BSR/ASHRAE/IES Addendum cl
to ANSI/ASHRAE/IES Standard 90.1-2016

Public Review Draft

Proposed Addendum cl to Standard 90.1-2016, Energy Standard for Buildings Except Low-Rise Residential Buildings

First Public Review (February 2019)
(Draft Shows Proposed Changes to Current Standard)

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ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305

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FOREWORD

This addendum makes changes throughout Section 11 to better align with Appendix G providing greater consistency between the two sections.

[Note to Reviewers: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.]

Addendum cl to 90.1-2016

Modify the standard as follows (IP and SI Units)

3.2 Definitions

simulation program: a computer program, including the simulation engine and the corresponding user interface, that is capable of simulating the energy performance of *building systems*.

11.4 Simulation General Requirements

11.4.1 Simulation Program

The *simulation program* shall be a computer-based program for the analysis of *energy* consumption in *buildings* ~~(a program such as, but not limited to, DOE-2 or BLAST). The *simulation program* shall include calculation methodologies for the *building* components being modeled~~. For components that cannot be modeled by the *simulation program*, the exceptional calculation methods requirements in Section 11.4.5 shall be used.

Informative Note

ASHRAE Standing Standard Project Committee 90.1 recommends that the *simulation program* ~~a compliance shell implementing~~ implements the rules of ~~a compliance supplement~~ Section 11 that controls simulation inputs ~~to~~ and ~~reports~~

outputs ~~from the required computer analysis program~~ be adopted for the purposes of easier use and simpler compliance.

11.4.1.1

The *simulation program* shall be approved by the *adopting authority* and shall, at a minimum, have the ability to explicitly model all of the following:

a. ~~A minimum of 1400~~ 8760 hours per year.

b. Hourly variations in occupancy, lighting power, miscellaneous *equipment* power, *thermostat set points*, and *HVAC system* operation, defined separately for each day of the week and holidays.

c. Thermal mass effects.

d. Ten or more thermal zones.

e. Part-load performance curves for mechanical *equipment*.

f. Capacity and *efficiency* correction curves for *mechanical heating* and *mechanical cooling equipment*.

g. *Air-side economizer* and *fluid economizer* with integrated *control*.

h. The *budget building design* characteristics unless otherwise specified in Section ~~11.4.5~~11.5.

11.4.1.2

The *simulation program* shall have the ability to either

a. directly determine the *design energy cost* and *energy cost budget* or

b. produce hourly reports of *energy* use by *energy* source suitable for determining the *design energy cost* and *energy cost budget* using a separate calculation ~~engine~~.

11.4.1.3

The *simulation program* shall be capable of performing design load calculations to determine required HVAC *equipment* capacities and air and water flow rates in accordance with Section 6.4.2 for both the *proposed design* and the *budget building design*.

11.4.1.4

The *simulation program* shall be tested according to ASHRAE Standard 140, except for Sections 7 and 8, and the results shall be furnished by the software provider.

11.4.2 Climatic Data

The *simulation program* shall perform the simulation using hourly values of climatic data, ~~such as~~ including temperature, ~~and~~ humidity, solar radiation, and wind speed and direction from representative climatic data, for the ~~city~~ site in which the *proposed design* is to be located. For locations ~~cities or urban regions with several climatic data entries, and for locations~~ for which several climatic data sources are available or where weather data ~~are~~ is not available, the designer shall select available weather data that best represents the climate at the *construction* site. ~~Such~~ The selected weather data shall be approved by the *authority having jurisdiction.*

11.4.5 Exceptional Calculation Methods

~~Where no *simulation program* is available that adequately models~~ When the *simulation* program does not model a design, material, or device, ~~the *authority having jurisdiction* may approve~~ an exceptional calculation method ~~to~~ shall be used as approved by the *authority having jurisdiction* to demonstrate compliance with Section 11. ~~Applications for approval of an exceptional method to include theoretical and empirical information verifying the method's accuracy shall include documentation to demonstrate that the exceptional calculation method and results~~

a. ~~make no change in any input parameter values specified by this standard and the *adopting authority*,~~

b. ~~provide input and output documentation that facilitates the enforcement agency's review and meets the formatting and content required by the *adopting authority*, and~~

c. ~~are supported with instructions for using the method to demonstrate that the *energy cost budget* and *design energy cost* required by Section 11 are met.~~

Where there are multiple designs, materials, or devices that the *simulation program* does not model, each shall be calculated separately and exceptional savings determined for each. All applications for approval of an exceptional method shall include the following:

a. Theoretical and empirical information verifying the method's accuracy, and step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.

b. Copies of all spreadsheets used to perform the calculations.

c. A sensitivity analysis of *energy* consumption when each of the input parameters that are estimated is varied from half to double the value assumed.

d. The calculations shall be performed on a time-step basis consistent with the *simulation program* used.

e. The energy cost budget and design energy cost calculated with and without the exceptional calculation methods.

11.5 Calculation of Design Energy Cost and Energy Cost Budget

11.5.2 HVAC Systems

The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and the following rules:

a. **Budget *Building Systems* Not Listed.** Components and parameters not listed in Figure 11.5.2 and Table 11.5.2-1 or otherwise specifically addressed in this subsection shall be identical to those in the *proposed design*.

Exception to 11.5.2(a)
Where there are specific requirements in Sections 6.4 and 6.5, the component *efficiency* in the *budget building design* shall be adjusted to the lowest *efficiency* level allowed by the requirement for that component type.

b. **Minimum *Equipment Efficiency*.** All HVAC and *service water-heating equipment* in the *budget building design* shall be modeled at the minimum *efficiency* levels, both part load and full load, in accordance with Sections 6.4 and 7.4. Chillers shall use Path A efficiencies as shown in Table 6.8.1-3.

c. **Supply Fan *Energy* in Certain Package *Equipment*.** Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy*. For Budget *System* Types 3, 4, 6, 8, 9, 10, and 11, calculate the minimum *COPnfcooling* and *COPnfheating* using the equation for the applicable performance rating as indicated in Tables 6.8.1-1 through 6.8.1-4. Where multiple *HVAC zones* are combined into a single *thermal block* in accordance with Table 11.5.1, the efficiencies for budget System Types 6, 8, and 10 taken from Tables 6.8.1-1 through 6.8.1-4, shall be based on 9,000 Btu/hr equipment capacity for *residential spaces* otherwise it shall be based on the capacity of the *thermal block* divided by the number of *HVAC zones*. Budget System Types 3, 4, 9, and 11 efficiencies taken from Table 6.8.1-1 through 6.8.1-4 shall be based on the cooling equipment capacity of a single floor when grouping identical floors in accordance with Table 11.5.1. Where a full- and part-load *efficiency* rating is provided in Tables 6.8.1-1 through 6.8.1-4, the full-load equation below shall be used:

$$COP_{nfcooling} = 7.84E\text{-}8 \times EER \times Q + 0.338 \times EER$$

$$COP_{nfcooling} = -0.0076 \times SEER^2 + 0.3796 \times SEER$$

$$COP_{nfheating} = 1.48E\text{-}7 \times COP_{47} \times Q + 1.062 \times COP_{47}$$

(applies to ~~heat pump~~ Systems 6 and 9 heating *efficiency* only)

$$COP_{nfheating} = -0.0296 \times HSPF^2 + 0.7134 \times HSPF$$

$$COP_{nfcooling} = 0.3322 \times EER - 0.2145$$

(applies to Systems 8 and 10 cooling *efficiency* only)

$$COP_{nfheating} = 1.1329 \times COP - 0.214$$

(applies to System 8 heating *efficiency* only)

where $COP_{nfcooling}$ and $COP_{nfheating}$ are the packaged HVAC *equipment* cooling and heating *energy efficiency*, respectively, to be used in the *budget building design*, which excludes supply fan power, and Q is the AHRI-rated cooling capacity in Btu/h.

EER, *SEER*, *COP*, and *HSPF* shall be at AHRI test conditions. Fan *energy* shall be modeled separately according to Section 11.5.2(h). 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 11.5.2-1.

d. **Minimum *Outdoor Air Ventilation* Rate.** Minimum *outdoor air ventilation* rates shall be the same for both the *budget building design* and *proposed design*. Exhaust air heat recovery shall be modeled for the *budget building design* in accordance with Section 6.5.6.1.

