ENERGY STAR®
MULTIFAMILY NEW CONSTRUCTION PROGRAM

Simulation Guidelines
Version 1, Revision 021
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i. DEFINITIONS

***ASHRAE 90.1-2007 (or 2010)*:** energy standard for buildings, except low-rise residential buildings. Minimum requirements for the energy-efficient design of multifamily buildings over three stories above grade are included within this standard.

***ASHRAE 90.1-2007 (or 2010) Appendix G (Appendix G)*:** protocols for generating an energy *Performance Rating* for buildings that exceed the requirements of ASHRAE 90.1-2007 (or 2010) is included within this appendix.

***ASHRAE Path Calculator*:** set of spreadsheet calculators provided by the Program to assist energy modelers in generating certain specific data inputs needed to complete the energy model for the *Baseline Building Design* and *Proposed Design* as referenced in this document, as well as summarize modeling results.

***As-Built*:** conditions observed and measured in the completed building. The *As-Built* energy model must represent the actual observed and measured conditions in the constructed building, excluding envelope leakage and duct leakage of *in-unit* forced air systems.

***Baseline Building Design*:** a computer representation of a hypothetical design based on the proposed building project. This representation is used as the basis for calculating the *Baseline Building Performance* for rating above-standard design.

***Baseline Building Performance*:** the annual energy use of the *Baseline Building Design*, expressed in the units of energy cost or alternate units if EPA guidance approves them for use.

***common space*:** any space~~s~~ within a building that serves a function in support of the residential part of the building that is not part of a *dwelling* or *sleeping* *unit*. This includes spaces used by residents, such as corridors, stairs, lobbies, laundry rooms, exercise rooms, residential recreation rooms, and dining halls, as well as offices and other spaces used by building management, administration or maintenance in support of the residents~~parking used exclusively by residents, building staff, and their guests. This also includes offices used by building management, administration or maintenance and all special use areas located in the building to serve and support the residents such as day-care facilities, gyms, dining halls, etc~~.

***design team*:** group of professionals responsible for the final design of a building including, but not limited to: ~~-~~the developer, the general contractor, the architect, and design engineers.

***dwelling unit*:** a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

dwelling unit mechanical ventilation: A mechanical exhaust system, supply system, or combination thereof that provides each *dwelling unit* with outdoor air each hour at no less than the rate specified in Table 4.1a of ASHRAE 62.2-2010 or 2013, or equivalently, Equation 4.1a of ASHRAE 62.2-2010 or 2013, based on the floor area of the *dwelling unit* and number of bedrooms.

energy neutral**:** element of the simulation that is kept identical in the *Baseline Building Design* and *Proposed Design*.

in-unit**:** term used to describe features in the building that are located within the *dwelling unit*s. For example, "in-unit lighting" is used to reference lighting located within the apartments.

local mechanical exhaust: An intermittent or continuously operating exhaust fan that removes air from a conditioned space, such as the *dwelling unit*'s bathrooms and kitchen, and discharges to the outside. A bathroom is any room containing a bathtub, a shower, a spa, or similar source of moisture. A kitchen is any space containing cooking appliances.

nonresidential**:** spaces in mixed-use buildings other than *residential*, or *common space*, or residential parking garages, such as commercial spaceretail or office spaces that do not serve and support the residents. Parking garages or lots where the cost of the energy use of the parking garage or lot is not the responsibility of the Builder/Developer, Building Owner or Property Manager, are considered nonresidential.

Performance Rating**:** percent reduction in the *Baseline Building Performance* compared to the *Proposed Building Performance* or *As-Built* performance across all end-uses.

Performance Target**:** minimum *Performance Rating* required to earn the ENERGY STAR. The Performance Target depends on the state commercial code. Performance Target options are listed in the National Program Requirements and on the ENERGY STAR website. Energy savings associated with on-site power generation, including cogeneration, photovoltaics, or wind turbines, may not contribute to meeting the *Performance Target*, but may be used to exceed it.

Proposed Building Performance**:** the annual energy use of the *Proposed Design*, expressed in the units of energy cost or alternate units if EPA guidance approves them for use.

Proposed Design**:** a computer representation of the actual proposed building design or portion thereof used as the basis for calculating the design energy consumption.

residential**:** spaces in buildings used primarily for living and sleeping. Residential spaces include, but are not limited to, *dwelling unit*s or *sleeping units*. This may include skilled nursing or assisted living units, when present in a building eligible for certification.

residential-associated: see *common space*

sleeping units: A room or space in which people sleep, which does not meet the definition of *dwelling unit*. Such rooms and spaces that are also part of a *dwelling unit* are not *sleeping units*. For the purpose of these Simulation Guidelines, model *sleeping units* in the same manner as *dwelling units*, unless otherwise specified, such as *local mechanical exhaust* requirements, which may not be applicable.

***ventilation*:** the process of supplying outdoor air to or removing air from a space by mechanical means.

1. SCOPE.

1.1 General. This document contains the methodology for calculating a *Performance Rating* for multifamily buildings participating in EPA's ENERGY STAR Multifamily New Construction Program ("Program"), that are complying with a Performance Target that is based on *ASHRAE 90.1-2007* or *ASHRAE 90.1-2010 Appendix G*. Buildings complying with a *Performance Target* that is based on ASHRAE 90.1-2013 or ASHRAE 90.1-2016 Appendix G must instead use the "ENERGY STAR MFNC Simulation Guidelines_AppG2016".

This is not a stand-alone document. It is intended to be used as a supplement to the procedures described in *ASHRAE 90.1-2007 (or 2010)*, *Appendix G*. The *ASHRAE 90.1* standard includes a wide range of building types within its scope. As a result, this standard does not address certain characteristics commonly found in multifamily buildings with sufficient specificity to ensure that energy modeling results are consistent from one energy modeler to the next. This document is designed to address these issues so that the assumptions that must be made to complete these energy models are applied logically and consistently based on all of the features typically found in multifamily buildings.

While the scope of the *ASHRAE 90.1* standard does not include low-rise multifamily buildings, low-rise residential buildings following the ASHRAE Path of the ENERGY STAR Multifamily New Construction program are permitted to follow the modeling protocols within *Appendix G* for purposes of demonstrating compliance with their Performance Target for ENERGY STAR certification. These projects must follow these Simulation Guidelines, including the noted modifications of the *Appendix G* protocols for low-rise buildings. Exception: Townhouses are not permitted to use the ASHRAE Path.

1.2 Instructions. The document is to be used by ENERGY STAR Multifamily New Construction (MFNC) participants and energy modelers to calculate the *Performance Rating* of the *Proposed Design* for each building participating in the program. It may be shared with the developer or property owner if requested.

2. OBJECTIVES.

2.1 Ensure a consistent simulation methodology from building to building and from energy modeler to energy modeler based on *ASHRAE 90.1-2007(or 2010), Appendix G* to evaluate energy efficiency of multifamily buildings.

2.2 Ensure a consistent approach for handling the simulation of components that are not included in Appendix G, or included without the level of detail needed to support the simulation process.

2.3 Address those issues that Appendix G leaves for the "rating authority" to decide. The "rating authority" is EPA.

2.4 Ensure that the rating process facilitates energy efficient design from the beginning of the design process.

3. MODELING GUIDELINES

3.1 General Approach.

3.1.1 Baseline Building Design Components.

3.1.1.1 Components of the *Baseline Building Design* shall comply with *ASHRAE 90.1-2007 (or 2010)* and other applicable national standards as noted in the text and listed in **Appendix A** of this document. Addenda to the referenced standards may be used, but must be explicitly mentioned in the documentation provided by the energy modeler, including the related modeling implications.

3.1.1.2 End uses that do not exist in the *Proposed Design* cannot be included in the *Baseline Building Design*. For example, if the parking lot in the *Proposed Design* is not lit, then parking lot lighting power allowance cannot be added to the Baseline energy consumption.

3.1.2 Proposed Design Components.

3.1.2.1 Components in the *Proposed Design* must reflect the actual building components, except where otherwise specified in this document. Components in the *Proposed Design* must comply with the mandatory requirements of this Program as well as applicable state and local codes. If components are not installed during construction, (for example appliances or room air conditioners), then such components may not be modeled in the *Proposed Design* as contributing to energy savings.

3.1.3 As-Built Components.

3.1.3.1 Unless otherwise noted in this document, components in the *As-Built* model must reflect the actual building components, as verified or measured during inspections. At the completion of the project, these same guidelines must be used to calculate the *Performance Rating* for the *As-Built* model, by substituting "*As-Built*" where you find "*Proposed Design*". Components that are not required to reflect *As-Built* conditions within the energy model, such as envelope leakage, are specified in the relevant sections below. Although some required measurements are not incorporated in the energy model, they do have restrictions as described in the mandatory requirements.

3.1.4 Simulation Methodology.

3.1.4.1 The *Baseline Building Design* and *Proposed Design* of buildings in the scope of *ASHRAE Standard 90.1-2007* shall be simulated per *ASHRAE Standard 90.1-2007 Appendix G* and as described in this document. If the Performance Target is based on *ASHRAE Standard 90.1-2010,* it shall instead be simulated per *ASHRAE Standard 90.1-2010 Appendix G.*

3.1.4.2 The *Baseline Building Design* and *Proposed Design* shall include all dwelling units, ~~and~~ common spaces, and residential parking garages, as defined above, in the building.

3.1.4.3 In mixed use buildings, nonresidential areas such as retail stores or offices open to general public and unrelated to the building's residential function may be included or excluded from the simulations at the discretion of the energy modeler. If included, energy savings may only be modeled for a measure if it meets the relevant mandatory program requirements. Otherwise, they must be modeled as *energy neutral*. If excluded, the building may not be able ~~will not be eligible~~ to receive the "Designed to Earn ENERGY STAR (DEES)" credential, unless the energy use for the nonresidential areas has been estimated using other calculations when generating a Statement of Energy Design Intent while applying for the recognition.

Note: Earning the DEES credential is not a requirement of the ENERGY STAR MFNC program, but an option available to eligible projects to promote the energy efficient design of their building during the construction process.

3.1.4.4 Separate *Baseline Building Design* and *Proposed Design* models shall be created for each non-identical building in the project. The *Performance Rating* shall be calculated individually for each such building.

