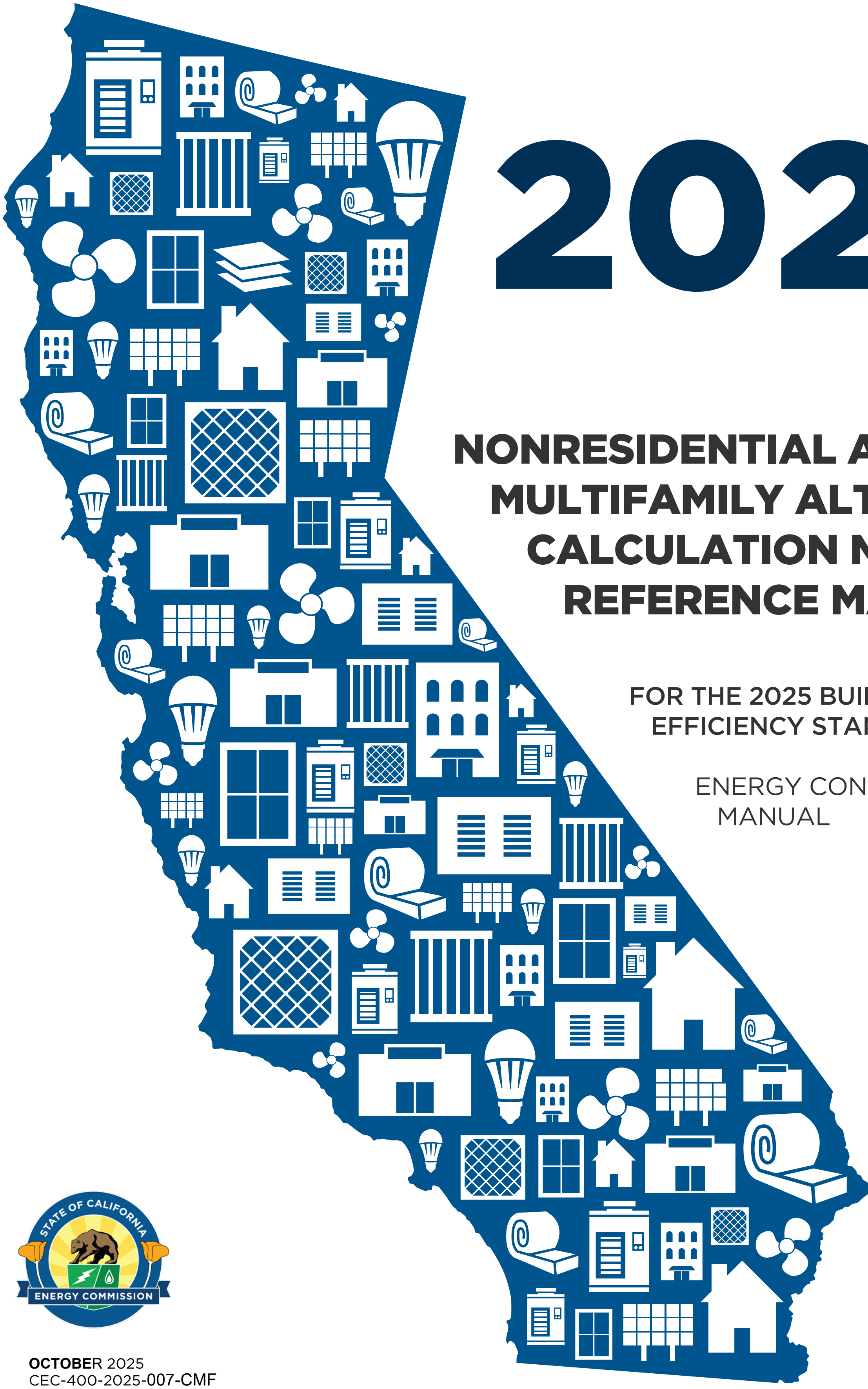

2025

NONRESIDENTIAL AND MULTIFAMILY ALTERNATIVE CALCULATION METHOD REFERENCE MANUAL

FOR THE 2025 BUILDING ENERGY EFFICIENCY STANDARDS

ENERGY CONSERVATION MANUAL

OCTOBER 2025
CEC-400-2025-007-CMF

CALIFORNIA ENERGY COMMISSION
Gavin Newsom, Governor

CALIFORNIA ENERGY COMMISSION

California Energy Commission

STAFF REPORT

2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual

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California Energy Commission

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The California Energy Commission (CEC) adopted and put into effect the first *Building Energy Efficiency Standards* in 1978 and have updated these standards periodically in the intervening years. The *Building Energy Efficiency Standards* are a unique California asset that has placed the state on the forefront of energy efficiency, sustainability, energy independence, and climate change issues and have provided a template for national standards within the United States as well as for other countries around the globe. They have benefitted from the conscientious involvement and enduring commitment to the public good of many persons and organizations along the way. The *2025 Building Energy Efficiency Standards* for residential and nonresidential buildings development and adoption process continues a long-standing practice of maintaining the standards with technical rigor, challenging but achievable design and construction practices, public engagement, and full consideration of the views of stakeholders.