Exceptions to 11.5.2(d)

1. When modeling *demand control ventilation* in the *proposed design* for spaces where *demand control ventilation* is not required per 6.4.3.8.
2. Where the minimum *outdoor air* intake flow in the *proposed design* is provided in excess of the amount required by Section 6.5.3.7, the *baseline building design* shall be modeled to reflect the minimum amount required by Section 6.5.3.7.

e. **Economizers.** Budget *building systems* as listed in Table 11.5.2-1 shall have *air economizers* or *fluid economizers*, the same as in the *proposed design*, in accordance with Section 6.5.1. The high-limit shutoff shall be in accordance with Table 11.5.2-4.

f. **Preheat Coils.** If the *proposed design system* has a preheat coil, the *budget building design*'s *system* shall be modeled with a preheat coil controlled in the same manner.

g. **Supply Airflow Rates.** *System* design supply air rates for the *budget building design* shall be based on a supply-air-to-room ~~air~~ temperature set-point difference of 20°F or the minimum outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is greater. For *systems* with multiple zone *thermostat set points*, use the design *set point* that will result in the lowest supply air cooling *set point* or highest supply air heating *set point*. If return or relief fans are specified in the *proposed design*, the *budget building design* shall also be modeled with ~~the same fan type sized for the~~ fans serving the same functions and sized for the budget *system* supply fan air quantity less the minimum *outdoor air*, or 90% of the supply fan air quantity, whichever is larger.

Exceptions to 11.5.2(g)

1. For *systems* serving laboratory *spaces*, airflow rate shall be based on a supply-air-to-room temperature *set-point* difference of 17°F or the required *ventilation* air or *makeup air*, whichever is greater.

2. If the *proposed design HVAC system* airflow rate based on latent loads is greater than the design airflow rate based on sensible loads, then the same supply-air-to-room-air humidity ratio difference (gr/lb) used to calculate the *proposed design* airflow shall be used to calculate design airflow rates for the *budget building design*.

h. **Fan *System Efficiency*.** 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 6.5.3.1, 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 10.4.1 for the appropriate motor size for each fan.

i. ***Equipment* Capacities.** The *equipment* capacities for the *budget building 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 *budget building design*. *Unmet load hours* for the *proposed design* or *baseline building designs* shall not exceed 300 hours (of the 8760 hours simulated). The *unmet load hours* for the *proposed design* shall not exceed the *unmet load hours* for the *budget building design*. Alternatively, *unmet load hours* exceeding these limits may be approved by the *building official*, provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

j. **Determining the HVAC System.** Each *HVAC system* in a *proposed design* is mapped on a one-to-one correspondence with one of eleven *HVAC systems* in the *budget building design*. To determine the budget *building system*, do the following:

1. Enter Figure 11.5.2 at "Water" if the *proposed design system* condenser is water or evaporatively cooled; enter Figure 11.5.2 at "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 budget *system* shall be water-source heat pump (*System* 6).

2. 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 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 *budget building design*, and the primary heating source type shall be used in Figure 11.5.2 to determine budget *system* type.

3. Select the *budget building 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.

k. **Kitchen Exhaust.** For kitchens with a total exhaust hood airflow rate greater than 5000 cfm, use a *demand ventilation system* on 75% of the exhaust air. The *system* shall reduce exhaust and *replacement air system* airflow rates by 50% for one half of the kitchen occupied hours in the *baseline building design*. If the *proposed design* uses *demand ventilation*, the same airflow rate schedule shall

be used. The maximum exhaust flow rate allowed for the hood or hood section shall meet the requirements of Section 6.5.7.2.2 for the numbers and types of hoods and appliances provided in the *proposed design*.

11.7 Documentation Requirements

Compliance shall be documented and submitted to the *authority having jurisdiction*. The information submitted shall include the following:

a. The *energy cost budget* for the *budget building design* and the *design energy cost* for the *proposed design*.

b. The *simulation program* used, the version of the *simulation program*.

c. An overview of the project that includes the number of stories (above and below *grade*), the typical *floor* size, the uses in the *building* (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is *conditioned*.

d. ~~b.~~ A list of the *energy*-related features that are included in the design and on which compliance with the provisions of Section 11 is based. This list shall document all *energy* features that differ between the models used in the *energy cost budget* and the *design energy cost* calculations.

e. A list showing compliance for the *proposed design* with all the requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 (mandatory provisions).

f. *Building* elevations and *floor* plans.

g. A diagram showing the *thermal blocks* used in the computer simulation.

h. An explanation of any significant modeling assumptions.

i. Backup calculations and material to support data inputs (e.g., *U-factors* for *building envelope* assemblies, NFRC ratings for *fenestration*, end-uses identified in Table 11.5.1, "1. Design Model," paragraph [a]).

j. ~~c.~~ The input and output reports from the *simulation program*, including a breakdown of *energy* usage by at least the following components: lights, internal *equipment* loads, *service water-heating equipment*, *space*-heating *equipment*, *space* cooling and heat-rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of time any loads are not met by the *HVAC system* for both the *proposed design* and *budget building design*.

k. *Purchased energy rates* used in the simulations.

l. ~~d.~~ An explanation of any error messages noted in the *simulation program* output.

m. For any exceptional calculation methods employed, document the predicted *energy* savings by *energy* type, the *energy* cost savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.

n. ~~e.~~ The reduction in *design energy cost* associated with *on-site renewable energy*.

Table 11.5.1 Modeling Requirements for Calculating *Design Energy Cost* and *Energy Cost Budget*

***Proposed Design* (Column A)** ***Design Energy Cost* (DEC)**	***Budget Building Design* (Column B)** ***Energy Cost Budget* (ECB)**
3. *Space* Use Classification	
The *building* area type or *space* type classifications shall be chosen in accordance with Section 9.5.1 or 9.6.1. The user or designer shall specify the *space* use classifications using either the *building* area type or *space* type categories but shall not combine the two types of categories within a single permit application. More than one *building* area type category may be used for a *building* if it is a mixed-use facility. Exception: Where *space* types neither exist nor are designated in design documents, use type shall be specified in accordance with 9.5.1.	Same as *proposed design*.
4. Schedules	
The schedule types listed in Section 11.4.1.1(b) shall be required input. The schedules shall be typical of the *proposed design* as determined by the designer and approved by the *authority having jurisdiction*. Required schedules shall be identical for the *proposed design* and *budget building design*. **Temperature and Humidity Schedules.** Temperature and humidity *control set points* and schedules as well as *temperature control throttling range* shall be the same for *proposed design* and *baseline building design*. **HVAC Fan Schedules.** Schedules for HVAC fans that provide *outdoor air* for *ventilation* shall run continuously whenever *spaces* are occupied and shall be cycled ON and OFF to meet heating and cooling loads during unoccupied hours. **Exceptions:** 1. Where no heating and/or cooling *system* is to be installed, and a heating or cooling *system* is being simulated only to meet the requirements described in this table, heating and/or cooling *system* fans shall not be simulated as running continuously during occupied hours but shall be cycled ON and OFF to meet heating and cooling loads during all hours. 2. HVAC fans shall remain on during occupied and unoccupied hours in *spaces* that have health- and safety-mandated minimum *ventilation* requirements during unoccupied hours. 3. Dedicated outdoor air supply fans shall stay off during unoccupied hours. HVAC fans shall remain on during occupied and unoccupied hours in *systems* primarily serving *computer rooms*.	Same as *proposed design*.
5. *Building Envelope*	
All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as ~~installed~~ built for *existing building envelopes*. **Exceptions:** The following *building* elements are permitted to differ from architectural drawings.	The *budget building design* shall have identical *conditioned floor area* and identical exterior dimensions and orientations as the *proposed design*, except as follows:

