ENERGY STAR Multifamily High Rise
Energy Modeling Quality Control Checklist, V1.0

Introduction

This optional checklist was developed to help energy modelers create energy models that comply with the requirements of the ENERGY STAR Multifamily High Rise Program. This checklist has been created based on eQUEST energy modeling software, however, the overall guidance can be applied to other energy modeling software approved for use in this program. The checklist is not a substitution for the Simulation Guidelines and does not automatically confirm that all requirements within the Simulation Guidelines have been met.

Verifying Modeling Inputs

General
1. When possible, have you modeled the Proposed Design using parametric runs within the same file as the Baseline, rather than a separate and independent file?
2. Have you used the Performance Path calculator and Simulation Guidelines to develop the inputs to the model?
3. Review the eQUEST report, "LV-B Summary of Spaces". Confirm that the square footage listed matches the areas listed in the 'Basic Info' and 'Interior Lighting' worksheet of the Performance Path calculator. Revise your model and Performance Path Calculator worksheets so that the square footage of conditioned and unconditioned spaces is consistent.
4. Has the correct weather file been selected?

TIP: Rename zones such that they can be easily identified in the Simulation Output reports.

Building Shell
1. Review the eQUEST report, "LV-D Details of Exterior Spaces". Using building perimeter and height, confirm that reported areas are appropriate and that all floors have been included in the model.
2. Do the gross wall and window areas of the eQUEST report "LV-D Details of Exterior Surfaces," match your take-offs?
3. Does the total conditioned square footage (LS-C report) match the 'Basic Info' worksheet? See definition of "space" in ASHRAE 90.1-2007 to determine if your indirectly conditioned spaces can be included. If they can, these spaces can be modeled as 'conditioned' in your energy model, although no active conditioning system is present. Leave the temperature schedule as "undefined" and assign the space to the HVAC system which is indirectly providing heating and/or cooling.
4. Have you selected the correct window parameters for your baseline model for your climate zone? See Table 5.5 of ASHRAE 90.1-2007 or the 'Windows eQUEST' worksheet in the Performance Path Calculator.
5. Have you included nonresidential associated spaces such as retail or commercial spaces? If these spaces do not exceed 20,000 ft², they should have the same baseline HVAC as the residential spaces (Appendix G, G3.1.1).
6. Check that U-values in Constructions match the U-values in ASHRAE Tables 5.5. (including the door). TIP: Create a "Test U-Value" Construction to easily test the layers you have created to confirm their U-value.
7. Does your baseline have the same window distribution as your proposed? The Appendix G baseline no longer requires that windows be distributed uniformly in horizontal bands. The maximum 40% window-to-wall ratio still applies in the baseline – if your Proposed design has greater window area, have you modeled it?

8. Are slab-below-grade floors in the baseline modeled with the same specifications as in the proposed? As these floors are not regulated in ASHRAE, they must be modeled the same as the Proposed.
9. Are floors above unconditioned spaces modeled in the baseline per ASHRAE Table 5.5?
10. Have the walls, floors and roofs been tailored such that residential and nonresidential specifications can be assigned accordingly?
11. Have the floors and roofs been tailored such that spaces on the same floor with differing boundary conditions can be modeled accordingly?
12. Has the floor perimeter been modeled explicitly or has the average U-value of the wall assembly been properly derated to accommodate floor perimeter with different insulation than the floor-to-ceiling insulation?