3.1.5 Final Design. The *Baseline Building Design* and *Proposed Design* shall be based on the final design of the building, not the initial or preliminary design that was received by the energy modeler from the *design team*.

3.1.6 Design Changes. The *Baseline Building Design* may require changes until all the parameters in the *Proposed Design* that affect the *Baseline Building Design* are finalized.

3.1.5 Schedules

3.1.5.1 The schedules described within this document, or approved equivalent schedules, must be used. All schedule assumptions that differ from the ones specified in these Simulation Guidelines shall be documented and submitted to an EPA-recognized Multifamily Review Organization (MRO) for review and approval. The same schedules must be used in both the *Baseline Building Design* and *Proposed Design* unless explicitly allowed otherwise in Appendix G or this document. Any difference in the schedules must be documented.

3.2 Performance Rating and Documentation Requirements (G1.2 and G1.4)

3.2.1 The *Proposed Building Performance* and *Baseline Building Performance* must each be calculated as the sum of predicted energy consumption by end use. The energy consumption for each end use shall be taken from the report generated by the simulation program as described in Section G1.4 of Appendix G and in this document.

3.2.2 Some modeling software cannot calculate energy usage for all types of technologies proposed for multifamily buildings. Energy use for these features can be determined using separate calculators, custom software, spreadsheets, or other applicable and reasonable means of estimating the energy impact of those features. When calculations of this nature are completed outside of the primary modeling tool, the energy modeler must document both the basis for the calculation and how it was incorporated into the final *Performance Rating*. Calculations performed outside of the primary modeling tool and not described in this document shall be submitted to an EPA-recognized Multifamily Review Organization (MRO) for review and approval.

3.2.3 End-use Energy Consumption used in the Percentage Improvement equation shall be adjusted to incorporate the results of approved calculations done outside of the modeling tool and as described in this document.

3.2.4 Modeling Assumptions that are not explicitly specified in Appendix G or this document shall be documented and submitted to an EPA-recognized Multifamily Review Organization (MRO) for review and approval.

3.2.5 A summary of the performance calculation requirements are listed below but may differ depending on the software tool being used. For example, some tools may be able to automatically calculate exposure-neutral baseline (steps below) or generate a *Performance Rating* automatically based on the entered parameters of the *Proposed Design*.

3.2.5.1 Baseline Building Performance shall be determined as follows:

a. Export into a spreadsheet file all total electricity and fuel usages from the energy modeling software tool, for each of the four *Baseline Building Design*s (actual orientation, and 90, 180, 270 degree rotations, per Table G3.1 of Appendix G). *Exception: Baseline Building Performance* may be based on the actual building exposure if it is demonstrated that the building orientation is dictated by site conditions.
b. Show usage of each fuel according to at least the following components: lights, internal equipment loads such as appliances and plug loads, service (and domestic) hot water heating equipment, space heating equipment, space cooling equipment, fans and other HVAC equipment (e.g. pumps), and otherwise meet the requirements of Section G1.4 of Appendix G.
c. Average the results of the four building orientations, for each fuel and per each usage component, if applicable.
d. Adjust the result to include the approved calculations performed outside of the energy modeling software tool.
e. If the energy consumption inputs in steps a-d above were expressed in units other than dollars, then after adjusting the simulation outputs as described above, multiply the result by the appropriate fuel rates to obtain the dollar value ($) of your *Baseline Building Performance*.

3.2.5.2 Proposed Building Performance is determined as follows:

a. Export into a spreadsheet file all total electric and fuel usages from the energy modeling software tool (only the actual building orientation is required; no rotations).
b. Adjust the result to include the approved calculations performed outside of the energy modeling software tool.
c. Show usage of each fuel by end use.
d. If the energy consumption inputs in steps a-c above were expressed in units other than dollars, then after adjusting the simulation outputs as described above, multiply the result by the same fuel rates as used for the Baseline simulation to obtain the dollar value ($) of your *Proposed Building Performance*.

3.2.6 Performance Rating. Calculate the Performance Rating as:

100*(*Baseline Building Performance* - *Proposed Building Performance*) ÷ (*Baseline Building Performance*)

3.3 Simulation Program (Section G2.2)

3.3.1 Modeling Requirements. The simulation program must meet the requirements of Appendix G, Section G2.2. Although not limited to this list, examples of programs that meet these requirements are DOE-2, eQUEST, TRACE, HAP and EnergyGauge.

3.4 Building Envelope: Opaque Assemblies

3.4.1 Baseline Surfaces. The properties of the Baseline surfaces shall be determined as follows (using the corresponding sections from ASHRAE 90.1-2010 as needed):

a. Requirements for multifamily buildings greater than 3 stories are based on the surface type outlined in ASHRAE 90.1-2007 Appendix G, prescriptive envelope requirements from Table 5.5, and detailed surface descriptions from ASHRAE 90.1-2007 Appendix A. For example, the roof in the baseline shall be modeled as insulated entirely above deck, with continuous insulation R-value from Table 5.5 for the appropriate climate zone. Walls above grade shall have steel framing 16" OC, stucco R-0.08 (exterior layer), 0.625" gypsum board R-0.56, cavity and/or continuous insulation from Table 5.5 for the appropriate climate zone and accounting for the thermal bridging, and 0.625" gypsum board R-0.56 (interior layer). When using Table 5.5, use Appendix B to ASHRAE 90.1-2007 to determine climate zone.

b. Requirements for multifamily buildings 3 stories and less are based on the wood-framed building requirements from Table 5.5 and detailed surface descriptions from ASHRAE 90.1-2007 Appendix A. For example, the baseline shall be modeled with an attic and not insulated entirely above deck, with U-factor from Table 5.5 for the appropriate climate zone. Walls above grade shall have wood framing 16" OC, stucco R-0.08 (exterior layer), 0.625" gypsum board R-0.56, cavity and/or continuous insulation from Table 5.5 for the appropriate climate zone and accounting for the thermal bridging, and 0.625" gypsum board R-0.56 (interior layer). When using Table 5.5, use Appendix B to ASHRAE 90.1-2007 to determine climate zone.

c. 'Residential' envelope requirements apply only to *dwelling units*. Examples of spaces that are considered '*nonresidential*' for the purpose of envelope requirements include *common space* such as corridors, stairwells, and lobbies, and commercial spaces being included in the energy model.

d. Per ASHRAE 90.1-2007 Section 5.5.2, if a building contains any semiheated or unconditioned space, then the semi-exterior building envelope of the *Baseline Building Design* shall comply with the requirements for 'Semiheated' space in Tables 5.5. For more information on space types and envelope definitions, see definition of 'space' and Figure 5-5 in ASHRAE 90.1-2007, or 5-C of the 90.1-2007 User's Manual. For example, for the purpose of identifying exterior envelope requirements, indirectly conditioned basements and non-vented crawlspaces with insulated walls, rather than ceilings, generally will still be considered 'conditioned space' and therefore the '*nonresidential*' requirements apply.

e. The surface properties for existing buildings that undergo major renovations shall reflect existing conditions prior to any revisions that are part of the scope of work being evaluated, per Table G3.1 Section 5(f) of Appendix G. This requirement applies to the thermal properties and areas of the different envelope components. For example, if window area was changed as part of the renovation, the pre-retrofit window area shall be modeled in the baseline, and post-retrofit window area shall be modeled in the *Proposed Design*. This requirement does not apply to envelope air-tightness – the same air leakage must be modeled in the baseline and proposed models. Note: Projects using ASHRAE 90.1-2016 Appendix G are permitted to model credit for measured infiltration rates that are lower than mandatory program requirements. ASHRAE 90.1-2016 Appendix G can also be used to demonstrate a *Performance Target* above *ASHRAE 90.1-2007 (or 2010)*.

f. Spandrel areas of curtain wall systems are modeled as opaque assemblies in the Baseline and follow the U-factor requirements for Above-Grade steel-framed walls.

3.4.2 F-factor. If the energy modeling software tool does not allow input of the perimeter heat loss factor (F-factor), then the slab-on-grade construction that corresponds to the F-factor shall be modeled as is appropriate to the software tool being used. If the slab-on-grade insulation in the *Proposed Design* is a permitted method, as described in Section 5.3.1.5 of the Standard 90.1 User's Manual, model slab-on-grade as *energy neutral*. If the slab-on-grade insulation is not a permitted method, model as uninsulated in the *Proposed Design*.

3.4.3 Shading Devices. Automatically-controlled fenestration shades or blinds and permanent shading devices (side fins, overhangs, balconies) may be accounted for to calculate energy savings in *Proposed Design* (per Appendix G).

3.4.4 HVAC Penetrations. Through-wall AC sleeves and PTAC/PTHP penetrations must be modeled in the *Proposed Design* with the U-factor required in Table 5-5 for vertical glazing with metal framing (all other). Any insulated cover that is not used every day may not be included in the model.

3.4.5 Doors. Doors that are more than one-half glass are considered fenestration, per Section 3 of *ASHRAE 90.1-2007*, and shall be modeled with properties required for vertical glazing from ASHRAE 90.1 Table 5-5 in the *Baseline Building Design*, as described in Section 3.5 of this document.

3.4.6 Unique envelope assemblies such as projecting balconies, perimeter edges of intermediate floor slabs, concrete floor beams over parking garages, and roof parapets, shall be separately modeled in the *Proposed Design*, per Appendix G Table G3.1, Section 5(a). A weighted average of the U-factors of these assemblies is acceptable in the simulation. Projected balconies and perimeter edges of intermediate floor slabs are considered to be a wall, per wall definition in Section 3 of *ASHRAE 90.1-2007*, and shall be modeled in the *Baseline Building Design* as having the U-factor required in Table 5-5 for exterior steel-frame or wood-frame walls, depending on building height.

3.4.7 Thermal Bridging. Components in the *Proposed Design* shall be modeled in accordance with their actual properties and accounting for thermal bridging, as described in *ASHRAE 90.1-2007* Appendix A and the following section.

