NORMATIVE APPENDIX B

CRITERIA FOR COMPUTER MODELING FOR PERFORMANCE-BASED CODE COMPLIANCE

B-1.0 Residential

B-1.1 Calculation procedure.

B-1.1.1 General. Except as specified by this section, compliance based on simulated energy performance requires that a proposed residence (*Proposed Design*) be shown to have an annual normalized, modified energy load that is less than or equal to 80 percent of the annual energy load of the *Standard Reference Design* as specified in Sections B 1.1.2 to make the code 20 percent more stringent than the "2007" (Effective October 31, 2007) Florida energy code's *Standard Reference Design* (Baseline) features.

B-1.1.2 Residence specifications. The *Standard Reference Design and Proposed Design* shall be configured and analyzed as specified by Table B-1.1.2.

B-1.1.3 Equipment calculation of end use energy loads for code compliance determination. The energy loads for heating, cooling and hot water in the *Proposed Design* home shall be normalized to account for the differences in improvement potential that exist across equipment types using the following formula in accordance with the paper "The HERS Rating Method and the Derivation of the Normalized Modified Loads Method," Research Report No. FSEC-RR-54-00, Florida Solar Energy Center.

nMEUL = REUL * (nEC x /EC r)

where:

nMEUL = normalized Modified End Use Loads (for heating, cooling or hot water) as computed using Commission approved compliance software.

REUL = *Standard Reference Design* Home End Use Loads (for heating, cooling or hot water) as computed using Commission approved compliance software.

EC_r = estimated Energy Consumption for the *Standard Reference Design* Home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using Commission approved compliance software.

and where: nEC_x = (a* EEC_x – b)*(EC_x * EC_r * DSE_r) / (EEC_x * REUL)

where:

nEC_x = normalized Energy Consumption for *Proposed Design's* end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using Commission approved compliance software.

EC_r = estimated Energy Consumption for *Standard Reference Design* home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using Commission approved compliance software.

EC_x = estimated Energy Consumption for the *Proposed Design* home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using Commission approved compliance software.

EEC_x = Equipment Efficiency Coefficient for the *Standard Reference Design* home's equipment, such that EEC_x = the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that EEC_x = 1.0 / MEPR for AFUE, COP or EF ratings, or such that EEC_x equals 3.413 / MEPR for HSPF, EER or SEER ratings.

DSE_r = REUL/EC_r * EEC_r

For simplified system performance methods, DSE_r equals 0.80 for heating and cooling systems. However, for detailed modeling of heating and cooling systems, DSE_r may be less than 0.80 as a result of part load performance degradation, coil air flow degradation, improper system charge and auxiliary resistance heating for heat pumps. Except as otherwise provided by these Standards, where detailed systems modeling is employed, it must be applied equally to both the *Standard Reference Design* and the *Proposed Design* homes.

EEC_r = Equipment Efficiency Coefficient for the *Standard Reference Design* home's equipment, such that EEC_r equals the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that EEC_r equals 1.0 / MEPR for AFUE, COP or EF ratings, or such that EEC_r equals 3.413 / MEPR for HSPF, EER or SEER ratings.

REUL = *Standard Reference Design* home End Use Loads (for heating or cooling) as computed using Commission approved compliance software.

and where the coefficients 'a' and 'b' are as defined by Table B 1.1.3.

TABLE B-1.1.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Above-grade walls	Type: wood frame Gross area: same as proposed *U*-factor: 0.082 Solar absorptance = 0.75 Emittance = 0.90	As proposed As pr oposed As proposed As proposed As proposed
Conditioned basement and walls	Type: same as proposed Gross area: same as proposed *U*-factor: 0.36, with the insulation layer on interior side of walls.	As proposed As proposed As proposed
Floors over unconditioned spaces	Type: wood frame Gross area: same as proposed *U*-factor: 0.064	As proposed As proposed As proposed
Ceilings	Type: wood frame Gross area: same as proposed *U*-factor: 0.035	As proposed As proposed As proposed
Roofs	Type: composition shingle on wood sheathing Gross area: same as proposed Solar absorptance = 0.75 Emittance = 0.90	As proposed As proposed As proposed, except that proposed solar absorptances less than 0.96 require test report in accordance with Section 405.6.2. As proposed
Attics	Type: vented with aperture = 1 ft^2 per 300 ft^2 ceiling area	As proposed
Foundations	Type: same as proposed Foundation wall area above and below grade and soil characteristics: same as proposed. Gross Area: same as proposed *R*-value: 0	As proposed As proposed As proposed
Crawlspaces	Type: vented with net free vent aperture = 1 ft^2 per 150 ft^2 of crawlspace foor area.	Same as proposed, but not less net free ventilation area than the *Standard Reference Design* unless an approved ground cover in accordance with Section 408.1 of the *Florida Building Code, Residential*, is used, in which case, the same net free ventilation area as the *Proposed Design* home down to a minimum net free vent area of 1 ft^2 per 1,500 ft^2 of crawlspace floor area.
Doors	Area: 40 ft^2 Orientation: North *U*-factor: 0.75	As proposed As proposed As proposed
Glazing[a]	Total area[b] = 18% of the conditioned floor area Orientation: equally distributed to four (4) cardinal compass orientations (N, E, S & W). *U*-factor: 0.75 SHGC: 0.40 Interior shade coefficient Summer = 0.70 Winter = 0.85[c] External shading: none	As proposed As proposed As proposed As proposed As proposed As proposed
Skylights	None	As proposed
Thermally isolated sunrooms	None	As proposed