1. Any *building 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 a *building envelope* assembly must be added to the area of the adjacent assembly of that same type. 2. Exterior surfaces whose azimuth *orientation* and tilt differ by ~~no more~~ less than 45 degrees and are otherwise the same ~~may~~ shall be described as either a single surface or by using multipliers. 3. The exterior *roof* surface shall be modeled using the aged solar *reflectance* and thermal *emittance* determined in accordance with Section 5.5.3.1.1(a). Where aged test data are unavailable, the *roof* surface shall be modeled with a solar *reflectance* of 0.30 and a thermal *emittance* of 0.90. 4. 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.	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 Section 5.5 for new *buildings* or additions and Section 5.1.3 for *alterations*. b. The exterior *roof* surfaces shall be modeled with a solar *reflectance* and thermal *emittance* as required in Section 5.5.3.1.1(a). All other *roofs*, including *roofs* exempted from the requirements in Section 5.5.3.1.1, shall be modeled the same as the *proposed design*. c. No shading projections are to be modeled; *fenestration* shall be assumed to be flush with the *wall* or *roof*. If the *fenestration area* for new *buildings* or additions exceeds the maximum allowed by Section 5.5.4.2, the area shall be reduced proportionally along each exposure until the limit set in Section 5.5.4.2 is met. If the *vertical fenestration area* facing west or east of the *proposed design* exceeds the area limit set in Section 5.5.4.5 then the *energy cost budget* shall be generated by simulating the *budget building design* with its actual *orientation* and again after rotating the entire *budget building design* 90, 180, and 270 degrees and then averaging the results. *Fenestration U-factor* shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate, and the *SHGC* shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate. For portions of those tables where there are no *SHGC* requirements, the *SHGC* shall be equal to that determined in accordance with Section C3.6(c). The *VT* shall be equal to that determined in accordance with Section C3.6(c). The *fenestration* model for *building envelope alterations* shall reflect the limitations on area, *U-factor*, and *SHGC* as described in Section 5.1.3. c. *Skylights* shall be included in each *thermal block* when required by 5.5.4.2.3. **Exceptions:** When trade-offs are made between an addition and an *existing building*, as described in the exception to Section 4.2.1.2, the *building envelope* assumptions for the *existing building* in the *budget building design* shall reflect existing conditions prior to any revisions that are part of this permit.
7. *Thermal Blocks—HVAC Zones* Designed	
Where *HVAC zones* are defined on HVAC design drawings, each *HVAC zone* shall be modeled as a separate *thermal block*.	Same as *proposed design*.

Exceptions: Different *HVAC zones* may be combined to create a single *thermal block* or identical *thermal blocks* to which multipliers are applied, provided that all of the following conditions are met: 1. The *space*-use classification is the same throughout the *thermal block* or all of the zones have peak internal loads that differ by less than 10 Btu/h·ft2 from the average. 2. All *HVAC zones* in the *thermal block* that are adjacent to glazed *exterior walls* and glazed *semiexterior walls* face the same *orientation* or their orientations ~~are within 45 degrees of each other~~ vary by less than 45 degrees. 3. All of the zones are served by the same *HVAC system* or by the same kind of *HVAC system*. 4. All of the zones have schedules that differ by 40 or less equivalent full-load hours per week.	
8. *Thermal Blocks—HVAC Zones* Not Designed	
Where the *HVAC zones* and *systems* have not yet been designed, *thermal blocks* shall be defined based on similar internal load densities, occupancy, lighting, thermal and *space* temperature schedules, and in combination with the following: a. Separate *thermal blocks* shall be assumed for interior and perimeter *spaces*. Interior *spaces* shall be those located more than 15 ft from an *exterior wall* or *semiexterior wall*. Perimeter *spaces* shall be those located closer than 15 ft from an *exterior wall* or *semiexterior wall*. A separate thermal zone does not need to be modeled for areas adjacent to *semiexterior walls* that separate *semiheated space* from *conditioned space*. b. Separate *thermal blocks* shall be assumed for *spaces* adjacent to glazed *exterior walls* or glazed *semiexterior walls*; a separate zone shall be provided for each *orientation*, except that orientations that differ by ~~no more~~ less than 45 degrees may be considered to be the same *orientation*. Each zone shall include all *floor* area that is 15 ft or less from a glazed perimeter *wall*, except that *floor* area within 15 ft of glazed perimeter *walls* having more than one *orientation* shall be divided proportionately between zones. c. 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. d. Separate *thermal blocks* shall be assumed for *spaces* having exterior ceiling or *roof* assemblies from zones that do not share these features.	Same as *proposed design*.
9. *Thermal Blocks*—Multifamily *Residential Buildings*	
Residential spaces shall be modeled using at least one ~~*thermal block*~~ *HVAC zone* per ~~*space*~~ *dwelling unit* except ~~that~~ for those units with ~~facing~~ the same orientations which may be combined into one *thermal block*. Corner units and units with *roof* or *floor* loads shall only be combined with units sharing these features.	Same as *proposed design*.
10. *HVAC Systems*	
The *HVAC system* type and all related performance parameters, such as *equipment* capacities and efficiencies, in the *proposed design* shall be determined as follows:	The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and in accord with rules specified in Section 11.5.2(a) through 11.5.2(k).

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 Section 6.4.1 if required by the simulation model. Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy* from the *efficiency* rating in the *budget building design*. The equations in Section 11.5.2 shall not be used in the *proposed design*. The *proposed design HVAC system* shall be modeled using *manufacturers*' full- and part-load data for the *HVAC system* without fan power.
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 *budget building 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 *budget building design*.

11. *Service Water-Heating Systems*

The *service water-heating 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 water-heating system* exists, the model shall reflect the actual *system* type using actual component capacities and efficiencies.
b. Where a *service water-heating system* has been designed and submitted with design documents, the *service water-heating* model shall be consistent with design documents.
c. Where no *service water-heating system* exists or ~~is specified~~ has been submitted with the design documents, no *service water heating* shall be modeled.

Piping losses shall not be modeled.

The *service water-heating system* type in the *budget building design* shall be identical to the *proposed design*. The *service water-heating system* performance of the *budget building design* shall meet the requirements of ~~Table~~ 7.8 Sections 7.4 and 7.5..

Exceptions:

1. If the *service water-heating system* type is not listed in Table 7.8, it shall be ~~identical to the *proposed design*~~ determined based on Table G3.1.1-2.
2. Where Section 7.5 applies, the *boiler* shall be split into a separate *space*-heating *boiler* and hot-*water heater* with *efficiency* requirements set to the least efficient allowed.
3. For 24-hour facilities that meet the prescriptive criteria for use of condenser heat recovery *systems* described in Section 6.5.6.2, a *system* meeting the requirements of that section shall be included in the *baseline building design*, regardless of the exceptions to Section 6.5.6.2. If a condenser heat recovery *system* meeting the requirements described in Section 6.5.6.2 cannot be modeled, the requirement for including such a *system* in the actual *building* shall be met as a prescriptive requirement in accordance with Section 6.5.6.2 and no heat recovery *system* shall be included in the *proposed design* or *budget building design*.