3.4.8 Metal Fasteners. The *Proposed Design* model must account for thermal bridging through portions of the wall assembly where non-thermally broken shelf angles, metal clips, z-girts, brick ties, or other continuous metal fastened to the wall are used. Where those conditions exist (see Figure 1), the insulation cannot contribute to the assembly

U-factor for those areas. An overall U-factor shall be calculated based on an area weighted average of the thermal properties. For example, if the U-factor of a wall assembly is U-0.064 for portions where there is rigid insulation and cavity insulation, the U-factor for the areas thermally bypassed by the shelf angle could be reduced to U-0.097, if the rigid insulation is ignored. If the vertical component of the shelf angle comprises 5% of the vertical wall area, the overall U-factor decreases to U-0.066 (U=0.064*0.95+0.097*0.05).

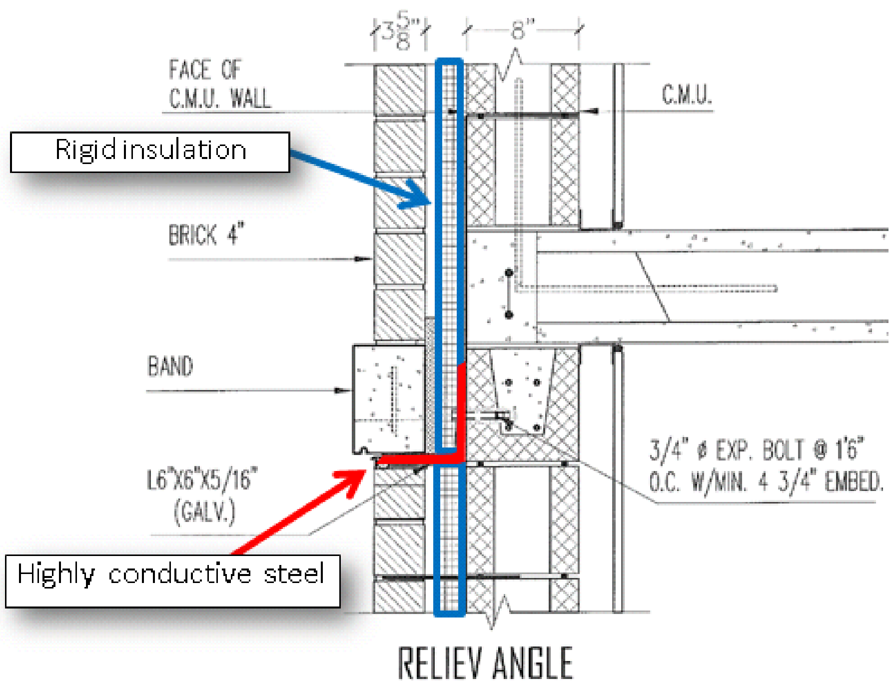

Figure 1: Wall construction utilizing shelf angle

Example: The vertical portion of the wall thermally bypassed by the shelf angle (the red line in Figure 1) must be treated as having no rigid insulation when calculating the weighted average thermal properties of the wall in the *Proposed Design*.

3.5 Building Envelope: Vertical Fenestration

3.5.1 Fenestration. Per Appendix G, fenestration area shall be distributed on each face of the building in the same proportion as the *Proposed Design*, without exceeding 40% of gross above-grade wall area. See *ASHRAE 90.1-2007* for definition of "fenestration."

3.5.1.1 Baseline Fenestration properties shall be determined as follows:

3.5.1.1.1 When the *Proposed Design* is a wood-frame building or a building 3 stories and less, properties of fenestration in the baseline shall be based on prescriptive requirements of *ASHRAE 90.1-2007 (or 2010)* for vertical glazing with nonmetal framing. For all other building types, properties of fenestration shall be based on prescriptive requirements for the applicable metal framing. *ASHRAE*

90.1-2007 (or 2010) requirements for vertical glazing are shown in Tables 5.5-1 through 5.5-8 based on the framing material.

3.5.1.1.2 For gut rehabilitation projects, the *Baseline Building Design* shall reflect existing conditions prior to any revisions that are part of the scope of work being evaluated, as described in building envelope section of Table G3.1 of Appendix G.

3.5.1.2 Proposed Fenestration. For the *Proposed Design*, the properties of fenestration specified in the drawings shall be used. These properties must include rated U-factor and SHGC shown on the National Fenestration Rating Council (NFRC) label. NFRC rating reflects the overall performance of the fenestration assembly and includes both frame and glazing of the standard size window. Certification provided by the installer or supplier listing the assembly U-factor and SHGC can be used in lieu of NFRC labels, provided that they comply with Section 5.8.2.2, 5.8.2.4 and 5.8.2.5 of ASHRAE 90.1-2007. Results from Lawrence Berkley National Laboratory's WINDOW software or NFRC's CMAST may also be used in lieu of NFRC labels.

3.5.1.3 Partially Glazed Doors. Modeling of partially glazed doors:

3.5.1.3.1 Doors that are more than one-half glass:

a. The entire door area shall be counted as vertical fenestration when calculating the vertical fenestration-to-wall ratio.
b. The door shall be modeled as a single fenestration unit in both the *Baseline Building Design* and *Proposed Design*.
c. The door U-factor and SHGC in the *Baseline Building Design* shall be determined based on requirements for vertical glazing in Tables 5.5-1 through 5.5-8, based on the applicable climate zone and framing.
d. In the *Proposed Design*, the door U-factor and SHGC shall be modeled as per the NFRC label for the door specified in the final design.

3.5.1.3.2 Doors that have glazing area of 50% or less:

a. Only the glazed portion of the door shall be included when calculating the vertical fenestration-to-wall ratio.
b. Use one of the following options to model the door:
   1. Model the entire door as opaque in the *Baseline Building Design* and *Proposed Design*. The baseline door U-factor shall be modeled based on the *ASHRAE 90.1-2007 (or 2010)* requirements for opaque doors of appropriate type[1]. The proposed door U-factor shall be modeled as per the NFRC label.
   2. Model the *Baseline Building Design* with a door of identical distribution of opaque/glazed area to the proposed door and apply the *ASHRAE 90.1-2007 (or 2010)* requirements for opaque doors of appropriate type to the opaque area and the U-factor and SHGC for the appropriate window frame type to the glazing area. The proposed door U-factor shall be modeled as per the NFRC label.

[1] The intent of this procedure is to simplify the modeling requirements for doors with less than 50% glazing area and not to create an energy penalty in the analysis for doors with less than 50% glazing area.

3.6 Lighting (Table G3.1, Section 6)

3.6.1 General.

3.6.1.1 The installed lighting power in the *Proposed Design* is typically not just equal to the total wattage of the bulbs and must be calculated as described in Section 9.1.3 of ASHRAE 90.1 to include power consumed by the ballasts. **In contrast to Appendix G, EPA allows installed lamp wattage to be used, even if the fixture is rated for greater wattage**. For example, a screw-based fixture rated at 100 Watt maximum, with a 26 Watt CFL installed, may be modeled as 26 Watts.

3.6.1.2 Lighting Schedules must comply with the Schedules section of this document and as specified below based on space type.

3.6.1.3 Lighting energy savings credit may be claimed only for hardwired lighting fixtures. If proposed lighting power of a common space or parking garage represents a 30% reduction compared to the space-by-space lighting power allowance in the *reference edition of 90.1*, or if the proposed in-unit lighting is below 0.6 W/SF, the savings in excess of these limits (i.e. higher than 30% savings for common spaces, or lower than 0.6 W/SF in-unit lighting power density) may be modeled only if the proposed fixtures are demonstrated to meet the recommended weighted average footcandles based on the 10th edition of the Illuminating Engineering Society (IESNA) Lighting Handbook for the given space type, as quoted in Table 1.

Table 1: Recommended Light Levels

ASHRAE Space Type	Recommended Light Levels (Weighted Avg. Footcandles)	ASHRAE Space Type	Recommended Light Levels (Weighted Avg. Footcandles)
Apartments	10	Stairs - Active	5
Storage, >50ft^2	5	Restroom	5
Storage, <50ft^2	10	Office	30
Lounge/ Recreation	15	Conference/meeting/multipurpose	30
Exercise Area	15	Electrical/ Mechanical	10
Lobby	10	Workshop	40
Corridor/ Transition	~~10~~5	Parking garage	5
Laundry	20		

3.6.1.4 Lighting energy savings credit may be claimed for reduced power density compared to requirements in *ASHRAE 90.1-2007 (or 2010).* For housing for seniors or people with special visual needs, lighting power density in the Baseline may be increased according to the table below, if the project is designed to meet the light levels in ANSI / IES RP-28. Documentation shall be provided to the MRO that demonstrates eligibility to use this allowance.

Table 2: Senior Housing

Space Type	**LPD (W/ft^2)**	**Space Type**	**LPD (W/ft^2)**
Lobby	2.26	Dwelling Unit	1.65
Corridor/Transition	1.15	Public Restroom	1.52

3.6.1.5 As per the exception of Appendix G Table G3.1, Section 6, identical lighting power shall be assumed in the *Baseline Building Design* and *Proposed Design* for any lighting that is connected via receptacles and/or not shown or provided for on building plans.

3.6.1.6 Credit for automatic controls can only be taken for spaces where such controls are not required by Section 9.4 of *ASHRAE 90.1-2007 (or 2010)*.

3.6.1.7 Decorative lighting allowance described in *ASHRAE 90.1* Section 9.6.2 must not be used to increase the baseline lighting power density for any of the spaces.

3.6.2 In-unit Lighting

3.6.2.1 Lighting inside the *dwelling unit*s (*in-unit* lighting) shall be included in the *Performance Rating* calculations.

3.6.2.2 In the *Baseline Building Design*, *in-unit* lighting power density of 1.07 W/ft^2 shall be incorporated into the model.

3.6.2.3 In the *Proposed Design*, *in-unit* lighting power density of 1.07 W/ft^2 shall be modeled for rooms or portions of the rooms with no specified hardwired lighting. Where hardwired *in-unit* lighting is specified in the *Proposed Design*, the actual installed lighting power density shall be modeled. This lighting power density must take into account the total effective wattage of the installed fixtures and floor area of rooms or portions of the rooms in which they are intended. Hardwired fixtures in rooms, such as bedrooms and living rooms, that may be supplemented by lighting that is connected to receptacles must be estimated to provide illumination at a rate of no more than 3 ft^2 per Watt.