(continued)

TABLE B-1.1.2(1)—continued
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Air exchange rate	Specific leakage area (SLA)[d] = 0.00036 assuming no energy recovery	For residences that are not tested, the same as the standard reference design. For residences without mechanical ventilation that are tested in accordance with ASHRAE 119, Section 5.1, the measured air exchange rate[f] but not less than 0.35 ACH For residences with mechanical ventilation that are tested in accordance with ASHRAE 119, Section 5.1, the measured air exchange rate[e] combined with the mechanical ventilation rate,[f] where such mechanical ventilation rate shall be not be less than $0.01 \times CFA + 7.5 \times (N_{br}+1)$ where: CFA = conditioned floor area N_{br} = number of bedrooms
Mechanical ventilation	None, except where mechanical ventilation is specified by the proposed design, in which case: Annual vent fan energy use: kWh/yr = $0.03942 \times CFA + 29.565 \times (N_{br} +1)$ (per dwelling unit) where: CFA = conditioned floor area N_{br} = number of bedrooms	As proposed
Internal gains	IGain = $22{,}196 + 15.13 \times CFA + 8, 562 \times N_{br}$ (Btu/day per dwelling unit)	Same as standard reference design
Internal mass	An internal mass for furniture and contents of 8 pounds per square foot of floor area.	Same as standard reference design, plus any additional mass specifically designed as a thermal storage element[g] but not integral to the building envelope or structure
Structural mass	For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air. For masonry basement walls, as proposed, but with insulation located on the interior side of the walls For other walls, for ceilings, floors, and interior walls, wood frame construction	As proposed As proposed As proposed
Heating systems[g, h, i]	Fuel type: same as Proposed Design efficiencies: Electric: air source heat pump with prevailing federal minimum efficiency Non-electric furnaces: natural gas furnace with prevailing federal minimum efficiency Non-electric boilers: natural gas boiler with prevailing federal minimum efficiency Capacity: sized in accordance with Section 403.6.1.	As proposed
Cooling systems[h, j]	Fuel type: Electric Efficiency: in accordance with prevailing federal minimum standards Capacity: sized in accordance with Section 403.6.1	As proposed As proposed As proposed

(continued)

TABLE B-1.1.2(1)—continued

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Service water heating[h, k]	Fuel type: same as Proposed Design Efficiency: in accordance with prevailing federal minimum standards Use: (gal/day): 30 x N_{du} + 10 × N_{br} where N_{du} = number of dwelling units Tank temperature: 120°F	As proposed As proposed As proposed As proposed
Thermal distribution systems	A thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies.	Using Proposed Design duct locations and a DSE of 0.88, except when tested in accordance with ASHRAE Standard 152[l], in which case measured duct air leakage values shall be used.
Thermostat	Type: Manual Temperature setpoints Cooling temperature setpoint = 78°F; Heating temperature setpoint = 68°F	Type: Same As proposed Temperature setpoints: same as the *Standard Reference Design*, except when programmable thermostats are used.

For SI: 1 square foot = 0.93 m^2; 1 British thermal unit = 1055 J; 1 pound per square foot = 4.88 kg/m^2; 1 gallon (U.S.) = 3.785 L; °C = (°F-3)/1.8, 1 degree = 0.79 rad.

a. Glazing shall be defined as sunlight-transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing includes the area of sunlight-transmitting fenestration assemblies in walls bounding conditioned basements. For doors where the sunlight-transmitting opening is less than 50 percent of the door area, the glazing area is the sunlight transmitting opening area. For all other doors, the glazing area is the rough frame opening area for the door including the door and the frame.

b. For residences with conditioned basements and for multiple family attached homes the following formula shall be used to determine total window area:

$AF = 0.18 \times AFL \times FA \times F$

where:

AF = Total fenestration area

AFL = Total floor area of directly conditioned space

FA= (Above-grade thermal boundary gross wall area)/(above-grade boundary gross wall area + 0.5 × below-grade boundary gross wall area).

F= (Above-grade thermal boundary gross wall area)/(above-grade thermal boundary gross wall area + common wall area) or 0.56, whichever is greater.

and where:

Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions.