The revisions in the *2025 Building Energy Efficiency Standards* for residential and nonresidential buildings were conceptualized, evaluated, and justified through the excellent work of CEC staff and consultants working under contract to the CEC, supported by the utility-organized Codes and Standards Enhancement Initiative and shaped by the participation of more than 150 stakeholders and the contribution of formal public comments.

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ABSTRACT

The California Energy Commission's (CEC) *2025 Building Energy Efficiency Standards* for residential and nonresidential buildings allow compliance by either a prescriptive or performance method. The performance compliance approach uses computer modeling compliance software to trade-off efficiency measures. Performance compliance is the most popular compliance method because of the flexibility it provides in building design.

Compliance software must be certified by the CEC, following rules established for modeling compliance software. This document establishes the rules for creating a building model, describing how the proposed design is defined, explaining how the standard design is established, and reporting on the performance compliance certificate. This document also describes the procedure for performance calculation, necessary rule sets, reference method for testing compliance software accuracy, and the minimum reporting requirements. The CEC reserves the right to approve vendor software for limited implementations of what is documented in this manual.

This *Nonresidential and Multifamily Alternative Calculation Method Reference Manual* explains how the proposed and standard designs are determined. The explanations for single-family building proposed and standard designs are described in the *Single-Family Residential Alternative Calculation Method Reference Manual*.

The compliance manager, public domain compliance software provided by the CEC, is called California Building Energy Code Compliance (CBECC). CBECC and all third-party compliance software must meet rules described in the *Nonresidential and Multifamily Buildings ACM Reference Manual*.

Keywords: ACM, alternative calculation method, Building Energy Efficiency Standards, California Energy Commission, California Building Energy Code Compliance, CBECC compliance manager, compliance software, computer compliance, energy budget, time dependent valuation, energy code, energy use, prescriptive compliance, performance compliance, design, proposed design, standard design, VRF

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1. Overview

1.1 Purpose

The Warren-Alquist Act created the California Energy Commission's (CEC) authority to establish and regularly update building efficiency standards codified in Public Resources Code Sections 25402 subdivisions (a)-(b). Public Resources Code, Section 25402.1(e) directs the CEC to certify an energy conservation manual for use by designers, builders, and contractors of residential and nonresidential buildings, specifically including instructions for use of a public domain computer program for calculating energy consumption in residential and nonresidential buildings (Public Resources Code, section 25402.1[e]5).

The *Nonresidential and Multifamily Alternative Calculation Method (ACM) Reference Manual* explains the requirements for approval of nonresidential and multifamily Energy Code compliance software in California. Approved compliance software is used to demonstrate minimum compliance with the *2025 Building Energy Efficiency Standards* (Energy Code), CALGreen (Title 24, Part 11), or any metric approved by the CEC. Definitions and terms in this manual may be found in the 2025 Energy Code. The procedures and processes described in this manual are designed to provide consistency and accuracy while preserving integrity of compliance.

This manual addresses compliance software for nonresidential buildings, hotels, motels, and multifamily buildings as specified in Title 24, Part 6, Subchapter 5, Section 140.1, and Subchapter 11, Section 170.1. A separate ACM reference manual applies to single-family residential buildings. The approval process for nonresidential and multifamily compliance software programs is specified in Title 24, Part 1, Section 10-109, 10-110, and 10-116 of the California Code of Regulations. The ACM Reference Manual can be updated outside of the standard Energy Code update process to incorporate new modeling features or address modeling and rule errors. The ACM Reference Manual will be updated no more than twice annually, in January and July.

1.2 Scope

This manual is intended to be used as a reference for the modeling methods of compliance software and a guide to software programs seeking certification as Energy Code compliance software for nonresidential and multifamily buildings.

The *ACM Reference Manual* can be modified during a code cycle without a formal rulemaking. Therefore, the goal of the compliance software development team is to provide periodic updates to improve the accuracy and usability of compliance software.