3.6.2.4 The savings shall be modeled as described on the *In-unit Lighting* worksheet of the *ASHRAE Path Calculator*.

3.6.2.5 Baseline and *Proposed Design* lighting inside *dwelling unit*s shall be modeled as lit for 2.34 hours per day. Balcony lighting shall use the same schedule as the *dwelling unit*s. No schedule-based performance credits may be claimed for lighting inside *dwelling unit*s.

3.6.3 Interior Lighting Except In-unit Lighting

3.6.3.1 Lighting shall be simulated as described in Table G3.1 of Appendix G, using either the building area or space-by-space method. If the Building Area method is used, then the Baseline power density of 0.7 W/ft^2 (as per Table 9.5.1, for "Multifamily") shall be used for all non-dwelling unit spaces. If the space-by-space method is used, then the *Baseline Building Design* power density in non-dwelling unit spaces shall be modeled as per Table 9.6.1 of ASHRAE 90.1. As per ASHRAE 90.1-2007 Section 9.6.1(a), for types of building spaces not listed in Table 9.6.1, selection of a reasonable equivalent type shall be permitted. For the spaces below, the equivalent space type that must be used has been established, and the lighting power density has been listed for your convenience. For rooms that include more than one space type such as a large basement space with part of the area used to house electrical/mechanical equipment and the rest used for storage, apply the lighting power density to the appropriate square footage and model the weighted average.

Table 3: Space Type Mapping

Space Type	**90.1- 2007 LPD (W/ft^2)**	**90.1-2010 LPD (W/ft^2)**	**Space Type**	**90.1-2007 LPD (W/ft^2)**	**90.1-2010 LPD (W/ft^2)**
Computer Room	1.2	1.11	Laundry Room	1.3	1.23
Lounge/Recreation	1.2	0.73	Janitor Closet	0.8	0.63
Exercise Room	0.9	0.72	Community Room	1.2	1.11
Trash Chute/Room	0.8	0.63	Elevator (interior)	1.3	1.30
Retail	1.5	1.40	Tenant Storage	0.3	0.63

3.6.3.2 Lighting power trade-offs (as per Section 9.5.1 (d) and 9.6.1 (d)) are allowed only between the areas that have hardwired lighting specified on the *Proposed Design* drawings. If lighting is specified for only a portion of the space, then the ASHRAE 90.1 lighting power allowance must be assigned to the remainder of the space (for which the lighting is not specified on the drawings) in both *Baseline Building Design* and *Proposed Design*. The *Interior Lighting* worksheet of the *ASHRAE Path Calculator* shall be used to calculate interior lighting power trade-offs.
3.6.3.3 Automatic lighting controls are a Baseline and *Proposed Design* requirement for all spaces listed in ASHRAE 90.1-2007 Section 9.4.1.2a (or ASHRAE 90.1-2010 Section 9.4.1.2b), which, per these Guidelines, include community rooms and computer rooms. Performance credit when using ASHRAE 90.1-2007 may be claimed in the *Proposed Design* for installing automatic controls where such controls are not required by ASHRAE 90.1-2007, including but not limited to, janitor closets, laundry rooms, offices, public restrooms, trash/refuse rooms, corridors, stairwells, elevators and lobbies. Due to changes between 90.1-2007 and 90.1-2010, performance credit when using ASHRAE 90.1-2010 may not be claimed in the

Proposed Design for installing automatic controls where such controls are required in the Baseline, including classrooms, conference/meeting/training rooms, storage and supply rooms (including janitor closets and trash/refuse rooms) between 50 and 1,000 ft^2, offices up to 250 ft^2, public restrooms, stairwells, and garages. Appendix G Table G3.2, which describes the allowable lighting power adjustments for automatic controls, is replaced with the following table.

Table 4: Allowed Lighting Power Adjustment

Automatic Control Device	Space Type	Power Adjustment Percentage
Occupancy sensor	Hallways/Corridors Stairwells All other spaces	25%(1) 35% 10%(2)
Occupancy sensor and programmable timing control	All spaces	Same as with occupancy sensor only for the appropriate space type above, or per Table G3.2

(1) 25% power reduction in Hallways per 2005 Building Energy Efficiency Standards of California Energy Code, Section 146
(2) Appendix G, Table G3.2.

3.6.3.4 Baseline lighting in corridors, stairwells and lobbies shall be modeled as lit for 24 hours per day. If using ASHRAE 90.1-2010, stairwells shall instead be modeled as lit for 16 hours per day, to reflect the mandatory occupancy controls.
3.6.3.5 Hours of operation of Baseline lighting fixtures in areas not identified above may be estimated by the energy modeler based on occupancy type of each space and shall reflect the mandatory control requirements of *ASHRAE 90.1-2007 (or 2010)* Section 9.4.
3.6.3.6 The lighting power or schedule for the *Proposed Design* may be adjusted to account for non-mandatory lighting controls in *common space*s or parking garages as described above. Performance credit can be taken either by reducing modeled Lighting Power Density (LPD) or by reducing lighting hours of operation, as described in Appendix G Table G3.1 Section 6ge. Performance credit can be taken with bilevel or multilevel light fixtures or with occupancy sensors that activate select fixtures ON/OFF, as long as the selected design strategy achieves at least one intermediate step between full ON and full OFF that provides 30-70% of full lighting power to that space.

3.6.4 Exterior Lighting.
3.6.4.1 Exterior lighting that is connected to the site utility meters, (e.g., pole fixtures for walkways and parking, exterior lighting attached to the building) shall be included in the *Baseline Building Design* and *Proposed Design*. Exterior lighting performance credit may be claimed only for the Tradable Surfaces described in Table 9.4.5 for which lighting is specified on the drawings. For example, if the parking lot in the *Proposed Design* is not lit, then no parking lot lighting power shall be modeled in either the *Baseline Building Design* or *Proposed Design*. In addition, performance credit can only be modeled if associated with energy-efficiency, rather than a decrease in illumination. Per Section 9.4.5, building façade lighting in the *Proposed*

Design may not exceed the Baseline allowance by more than 5%. Lighting specified for apartment balconies can be evaluated as Tradable, using “Other doors”, or as Nontradable, using “Building façades”. Use the *Exterior Lighting* worksheet of the *ASHRAE Path Calculator* for exterior lighting calculations.

3.6.4.2 Baseline exterior lighting shall be modeled as lit for no more than 12 hours per day. This includes savings due to photosensors that are required per ASHRAE 90.1-2007 Section 9.4.1.3.

3.7 Thermal Blocks (Table G3.1, Sections 7, 8 and 9)

3.7.1 Requirements 7(b) and 9 of Table G.3.1 in Appendix G are not required in the MFHR program. The referenced sections disallow aggregation of corner units with other *dwelling unit*s and disallow aggregation of units that have different orientation and/or are adjacent to different types of surfaces (e.g. roof or slab). Under these guidelines, this simplification is allowed but not required.

3.7.2 All other Thermal Blocks modeling requirements outlined in Table G3.1 must be followed. For example, *common space*s, utility areas and other non-living areas must be modeled as separate thermal blocks.

3.7.3 The thermal block configuration must remain identical between the *Baseline Building Design* and *Proposed Design* building models.

3.8 HVAC

3.8.1 Every space that is modeled as cooled in the *Proposed Design* simulation shall also be modeled as cooled in the *Baseline Building Design*. Likewise, every space that is modeled as heated in the *Proposed Design* simulation shall also be modeled as heated in the *Baseline Building Design*. Unconditioned and semi-heated spaces shall also match between the *Proposed Design* simulation and *Baseline Building Design*.

a. Model the entire living (including all *dwelling unit*) space, as well as offices, community rooms and other conditioned spaces, except as described below, as heated and cooled.
b. Do not model cooling in corridors and utility spaces such as mechanical rooms, laundry rooms, etc. unless the spaces are cooled in the *Proposed Design*. Per addendum dn to ASHRAE 90.1-2007, such thermal zones shall be modeled using constant volume Heating and Ventilation systems in the *Baseline Building Design*. The heating source shall be warm-air furnace, gas-fired, if the building’s predominant heating source is Fossil Fuel, Fossil/Electric Hybrid, or Purchased Heat, and warm-air furnace, electric resistance in other cases. System design supply airflow rates for these baseline systems shall be based on the temperature difference between a supply air temperature setpoint of 105°F and the design space heating temperature setpoint; the minimum outdoor air flow rate; or the air flow rate required to comply with applicable codes or

accreditation standards, whichever is greater. Each thermal block shall be modeled with a separate HVAC system and the following baseline fan power:

$P_{fan,supply} = CFM_S * 0.3$.

$P_{fan,supply}$	electric power to supply fan motor (watts)
CFM_S	the baseline system maximum design supply fan airflow rate in cfm

3.8.2 The Baseline and Proposed HVAC system shall be modeled as per Appendix G, and as clarified in the first note below Appendix G Table G3.1.1A, "…Residential building types include dormitory, hotel, motel, and multifamily." Following this note, *common spaces* that are essential to the building's residential function, including but not limited to corridors and stairwells, must be modeled with residential baseline HVAC system type (System 1 or 2 only) depending on the predominant fuel source in the building, except as allowed in 3.8.1. Appendix G exception G3.1.1(a) that allows the use of additional system types for nonpredominant conditions if they total more than 20,000 ft^2, only applies to heating source, not space function. Baseline HVAC System Types 3-8 may not be used, except in appropriate *nonresidential* spaces that exceed 20,000 ft^2.

Example 1: 25 story multifamily building heated predominantly with gas has 1,000 ft^2 of *common space* on each floor, including corridors, trash rooms, and stairwells. Together, these spaces account for 25,000 ft^2. Corridors are heated with gas and cooled. Stairs are heated with electric resistance but not cooled. What baseline system type should be modeled for the *common spaces*?

Correct Approach: Apartments and corridors are modeled with Baseline HVAC System 1-PTAC. Stairs that are heated but not cooled are modeled with Heating and Ventilation System as described in 3.8.1, which results in Baseline HVAC System 9, not 10.

Incorrect Approach: *Common spaces* are modeled with baseline System 7 following exception G3.1.1(a), since they account for over 20,000 ft^2 and cover more than 5 floors.