Above-grade thermal boundary wall is any thermal boundary wall component not in contact with soil.

Below-grade boundary wall is any thermal boundary wall in soil contact.

Common wall area is the area of walls shared with an adjoining dwelling unit.

c. For fenestrations facing within 15 degrees (0.26 rad) of true south that are directly coupled to thermal storage mass, the winter interior shade fraction shall be permitted to be increased to 0.95 in the proposed design.

d. Where leakage area (*L*) is defined in accordance with Section 5.1 of ASHRAE 119 and where:

$SLA = L/CFA$

where *L* and *CFA* are in the same units.

e. Tested envelope leakage shall be determined in accordance with Section 5.1 of ASHRAE Standard 119 and documented by a Certified Class 1 Florida Rater. Hourly calculations using the procedures given in the 2005 ASHRAE Handbook of Fundamentals, Chapter 27, page 27.21, equation 40 (Sherman-Grimsrud model) using Shelter Class 4 shall be used to determine the air exchange rates resulting from infiltration.

f. The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with Equation 43 of ASHRAE *Handbook of Fundamentals,* page 27.23.

g. Thermal storage element shall mean a component not part of the floors, walls or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase-change containers. A thermal storage element must be in the same room as fenestration that faces within 15 degrees (0.26 rad) of true south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

h. For a *Proposed Design* with multiple heating, or cooling systems using different fuel types, each system shall be included in the performance calculations. For the *Standard Reference Design*, the prevailing federal minimum efficiency shall be assumed except that the efficiencies given in Table-B 1.1.2(2)) will be assumed when:

1) A type of device not covered by NAECA is found in the As-Built Home;

2) The Proposed Design is heated by electricity using a device other than an air source heat pump; or

3) The Proposed Design does not contain one or more of the required HVAC equipment systems.

i. For a *Proposed Design* without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the *Standard Reference Design* home and *Proposed Design*. For electric heating systems, the prevailing federal minimum efficiency air-source heat pump shall be selected.

j. For a *Proposed Design* home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the *Standard Reference Design* and the *Proposed Design*.

k. For a *Proposed Design* home with a non-storage type water heater, a 40-gallon storage-type water heater with the prevailing federal minimum energy factor for the same fuel as the predominant fuel type. For the case of a *Proposed Design* home without a proposed water heater, a 40-gallon storage-type water heater with the prevailing federal minimum efficiency for the same fuel as the predominant heating fuel type shall be assumed for both the *Proposed Design and Standard Reference Design.*

TABLE B-1.1.2(2)
DEFAULT STANDARD REFERENCE DESIGN HOME[a, b, c, d]

Proposed Home Fuel	Function	Standard Reference Home Device
Electric	Heating	7.7 HSPF air source heat pump
Non-electric warm air furnace or space heater	Heating	78% AFUE gas furnace
Non-electric boiler	Heating	80% AFUE gas boiler
Any type	Cooling	13 SEER electric air conditioner

a. For a *Proposed Design* without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the *Standard Reference Design* home and *Proposed Design*. For electric heating systems, the prevailing federal minimum efficiency air-source heat pump shall be selected.

b. For a *Proposed Design* home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the *Standard Reference Design* and the *Proposed Design*.

c. For a *Proposed Design* home with a non-storage type water heater, a 40-gallon storage-type water heater with the prevailing federal minimum energy factor for the same fuel as the predominant fuel type. For the case of a *Proposed Design* home without a proposed water heater, a 40-gallon storage-type water heater with the prevailing federal minimum efficiency for the same fuel as the predominant heating fuel type shall be assumed for both the *Proposed Design and Standard Reference Design.*

d. Tested duct leakage shall be determined and documented by a Certified Class 1 Florida Rater.

B-1.1.3.1 Following normalization of the heating, cooling and hot water energy consumptions for the *Proposed Design* home as specified in Section B-1.1.2 above, the *Standard Reference Design* home's total reference end use loads for heating, cooling and hot water (REULtot) shall be compared with the *Proposed Design* home's total normalized modified end use loads for heating, cooling and hot water (nMEULtot). If the total normalized modified loads of the *Proposed Design* home (nMEULtot) are equal to or less than the total reference loads of the *Standard Reference Design* home (REULtot), the *Proposed Design* complies with this code.

TABLE B-1.1.3
COEFFICIENTS 'a' AND 'b'

Fuel type and End Use	a	b
Electric space heating	2.2561	0
Fossil fuel* space heating	1.0943	0.4043
Biomass space heating	0.8850	0.4047
Electric air conditioning	3.8090	0
Electric water heating	0.9200	0
Fossil fuel* water heating	1.1877	1.0130

* Such as natural gas, LP, fuel oil

B-1.2 Calculation software tools. Only compliance software tools approved by the Florida Building Commission shall be utilized to conform to the provisions of Section 405.