Internal Loads
13. Under Infiltration for apartment zones, have you used the 'Infiltration and Ventilation' worksheet of the Performance Path Calculator to combine apartment Supply air, Exhaust air, and Infiltration, in CFM/SF and operate 24 hours/day? Have you checked that they exceed 0.35 ACH (LV-B)? Outside air and exhaust for other zones can be modeled in *Air-Side HVAC* properties.
14. Under Equipment, Equipment #1 is reserved for miscellaneous plug loads. Are you using the IN-UNIT plug load schedule that adds to 5.8 hours and 0.5 W/SF in each apartment zone? Are you using the non-UNIT plug load schedule that adds to 9 hours for common area plug loads? Are you using 0.2 W/SF in all corridors, restrooms and stairs zones,1.5 W/SF in offices, and 0.5 W/SF in other public and common zones?
15. Under Equipment, Equipment #2-5 reserved for appliances. Are you using the IN-UNIT plug load schedule that adds to 5.8 hours for refrigerators, dishwashers, electric stoves and in-unit clothes washers and electric dryers?
16. Equipment #2 for common laundry rooms (common dryers) should also use the non-UNIT plug load schedule.
17. The elevator energy (W/SF) should be based on the AREA of one elevator zone and entered only for ONE zone in Equipment #1, using non-UNIT plug load schedule. The kWh/yr should be based on the 'Appliance' worksheet of the Performance Path Calculator
18. Under Equipment, have you assigned the proper sensible and latent heat ratios for each appliance, according to the Simulation Guidelines? Do your inputs (W/SF) match the 'Appliance' worksheet of the Performance Path Calculator?
19. Under Lighting, have you added Exits signs (5 W/face) as 'Lighting kW 2' to the Baseline spaces per the Proposed design? Most common spaces to include Exit signs are corridors, lobbies, and stairs. As an alternative, the total kW for exit signs can be added directly to the electric meter, under 24hours/day schedule.
20. Have you only entered in lighting for ONE of the elevator zones?
21. Under Lighting, does your apartment schedule add up to 2.34 hours? Do your non-apartment lighting schedules for stairs, halls, corridors, exit signs, elevators and garages, operate 24 hours/day? Does your exterior lighting schedule account for photosensors (cannot exceed 12 hours/day)?
22. Have you filled in the 'Interior Lighting' and 'In-Unit Lighting' worksheets of the Performance Path Calculator? Does it include information about specific lighting fixtures used to obtain improved lighting power density? It is unlikely for overall In-Unit Proposed LPD to be lower than 0.5 W/Sf.
23. If taking credit for occupancy sensors in the halls and stairs of the Proposed Design, have you properly applied the 25% and 35% reductions, respectively, to the proposed lighting power density?
24. Are you taking credit for occupancy sensors in all other common spaces, as per proposed design, not intended for 24 hours/day operation? 10% reductions can be applied to storage rooms, offices, and public restrooms, but credit cannot be applied to conference/meeting rooms and employees lunch and break rooms.

25. Under Internal Energy Sources, have you added 2,126 BTUH for each apartment that has a gas stove? Are you using the In-Unit plug load schedule that adds to 5.8 hours? Have you added the gas energy for the dryers, within each apartment or in the laundry room zone?
26. Has the proposed energy usage of appliances been calculated using the Performance Path Calculator (or Simulation Guidelines)?
27. Have In-Unit clothes washers and dryers been added as individual loads for each apartment space? Have common clothes washers been added to laundry zones (Equipment #1)?

Water-Side HVAC
General
28. Do the capacities of the Proposed boilers entered into eQUEST match the mechanical drawings?
29. Have you selected a boiler curve and HW system that best corresponds to the proposed system (e.g. condensing boiler curve)?
30. Are you using the same efficiency units in the baseline and proposed?

Baseline HVAC 1 – PTAC
31. For Baseline HVAC System 1, do you have the right number of space heating boilers (2 if over 15,000 SF)? Are they in the correct zone? Are they the right efficiency? Check PS-C for capacity needed. Use the calculated baseline heating load and 25% oversizing requirement of G3.1.2.2 to determine if the baseline boiler efficiency should be 80% AFUE or 80% Et. Baseline capacities for boilers should be auto sized by the modeling software.
32. For Baseline HVAC System 1, have you added the HW pump ('Standard' Motor Class and Capacity Control 'One-Speed')? Use 'Variable Speed' for buildings over 120,000SF. For the Baseline, you will need to check the "PV-A Plant Design Parameters" report and then adjust inputs until 19 W/GPM is achieved.
33. Make sure Loop Operation is "Standby", Setpoint Control is "OA Reset" and that 50 DT is specified on Boiler and HW Circulation Loop properties. Check that the OA Reset schedule is correct (180 supply at 20F and 150 supply at 50F).
34. For proposed heating systems with central boilers, if the Proposed Design has a different supply or return temperature or outdoor reset conditions than the ASHRAE baseline, include that in the Proposed Design model as a parametric run.