Example 2: 25 story multifamily building heated predominantly with electricity has 1,000 ft^2 of *common space* on each floor, including corridors, trash rooms, and stairwells. Together, these spaces account for 25,000 ft^2. Corridors are heated with gas and cooled, and account for 21,000 ft^2. Stairs are heated with electric resistance but not cooled. What baseline system type should be modeled for the *common spaces*?

Correct Approach: Apartments are modeled with Baseline HVAC System 2-PTHP. Stairs that are heated but not cooled are modeled with Heating and Ventilation System as described in 3.8.1, which results in Baseline HVAC System 10 since the building's predominant heating source is electric. Corridors can use Appendix G exception G3.1.1(a) in order to model Baseline HVAC System 1-PTAC in the corridors of the *Baseline Building Design.*

Example 3: 25 story multifamily building with electric heat pumps serving the apartments and corridors are heated with gas, but provide ventilation directly to the apartments. What baseline system type should be modeled for the apartments?

Correct Approach: This qualifies as fossil/electric hybrid and therefore apartments and corridors are modeled with Baseline HVAC System 1-PTAC.

3.8.2.1 For buildings with fossil fuel, fossil/electric hybrid, or purchased heating in the *Proposed Design*, the Baseline HVAC system type shall be modeled as a packaged terminal air conditioner (PTAC) with a constant volume fan control and a hot water natural draft fossil fuel boiler. As required by G3.1.3.2, the Baseline HVAC system shall be modeled as having a single boiler if the boiler serves a conditioned floor area of 15,000 ft^2 or less. If the Baseline HVAC system serves more than 15,000 ft^2 of conditioned space, the HVAC system shall be modeled as having two equally sized boilers.

3.8.2.2 For electric and other heating sources, a packaged terminal heat pump (PTHP) shall be used in the Baseline (DX heating instead of a boiler) and shall be modeled with electric auxiliary heat controlled as required by G3.1.3.1. The electric auxiliary heat may not be used in the model at temperatures above 40ºF and the PTHP must be modeled to allow operation in conjunction with the auxiliary heat at temperatures of 25ºF and higher. Below 25ºF, only the auxiliary heat should be modeled. For example, for eQUEST users, set “Minimum HP Heat Temp” to 25ºF and “Maximum HP Supp Temp” to 40ºF.

3.8.2.3 If snow/ice melting systems, freeze protection for piping, and/or space heating systems are installed in a garage, plenum, or other unconditioned area, energy consumption associated with these heating systems must be included in the *Proposed Design* and the Baseline. In mixed used buildings where the nonresidential spaces are not being modeled, if these systems serve both residential and nonresidential spaces, they shall be pro-rated accordingly.

3.8.3 All Baseline HVAC equipment shall be modeled using the minimum efficiency levels as described in Section 6.4. The Baseline equipment capacities shall be oversized by 15% for cooling and 25% for heating as required by G3.1.2.2. Only the cooling and heating capacities, and not the fan flow rates, shall be oversized The *Proposed Design* equipment shall be modeled using the capacity and supply airflow of the equipment selected; it cannot use default or calculated values from the software. In all cases, the same modeling method and/or efficiency units shall be used in the Baseline and Proposed model. For example, if thermal efficiency (not AFUE or combustion efficiency) is used in the *Baseline Building Design*, then thermal efficiency (not AFUE or combustion efficiency) shall also be used for the *Proposed Design*. The same rule applies to SEER / EER input for cooling equipment.

3.8.4 If the HVAC system efficiency for the *Baseline Building Design* or *Proposed Design* is given as SEER and the EER rating is not available from manufacturer’s data and the approved simulation tool does not automatically perform SEER to EER conversion, the equivalent EER for the model must be calculated as follows:

All Equipment: EER = –0.02 x SEER^2 + 1.12 x SEER

Similarly, HSPF must be converted to COP as follows, and further adjusted to remove fan energy if needed (use *ASHRAE* Path Calculator):

All Single Package Equipment: COP = 0.2778 x HSPF + 0.9667
Split Systems < 65,000 Btu/h: COP = -0.0255 x HSPF^2 + 0.6239 x HSPF
All other Split Systems: COP = 0.4813 x HSPF – 0.2606

3.8.5 Baseline hydronic system shall be modeled as described in Appendix G, including section G3.1.3.2 - G3.1.3.6.

3.8.6 Setpoint temperature of 72ºF and setback temperature of 70ºF shall be used for heating. Setpoint temperature of 78ºF and setback temperature of 80ºF shall be used for cooling. The *Baseline Building Design* must have setback for both heating and cooling. The following hourly schedule shall be used to simulate setback control:

Hour of day	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Heating set-point °F	70	70	70	70	70	70	70	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	70
Cooling set-point °F	78	78	78	78	78	78	78	78	78	80	80	80	80	80	80	78	78	78	78	78	78	78	78	78

3.9 Domestic (Service) Hot Water Systems (Table G3.1, Section 11)

3.9.1 Equipment Type and Efficiency

3.9.1.1 Baseline and Proposed system type, capacity and fuel shall be the same as specified in the *Proposed Design* unless a combination heating/hot water system is used in the final design. In this case, separate stand-alone systems for both heating and hot water meeting the minimum efficiency requirements for each system shall be modeled as the Baseline system. The requirements are as described in Appendix G Table G3.1 Section 11.

3.9.1.2 Baseline system efficiency shall meet the requirements in Section 7.4.2 of *ASHRAE 90.1-2007 (or 2010)*.

3.9.1.3 Water heater efficiency may be described through different parameters including thermal efficiency, combustion efficiency, stand-by loss, recovery efficiency, energy factor, etc. The same units of efficiency shall be used in *Baseline Building Design* and *Proposed Design*. If modeling software requires the input of more than one efficiency type (for example Recovery Efficiency and Energy Factor), but only one efficiency type is provided in *ASHRAE 90.1-2007 (or 2010)* or manufacturer specifications, then the same algorithm shall be used to generate the missing efficiency for both the *Baseline Building Design* and *Proposed Design*. All such conversions must be documented and submitted with the model.

3.9.1.4 Unfired storage tank insulation in the *Baseline Building Design* shall be R-12.5, per ASHRAE 90.1 Table 7.8.

3.9.2 Hot Water Demand.

3.9.2.1 Baseline Hot Water Demand. Hot water demand in the *Baseline Building Design* shall be determined based on the number of occupants in the building when fully occupied assuming one person per bedroom.

a. Per-person consumption of 12/25/44 gal/day shall be used based on low/medium/high usage determined based on appropriate occupancy demographics. Low per-person values are associated with buildings having such occupant demographics as all occupants working, seniors, and middle income. High usage is associated with high percentages of children, low income, public assistance, or no occupants working, and can only be used if the building qualifies as affordable housing.

b. Hot water consumption of clothes washers and dishwashers is not included in the per-person usages above and shall be added according to the calculations described below.

3.9.2.2 Low-flow Fixtures. Hot water demand in the *Proposed Design* may be reduced to reflect lower flow rates of the installed fixtures if lower than required by the Energy Policy Act 1992 (EPACT 1992). The adjusted demand shall be calculated as follows:

ProposedHWDemand[Gal/day]=BaselineHWDemand*(0.36+0.54*LFS/2.5+0.1*LFF/2.5)

Where:
LFS [GPM_{80psi}] = rated flow rate of the low-flow showerheads specified on the drawings
LFF [GPM_{80psi}] = rated flow rate of the low-flow faucets specified on the drawings

OR, for faucets rated at 60 psi:

ProposedHWDemand[Gal/day]=BaselineHWDemand*(0.36+0.54*LFS/2.5+0.1*LFF/2.2)

Where:
LFS [GPM_{80psi}] = rated flow rate of the low-flow showerheads specified on the drawings
LFF [GPM_{60psi}] = rated flow rate of the low-flow faucets specified on the drawings

3.9.2.3 Dishwashers.

3.9.2.3.1 In the *Proposed Design*, if no dishwasher is specified or a dishwasher is specified that is not ENERGY STAR certified, in the *Baseline Building Design* and *Proposed Design*, model hot water consumption of 1290 gal/year per apartment for washing dishes.

3.9.2.3.2 If an ENERGY STAR certified dishwasher is specified in the *Proposed Design*, hot water savings may be calculated as follows: in the *Proposed Design*, model hot water consumption of 860 gal/year per ENERGY STAR dishwasher [this default is used by EPA for an ENERGY STAR certified dishwasher]. Calculate annual per-unit hot water demand reduction by subtracting annual hot water usage of the Proposed dishwasher from 1290 gal/year for a standard dishwasher [this default is used by EPA for conventional dishwashers or no dishwashers].

3.9.2.3.3 Divide annual per unit savings calculated in the previous step by 365 and multiply by the number of dishwashers in the building to obtain total daily savings for the building.

3.9.2.3.4 Subtract total daily savings from ProposedHWDemand to obtain adjusted daily demand of the *Proposed Design*.

3.9.2.3.5 Use the *DHW Demand* worksheet of the *ASHRAE Path Calculator* for reduced hot water demand calculations.

3.9.2.4 Clothes Washer Hot Water Usage. If clothes washers are not specified in the *Proposed Design*, neither the *Baseline Building Design* nor *Proposed Design* shall be modeled with hot water consumption associated with washing clothes. If clothes washers are specified in the *Proposed Design*, determine hot water usage by each clothes washer in Baseline and Proposed Design as follows, using the Baseline values in the *Proposed Design* for clothes washers that are not ENERGY STAR certified:

	Baseline Design Hot Water Gal/yr	Proposed Design Hot Water Gal/yr (ENERGY STAR certified only)
In-unit clothes washer	0.2*12,179	0.2*5,637
Common space clothes washer	0.2*29,515	0.2*13,661

0.2 = estimated ratio of hot water to total water consumed per year.
Values based on annual water consumption of conventional and ENERGY STAR clothes washers, from EPA Savings Calculator for Clothes Washers.
Usage assumptions used by EPA for commercial clothes washers are based on 950 loads/year.

3.9.2.4.1 Convert annual hot water consumption calculated above to hourly values using appropriate hourly load profile as recommended by the energy modeling software tool.

3.9.3 Domestic Hot Water Distribution System

3.9.3.1 The same piping area shall be used in the *Baseline Building Design* and *Proposed Design*.

3.9.3.2 Hot water setpoint capable of delivering a temperature of 120ºF at the point of use shall be used in both *Baseline Building Design* and *Proposed Design*.