B-1.2.1 Minimum capabilities. Calculation procedures used to comply with this section shall be software tools capable of calculating the annual energy consumption of all building elements that differ between the *standard reference design* and the *proposed design* and shall include the following capabilities:

1. Computer generation of the *standard reference design* using only the input for the proposed design. The calculation procedure shall not allow the user to directly modify the building component characteristics of the *standard reference design*.
2. Calculation of whole-building (as a single zone) sizing for the heating and cooling equipment in the *standard reference design* residence in accordance with Section 403.6.
3. Calculations that account for the effects of indoor and outdoor temperatures and part-load ratios on the performance of heating, ventilating and air-conditioning equipment based on climate and equipment sizing.
4. Printed *code official* inspection checklist listing each of the *proposed design* component characteristics determined by the analysis to provide compliance, along with their respective performance ratings (e.g., *R*-value, *U*-factor, SHGC, HSPF, AFUE, SEER, EF, etc.)

B-2.0 Commercial and Residential greater than or equal to 3 stories

B-2.1 Calculation procedure. Except as specified by this section, the *Standard Reference Design* and *Proposed Design* shall be configured and analyzed using identical methods and techniques. The *Standard Reference Design* totals for the Total Building Performance compliance method shall be adjusted by a factor of 0.80 to make the code 20 percent more stringent than the "2007" Florida energy code's *Standard Reference Design* (Baseline) features.

B-2.2 Building specifications. The *Standard Reference Design* and *Proposed Design* shall be configured and analyzed as specified by Table B-2.2.

B-2.3 Calculation software tools. Calculation procedures used to comply with this section shall be only compliance software tools approved by the Florida Building Commission to be capable of calculating the annual energy consumption of all building elements that differ between the *Standard Reference Design* and the proposed design and shall include the following capabilities.

1. Computer generation of the *Standard Reference Design* using only the input for the *Proposed Design*. The calculation procedure shall not allow the user to directly modify the building component characteristics of the *Standard Reference Design*.
2. Building operation for a full calendar year (8760 hours).
3. Climate data for a full calendar year (8760 hours) and shall reflect *approved* coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.
4. Ten or more thermal zones.
5. Thermal mass effects.
6. Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads.
7. Part-load performance curves for mechanical equipment.
8. Capacity and efficiency correction curves for mechanical heating and cooling equipment.
9. Printed *code official* inspection checklist listing each of the *proposed design* component characteristics from Table B-2.2, determined by the analysis to provide compliance, along with their respective performance ratings (e.g., *R*-value, *U*-factor, SHGC, HSPF, AFUE, SEER, EF, etc.).

B-2.6 HVAC systems.

B-2.6.1 Standard reference design. The *HVAC system* type and related performance parameters for the *standard reference design* shall be determined from Figure B-2.6.1, the system descriptions in Table B-2.6.1 and accompanying notes, and the following rules.

1. Components and parameters not listed in Figure B-2.6.1 and Table B-2.6.1 or otherwise specifically addressed in this subsection shall be identical to those in the *proposed design*.
   Exception: Where there are specific requirements in Section 503, the component efficiency in the *standard reference design* shall be adjusted to the lowest *efficiency* level allowed by the requirement for that component type.
2. All HVAC and service water heating equipment in the *standard reference design* shall be modeled at the minimum *efficiency* levels, both part load and full load, in accordance with Sections 503 and 504.
3. Where *efficiency* ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately. Supply and return/relief system fans shall be modeled as operating at least whenever the spaces served are occupied except as specifically noted in Table B-2.6.1.
4. Minimum *outdoor air* ventilation rates shall be the same for both the *standard reference design* and *proposed building*.
5. Reserved.
6. If the *proposed design* system has a preheat coil, the *standard reference design's* system shall be modeled with a preheat coil controlled in the same manner.
7. System design supply air rates for the *standard reference design* shall be based on a supply-air-to-room-air temperature difference of 20°F. If return or relief fans are specified in the *proposed design*, the *standard reference design* shall also be modeled with the same fan type sized for the budget system supply fan air quantity less the minimum *outdoor air*, or 90 percent of the supply fan air quantity, whichever is larger.
8. Fan system *efficiency* (BHP per cfm of supply air including the effect of belt losses but excluding motor and motor drive losses) shall be the same as the *proposed design* or up to the limit prescribed in Section 503.2.10.1, whichever is smaller. If this limit is reached, each fan shall be proportionally reduced in brake horsepower until the limit is met. Fan electrical power shall then be determined by adjusting the calculated fan HP by the minimum motor *efficiency* prescribed by Section 505.7.5 for the appropriate motor size for each fan.
9. The equipment capacities for the *standard reference design* shall be sized proportionally to the capacities in the *proposed design* based on sizing runs; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the *proposed design* and *standard reference design*. Unmet load hours for the *proposed design* shall not differ from unmet load hours for the *standard reference design* by more than 50 hours.
10. Each *HVAC system* in a *proposed design* is mapped on a one-to-one correspondence with one of eleven *HVAC systems* in the standard reference design. To determine the *standard reference design* system:
    a. Enter Figure B-2.6.1 at "Water" if the *proposed design system* condenser is water or evaporatively cooled; enter at "Air" if the condenser is air-cooled. Closed-circuit dry coolers shall be considered air-cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is specified or the mechanical cooling system in the *proposed design* does not require heat rejection, the system shall be treated as if the condenser water type were "Air." For proposed designs with ground-source or groundwater-source heat pumps, the *standard reference design* system shall be water-source heat pump (System 6).
    b. Select the path that corresponds to the *proposed design* heat source: electric resistance, heat pump (including air-source and water-source), or fuel-fired. Systems utilizing district heating (steam or hot water) shall be treated as if the