Domestic Water Heating
35. If Proposed design has central gas DHW, does the DHW heater have HIR=1.25 specified? Has the volume from the Proposed design been entered? Has the UA been calculated based on R-12.5 and an assumed surface area of the tank? The default value is also acceptable if no energy efficiency measure related to the storage tank is proposed.
36. If in-unit gas or electric storage water heaters are proposed, is the baseline energy factor calculated from Table 7.8 of ASHRAE 90.1-2007?
37. Has a DHW pump been added? Has the GPM for the baseline Process Loads been entered with the DHW schedule (6.7 hours)? Does it match the 'DHW Demand' Worksheet from the Performance Path Calculator?
38. Review the eQUEST Report "PV-A Plant Design Parameters" for the capacity of the baseline domestic hot water heater. Gas storage water heaters greater than 75,000 Btu/h must be modeled with a thermal efficiency of 80%.
39. As per Simulation Guidelines, the baseline and proposed DHW system type, capacity and fuel should be the same, except when modeling integrated or indirect hot water systems. In this situation, the Baseline should be modeled as independent systems and the baseline capacity for the DW heater should be auto sized by the modeling software

Air-Side HVAC

40. At the system level, 'Pkgd Terminal AC' should be selected for baseline models if the design uses natural gas for heating. Cool and Heat Sizing Ratios should be 1.15 and 1.25 respectively. PTAC fans should be 0.0003 kW/CFM and Unitary Power for cooling will generally be 0.3123 EIR (equivalent to 9.305 EER less the supply fan energy).
41. If your proposed model uses baseboards rather than fan coils, be sure to add those. If you proposed model uses gas furnaces, be sure to eliminate the heating boiler and add the specifications for the gas furnace.
42. At the Zone level, under Outside Air & Exhaust, exhaust should not be listed in corridor or apartment zones. This should have been accounted for in Infiltration already. Exhaust CFM for dryers and refuse rooms should be accounted for as "Exhaust flow" not "OA Air Flow".
43. Per the Simulation Guidelines, is the cooling set point set at 80°F for 6 hours each day and 78°F for the remaining hours? Is the heating set point set at 70°F for 8 hours each day and 72°F for the remaining hours?
44. Ventilation rates in corridors and other common spaces shall be modeled in the Proposed as specified on the drawings. The same rates should be used in the Baseline, without exceeding ASHRAE 62.1-2007 rates by more than 50%. Review the eQUEST report "LV-B Summary of Spaces" to verify air changes in these spaces.
45. As per Simulation Guidelines, cooling in corridors and utility spaces such as mechanical rooms should not be modeled unless cooling is provided in the proposed design. Verify in your model.
46. Are you using the following equation for calculating fan power? Pfan = bhp x 746/Fan Motor Efficiency
47. Verify pumps and distribution valve inputs are correct per ASHRAE 90.1 Section G3.1.3.5. For buildings under 120,000 sf, baseline space heating circulating pumps should be modeled as a pump that rides its curve. Therefore, a two-way valve should be modeled rather than a three-way valve for the baseline PTAC Air-Side HVAC Systems. For buildings 120,000 sf and larger, pumps should be variable flow and also have two-way valves.

Utility & Economics

48. Have you modeled the exterior lighting as "Exterior Lighting" enduse in Direct Loads - Exterior of Electric Meter? Does this match the calculation in the Performance Path Caclulator based on linear square feet and façade area? Is this based on a 12-hour schedule? Credit in the Proposed Design can only be taken on the Tradable Surfaces. NO credit can be taken for reduced lighting power on building facades. Non-Tradable surfaces should have the same lighting power in Baseline and Proposed.
49. Have you modeled the dryer and refuse exhaust fans as Direct Loads-Interior and assigned them to "Ventilation Fans" enduse? Are these based on 24 hour operation schedules and BHP from plans?
50. Have you modeled the apartment exhaust fans as Direct Loads-Interior and assigned them to "Ventilation Fans" enduse? Are these based on 24 hour operation schedules? If they are rooftop fans, are the kW based on BHP from plans? If they are ceiling or in-line fans inside the apartment, are the baseline kW based on either 1.2 CFM/W or 2.3 CFM/W?
51. Have you modeled accessory pumps, fans, and equipment in the Direct Loads – Interior of Electric Meter?