3.9.3.3 If a hot water recirculation system or booster pumps are present in the *Proposed Design*, they shall be included in both Baseline and *Proposed Designs*, per Section 11 (h) of Appendix G.

3.10 Receptacles and other plug loads (Table G3.1, Section 12)

3.10.1 Non-lighting receptacle loads shall be included in the simulation and shall be identical in the *Baseline Building Design* and *Proposed Design*, unless the particular load source, such as appliances, is impacted by a specific Energy Reduction Measure. Where the appliance is not specified or installed but a space or room is intended for an appliance, its energy consumption shall be included in the simulation.

Exception: Energy consumption of dishwashers, clothes washers, and clothes dryers shall not be included in either *Baseline Building Design* or *Proposed Design* if they are not specified for the project and no space or room has been designed for them.

3.10.2 The fraction of loads contributing to internal heat gain, shall be identical in the *Baseline Building Design* and *Proposed Design,* as specified in the following table.

3.10.3 Where the *Proposed Design* specifies ENERGY STAR certified appliances, the default values in the following table may be used. Alternatively, the rated energy consumption of the installed appliance may be used in the *Proposed Design*, if the Baseline electricity usage is based on the maximum allowed by the Federal Standard for that specific appliance.

3.10.4 Where the *Proposed Design* specifies non-ENERGY STAR certified appliances, and energy savings are not being modeled, energy consumption for the appliances in the *Baseline Building Design* and *Proposed Design* can both either be the Baseline values in the table below or can be the rated energy consumption of the installed appliance.

3.10.5 Where the *Proposed Design* specifies non-ENERGY STAR certified appliances, and energy savings are being modeled, the rated energy consumption of the installed appliance shall be used in the *Proposed Design*, and the Baseline electricity usage must be based on the maximum allowed by the Federal Standard for that specific appliance.

3.10.6 Where annual or daily consumption is provided in the table below, it must be converted into the equivalent design load (Watt or Watt/ft^2) and hourly schedule as appropriate for the energy modeling software being used.

Load Source	Energy Consumption	Sensible/ Latent Load Fraction (4)
Refrigerator (1)	529 kWh/yr Baseline Building electricity usage (conventional unit) 423 kWh/yr Proposed Design electricity usage (ENERGY STAR unit)	1.00/0.0
Dishwasher (1)	206 kWh/yr Baseline Building electricity usage (conventional unit) 164 kWh/yr Proposed Design electricity usage (ENERGY STAR unit)	0.60/0.15
Clothes Washer (1)	In-unit clothes washers: 81 kWh/yr Baseline Building electricity usage (conventional unit) 57 kWh/yr Proposed Design electricity usage (ENERGY STAR unit) Commercial clothes washers: 196 kWh/yr Baseline Building electricity usage (conventional unit) 138 kWh/yr Proposed Design electricity usage (ENERGY STAR unit)	0.80/0.0
Cooking (2) (electric stove/range)	604 kWh/year	0.40/0.30
Cooking (2) (gas stove/range)	45 Therms/year	0.30/0.20
Clothes Dryer (2)(5)	Vented/Ventless Electric Dryer, Standard: kWh/yr = [418 + (139*Nbr)]*F (conventional unit) kWh/yr = [331 + (110*Nbr)]*F (ENERGY STAR unit)	Electric Dryer: 0.15/0.05
	Vented/Ventless Electric Dryer, Compact (120 V): 282*F kWh/yr (conventional unit) 223*F kWh/yr (ENERGY STAR unit)	Electric Dryer: 0.15/0.05
	Vented Electric Dryer, Compact (240 V): 311*F kWh/yr (conventional unit) 246*F kWh/yr (ENERGY STAR unit)	Electric Dryer: 0.15/0.05
	Ventless Electric Dryer, Compact (240 V): 399*F kWh/yr (conventional unit) 317*F kWh/yr (ENERGY STAR unit)	Electric Dryer: 0.15/0.05

Load Source	Energy Consumption	Sensible/ Latent Load Fraction (4)
	Gas Dryer: Electricity: kWh/yr = [38.0 + (12.7*Nbr)]*F (conventional unit) Gas: Therms/yr = [26.5 + (8.8*Nbr)]*F (conventional unit) Electricity: kWh/yr = [31.0 + (10.4*Nbr)]*F (ENERGY STAR unit) Gas: Therms/yr = [21.6 + (7.2*Nbr)]*F (ENERGY STAR unit)	Gas Dryer: Electricity – 1.0/0.0 Gas – 0.10/0.05
	Nbr = Average number of Bedrooms in dwelling units. F = scale factor to account for increased number of cycles of common space clothes dryers. F=1 for in-unit clothes dryers. F=2.423 for common space clothes dryers.	
Miscellaneous dwelling unit Plug Loads (3)	0.5 W/ft^2 or 1.05 kWh/FFA FFA = Finished Floor Area of living space in square feet	0.90/0.1
Miscellaneous Non-dwelling unit Plug Loads (3)	Corridors, restrooms, stairs, and support areas: 0.2 W/ft^2 design; 0.7 kWh/ft^2 annual usage. Offices: 1.5 W/ft^2 design; 4.9 kWh/ft^2 annual usage Other Multifamily Public& Common Areas: 0.5 W/ft^2 design; 1.6 kWh/ft^2 annual usage	1.0/0.0

Notes to table:

(1) Energy consumption of refrigerator, dishwashers and clothes washers is based on information posted at www.energystar.gov, including the *Product Lists* and *Savings Calculators*

(2) Energy consumption data for conventional units is per Table 11 of the Building America Research Benchmark Definition, Updated December 29, 2004, as made available at http://www.p2pays.org/ref/36/35765.pdf

(3) Plug loads are per Table N2-3 of California's 2005 *Nonresidential* ACM Manual; non-dwelling units modeled with a 9 hour/day schedule, *dwelling unit*s modeled with a 5.8 hour/day schedule.

(4) Sensible and Latent Load Fractions are expressed as the fraction of the annual energy consumption and are based on Table 11 of the Building America Research Benchmark Definition, Updated December 29, 2004, as made available at http://www.p2pays.org/ref/36/35765.pdf

(5) Performance credit for reduced mechanical exhaust rates may be awarded for use of ventless dryers. Infiltration rate reduction of 3 CFM per dryer may be modeled in the proposed design if ventless dryers are specified. Sensible/latent load fraction shall be 0.6/0.15.

3.11 Elevator Loads.

3.11.1 In order to take credit for energy savings associated with improvements to the elevator system, baseline and *Proposed Design* energy estimates must be completed by a design engineer using a simulation based on first principles, traffic models, and engineering data from empirical studies. This energy model must include energy consumed when the elevator is idling and in stand-by as well as the energy consumed when actively transporting the cabs (loaded and unloaded) based on an appropriate traffic model for the building. Some elevator equipment manufacturers will provide these calculations upon request as part of their design assistance service.

3.11.2 When elevator energy usage is modeled using the approach described above, the baseline elevator design shall use the following table and assumptions noted in a-g:

The baseline elevator technology shall be based on number of stories serviced by the elevator as shown in the following table:

Elevator Service Height	Baseline Technology
4 to 6 stories	hydraulic
7-20 stories	geared traction
21+ stories	gearless traction

a. Standard efficiency DC motors
b. Variable Voltage Variable Frequency Drive
c. No regeneration of braking power losses
d. Controls based on simple elevator algorithm
    1. Continue traveling in same direction if there are remaining calls for service in that direction
    2. If no more calls for service in direction being traveled, stop and remain idle, or change direction if there are calls for service in that direction
e. Traction elevators are equipped with counterweights sized at 50% of full load capacity. Hydraulic elevators have no counterweight or hydraulic accumulators.
f. Worm gears for geared traction elevators
g. 2:1 roping scheme

3.11.3 If the elevator system is not modeled using the approach described above, use the default table below to determine the total energy consumption associated with all elevators in the building for both the *Baseline Building Design* and the *Proposed Design*. If “NA”, model as *energy neutral*, using no less than 2.0 MWh per year.

Default Elevator Energy Usage Table

Class	Annual Energy Consumption (MWh) HYDRAULIC (1-6 stories)	GEARED TRACTION (7-20 stories)	GEARLESS TRACTION (21+ stories)
1: UP TO 6 DWELLING UNITS	1.91	NA	NA
2: 7 TO 20 DWELLING UNITS	2.15	NA	NA
3: 21 TO 50 DWELLING UNITS	2.94	3.15	NA
4: MORE THAN 50 DWELLING UNITS	4.12	4.55	7.57

3.11.4. Space Heat Gains. 10% of elevator energy usage shall be added to space heat gains.

3.11.5 Savings related to lighting in the cabin may be claimed as a separate performance credit if not included in an elevator system simulation. Cab lighting in the baseline model shall be equal to 1.3 W/ft^2 operated 24/7.

3.11.6 Ventilation system improvements may also claim savings based on high efficiency fans and/or modified control systems. Elevator cab ventilation in the baseline model shall be modeled using standard efficiency fans operating 24/7.

3.12 Ventilation and Infiltration

3.12.1 Infiltration.

3.12.1.1 Infiltration Method. If the energy modeling software supports multiple infiltration algorithms, the same method must be used in the *Baseline Building Design* and *Proposed Design*.

3.12.1.2 Infiltration Rates. The infiltration rates must be the same in the *Baseline Building Design* and *Proposed Design*, except where modeling energy savings associated with ventless dryers in accordance with Section 3.10. In the *As-Built* model, measured infiltration rates are not used, however the measured infiltration must comply with the mandatory requirements. Note: Projects using ASHRAE 90.1-2016 Appendix G are permitted to model measured infiltration rates.