Service water-heating energy consumption shall be calculated explicitly based upon the volume of *service water heating* required and the entering makeup water and the leaving *service water-heating* temperatures. Entering water temperatures shall be estimated based upon the

	location. Leaving temperatures shall be based upon the end-use requirements. Service water loads and use shall be the same for both the *proposed design* and *baseline building design* and typical of the proposed *building* type. Piping losses shall not be modeled.
12. Miscellaneous Loads	
Receptacle, motor, and *process loads* shall be modeled and estimated based on the *building area type* or *space* type category and shall be assumed to be identical in the proposed and *budget building designs*. 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 Section~~s~~ 13 ~~and 14~~ of Table 11.5.1, 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. Where power and other systems covered by Sections 8 and 10 have been designed and submitted with design documents, those systems shall be determined in accordance with Sections 8 and 10. b. Where power and other systems covered by Sections 8 and 10 have not been submitted with design documents, those systems shall comply with but not exceed the requirements of those sections.	~~Receptacle, motor, and *process loads* shall be modeled and estimated based on the *building area type* or *space* type category and shall be assumed to be identical in the *proposed design* and *budget building 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 Sections 13 and 14 of Table 11.5.1, 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*.~~ Same as *proposed design*.
13. Refrigeration	
Where refrigeration equipment in the proposed design is rated in accordance with AHRI 1200, the rated energy use shall be modeled. Otherwise, the proposed design shall be modeled using the actual equipment capacities and efficiencies.	Where refrigeration equipment is specified in the proposed design and listed in Table 6.8.1-13, the budget building design shall be modeled as specified in Table 6.8.1-13 using the actual equipment capacities. If the refrigeration equipment is not listed in Table 6.8.1-13, the budget building design shall be modeled the same as the proposed design.
14~~13~~. Modeling Exceptions	
~~14. Modeling Limitations to the *Simulation Program*~~	
~~If the *simulation program* cannot model a component or *system* included in the *proposed design*, one of the following methods shall be used with the approval of the *authority having jurisdiction*:~~ ~~a. Ignore the component if the *energy* impact on the trade-offs being considered is not significant.~~ ~~b. Model the component substituting a thermodynamically similar component model.~~ ~~c. Model the *HVAC system* components or *systems* using the *budget building design*'s *HVAC system* in accordance with Section 10 of Table 11.5.1. Whichever method is selected,~~	~~Same as *proposed design*.~~

~~the component shall be modeled identically for both the *proposed design* and *budget building design*.~~

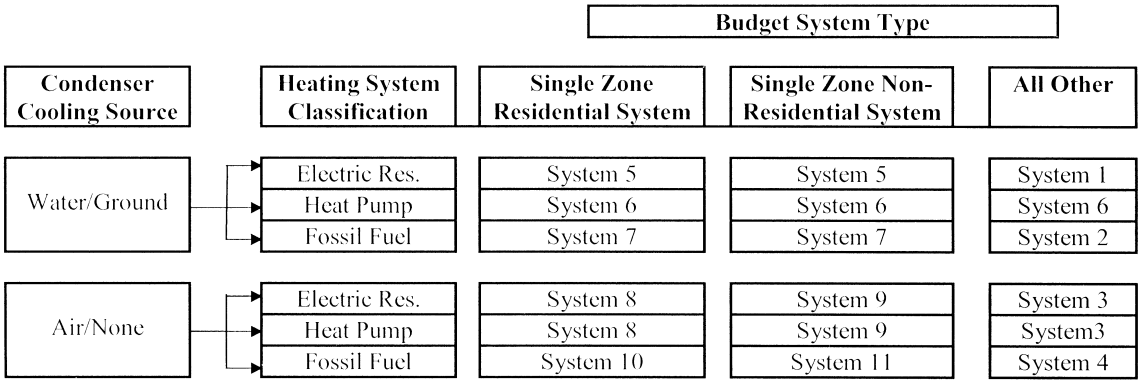

Figure 11.5.2 *HVAC systems* map.

Table 11.5.2-1 Budget *System* Descriptions

***System* No.**	***System* Type**	**Fan *Control***	**Cooling Type**	**Heating Type**
1	*VAV* with parallel fan-powered boxes[a]	VAV[d]	Chilled water[e]	*Electric resistance*
2	*VAV* with reheat[b]	VAV[d]	Chilled water[e]	Hot-water *fossil fuel* boiler[f]
3	Packaged *VAV* with parallel fan-powered boxes[a]	VAV[d]	Direct expansion[c]	*Electric resistance*
4	Packaged *VAV* with reheat[b]	VAV[d]	Direct expansion[c]	Hot-water *fossil fuel* boiler[f]
5	Two-pipe fan coil	Single- or two-speed fan [i,j]	Chilled water[e]	*Electric resistance*
6	Water-source heat pump	Single- or two-speed fan [i,j]	Direct expansion[c]	Electric heat pump and boiler[g]
7	Four-pipe fan-coil	Single- or two-speed fan [i,j]	Chilled water[e]	Hot-water *fossil fuel* boiler[f]
8	*Packaged terminal heat pump*	Single-speed fan[i]	Direct expansion[c]	Electric heat pump[h]
9	Packaged rooftop heat pump	Single- or two-speed fan [i,j]	Direct expansion[c]	Electric heat pump[h]
10	*Packaged terminal air conditioner*	Single-speed fan[i]	Direct expansion	Hot-water *fossil fuel* boiler[f]
11	Packaged rooftop air conditioner	Single- or two-speed fan [i,j]	Direct expansion	*Fossil fuel* furnace

a. ***VAV* with Parallel Fan-Powered Boxes:** Fans in parallel *VAV* fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume *set points* for fan-powered boxes shall be equal to the minimum rate for the *space* required for *ventilation* consistent with Exception 1(b) to Section 6.5.2.1. Supply air temperature *set point* shall be constant at the *design condition* (see Section 11.5.2[g]).

b. ***VAV* with *Reheat*:** Minimum volume *set points* for *VAV reheat* boxes shall be 30% of zone peak airflow or the minimum *ventilation* rate, whichever is larger, consistent with Exception 1(a) to Section 6.5.2.1. The supply air temperature for cooling shall be *reset* higher by 5°F under the minimum cooling load conditions.

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 (2) to Section 6.5.2.1. Otherwise, the~~ The supply, return, or relief fan motor shall be modeled assuming a variable-speed drive and shall meet the *VAV* fan part-load performance requirements of Section G3.1.3.15. If the *proposed design*'s *system* has a *DDC system* at the zone level, static pressure *set-point reset* based on zone requirements in accordance with Section 6.5.3.2.3 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 Section 11.4.3. Otherwise, the *budget building design*'s chiller plant shall be modeled with chillers having the number as indicated in Table 11.5.2-2 as a function of *budget building design* chiller plant load and type as indicated in Table 11.5.2-3 as a function of individual chiller load. Where chiller *fuel* source is mixed, the *system* in the *budget building 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 6.5.4.4. *Pump system power* for each pumping *system* shall be the same as for the *proposed design*; if the *proposed design* has no chilled-water pumps, the *budget building design* pump power shall be 22 W/gpm (equal to a pump operating against a 75 ft head, 65% 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 6.5.4.2. The

heat-rejection device shall be an open-circuit axial-fan cooling tower with variable-speed fan *control*, if required in Section 6.5.5, and shall meet the performance requirements of Table 6.8.1-7. Condenser water design supply temperature shall be calculated using the cooling tower approach to the 0.4% evaporation design wet-bulb temperature as generated by the formula below, with a design temperature rise of 10°F:

$Approach_{10°FRange} = 25.72 – (0.24 \times WB)$
where WB is the 0.4% *evaporation design wet-bulb temperature* in °F, valid for wet bulbs from 55°F to 90°F.

Except during economizer operation, 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*~~ a cooling tower leaving water temperature, where weather permits, per Table 11.5.2-5, floating up to the design leaving water temperature for the cooling tower. *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 *budget building design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% 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 *budget building design boiler* plant shall be modeled with a single *boiler* if the *budget building 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. 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 6.5.4.4. *Pump system power* for each pumping *system* shall be the same as for the *proposed design*; if the *proposed design* has no hot-water pumps, the *budget building design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% 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 6.5.4.2.

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 a closed-circuit axial-fan evaporative fluid cooler with ~~two-speed fans if~~ fan speed control as required in Section 6.5.5.2. 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 budget *building boilers* shall be *fossil fuel*. The *budget building design boiler* plant shall be modeled with a single *boiler* if the *budget building 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 for the *proposed design*; if the *proposed design* has no pumps, the *budget building design* pump power shall be 22 W/gpm, which is equal to a pump operating against a 75 ft head, with a 65% 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 6.5.4.5. Loop pumps shall be modeled as riding the pump curve or with variable-speed drives when required by Section 6.5.4.2.

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. **Fan *System* Operation:** 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.

j. **Fan Speed *Control*:** Fans shall operate as one or two speed as required by Section 6.5.3.2, regardless of the fan speed *control* used in the *proposed design*.