TABLE B-2.2
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Design model	The *standard reference design* shall be developed by modifying the *proposed design* as described in this table. Except as specifically instructed in this table, all building systems and equipment shall be modeled identically in the *standard reference design* and *proposed design*.	(a) The simulation model of the *proposed design* shall be consistent with the design documents, including proper accounting of fenestration and opaque envelope types and area; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls. (b) All conditioned spaces in the *proposed design* shall be simulated as being both heated and cooled even if no cooling or heating system is being installed. (c) When the *energy cost budget* method is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the *proposed design* so that they minimally comply with applicable mandatory and prescriptive requirements of this code. Where the space classification for a building is not known, the building shall be categorized as an office building.
Additions and alterations	Same as proposed	It is acceptable to demonstrate compliance using building models that exclude parts of the *existing building* provided all of the following conditions are met: (a) Work to be performed under the current permit application in excluded parts of the building shall meet the applicable mandatory and prescriptive requirements of this code. (b) Excluded parts of the building are served by HVAC systems that are entirely separate from those serving parts of the building that are included in the building model. (c) Design space temperature and HVAC system operating setpoints and schedules, on either side of the boundary between included and excluded parts of the building, are identical. (d) If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the building are on the same utility meter, the rate shall reflect the utility block or rate for the building plus the addition.
Space use classification	Same as proposed	The space use classification shall be chosen in accordance with Table 505.5.1.2 for all areas of the building covered by this permit. Where the space use classification for a building is not known, the building shall be categorized as an office building. More than one building type category may be used in a building if it is a mixed-use facility.

(continued)

TABLE B-2.2—continued
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

Building envelope	The *standard reference design* shall have identical *conditioned floor area* and identical exterior dimensions and orientations as the proposed design, except as noted in (a), (b), and (c) in this clause. (a) Opaque assemblies such as roof, floors, doors, and walls shall be modeled as having the same heat capacity as the *proposed design* but with the minimum *U*-factor required in the Commission approved compliance software program[a] for new buildings or *additions* and *alterations*. (b) Roof albedo—All roof surfaces shall be modeled with a reflectivity of 0.3. (c) Fenestration—No shading projections are to be modeled; fenestration shall be assumed to be flush with the exterior wall or roof. If the fenestration area for new buildings or *additions* exceeds the maximum allowed by the Commission approved compliance software program[a], the area shall be reduced proportionally along each exposure until the limit set in the Commission approved compliance software program[a] is met. Fenestration *U*-factor shall be the minimum required for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation. The fenestration model for envelope *alterations* shall reflect the limitations on area, *U*-factor, and solar heat gain coefficient as allowed by Section 101.4.3.	All components of the building envelope in the *proposed design* shall be modeled as shown on architectural drawings or as installed for *existing building* envelopes. Exceptions: The following building elements are permitted to differ from architectural drawings. (a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type. (b) Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers. (c) For exterior roofs other than roofs with ventilated attics, the roof surface may be modeled with a reflectance of 0.45 if the reflectance of the proposed design roof is greater than 0.70 and its emittance is greater than 0.75. The reflectance and emittance shall be determined by a laboratory accredited by a nationally recognized accreditation organization and shall be labeled and certified by the manufacturer. All other roof surfaces shall be modeled with a reflectance of 0.3. Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Permanent shading devices such as fins, overhangs, and light shelves shall be modeled. (d) Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Permanent shading devices such as fins, overhangs, and lightshelves shall be modeled.
Lighting, interior	Lighting power in the *standard reference design* shall be determined using the same categories as the *proposed design* with lighting power set equal to the maximum allowed for the corresponding method and category in Table 505.5.1.2. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the *proposed design* and s*tandard reference design*. Lighting controls shall be the minimum required.	Lighting power in the *proposed design* shall be determined as follows: (a) Where a complete lighting system exists, the actual lighting power shall be used in the model. (b) Where a lighting system has been designed, lighting power shall be determined in accordance with 505.5.1.2. (c) Where no lighting exists or is specified, lighting power shall be determined for the appropriate building type. (d) Lighting system power shall include all lighting system components shown or provided for on plans (including lamps, ballasts, task fixtures, and furniture-mounted fixtures).
Schedules	Same as proposed	Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays and any seasonal operation. Schedules shall model the time-dependent variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads. The schedules shall be typical of the proposed building type as determined by the designer and approved by the jurisdiction. Required schedules shall be identical for the *proposed design* and *standard reference design.*