3.12.2 Baseline Building Design-Ventilation.

3.12.2.1 Local Mechanical Exhaust. The *Baseline Building Design local mechanical exhaust* in all *dwelling unit* bathrooms and kitchens shall be modeled using the same rates as the *Proposed Design*, except where the rates in the *Proposed Design* are provided in excess of the amount required by the building code or ASHRAE 62.2-2013 (5ACH/100 CFM in kitchens and 20 CFM/50 CFM in bathrooms, where the continuous and intermittent rates are shown in that order). In that case, the *Baseline Building Design* shall be modeled to reflect the greater of that required by either ASHRAE 62.2-2013 or the building code and will be less than the *Proposed Design*. Where using rates from the building code in the *Baseline Building Design*, documentation supporting those rates shall be submitted to an EPA-recognized Multifamily Review Organization (MRO) for review and approval. If not specified otherwise, intermittent exhaust shall be modeled with a 2 hr/day runtime or converted to an equivalent 24 hr/day runtime if combined with *dwelling unit mechanical ventilation* in the model.

3.12.2.2 Dwelling Unit Mechanical Ventilation. The *Baseline Building Design dwelling unit mechanical ventilation* rates in all *dwelling units* shall be modeled using the same rates as the *Proposed Design*, except where the rates in the *Proposed Design* exceed the amount required by the building code or ASHRAE 62.2-2016 (0.03 x Area + 7.5 x (#BR + 1)) by more than 15 cfm or 15%. In that case, the *Baseline Building Design* shall be modeled to reflect the greater of that required by either ASHRAE 62.2-2016 or the building code, plus 15 cfm or 15%, and will be less than the *Proposed Design*. Where using rates from the building code in the *Baseline Building Design*, documentation supporting those rates shall be submitted to an EPA-recognized Multifamily Review Organization (MRO) for review and approval.

3.12.2.3 Combined Ventilation Systems. If the same mechanical ventilation system is used to provide both *local mechanical exhaust* and *dwelling unit mechanical ventilation*, the maximum is based on the greater of the two rates. For example, a two-bedroom, 1,000 ft^2 apartment with one bathroom, would need 32.5 CFM to meet the minimum recommendations for *dwelling unit mechanical ventilation*, per Equation 4.1a of ASHRAE 62.2-2010. If the *local mechanical exhaust* system serving the bathroom also provides *dwelling unit mechanical ventilation*, and runs continuously, it may be modeled as 32.5 CFM in the Baseline, even though it exceeds the *local mechanical exhaust* requirement of 20 CFM.

3.12.2.4 Common Spaces. When local or national codes allow the use of natural ventilation to maintain acceptable indoor air quality in *common spaces*, the lesser of ventilation rates specified on drawings or mechanical ventilation recommended by ASHRAE 62.1-2010, Table 6-1, without reliance on natural ventilation, shall be modeled in the Baseline. For mechanically ventilated *common spaces*, the *Baseline Building Design* outdoor air rates shall be modeled using the same rates as the *Proposed Design*, except where the rates in the *Proposed Design* exceed the amount required by the building code or ASHRAE 62.1-2016, by more than 15 cfm or 15%. In that case, the *Baseline Building Design* shall be modeled to reflect the greater of that required by either ASHRAE 62.1-2016 or the building code, plus 15 cfm or 15%, and will be less than the *Proposed Design*. Where using rates from the building code in the *Baseline Building Design*, documentation supporting those rates shall be submitted to an EPA-recognized Multifamily Review Organization (MRO) for review and approval. Where corridors in the *Proposed Design* are supplied with outdoor air to meet the required rates for both the corridor and dwelling units, corridors in the *Baseline Building Design* shall only be modeled with outdoor air at the rates required just for the corridor.

3.12.2.5 Ventilation controls required by *ASHRAE 90.1-2007 (or 2010)*, Section 6.4.3.4 shall be modeled where applicable. For example, according to Section 6.4.3.4.3, both outdoor air supply and exhaust systems shall be equipped with motorized dampers to automatically shut when the systems or spaces served are not in use. This requirement generally applies to *common space*s such as community rooms, offices, laundry rooms, etc.

3.12.2.6 Heat Recovery. No heat recovery shall be modeled in the *Baseline Building Design*, unless it is required by local code or Appendix G for specific field conditions (see Section G3.1.2.10) applicable to baseline systems. Heat recovery is typically not required in multifamily buildings.

3.12.2.7 Demand Control Ventilation. No demand control ventilation shall be modeled in the *Baseline Building Design* unless required by local or national code for specific field conditions, such as high-occupancy areas described in *ASHRAE 90.1-2007 (or 2010)*, Section 6.4.3.9. Demand control is typically not required in multifamily buildings.

3.12.3 Proposed Design-Ventilation.

3.12.3.1 Common Space Ventilation. If *common space* mechanical ventilation does not provide 100% of the required outdoor air rate per Table 6-1 of ASHRAE 62.1-2010 or 2013, then calculations for the "naturally ventilated spaces" must be provided to an EPA-recognized Multifamily Review Organization (MRO) for review and approval to demonstrate compliance with ASHRAE 62.1-2010 Section 5.1.1.

3.12.3.3 In-Unit Ventilation. The modeled *local mechanical exhaust* and *dwelling unit mechanical ventilation* rates shall be as specified on the drawings and other design documents, until measured rates are available from testing reports. If not specified, intermittent *local mechanical exhaust* shall be modeled with a 2 hr/day runtime or converted to an equivalent 24 hr/day runtime if combined with *dwelling unit mechanical ventilation*.

3.12.3.4 Mechanical Ventilation Schedule. The mechanical ventilation schedule may differ between *Baseline Building Design* and *Proposed Design* when necessary to model nonstandard efficiency measures, provided that the revised schedules are approved by the rating authority. Measures that may warrant use of different schedules include Demand Control Ventilation (DCV), as described in Appendix G. Individual exhaust ventilation in kitchens and bathrooms with manual control or interlocked with lighting switch does not qualify as a DCV measure.

3.12.3.5 Mechanical Ventilation Rates. The mechanical ventilation rates may differ between *Baseline Building Design* and *Proposed Design* if the *Proposed Design* has specified rates that exceed either the building code or ASHRAE 62 recommendations, resulting in an energy penalty associated with over-ventilating. Exception: Up until the measured ventilation rate exceeds the design values by more than 15 cfm or 15%, as allowed in the Rater Field Checklist, no energy penalty is required to be modeled for that allowed amount of over-ventilating.

3.13 HVAC Distribution Losses

3.13.1 Modeling Piping and Duct Losses. Do not model piping or duct losses. Refer to the mandatory requirements for specifications relating to pipe insulation, duct insulation and duct leakage amounts.

3.13.2 Ventilation Ductwork. Projects *may* pursue performance credit for sealing central exhaust ventilation ductwork. To receive this credit, the actual measured duct leakage must be below the mandatory requirements of the program. To model the energy savings, the actual measured leakage shall be added to exhaust CFM in the *Proposed Design*. Similarly, add the exhaust leakage allowed in the mandatory requirements to the exhaust CFM in the *Baseline Building Design*.

3.14 Fan Motor Energy

3.14.1 HVAC Fan Power

Proposed Design system fan power must be modeled based on the specified heating, ventilation, and air-conditioning equipment.

Baseline Building Design system fan power must be modeled following Appendix G Section G3.1.2.9. System fan electrical power for supply, return, exhaust, and relief (excluding power to fan powered VAV boxes) shall be calculated for Systems 1 & 2 as follows:

$P_{fan} = CFM_S \cdot 0.3$
P_{fan} = electric power to fan motor (watts)
CFM_S = the baseline system maximum design supply fan airflow rate in cfm

CFM_S must be determined as described in 90.1 Section G3.1.2.8. Following G3.1.2.9, system fan electrical power for supply, return, exhaust, and relief fans shall be 0.3 W/CFM_S.

3.14.2 HVAC Fan Schedule

Appendix G Table G3.1 Section 4 is quoted below for reference and must be followed:

Proposed Design: HVAC fans that provide outdoor air for ventilation shall run continuously whenever spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours.

Baseline Building Design: Same as *Proposed Design*

Example A:

Q: A multifamily project has fan-coil units that provide heating and cooling to apartments. A dedicated gas-fired make-up air unit with energy recovery provides outdoor air to apartments and corridors. What should be the baseline and proposed fan power and schedule for systems serving apartments and corridors?

A: *Proposed Design* must reflect the fan power and schedule of the specified systems, including individual apartment fan coils cycling with heating/cooling load and continuously running make-up air unit.
Baseline Building Design must be modeled with continuously running System 1 (PTAC), to match continuous operation of supply fans in the make-up air unit in the *Proposed Design* that supplies ventilation air to thermal blocks. The total baseline fan power allowance is 0.3 W/CFM$_S$, with no additional allowance for the dedicated make-up air unit used in the *Proposed Design* or energy recovery. Energy Recovery fan power adjustment does not apply to baseline Systems 1 & 2, and also cannot be used when energy recovery is not required in the baseline (see Table G3.1.2.9 including notes below the table).

Example B:

Q: Apartments in a multifamily project are heated by hydronic baseboards with hot water provided by a gas-fired boiler, and use window AC for cooling. *Dwelling unit mechanical ventilation* is provided by a continuously running bathroom exhaust fan that pulls make-up air through trickle vents in bedrooms and living areas. *Local mechanical exhaust* for the bathroom is met by the same continuously running exhaust fan. *Local mechanical exhaust* for the kitchen is met by an intermittent range hood. What should be the baseline and proposed fan power and schedule for systems serving apartments?

A: *Proposed Design* must reflect the fan power and schedule of the specified systems, including individual window air conditioners cycling with cooling load, continuously running bathroom exhaust fan, and intermittent kitchen exhaust fan.
Baseline Building Design must be modeled with continuously running System 1 (PTAC), to match continuous operation of bathroom exhaust fan in the *Proposed Design* that provides *dwelling unit mechanical ventilation*. The total baseline fan power allowance is 0.3 W/CFM$_S$, with no additional allowance for the bathroom exhaust fan explicitly used in the *Proposed Design* to provide *dwelling unit mechanical ventilation*. See Section 3.14.2 for fan power allowance permitted for intermittently running kitchen exhaust fan.

Example C:

Q: Apartments in a multifamily project are heated and cooled by individual split-system heat pumps. *Dwelling unit mechanical ventilation* is provided by supplying outside air directly into the return ductwork of the air handler. *Local mechanical exhaust* for the bathroom is met by an intermittently running exhaust fan. *Local mechanical exhaust* for the kitchen is met by an intermittent range hood. What should be the baseline and proposed fan power and schedule for systems serving apartments?