Table 11.5.2-3 Water Chiller Types

Individual Chiller Plant Capacity	Electric Chiller Type	*Fossil Fuel* Chiller Type
≤100 tons	~~Reciprocating~~ Scroll	Single-effect absorption, direct fired
>100 tons, <~~300~~ 600 tons	Screw	Double-effect absorption, direct fired
≥~~300~~ 600 tons	Centrifugal	Double-effect absorption, direct fired

Table 11.5.2-5 Cooling Tower Leaving Water Temperature

Climate Zone	Leaving Water Temperature
5B, 5C, 6B, 8	65°F
0B, 1B, 2B, 3B, 3C, 4B, 4C, 5A, 6A, 7	70°F
3A, 4A	75°F
0A, 1A, 2A	80°F

Clean Version representing final Addendum (reference only and not for comment)
This section represents the final published changes for other addenda affecting the following sections.

3.2 Definitions

simulation program: a computer program, including the simulation engine and the corresponding user interface, that is capable of simulating the *energy* performance of *building systems*.

11.4 Simulation General Requirements

11.4.1 Simulation Program

The *simulation program* shall be a computer-based program for the analysis of *energy* consumption in *buildings*. For components that cannot be modeled by the *simulation program,* the exceptional calculation methods requirements in Section 11.4.5 shall be used.

Informative Note

ASHRAE Standing Standard Project Committee 90.1 recommends that the *simulation* program implements the rules of Section 11 that controls simulation inputs and outputs be adopted for the purposes of easier use and simpler compliance.

11.4.1.1

The *simulation program* shall be approved by the *adopting authority* and shall, at a minimum, have the ability to explicitly model all of the following:

a. 8760 hours per year.
b. Hourly variations in occupancy, lighting power, miscellaneous *equipment* power, *thermostat set points*, and *HVAC system* operation, defined separately for each day of the week and holidays.
c. Thermal mass effects.
d. Ten or more thermal zones.
e. Part-load performance curves for mechanical *equipment*.
f. Capacity and *efficiency* correction curves for *mechanical heating* and *mechanical cooling equipment*.
g. *Air-side economizer* and *fluid economizer* with integrated *control*.
h. The *budget building design* characteristics specified in Section 11.5.

11.4.1.2

The *simulation program* shall have the ability to either

a. directly determine the *design energy cost* and *energy cost budget* or
b. produce hourly reports of *energy* use by *energy* source suitable for determining the *design energy cost* and *energy cost budget* using a separate calculation.

11.4.1.3

The *simulation program* shall be capable of performing design load calculations to determine required HVAC *equipment* capacities and air and water flow rates in accordance with Section 6.4.2 for both the *proposed design* and the *budget building design*.

11.4.1.4

The *simulation program* shall be tested according to ASHRAE Standard 140, except for Sections 7 and 8 of Standard 140 and the results shall be furnished by the software provider.

11.4.2 Climatic Data

The *simulation program* shall perform the simulation using hourly values of climatic data, including temperature, humidity, solar radiation, and wind speed and direction from representative climatic data, for the site in which the *proposed design* is to be located. For locations for which several climatic data sources are available or where weather data is not available, the designer shall select available weather data that best represent the climate at the *construction* site. The selected weather data shall be approved by the *authority having jurisdiction*.

11.4.5 Exceptional Calculation Methods

When the *simulation program* does not model a design, material, or device, an exceptional calculation method shall be used as approved by the *authority having jurisdiction* to demonstrate compliance with Section 11.

Where there are multiple designs, materials, or devices that the *simulation program* does not model, each shall be calculated separately and exceptional savings determined for each. All applications for approval of an exceptional method shall include the following:

f. Theoretical and empirical information verifying the method's accuracy, and step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.

g. Copies of all spreadsheets used to perform the calculations.

h. A sensitivity analysis of *energy* consumption when each of the input parameters that are estimated is varied from half to double the value assumed.

i. The calculations shall be performed on a time-step basis consistent with the *simulation program* used.

j. The energy cost budget and design energy cost calculated with and without the exceptional calculation methods.

11.5 Calculation of Design Energy Cost and Energy Cost Budget

11.5.2 HVAC Systems

The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and the following rules:

a. **Budget *Building Systems* Not Listed.** Components and parameters not listed in Figure 11.5.2 and Table 11.5.2-1 or otherwise specifically addressed in this subsection shall be identical to those in the *proposed design*.

Exception to 11.5.2(a)

Where there are specific requirements in Sections 6.4 and 6.5, the component *efficiency* in the *budget building design* shall be adjusted to the lowest *efficiency* level allowed by the requirement for that component type.

b. **Minimum *Equipment Efficiency*.** All HVAC and *service water-heating equipment* in the *budget building design* shall be modeled at the minimum *efficiency* levels, both part load and full load, in accordance with Sections 6.4 and 7.4. Chillers shall use Path A efficiencies as shown in Table 6.8.1-3.

c. **Supply Fan *Energy* in Certain Package *Equipment*.** Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy*. For Budget *System* Types 3, 4, 6, 9, and 11, calculate the minimum *COPnfcooling* and *COPnfheating* using the equation for the applicable performance rating as indicated in Tables 6.8.1-1 through 6.8.1-4. Where multiple *HVAC zones* are combined into a single *thermal block* in accordance with Table 11.5.1, the efficiencies for budget System Types 6, 8, and 10 taken from Tables 6.8.1-1 through 6.8.1-4, shall be based on 9,000 Btu/hr equipment capacity for *residential spaces* otherwise it shall be based on the capacity of the *thermal block* divided by the number of *HVAC zones*. Budget System Types 3, 4, 9, and 11 efficiencies taken from Table 6.8.1-1 through 6.8.1-4 shall be based on the cooling equipment capacity of a single floor when grouping identical floors in accordance with Table 11.5.1. Where a full- and part-load *efficiency* rating is provided in Tables 6.8.1-1 through 6.8.1-4, the full-load equation below shall be used:

$$COP_{nfcooling} = 7.84E\text{-}8 \times EER \times Q + 0.338 \times EER$$

$$COP_{nfcooling} = -0.0076 \times SEER^2 + 0.3796 \times SEER$$

$$COP_{nfheating} = 1.48E\text{-}7 \times COP_{47} \times Q + 1.062 \times COP_{47}$$
(applies to Systems 6 and 9 heating *efficiency* only)

$$COP_{nfheating} = -0.0296 \times HSPF^2 + 0.7134 \times HSPF$$

$$\underline{COP_{nfcooling} = 0.3322 \times EER - 0.2145}$$
(applies to Systems 8 and 10 cooling *efficiency* only)

$$\underline{COP_{nfheating} = 1.1329 \times COP - 0.214}$$
(applies to System 8 heating *efficiency* only)

where $COP_{nfcooling}$ and $COP_{nfheating}$ are the packaged HVAC *equipment* cooling and heating *energy efficiency*, respectively, to be used in the *budget building design*, which excludes supply fan power, and *Q* is the AHRI-rated cooling capacity in Btu/h. If Q is greater than 760,000 Btu/h, use 760,000 Btu/h in the calculation.

EER, *SEER*, *COP*, and *HSPF* shall be at AHRI test conditions. Fan *energy* shall be modeled separately according to Section 11.5.2(h). 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 11.5.2-1.

d. **Minimum *Outdoor Air Ventilation* Rate.** Minimum *outdoor air ventilation* rates shall be the same for both the *budget building design* and *proposed design*. Exhaust air heat recovery shall be modeled for the *budget building design* in accordance with Section 6.5.6.1.

Exceptions to 11.5.2(d)

3. When modeling *demand control ventilation* in the *proposed design* for spaces where *demand control ventilation* is not required per 6.4.3.8.
4. Where the minimum *outdoor air* intake flow in the *proposed design* is provided in excess of the amount required by Section 6.5.3.7, the *baseline building design* shall be modeled to reflect the minimum amount required by Section 6.5.3.7.

e. **Economizers.** Budget *building systems* as listed in Table 11.5.2-1 shall have *air economizers* or *fluid economizers*, the same as in the *proposed design*, in accordance with Section 6.5.1. The high-limit shutoff shall be in accordance with Table 11.5.2-4.

f. **Preheat Coils.** If the *proposed design system* has a preheat coil, the *budget building design*'s *system* shall be modeled with a preheat coil controlled in the same manner.

g. **Supply Airflow Rates.** *System* design supply air rates for the *budget building design* shall be based on a supply-air-to-room temperature set-point difference of 20°F or the minimum outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is greater. For *systems* with multiple zone *thermostat set points*, use the design *set point* that will result in the lowest supply air cooling *set point* or highest supply air heating *set point*. If return or relief fans are specified in the *proposed design*, the *budget building design* shall also be modeled with fans serving the same functions and sized for the budget *system* supply fan air quantity less the minimum *outdoor air*, or 90% of the supply fan air quantity, whichever is larger.