Assessing Validity of Modeling Outputs

1. After simulating the baseline and proposed energy models and pasting the results in the Performance Path calculator, review the BTU/SF on the Simulation Summary worksheet. Be prepared to explain any end-use categories that *increased* energy intensity over the Baseline.
2. After simulating the baseline and proposed energy models and pasting the results in the Excel calculator, divide average monthly energy costs for the Proposed Design by the number of apartments (see cells H32 and H33 of the 'Simulation Summary' worksheet). Does this monthly energy cost seem appropriate for an apartment in an energy efficient building?
3. After simulating the baseline and proposed energy models, review the baseline and proposed model's BEPS reports and confirm that "Percent of hours any system zone outside of the throttling range" is less than 300 and that the unmet hours in the proposed does not exceed the baseline by more than 50. Adjust equipment capacities per Appendix G, G3.1.2.2 until the hours meet the requirements. Refer to the eQUEST report "SS-R Performance Summary" to determine which zones are underheated or undercooled.
4. Please explain or correct the warning and caution errors in your proposed model from the eQUEST report "ATTN Simulation Messages for Review."
5. Review the eQUEST report "SS-D Building HVAC Load Summary." Are there months that show heating or cooling that shouldn't?
6. Review the eQUEST report "SS-E Building HVAC load hours." Are the annual hours of heating load for the proposed design similar to the baseline? Investigate as needed.
7. Review the eQUEST Report "SS-C System Load hours" for discrepancies between the Baseline and Proposed. Coincident heating and cooling indicate HVAC system is not performing correctly.
8. Review the eQUEST Report "PS-D Circulation Loop Loads" for circulation loop overloading. No loop may be overloaded.

Reviewing Results
1. Review the project description included in the Performance Path Calculator. As part of this step, make sure that Baseline and Proposed components are described fully and correctly, and reasonable and sufficient details are provided on how each improvement is modeled.
2. Verify that the magnitude of projected savings is consistent with the features of the design. As part of this step, qualitatively compare the simulated energy savings by end use to the building design to ensure that results are reasonable. For example, a significant projected reduction in lighting energy of the proposed design compared to the baseline should be questioned if the proposed design does NOT include significant improvements to the lighting fixtures or controls.
3. Use the eQUEST "10 Minute" and "30 Minute" QC checklists to further review results [developed by James J. Hirsch & Associates (February 2009)]
4. Exceeding ASHRAE 90.1-2007 by more than 15% is a challenge. Energy cost savings over 25% must be investigated.

"10 Minute" DOE2 Output QC Checklist

Report	Check	Comments
BEPU	Percent of hours outside throttling range	Eq. size, control (see SS-R, SS-F, and SS-O)
BEPU	Percent of hours loads not satisfied	Equip sizing, control (see PS-C, and PS-H)
BEPS	Energy use & cost intensity	Btu/sqft/year from BEPS, ($/sqft/year from ES-D)
BEPU	Energy use by category	Compare relative magnitudes
PS-E	kW and kWh by end-use (annual & monthly)	to check W/sqft, get conditioned area from LS-C
PS-D	Peak loads on loops	compare peak load (PS-D) with equip size (PV-A)
PS-C	Peak load & equipment sizes	compare peak load (PS-C) with equip size (PV-A)
PS-C	Calculate overall equipment efficiencies	Load met / energy used (see SS-P for unitary eq.)
PS-C	Equipment part-load ranges (annual)	for monthly - see PS-H, for unitary equip - see SS-P
PS-C	Total equipment operating hours	for monthly - see PS-H, for unitary equip - see SS-P
PS-A	Monthly pattern of heating and cooling loads	confirm realistic pattern (compare also SS-D & LS-D)
SS-N	Hours at Relative Humidity Levels	check RH levels by time of day
SS-J	System load and size checks	sqft/ton, cfm/sqft, min osa/per, cool/heat pk (Btuh/sf)
* any *	Proper weather file used	reported at top right corner of most reports

