.1 Specifying HVAC Capacities for the Proposed Design

As shown in Figure 2.4-1 [2], the proposed design shall have no more than 300 unmet load hours. If this requirement is violated, the software shall require the user to make changes to the proposed design building description to bring the unmet load hours below 300. This process is not automated by the software. There are two tests that must be met:

- Space loads must be satisfied: Space temperatures must be maintained within one half of the throttling range (e.g., 1°F with a 2°F throttling range) of the scheduled heating or cooling thermostat setpoints. This criterion may be exceeded for no more than 300 hours for a typical year.
- System loads must be satisfied: Plant equipment must have adequate capacity to satisfy the HVAC system loads. This criterion may be exceeded for no more than 300 hours for a typical year.

If either the space or system loads do not meet the above criteria, the equipment in the proposed design shall be resized by the user and appropriate changes shall be made to the construction documents such that the criteria are met. If the space conditioning criteria are not met because the HVAC equipment in the proposed design lacks the capability to provide either heating or cooling, equipment capable of providing the needed space conditioning must be added by the user. The type of equipment added will depend on the type of HVAC system in the proposed design and the judgment of the energy analyst.

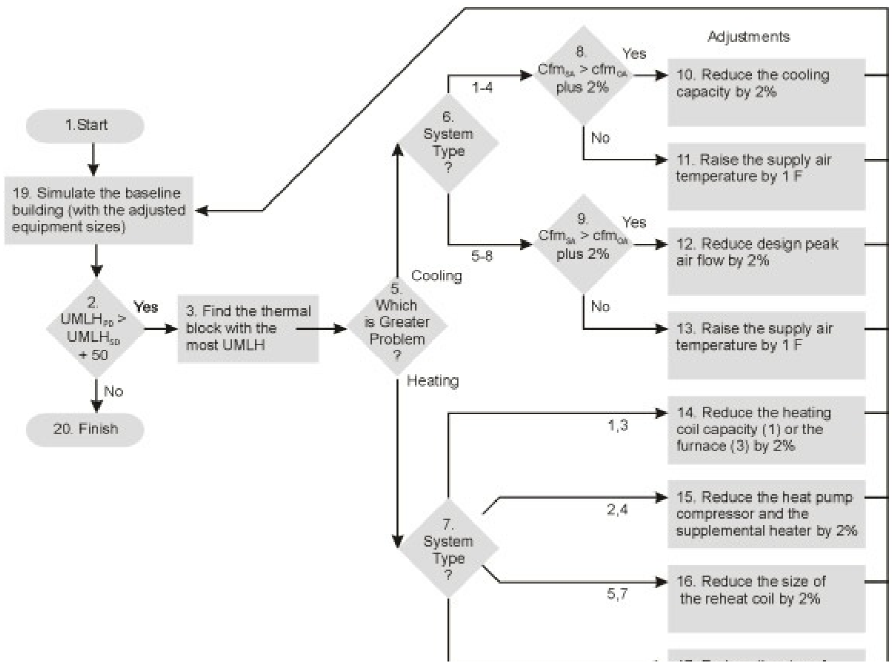
Equipment sizes for the proposed design shall be entered into the model by the energy analyst and shall agree with the equipment sizes specified in the construction documents. When the simulations of these actual systems indicate that specified space conditions are not being adequately maintained in one or more thermal block(s), the user shall be prompted to make changes to equipment sizes and to make corresponding changes to the construction documents. This occurs when the unmet load hours exceed 300 for the year.

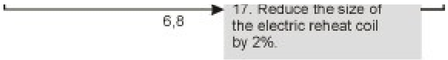
2.5.2 Sizing Equipment in the Baseline Building

Equipment in the baseline building is automatically oversized by the program (25% for heating and 15% for cooling). However, in cases when unmet load hours in the proposed design are greater than 50 hours compared to the baseline building, equipment in the baseline building may have to be downsized. The criterion is that the unmet load hours in the proposed design may be no greater than 50 hours more than the corresponding thermal block in the baseline building. Figure 2.5.2-1 [3] shows the recommended procedure for downsizing equipment in the baseline building so that the 50 hour delta requirement is satisfied. Note that this procedure may result in the baseline building equipment not meeting the 25% oversizing requirement for heating and the 15% oversizing requirement for cooling. It is also possible that the downsizing will result in a reduction in the 20 F delta-T specified in § G3.1.2.8 of the PRM.