Exceptions to 11.5.2(g)

3. For *systems* serving laboratory *spaces*, airflow rate shall be based on a supply-air-to-room temperature *set-point* difference of 17°F or the required *ventilation* air or *makeup air*, whichever is greater.

4. If the *proposed design HVAC system* airflow rate based on latent loads is greater than the design airflow rate based on sensible loads, then the same supply-air-to-room-air humidity ratio difference (gr/lb) used to calculate the *proposed design* airflow shall be used to calculate design airflow rates for the *budget building design*.

h. **Fan *System Efficiency*.** 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 6.5.3.1, 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 10.4.1 for the appropriate motor size for each fan.

i. ***Equipment* Capacities.** The *equipment* capacities for the *budget building 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 *budget building design*. *Unmet load hours* for the *proposed design* or *baseline building designs* shall not exceed 300 hours (of the 8760

hours simulated). The *unmet load hours* for the *proposed design* shall not exceed the *unmet load hours* for the *budget building design*. Alternatively, *unmet load hours* exceeding these limits may be approved by the *building official*, provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

j. **Determining the HVAC System.** Each *HVAC system* in a *proposed design* is mapped on a one-to-one correspondence with one of eleven *HVAC systems* in the *budget building design*. To determine the budget *building system*, do the following:

   1. Enter Figure 11.5.2 at "Water" if the *proposed design system* condenser is water or evaporatively cooled; enter Figure 11.5.2 at "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 budget *system* shall be water-source heat pump (*System* 6).
   2. 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 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 *budget building design*, and the primary heating source type shall be used in Figure 11.5.2 to determine budget *system* type.
   3. Select the *budget building 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.

k. **Kitchen Exhaust.** For kitchens with a total exhaust hood airflow rate greater than 5000 cfm, use a *demand ventilation system* on 75% of the exhaust air. The *system* shall reduce exhaust and *replacement air system* airflow rates by 50% for one half of the kitchen occupied hours in the *baseline building design*. If the *proposed design* uses *demand ventilation*, the same airflow rate schedule shall be used. The maximum exhaust flow rate allowed for the hood or hood section shall meet the requirements of Section 6.5.7.2.2 for the numbers and types of hoods and appliances provided in the *proposed design*.

11.7 Submittals

11.7.1 General

Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

11.7.2 Permit Application Documentation

Compliance shall be documented and submitted to the *building official*. The information submitted shall include the following:

a. The *energy cost budget* for the *budget building design* and the *design energy cost* for the *proposed design*.

b. The *simulation program* used, the version of the *simulation program.*

c. An overview of the project that includes the number of stories (above and below *grade*), the typical *floor* size, the uses in the *building* (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is *conditioned*.

d. A list of the *energy*-related features that are included in the design and on which compliance with the provisions of Section 11 is based. This list shall document all *energy* features that differ between the models used in the *energy cost budget* and the *design energy cost* calculations.

e. A list showing compliance for the *proposed design* with all the requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 (mandatory provisions).

f. *Building* elevations and *floor* plans.

g. A diagram showing the *thermal blocks* used in the computer simulation.

h. An explanation of any significant modeling assumptions.

i. Backup calculations and material to support data inputs (e.g., *U-factors* for *building envelope* assemblies, NFRC ratings for *fenestration*, end-uses identified in Table 11.5.1, "1. Design Model," paragraph [a]).

j. The input and output reports from the *simulation program*, including a breakdown of *energy* usage by at least the following components: lights, internal *equipment* loads, *service water-heating equipment*, *space*-heating *equipment*, *space* cooling and heat-rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of time any loads are not met by the *HVAC system* for both the *proposed design* and *budget building design*.

k. Purchased energy rates used in the simulations.

l. An explanation of any error messages noted in the *simulation program* output.

m. For any exceptional calculation methods employed, document the predicted *energy* savings by *energy* type, the *energy* cost savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.

n. The reduction in *design energy cost* associated with *on-site renewable energy*.

Table 11.5.1 Modeling Requirements for Calculating *Design Energy Cost* and *Energy Cost Budget*

Proposed Design **(Column A)** ***Design Energy Cost*** **(DEC)**	***Budget Building Design*** **(Column B)** ***Energy Cost Budget*** **(ECB)**
3. *Space* Use Classification	
The *building* area type or *space* type classifications shall be chosen in accordance with Section 9.5.1 or 9.6.1. The user or designer shall specify the *space* use classifications using either the *building* area type or *space* type categories but shall not combine the two types of categories within a single permit application. More than one *building* area type category may be used for a *building* if it is a mixed-use facility. Exception: Where *space* types neither exist nor are designated in design documents, use type shall be specified in accordance with 9.5.1.	Same as *proposed design*.
4. Schedules	
The schedule types listed in Section 11.4.1.1(b) shall be required input. The schedules shall be typical of the *proposed design* as determined by the designer and approved by the *authority having jurisdiction*. Required schedules shall be identical for the *proposed design* and *budget building design*. Temperature and Humidity Schedules. Temperature and humidity *control set points* and schedules as well as *temperature control throttling range* shall be the same for *proposed design* and *baseline building design*. HVAC Fan Schedules. Schedules for HVAC fans that provide *outdoor air* for *ventilation* shall run continuously whenever *spaces* are occupied and shall be cycled ON and OFF to meet heating and cooling loads during unoccupied hours. Exceptions: 4. Where no heating and/or cooling *system* is to be installed, and a heating or cooling *system* is being simulated only to meet the requirements described in this table, heating and/or cooling *system* fans shall not be simulated as running continuously during occupied hours but shall be cycled ON and OFF to meet heating and cooling loads during all hours. 5. HVAC fans shall remain on during occupied and unoccupied hours in *spaces* that have health- and safety-mandated minimum *ventilation* requirements during unoccupied hours. 6. Dedicated outdoor air supply fans shall stay off during unoccupied hours. HVAC fans shall remain on during occupied and unoccupied hours in *systems* primarily serving *computer rooms*.	Same as *proposed design*.
5. *Building Envelope*	
All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as built for *existing building envelopes*. All uninsulated assemblies and *linear thermal bridges* and *point thermal bridges* as identified in Section 5.5.5.1 through 5.5.5.5 (e.g., projecting balconies, perimeter edges of intermediate floor slabs, concrete floor	The *budget building design* shall have identical conditioned floor area and identical exterior dimensions and orientations as the *proposed design*, except as follows: a. *Opaque* assemblies, such as *roof*, *floors*, *doors*, and *walls*, shall be modeled as having the

beams over parking garages, *roof* parapet) shall be modeled using either of the following techniques:

a. Separate model of each of these assemblies within the *energy* simulation model.

b. When present, uninsulated assemblies and *linear thermal bridges* or *point thermal bridges* as identified in Section 5.5.5.1 through 5.5.5.5 shall be modeled by adjusting the *U-factor* in accordance with Appendix A10.

Exceptions: The following *building* elements are permitted to differ from architectural drawings.