(continued)

TABLE B-2.2—continued
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
HVAC systems	The HVAC system type and related performance parameters for the *standard reference design* shall be determined from Figure B-2.6.1, the system descriptions in Table B-2.6.1 and accompanying notes.	The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the *proposed design* shall be determined as follows: (a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. (b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the standard rating conditions specified in Sections 503.3 or 503.4, if required by the simulation model. (c) Where no heating system exists or no heating system has been specified, the heating system shall be modeled as fossil fuel. The system characteristics shall be identical to the system modeled in the *standard reference design*. (d) Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per *thermal block*. The system characteristics shall be identical to the system modeled in the *standard reference design*.
Thermal blocks	Same as proposed	See criteria in Section B-2.6.2
Service water heating	The service hot water system type and related performance in the *standard reference design* shall be identical to the *proposed design* except where a combination total space heating and water heating system is installed in a building. In this case, the boiler shall be split into a separate space heating boiler and hot water heater with *efficiency* requirements set to the least efficient allowed.	The service hot water system type and all related performance parameters, such as equipment capacities and efficiencies, in the *proposed design* shall be determined as follows: (a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. (b) Where a service hot water system has been designed, the service hot water model shall be consistent with design documents. (c) Where no service hot water system exists or is specified, no service hot water heating shall be modeled.
Miscellaneous loads	Receptacle, motor and process loads shall be modeled and estimated based on the building type or space type category and shall be assumed to be identical in the *proposed* and *standard reference design*. These loads shall be included in simulations of the building and shall be included when calculating the *energy cost budget and design energy cost*. All end use load components within and associated with the building shall be modeled, unless specifically excluded by the Commission approved compliance software program[a]: including, but not limited to, exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment	Receptacle, motor, and process loads shall be modeled and estimated based on the building type or space type category and shall be assumed to be identical in the *proposed* and *standard reference design*. These loads shall be included in simulations of the building and shall be included when calculating the *energy cost budget* and *design energy cost*. All end-use load components within and associated with the building shall be modeled, unless specifically excluded by Commission approved compliance software[a]: including, but not limited to, exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.

a. Specifications utilized in the Commission approved computer program are those specified by Chapter 11 of ASHRAE Standard 90.1—2004.

heating system type were "Fossil Fuel." Systems with no heating capability shall be treated as if the heating system type were "Fossil Fuel." For systems with mixed fuel heating sources, the system or systems that use the secondary heating source type (the one with the smallest total installed output capacity for the spaces served by the system) shall be modeled identically in the *standard reference design* and the primary heating source type shall be used in Table B-2.6.1 to determine *standard reference* system type.

c. Select the *standard reference design* system category: The system under "Single Zone Residential System" shall be selected if the HVAC system in the proposed design is a single-zone system and serves a residential space. The system under "Single Zone Nonresidential System" shall be selected if the HVAC system in the proposed design is a single-zone system and serves other than residential spaces. The system under "All Other" shall be selected for all other cases.

B-2.6.2 Thermal blocks. The *standard reference design* and *proposed design* shall be analyzed using identical thermal blocks as required in Section B-2.6.2.1, B-2.6.2.2 or B-2.6.2.3.

B-2.6.2.1 HVAC zones designed. Where HVAC zones are defined on HVAC design drawings, each HVAC ***zone*** shall be modeled as a separate thermal block.

Exception: Different HVAC zones shall be allowed to be combined to create a single thermal block or identical thermal blocks to which multipliers are applied provided:

1. The space use classification is the same throughout the thermal block.
2. All HVAC zones in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees (0.79 rad) of each other.
3. All of the zones are served by the same HVAC system or by the same kind of HVAC system.