Unmet load hours are evaluated at the building level by looking at the unmet load hours for each of the thermal blocks being modeled. One hour with unmet loads in one or more thermal block counts as a single unmet load hour for the building. Therefore, the unmet load hours for the building will never be less than the worst thermal block.

Figure 2.5.2-1 [3] shows the process of adjusting equipment sizes in the baseline building in order to meet the 50 hour delta requirement. Equipment in the baseline building is already oversized, so the process is to incrementally make adjustments to the thermal block with the most unmet load hours until the un-met load hours for the baseline building are within 50 of the proposed design. The process is explained in greater detail in the paragraphs that follow Figure 2.5.2-1 [3].





[5]

Figure 2.5.2-1: *"Procedure for Adjusting Equipment HVAC Sizes in the Baseline Building"*

1. The process begins with simulation results for both the proposed design and the baseline building.

2. Simulate the baseline building and calculate the un-met load hours for the building (see definition above).

3. Compare the unmet load hours between the proposed design and the baseline building. If the proposed design is no more than 50 hours greater than the baseline building, then move no adjustments are necessary and the process is complete (step 18), otherwise move to 4.

4. When the difference between the proposed design and the baseline building is greater than 50 unmet load hours, then determine the thermal block with the greatest total un-met load hours for heating and/or cooling. Adjustments will be made to this thermal block.

5. Test to see which is greater: the difference in heating unmet load hours or cooling unmet load hours.

6. If the difference for the thermal block is mostly cooling, then look at the system type serving the thermal block. If the system is type 1 through 4 (single zone systems) then go to 8, otherwise go to 9.

8. For system types 1 through 4, test to see if it is possible to reduce air flow to the thermal block and still maintain the minimum outside air ventilation level. If so, go to 10; otherwise, go to 11.

10. Reduce the cooling capacity of the packaged equipment by 2% and let the air flow to the zone scale in order to meet a 20°F delta-T difference between the setpoint temperature in the space and the supply air. Maintain the same ratio of sensible to total cooling capacity.

11. Raise the supply air temperature to the thermal block by 1°F. This reduces the 20°F delta-T, but is necessary to maintain air flow to the space at a volume adequate to meet the outside air ventilation requirement.

9. For system types 5 through 8, test to see if it is possible to reduce air flow to the thermal block and still maintain the minimum outside air ventilation level. If so, go to 12; otherwise, go to 13.

12. Reduce the design air flow rate to the thermal block by 2%. Allow the upstream coil and cooling equipment to be auto-sized so that their capacity is also reduced.

13. Raise the supply air temperature to the thermal block by 1°F. This reduces the 20°F delta-T, but is necessary to maintain air flow to the space at a volume adequate to meet the outside air ventilation requirement.

7. If the difference for the thermal block is mostly heating, then look at the system type serving the thermal block. If the system type is 1 or 3, go to 14; if the system type is 2 or 4, go to 15; if the system type is 5 or 6, go to 16; or if the system type is 6 or 8, go to 17.

14. For system types 1 or 3, reduce the heating coil capacity or the size of the furnace by 2%

15. For system types 2 or 4, reduce the size of the heat pump compressor and the supplemental heater by 2%. Note that for modeling purposes the size of the heat pump compressor is changed without changing the size of the cooling capacity.

16. For system types 5 or 6, reduce the size of the reheat coil by 2%. Auto size the boiler accordingly.

17. For system types 6 or 8 reduce the size of the electric reheat coil by 2%.

3. Move back to step 2.

20. Finish.

2.6 Ventilation Requirements

Assumptions regarding outside air ventilation shall be based on applicable building codes or ASHRAE Standard 62.1-2007 if local codes do not apply. If information on ventilation rates is unavailable, values from Appendix B shall be used. For most purposes, the same assumptions on outside air ventilation are used in the baseline building and the rated building; therefore, no credit can be realized by reducing ventilation rates in the rated building.

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