1. Any *building 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 a *building envelope* assembly must be added to the area of the adjacent assembly of that same type.
2. Exterior surfaces whose azimuth *orientation* and tilt differ by less than 45 degrees and are otherwise the same shall be described as either a single surface or by using multipliers.
3. The exterior *roof* surface shall be modeled using the aged solar *reflectance* and thermal *emittance* determined in accordance with Section 5.5.3.1.1(a). Where aged test data are unavailable, the *roof* surface shall be modeled with a solar *reflectance* of 0.30 and a thermal *emittance* of 0.90.
4. 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.

same *heat capacity* as the *proposed design* but with the minimum *U-factor* required in Section 5.5 for new *buildings* or additions and Section 5.1.3 for *alterations*.

b. Where *linear thermal bridges* and *point thermal bridges* as identified in Section 5.5.5.1 through 5.5.5.5 are modeled in the *proposed design*, they shall be represented as modified *U-factors* by adjusting the *U-factor* in accordance with the default values in Appendix A10. If the proposed design does not have *linear thermal bridges* and *point thermal bridges*, as identified in Sections 5.5.5.1 through 5.5.5.5, they shall not be modeled in the *budget building design*.

If the balcony length in the *proposed design* exceeds the maximum allowed by Section 5.5.5.2, Exception 2(c)(i), the area shall be reduced proportionally for each balcony until the limit set in Section 5.5.5.2, Exception 2(c)(i) is met.

c. The exterior *roof* surfaces shall be modeled with a solar *reflectance* and thermal *emittance* as required in Section 5.5.3.1.1(a). All other *roofs*, including *roofs* exempted from the requirements in Section 5.5.3.1.1, shall be modeled the same as the *proposed design*.

d. No shading projections are to be modeled; *fenestration* shall be assumed to be flush with the *wall* or *roof*. If the *fenestration area* for new *buildings* or additions exceeds the maximum allowed by Section 5.5.4.2, the area shall be reduced proportionally along each exposure until the limit set in Section 5.5.4.2 is met. If the *vertical fenestration area* facing west or east of the *proposed design* exceeds the area limit set in Section 5.5.4.5 then the *energy cost budget* shall be generated by simulating the *budget building design* with its actual *orientation* and again after rotating the entire *budget building design* 90, 180, and 270 degrees and then averaging the results. *Fenestration U-factor* shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate, and the *SHGC* shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate. For portions of those tables where there are no *SHGC* requirements, the *SHGC* shall be equal to that determined in accordance with Section C3.6(c). The *VT* shall be equal to that determined in accordance with Section C3.6(c). The *fenestration* model for *building envelope alterations* shall reflect the limitations on area,

	U-factor, and *SHGC* as described in Section 5.1.3. e. Skylights shall be included in each *thermal block* when required 5.5.4.2.3. **Exceptions:** When trade-offs are made between an addition and an *existing building*, as described in the exception to Section 4.2.1.2, the *building envelope* assumptions for the *existing building* in the *budget building design* shall reflect existing conditions prior to any revisions that are part of this permit.
7. *Thermal Blocks—HVAC Zones* Designed	
Where *HVAC zones* are defined on HVAC design drawings, each *HVAC zone* shall be modeled as a separate *thermal block*. **Exceptions:** Different *HVAC zones* may be combined to create a single *thermal block* or identical *thermal blocks* to which multipliers are applied, provided all of the following conditions are met: 1. The *space*-use classification is the same throughout the *thermal block* or all of the zones have peak internal loads that differ by less than 10 Btu/h·ft2 from the average. 2. All *HVAC zones* in the *thermal block* that are adjacent to glazed *exterior walls* and glazed *semiexterior walls* face the same *orientation* or their orientations vary by less than 45 degrees. 3. All of the zones are served by the same *HVAC system* or by the same kind of *HVAC system*. 7. All of the zones have schedules that differ by 40 or less equivalent full-load hours per week.	Same as *proposed design*.
8. *Thermal Blocks—HVAC Zones* Not Designed	
Where the *HVAC zones* and *systems* have not yet been designed, *thermal blocks* shall be defined based on similar internal load densities, occupancy, lighting, thermal and *space* temperature schedules, and in combination with the following: a. Separate *thermal blocks* shall be assumed for interior and perimeter *spaces*. Interior *spaces* shall be those located more than 15 ft from an *exterior wall* or *semiexterior wall*. Perimeter *spaces* shall be those located closer than 15 ft from an *exterior wall* or *semiexterior wall*. A separate thermal zone does not need to be modeled for areas adjacent to *semiexterior walls* that separate *semiheated space* from *conditioned space*. b. Separate *thermal blocks* shall be assumed for *spaces* adjacent to glazed *exterior walls* or glazed *semiexterior walls*; a separate zone shall be provided for each *orientation*, except that orientations that differ by less than 45 degrees may be considered to be the same *orientation*. Each zone shall include all floor area that is 15 ft or less from a glazed perimeter *wall*, except that floor area within 15 ft of glazed perimeter *walls* having more than one *orientation* shall be divided proportionately between zones. c. 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. d. Separate *thermal blocks* shall be assumed for *spaces* having exterior ceiling or *roof* assemblies from zones that do not share these features.	Same as *proposed design*.

9. *Thermal Blocks*—Multifamily *Residential Buildings*	
Residential spaces shall be modeled using at least one *HVAC zone* per *dwelling unit* except for those units with the same orientations which may be combined into one *thermal block*. Corner units and units with *roof* or *floor* loads shall only be combined with units sharing these features.	Same as *proposed design*.
11. *Service Water-Heating Systems*	
The *service water-heating 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 water-heating system* exists, the model shall reflect the actual *system* type using actual component capacities and efficiencies. b. Where a *service water-heating system* has been designed and submitted with design documents, the *service water-heating* model shall be consistent with design documents. c. Where no *service water-heating system* exists or has been submitted with the design documents, no *service water heating* shall be modeled. Piping losses shall not be modeled.	The *service water-heating system* type in the *budget building design* shall be identical to the *proposed design*. The *service water-heating system* performance of the *budget building design* shall meet the requirements of ~~Table~~ 7.8 Sections 7.4 and 7.5.. **Exceptions:** 4. If the *service water-heating system* type is not listed in Table 7.8, it shall be ~~identical to the *proposed design*~~ determined based on Table G3.1.1-2. 5. Where Section 7.5 applies, the *boiler* shall be split into a separate *space*-heating *boiler* and hot-*water heater* with *efficiency* requirements set to the least efficient allowed. 6. For 24-hour facilities that meet the prescriptive criteria for use of condenser heat recovery *systems* described in Section 6.5.6.2, a *system* meeting the requirements of that section shall be included in the *baseline building design*, regardless of the exceptions to Section 6.5.6.2. If a condenser heat recovery *system* meeting the requirements described in Section 6.5.6.2 cannot be modeled, the requirement for including such a *system* in the actual *building* shall be met as a prescriptive requirement in accordance with Section 6.5.6.2 and no heat recovery *system* shall be included in the *proposed design* or *budget building design*. *Service water-heating energy* consumption shall be calculated explicitly based upon the volume of *service water heating* required and the entering makeup water and the leaving *service water-heating* temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements. Service water loads and use shall be the same for both the *proposed design* and *baseline building design* and typical of the proposed *building* type. Piping losses shall not be modeled.
12. Miscellaneous Loads	
Receptacle, motor, and *process loads* shall be modeled and estimated based on the *building area type* or *space* type category and shall be assumed to be identical in the proposed and *budget building designs*. 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 Sections 13 of Table 11.5.1, including but not limited to exhaust	Same as proposed design.

fans, parking garage *ventilation* fans, exterior *building* lighting, swimming *pool* heaters and pumps, elevators and escalators, and cooking *equipment*. c. Where power and other systems covered by Sections 8 and 10 have been designed and submitted with design documents, those systems shall be determined in accordance with Sections 8 and 10. d. Where power and other systems covered by Sections 8 and 10 have not been submitted with design documents, those systems shall comply with but not exceed the requirements of those sections.	
13. Refrigeration	
Where refrigeration equipment in the proposed design is rated in accordance with AHRI 1200, the rated energy use shall be modeled. Otherwise, the proposed design shall be modeled using the actual equipment capacities and efficiencies.	Where refrigeration equipment is specified in the proposed design and listed in Table 6.8.1-13, the budget building design shall be modeled as specified in Table 6.8.1-13 using the actual equipment capacities. If the refrigeration equipment is not listed in Table 6.8.1-13, the budget building design shall be modeled the same as the proposed design.
14. Modeling Exceptions	
All elements of the *proposed design building envelope*, HVAC, *service water heating*, lighting, and electrical *systems* shall be modeled in the *proposed design* in accordance with the requirements of Sections 1 through 12 of Table 11.5.1. **Exceptions:** Components and *systems* in the *proposed design* may be excluded from the simulation model provided that 1. component *energy* use does not affect the *energy* use of *systems* and components that are being considered for trade-off and 2. the applicable prescriptive requirements of Sections 5.5, 6.5, 7.5, and either 9.5 or 9.6 applying to the excluded components are met.	None.