A: *Proposed Design* must reflect the fan power and schedule of the specified systems, including individual apartment air handlers running continuously, and intermittent bathroom and kitchen exhaust fans.
Baseline Building Design must be modeled with continuously running System 2 (PTHP), to match continuous operation of air handler in the *Proposed Design*. The total baseline fan power allowance is 0.3 W/CFM_S. See Section 3.14.2 for fan power allowance permitted for intermittently running bathroom and kitchen exhaust fans.

3.14.3 Local Mechanical Exhaust Fans

Exhaust fans that are installed for a purpose other than providing *dwelling unit mechanical ventilation* or *common space* ventilation, such as kitchen and bathroom *local mechanical exhaust* fans, laundry make-up air fans, trash room exhaust, etc. shall be considered process loads and modeled as follows:

a. Fan motors in the scope of Section 10.4.1 of ASHRAE 90.1-2007 qualify for performance credit only if they exceed minimum efficiency requirements listed in ASHRAE 90.1-2010 Tables 10.8A, 10.8B or 10.8C. The credit should be modeled as follows:
   Baseline fan power: P_{fan} = bhp x 746 / Fan Motor Efficiency,
   where Fan Motor Efficiency is based on ASHRAE 90.1-2010 Tables 10.8A, 10.8B or 10.8C, and bhp is the same as in the *Proposed Design*.

Actual motor efficiency must be used in the *Proposed Design.* Performance credit for ECM motors for *local mechanical exhaust* fans is permitted by reducing P_{fan} in the *Proposed Design* by 50%.

b. ENERGY STAR Ventilation Fans
   The following efficacy shall be used as the Baseline for ENERGY STAR certified exhaust fans classified as process load in the definition above:
   1. range hoods up to 500 CFM, bathroom and utility fans 90-500 CFM, and in-line ventilating fans: 2.3 CFM/Watt
   2. bathroom and utility room fans of 10-80 CFM: 1.2 CFM/Watt

   Actual motor CFM/Watt must be used in the *Proposed Design*
c. Fans not covered above do not have to be modeled explicitly. If included in the model, their design parameters shall be the same as in the *Proposed Design*, unless specifically allowed otherwise.
d. Runtime of *local mechanical exhaust* fans qualifying for the performance credit must be the same in the baseline and proposed design. Intermittent *local mechanical exhaust* shall be modeled with a 2 hr/day runtime.

3.14.5 Demand Control Ventilation. Fan motor energy savings from demand control ventilation may be modeled by reducing fan runtime in the *Proposed Design* compared to the Baseline. For example, reduced fan runtime from installing CO sensors in residential-associated garages may be modeled using 8.4 hr/day fan runtime in *Proposed Design*, compared to 24 hr/day runtime in the *Baseline Building Design*. If Demand Control Ventilation is modeled in the *Proposed Design*, the baseline ventilation CFM must be based on the lesser of the design ventilation flow rates required by the applicable code and the actual specified flow rate.

Example: Code applicable to the example project is aligned with the *International Mechanical Code* (ICC 2009a), allowing garage ventilation system operation to be reduced from 0.75 to 0.05 cfm/ft^2 with the use of a CO monitoring system that restores full ventilation when CO levels of 25 ppm are detected. *Proposed Design* calls for a 30 HP fan sized to provide 1 cfm/ft^2 peak flow and controlled by CO sensor. In the *Proposed Design*, the specified 30HP fan is modeled as running at full flow for 8.4 hours per day and not running for the other hours. In the *Baseline Building Design*, fan power is prorated to account for over-sizing, with a 22.5 HP [30*0.75/1] fan modeled as running 24 hours/day.

3.15 Pumps

3.15.1 Baseline hydronic equipment shall be modeled as described in sections G3.1.3.3, G3.1.3.4 and G3.1.3.5, including:

- **a.** Hot-water design supply temperature shall be modeled as 180°F and design return temperature as 130°F.
- **b.** Hot-water supply temperature shall be reset based on outdoor dry-bulb temperature using the following schedule: 180°F at 20°F and below, 150°F at 50°F and above, and ramped linearly between 180°F and 150°F at temperatures between 20°F and 50°F.
- **c.** Hot-water pump power shall be modeled as 19W/GPM.
- **d.** Pumping system shall be modeled with *continuous variable* flow.
- **e.** Systems serving 120,000 ft^2 or more shall be modeled with variable-speed drives, and systems serving less than 120,000 ft^2 shall be modeled as riding the pump curve (piping shall include two-way valves)

3.15.2 HVAC pumps in the *Proposed Design* shall be modeled using the actual system parameters including head, capacity control, and pump motor efficiency.

3.15.3 Non-HVAC pumps, such as recirculation or booster pumps serving DHW may receive performance credit for improvement in motor efficiency or capacity control as described below.

- **a.** If pump motor is included in the scope of Section 10 of ASHRAE 90.1 2007:
  - **1.** Obtain actual pump bhp from drawings or specifications of the *Proposed Design*
  - **2.** Obtain Baseline pump motor efficiency from section 10.4 of ASHRAE 90.1 for appropriate pump motor size
  - **3.** Use actual pump design parameters in combination with the Baseline pump motor efficiency as appropriate for the energy modeling software tool being used to model pump in the Baseline
  - **4.** Use actual pump design parameters in combination with the actual pump motor efficiency in the *Proposed Design*
- **b.** Constant flow capacity control may be assumed in the *Baseline Building Design*, unless required otherwise by ASHRAE 90.1 for the specific design conditions. Actual capacity control may be modeled in the *Proposed Design*.

c. If the pump motor is not included in the scope of ASHRAE 90.1 Section 10, the pump does not have to be modeled explicitly. If included in the model, its parameters shall be the same in the Baseline and *Proposed Design*.

3.16 Energy Rates

3.16.1 Unless provided otherwise by EPA, per Appendix G, Section G2.4, use 'either actual rates for purchased energy or state average energy prices published by DOE's Energy Information Administration' in energy simulations of *Baseline Building Design*, *Proposed Design*, and *As-Built* (www.eia.doe.gov). The same rate schedule must be used in all simulations.

3.16.2 Actual rate schedules and pricing, according to the rate class that will most likely be assigned to the property, may be used only if savings associated with demand reduction are modeled. In this case, supporting documentation must be provided showing monthly pricing for 12 consecutive months.

3.16.3 Performance credit for the reduced energy cost may be claimed only if the cost reduction is due to the reduced energy consumption or demand. Following this rule, savings associated with sub-metering shall not be included in the *Performance Rating*.

APPENDIX A: Referenced Standards and Data Sources (Informative)

American Society of Refrigeration and Air-conditioning Engineers (ASHRAE) Standard 90.1-2007 (or 2010): Energy Standard for Buildings Except Low-Rise Residential Buildings: Primary source document for *Baseline Building Design* features and guidance for creating a performance-based evaluation of a proposed building's energy features (Appendix G).

Air-conditioning, Heating, and Refrigeration Institute (AHRI): reference AHRI ratings to determine seasonal efficiencies of heating and cooling systems, www.ahridirectory.org.

Energy Policy Act 1992 (EPACT 1992): federal legislation including provisions describing minimum efficiencies for certain appliances and plumbing fixtures. The complete document can be found in the Library of Congress website at http://thomas.loc.gov/cgi-bin/query/z?c102:H.R.776.ENR:

ASHRAE Standard 62.1-2010 (or 2013): Ventilation for Acceptable Indoor Air Quality: Provides guidance for ventilation system design and other related building features to ensure acceptable indoor air quality. Scope includes all buildings except low-rise residential.

ASHRAE Standard 62.2-2010 (or 2013): Ventilation and Acceptable Indoor Air Quality in Low Rise Residential Buildings: Provides guidance for ventilation system design and other related building features to ensure acceptable indoor air quality.

APPENDIX B: Optional Water Cost Savings Calculations

In addition to energy savings associated with reduction in hot water usage, any measure that results in water savings can also contribute to water utility cost savings.

These water utility cost savings can improve the cost-effectiveness of a measure but are not factored into the *Performance Target*. For example, energy cost savings associated with reduced hot water use from low-flow showerheads can contribute to the *Performance Target*, but water utility cost savings from low-flow toilets cannot.

Water cost savings may be calculated as follows:

1. Begin by calculating baseline usage (in gallons) for each measure. EPAct 1992 flow requirements shall be used for baseline calculations. From the following table, determine the baseline flow rate for the appropriate fixture:

Baseline Fixtures	
Fixture	**Flow Rate**
Toilets (GPF)	1.6
Urinals (GPF)	1.0
Showerheads (GPM)	2.5
Bathroom Faucets (GPM)	2.5 @ 80 psi 2.2 @ 60 psi
Kitchen Faucets (GPM)	2.5

2. In addition, determine the number of uses per day per occupant and usage duration for the appropriate HW demand and fixture from the table below:

Fixture Use				
Fixture Type	**Duration (sec)**			**Uses/Day/Occupant**
Toilets	--			5
Urinals	--			5
HW gallons/day/person	12	25	44	--
Showerheads	150	300	600	1
Bathroom Faucets	8	15	30	5
Kitchen Faucets	30	60	80	4

3. Calculate total baseline usage for each fixture type using the calculations detailed in the *Water Savings* worksheet of the *ASHRAE Path Calculator*.
4. Once baseline usage for each measure has been calculated, proposed usage shall be calculated similarly.
5. GPF Fixtures: Calculate proposed usage using the same usage assumptions as for the baseline, and the actual flow rate of the specified fixtures.

6. GPM Fixtures: Calculate proposed usage using the same usage assumptions as for the baseline, and the actual flow rate of the specified fixtures. This will result in a total proposed water usage for cold and hot water combined. Please refer to Section 3.9.2 of the Simulation Guidelines to find guidance on calculating hot water usage savings to include as energy savings.
7. When on-site collected graywater or rainwater is used for sewage conveyance, the total estimated annual graywater quantity may be subtracted from the total annual design case water usage. Estimated graywater quantity may not be greater than the total usage of fixtures that utilize it. For example, if graywater will be used only in flush toilets, the estimated graywater quantity cannot be greater than the total annual water usage for toilets.

To calculate water utility cost savings ($), multiply the calculated water savings by the current local rates for municipal water/sewer service