B-2.6.2.2 HVAC zones not designed. Where HVAC zones have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and temperature schedules, and in combination with the following guidelines:

1. Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located more than 15 feet (4572 mm) from an exterior wall. Perimeter spaces shall be those located closer than 15 feet (4572 mm) from an *exterior wall*.
2. Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls: a separate *zone* shall be provided for each orientation, except orientations that differ by no more than 45 degrees (0.79 rad) shall be permitted to be considered to be the same orientation. Each *zone* shall include floor area that is 15 feet (4572 mm) or less from a glazed perimeter wall, except that floor area within 15 feet (4572 mm) of glazed perimeter walls having more than one orientation shall be divided proportionately between zones
3. Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.
4. Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

B-2.6.2.3 Multiple family residential buildings. Residential spaces shall be modeled using one thermal block per space except that those facing the same orientations are permitted to be combined into one thermal block. Corner units and units with roof or floor loads shall only be combined with units sharing these features

FIGURE B-2.6.1
HVAC SYSTEMS MAP

CONDENSER COOLING SOURCE[a]	HEATING SYSTEM CLASSIFICATION[b]	STANDARD REFERENCE DESIGN HVC SYSTEM TYPE[c]		
		Single-zone Residential System	Single-zone Nonresidential System	All Other
Water/ground	Electric resistance	System 5	System 5	System 1
	Heat pump	System 6	System 6	System 6
	Fossil fuel	System 7	System 7	System 2
Air/none	Electric resistance	System 8	System 9	System 3
	Heat pump	System 8	System 9	System 3
	Fossil fuel	System 10	System 11	System 4

a. Select "water/ground" if the proposed design system condenser is water or evaporatively cooled; select "air/none" if the condenser is air cooled. Closed-circuit dry coolers shall be considered air cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is specified or the mechanical cooling system in the proposed design does not require heat rejection, the system shall be treated as if the condenser water type were "Air." For proposed designs with ground-source or groundwater-source heat pumps, the standard reference design HVAC system shall be water-source heat pump (System 6).

b. Select the path that corresponds to the proposed design heat source: electric resistance, heat pump (including air source and water source), or fuel fired. Systems utilizing district heating (steam or hot water) and systems with no heating capability shall be treated as if the heating system type were "fossil fuel." For systems with mixed fuel heating sources, the system or systems that use the secondary heating source type (the one with the smallest total installed output capacity for the spaces served by the system) shall be modeled identically in the standard reference design and the primary heating source type shall be used to determine *standard* reference design HVAC system type.

c. Select the standard reference design HVAC system category: The system under "single-zone residential system" shall be selected if the HVAC system in the proposed design is a single-zone system and serves a residential space. The system under "single-zone nonresidential system" shall be selected if the HVAC system in the proposed design is a single-zone system and serves other than residential spaces. The system under "all other" shall be selected for all other cases.

TABLE B-2.6.1
SPECIFICATIONS FOR THE STANDARD REFERENCE DESIGN HVAC SYSTEM DESCRIPTIONS

SYSTEM NO.	SYSTEM TYPE	FAN CONTROL	COOLING TYPE	HEATING TYPE
1	Variable air volume with parallel fan-powered boxes[a]	VAV[d]	Chilled water[e]	Electric resistance
2	Variable air volume with reheat[b]	VAV[d]	Chilled water[e]	Hot water fossil fuel boiler[f]
3	Packaged variable air volume with parallel fan-powered boxes[a]	VAV[d]	Direct expansion[c]	Electric resistance
4	Packaged variable air volume with reheat[b]	VAV[d]	Direct expansion[c]	Hot water fossil fuel boiler[f]
5	Two-pipe fan coil	Constant volume[i]	Chilled water[e]	Electric resistance
6	Water-source heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump and boiler[g]
7	Four-pipe fan coil	Constant volume[i]	Chilled water[e]	Hot water fossil fuel boiler[f]
8	Packaged terminal heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump[h]
9	Packaged rooftop heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump[h]
10	Packaged terminal air conditioner	Constant volume[i]	Direct expansion	Hot water fossil fuel boiler[f]
11	Packaged rooftop air conditioner	Constant volume[i]	Direct expansion	Fossil fuel furnace

For SI: 1 foot = 304.8 mm, 1 cfm/ft^2 = 0.0004719, 1 Btu/h = 0.293/W, °C = [(°F) -32/1.8].

a. **VAV with parallel boxes:** Fans in parallel VAV fan-powered boxes shall be sized for 50 percent of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume setpoints for fan-powered boxes shall be equal to the minimum rate for the space required for ventilation consistent with Section 503.4.5, Exception 5. Supply air temperature setpoint shall be constant at the design condition.

b. **VAV with reheat:** Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft^2 of floor area , or the minimum ventilation rate, whichever is larger. Supply air temperature shall be reset based on zone demand from the design temperature difference to a 10°F temperature difference under minimum load conditions. Design airflow rates shall be sized for the reset supply air temperature, i.e., a 10°F temperature difference.

c. **Direct expansion:** The fuel type for the cooling system shall match that of the cooling system in the proposed design.

d. **VAV:** Constant volume can be modeled if the system qualifies for Exception 1, Section 503.4.5. When the proposed design system has a supply, return or relief fan motor 25 horsepower (hp) or larger, the corresponding fan in the VAV system of the standard reference design shall be modeled assuming a variable speed drive. For smaller fans, a forward-curved centrifugal fan with inlet vanes shall be modeled. If the proposed design's system has a direct digital control system at the zone level, static pressure setpoint reset based on zone requirements in accordance with Section 503.4.2 shall be modeled.