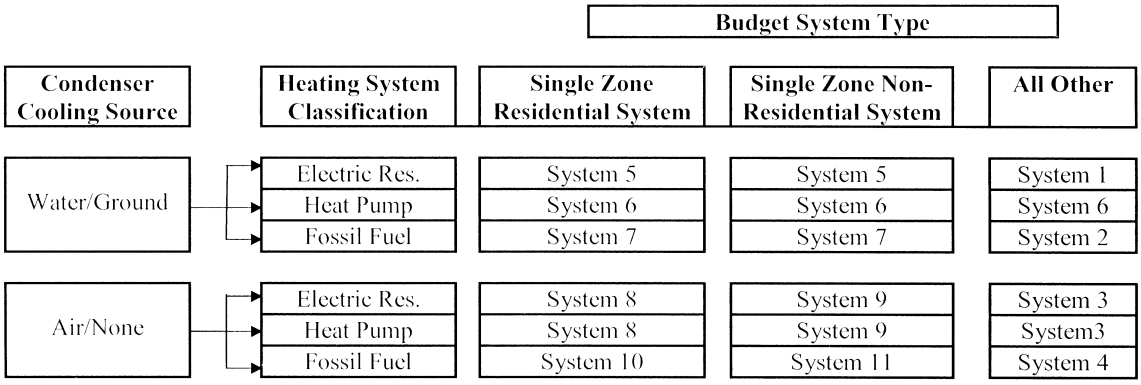

Figure 11.5.2 *HVAC systems* map.

Table 11.5.2-1 Budget *System* Descriptions

***System* No.**	***System* Type**	**Fan *Control***	**Cooling Type**	**Heating Type**
1	*VAV* with parallel fan-powered boxes[a]	VAV[d]	Chilled water[e]	*Electric resistance*
2	*VAV* with reheat[b]	VAV[d]	Chilled water[e]	Hot-water *fossil fuel* boiler[f]
3	Packaged *VAV* with parallel fan-powered boxes[a]	VAV[d]	Direct expansion[c]	*Electric resistance*
4	Packaged *VAV* with reheat[b]	VAV[d]	Direct expansion[c]	Hot-water *fossil fuel* boiler[f]
5	Two-pipe fan coil	Single- or two-speed fan [i,j]	Chilled water[e]	*Electric resistance*
6	Water-source heat pump	Single- or two-speed fan [i,j]	Direct expansion[c]	Electric heat pump and boiler[g]
7	Four-pipe fan-coil	Single- or two-speed fan [i,j]	Chilled water[e]	Hot-water *fossil fuel* boiler[f]
8	*Packaged terminal heat pump*	Single-speed fan[i]	Direct expansion[c]	Electric heat pump[h]
9	Packaged rooftop heat pump	Single- or two-speed fan [i,j]	Direct expansion[c]	Electric heat pump[h]
10	*Packaged terminal air conditioner*	Single-speed fan[i]	Direct expansion	Hot-water *fossil fuel* boiler[f]
11	Packaged rooftop air conditioner	Single- or two-speed fan [i,j]	Direct expansion	*Fossil fuel* furnace

a. ***VAV* with Parallel Fan-Powered Boxes:** Fans in parallel *VAV* fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume *set points* for fan-powered boxes shall be equal to the minimum rate for the *space* required for *ventilation* consistent with Exception 1(b) to Section 6.5.2.1. Supply air temperature *set point* shall be constant at the *design condition* (see Section 11.5.2[g]).

b. ***VAV* with *Reheat*:** Minimum volume *set points* for *VAV reheat* boxes shall be 30% of zone peak airflow or the minimum *ventilation* rate, whichever is larger, consistent with Exception 1(a) to Section 6.5.2.1. The supply air temperature for cooling shall be *reset* higher by 5°F under the minimum cooling load conditions.

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

d. ***VAV*:** The supply, return, or relief fan motor shall be modeled assuming a variable-speed drive and shall meet the *VAV* fan part-load performance requirements of Section G3.1.3.15. If the *proposed design*'s *system* has a *DDC system* at the zone level, static pressure *set-point reset* based on zone requirements in accordance with Section 6.5.3.2.3 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 Section 11.4.3. Otherwise, the *budget building design*'s chiller plant shall be modeled with chillers having the number as indicated in Table 11.5.2-2 as a function of *budget building design* chiller plant load and type as indicated in Table 11.5.2-3 as a function of individual chiller load. Where chiller *fuel* source is mixed, the *system* in the *budget building 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 6.5.4.4. *Pump system power* for each pumping *system* shall be the same as for the *proposed design*; if the *proposed design* has no chilled-water pumps, the *budget building design* pump power shall be 22 W/gpm (equal to a pump operating against a 75 ft head, 65% 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 6.5.4.2. The heat-rejection device shall be an open-circuit axial-fan cooling tower with variable-speed fan *control*, if required in Section 6.5.5, and shall meet the performance requirements of Table 6.8.1-7. Condenser water design supply temperature shall be calculated using the cooling tower approach to the 0.4% evaporation design wet-bulb temperature as generated by the formula below, with a design temperature rise of 10°F:

$Approach_{10°F Range} = 25.72 – (0.24 \times WB)$
where WB is the 0.4% *evaporation design wet-bulb temperature* in °F, valid for wet bulbs from 55°F to 90°F.

Except during economizer operation, the tower shall be controlled to maintain a cooling tower leaving water temperature, where weather permits, per Table 11.5.2-5, floating up to the design leaving water temperature for the cooling tower. *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 *budget building design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% 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 *budget building design boiler* plant shall be modeled with a single *boiler* if the *budget building 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. 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 6.5.4.4. *Pump system power* for each pumping *system* shall be the same as for the *proposed design*; if the *proposed design* has no hot-water pumps, the *budget building design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% 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 6.5.4.2.

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 closed-circuit axial-fan evaporative fluid cooler with fan speed control as required in Section 6.5.5.2. 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 budget *building boilers* shall be *fossil fuel*. The *budget building design boiler* plant shall be modeled with a single *boiler* if the *budget building 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 for the *proposed design*; if the *proposed design* has no pumps, the *budget building design* pump power shall be 22 W/gpm, which is equal to a pump operating against a 75 ft head, with a 65% 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 6.5.4.5. Loop pumps shall be modeled as riding the pump curve or with variable-speed drives when required by Section 6.5.4.2.

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. **Fan *System* Operation:** 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.
j. **Fan Speed *Control*:** Fans shall operate as one or two speed as required by Section 6.5.3.2, regardless of the fan speed *control* used in the *proposed design*.

Table 11.5.2-3 Water Chiller Types

Individual Chiller Plant Capacity	Electric Chiller Type	*Fossil Fuel* Chiller Type
≤100 tons	Scroll	Single-effect absorption, direct fired
>100 tons, <600 tons	Screw	Double-effect absorption, direct fired
≥600 tons	Centrifugal	Double-effect absorption, direct fired

Table 11.5.2-4 vEconomizer High-Limit Shutoff

Economizer Type	High-Limit Shutoff
Air	Table 6.5.1.1.3
Fluid (integrated)	When its operation will no longer reduce *HVAC system energy*

Table 11.5.2-5 Cooling Tower Leaving Water Temperature

Climate Zone	Leaving Water Temperature
5B, 5C, 6B, 8	65°F
0B, 1B, 2B, 3B, 3C, 4B, 4C, 5A, 6A, 7	70°F
3A, 4A	75°F
0A, 1A, 2A	80°F