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James J. Hirsch & Associates, February 2009

"30 Minute" DOE2 Output QC Checklist

Report	Check	Comments
⑧ LV-A	Proper weather file used	also reported at top right corner of most reports
LV-B	Lighting density in each space	0.6 - 2.5 W/sf, confirm no lights in plenums
LV-C	Average space height for each space	DOE2 bases this on volume/area
LV-D	Total (opaque + glass) wall area by orientation	approx equal areas for opposite orientations
LS-B	Peak space load per sqft for each space	perimeter: ~25 Btu/sf*win/flr ratio*SC+Internal
LS-C	Peak space load per sqft (building total)	% core*core Btuh/sf + % perim*perim Btuh/sf
LS-C	Outdoor temperatures coincident with peak	these are used in outdoor air design load calcs.
LS-C	Building net area (modeled area)	compare to known gross building area
LS-D	Peak lighting + plug load density	compare to inputs for lights & plugs (see also PS-F)
❽ LS-D	Monthly pattern of heating and cooling loads	confirm realistic pattern (see also SS-D & PS-A)
SV-A	Amount of outside air (if not scheduled)	check or reasonable values
SV-A	Sensible heat ratio	check or reasonable values
SS-D	Peak cooling load, square feet per ton	compare with PS-D and/or PS-C (if built-up equip)
❽ SS-D	Monthly pattern of heating and cooling loads	confirm realistic pattern (see also LS-D & PS-A)
SS-E	Cooling/heating/simultaneous hrs & availability	ensure realistic hours (check for too much simultaneous)
SS-A	For unitary DX, monthly pattern of loads	unitary loads are not totaled in SS-D
❻ SS-P	Average EER for unitary DX	cooling load / (compressor+fan kWh)
⑩ SS-J	System load and size checks	sqft/ton, cfm/sqft, min osa/per, cool/heat pk (Btuh/sf)
❶ SS-K	Avg temperature, cooling and heating hours	Compare to t-stat set points (includes unconditioned!)
❶ SS-O	Hours under cooled/heated by time-of-day	Compare to t-stat set points & throttling range
❶ SS-F	Hours under cooled/heated by zone	Excessive hours indicate faulty control
❶ SS-R	Hours under cooled/heated by system	Excessive hours indicate faulty control
SS-N	Hours at relative humidity levels	check RH levels by time of day
PV-A	Equipment sizes	compare with peak loads on PS-C and PS-D
⑧ PS-A	Monthly pattern of heating and cooling loads	confirm realistic pattern (compare SS-D & LS-D)
⑤ PS-C	Calculate overall equipment efficiencies	Load met / energy used (see SS-P for unitary eq.)
⑥ PS-C	Equipment part-load ranges (annual)	for monthly - see PS-H, for unitary equip - see SS-P
⑦ PS-C	Total equipment operating hours	for monthly - see PS-H, for unitary equip - see SS-P
④ PS-E	kW and kWh by end-use (annual & monthly)	to check W/sqft, get conditioned area from LS-C
⑨ PS-H	Average operating ratios	Equip sizing & load management check
PS-H	Peak load & equipment sizes	peak load & equipment size, 300 to 700 sqft/ton
①BEPU	Percent of hours outside throttling range	Eq. size, control, schedules (see SS-R, SS-F, SS-O)
① "	Percent of hours loads not satisfied	Equip sizing, control & schedules (see PS-C, PS-H)
③BEPU	Energy use by category	Compare relative magnitudes
③ "	Energy use & cost intensity	Btu/sqft/year from BEPU, ($/sqft/year from ES-D)

① primary check item
❶ secondary check item (related to a primary check)

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James J. Hirsch & Associates, February 2009