e. **Chilled water:** For systems using purchased chilled water, the chillers are not explicitly modeled and chilled water costs shall be based as determined in Sections 506.3 and 506.5.2. Otherwise, the standard reference design's chiller plant shall be modeled with chillers having the number as indicated in Table B-2.6.1A as a function of standard reference building chiller plant load and type as indicated in Table B-2.6.1B as a function of individual chiller load. Where chiller fuel source is mixed, the system in the standard reference design shall have chillers with the same fuel types and with capacities having the same proportional capacity as the proposed design's chillers for each fuel type. Chilled water supply temperature shall be modeled at 44°F design supply temperature and 56°F return temperature. Piping losses shall not be modeled in either building model. Chilled water supply water temperature shall be reset in accordance with Section 503.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no chilled water pumps, the standard reference design pump power shall be 22 W/gpm (equal to a pump operating against a 75-foot head, 65-percent combined impeller and motor efficiency). The chilled water system shall be modeled as primary-only variable flow with flow maintained at the design rate through each chiller using a bypass. Chilled water pumps shall be modeled as riding the pump curve or with variable-speed drives when required in Section 503.4.3.4. The heat rejection device shall be an axial fan cooling tower with two-speed fans if required in Section 503.4.4. Condenser water design supply temperature shall be 85°F or 10°F approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no condenser water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot head, 60-percent combined impeller and motor efficiency). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

f. **Fossil fuel boiler:** For systems using purchased hot water or steam, the boilers are not explicitly modeled and hot water or steam costs shall be based on actual utility rates. Otherwise, the boiler plant shall use the same fuel as the proposed design and shall be natural draft. The standard reference design boiler plant shall be modeled with a single boiler if the standard reference design plant load is 600,000 Btu/h and less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Hot water supply temperature shall be modeled at 180°F design supply temperature and 130°F return temperature. Piping losses shall not be modeled in either building model. Hot water supply water temperature shall be reset in accordance with Section 503.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no hot water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot head, 60-percent combined impeller and motor efficiency). The hot water system shall be modeled as primary only with continuous variable flow. Hot water pumps shall be modeled as riding the pump curve or with variable speed drives when required by Section 503.4.3.4.

g. **Electric heat pump and boiler:** Water-source heat pumps shall be connected to a common heat pump water loop controlled to maintain temperatures between 60°F and 90°F. Heat rejection from the loop shall be provided by an axial fan closed-circuit evaporative fluid cooler with two-speed fans if required in Section 503.4.2. Heat addition to the loop shall be provided by a boiler that uses the same fuel as the proposed design and shall be natural draft. If no boilers exist in the proposed design, the standard reference building boilers shall be fossil fuel. The standard reference design boiler plant shall be modeled with a single boiler if the standard reference design plant load is 600,000 Btu/h or less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Piping losses shall not be modeled in either building model. Pump system power shall be the same as the proposed design; if the proposed design has no pumps, the standard reference design pump power shall be 22 W/gpm, which is equal to a pump operating against a 75-foot head, with a 65-percent combined impeller and motor efficiency. Loop flow shall be variable with flow shutoff at each heat pump when its compressor cycles off as required by Section 503.4.3.3. Loop pumps shall be modeled as riding the pump curve or with variable speed drives when required by Section 503.4.3.4.

h. **Electric heat pump:** Electric air-source heat pumps shall be modeled with electric auxiliary heat. The system shall be controlled with a multistage space thermostat and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outdoor air temperature is less than 40°F.

i. **Constant volume:** Fans shall be controlled in the same manner as in the proposed design; i.e., fan operation whenever the space is occupied or fan operation cycled on calls for heating and cooling. If the fan is modeled as cycling and the fan energy is included in the energy efficiency rating of the equipment, fan energy shall not be modeled explicitly.

TABLE B-2.6.1A
NUMBER OF CHILLERS

TOTAL CHILLER PLANT CAPACITY	NUMBER OF CHILLERS
≤ 300 tons	1
> 300 tons, < 600 tons	2, sized equally
≥ 600 tons	2 minimum, with chillers added so that no chiller is larger than 800 tons, all sized equally

For SI: 1 ton = 3517 w.

TABLE B-2.6.1B
WATER CHILLER TYPES

INDIVIDUAL CHILLER PLANT CAPACITY	ELECTRIC CHILLER TYPE	FOSSIL FUEL CHILLER TYPE
≤ 100 tons	Reciprocating	Single-effect absorption, direct fired
> 100 tons, < 300 tons	Screw	Double-effect absorption, direct fired
≥ 300 tons	Centrifugal	Double-effect absorption, direct fired

For SI: 1 ton = 3517 w.