1.3 Organization

This document is organized in five chapters and several appendices, as follows:

Chapters and descriptions:

1. Overview
   The purpose, organization, and content of the manual.
2. General Modeling Procedures
   An overview of the modeling process, outlining the modeling rules and assumptions that are implemented in the same way for the standard design and the proposed design, and procedures for determining system types and equipment sizes.
3. Compliance Software Requirements
   Requirements for the simulation engines and implementation of compliance rules used to make calculations, and special reporting requirements for nonstandard building features.
4. Content and Format of Standard Reports
   The content and organization of the standard reports produced by qualifying compliance software.
5. Nonresidential Building Descriptors Reference
   The acceptable range of inputs for the proposed design and a specification for the standard design for nonresidential buildings.
6. Multifamily Building Descriptors Reference
   The acceptable range of inputs for the proposed design and a specification for the standard design for multifamily buildings.

In addition, there are several appendices that contain reference material supporting definition of the proposed design and standard design. The numbering for these appendices generally aligns with the chapter numbers in the main manual that reference the appendices.

1.4 Compliance Software

Compliance software is software that has been approved by the Energy Commission to demonstrate compliance with the Energy Code through the performance compliance pathway. Compliance software must meet the appropriate application procedures and requirements in the Energy Code Section 10-109, 10-110 and 10-116. Compliance software approval process and compliance software vendor requirements are further supported in this ACM Reference Manual, Alternative Calculation Method Compliance Software Approval Process and 1.8 Guidance for the Vendor of the Compliance

Software. Compliance software requirements are further supported in this ACM Reference Manual, 3 Compliance Software Test Requirements. Compliance software includes the compliance manager, other public domain computer programs, and ACM compliance software.

Companion documents that are helpful in preparing software for certification as compliance software include the latest editions of the following CEC publications:

- Energy Efficiency Standards
- Appliance Efficiency Regulations
- Nonresidential Compliance Manual
- Reference Nonresidential Appendices
- Reference Appendices

1.5 Modeling Assumptions

When calculating annual energy use, it is necessary to make assumptions about how the proposed building is operated. Operating assumptions include thermostat settings, number of occupants, receptacle loads, process loads, hot water loads, and operation schedules for heating, ventilation, and air-conditioning (HVAC) systems, lighting systems, and other systems. Sometimes these data points are known with some certainty, and other times (for instance, for buildings with yet to be determined occupancy), it is necessary to make estimates. Some of these inputs are prescribed (fixed for the proposed and standard design buildings and cannot be changed), while others are defaults.

Modeling assumptions used by compliance software are provided in this ACM Reference Manual, 2 General Compliance Software_Modeling Procedures and Requirements, 5 Nonresidential Building Descriptors Reference, and 6 Multifamily Building Descriptors Reference.

1.6 Reference Method

To ensure a minimum level of deviation in modeled building energy usage and compliance results between compliance software offered by different vendors, a reference method is developed. The reference method includes procedures that compliance software must meet and test cases that compliance software must run. The test cases are compared against a reference to ensure that modeled energy usage and efficiency between compliance software are approximately the same. All compliance software is compared against modeling results of the compliance manager. The reference method includes:

- A series of reference method test cases used for comparison.
- Input that may vary for credit and input that is fixed or restricted.

- Standard report output requirements.
- Certification of the software vendor requirements in this manual.

General requirements for compliance software can be found in this ACM Reference Manual, 2 General Compliance Software Modeling Procedures and Requirements. Description of compliance software testing requirements used in the reference method can be found in this ACM Reference Manual, 3 Compliance Software Test Requirements. These descriptions are based on requirements laid out in Section 10-109 and 10-116 of the 2025 California Building Standards Code, Title 24, Part 1.

1.7 Alternative Calculation Method Compliance Software Approval Process

The alternative calculation method compliance software approval process is documented in Sections 10-109, 10-110, and 10-116 of the Energy Code. This section of the ACM Reference Manual supports this process. Alternative calculation method compliance software that is being submitted for approval through this process is considered alternative calculation method (ACM) candidate compliance software until approved by the Energy Commission. The proponent of ACM candidate compliance software is considered the compliance software vendor or the vendor of the compliance software.

1.7.1 Application Checklist

The following items shall be included in an application package submitted to the CEC for compliance software approval:

- Compliance software vendor certification statement. A copy of the statement provided by the Energy Commission to the applicant, signed by the compliance software vendor, certifying that the ACM candidate compliance software meets all Energy Commission requirements, including requirements for accuracy and reliability when used to demonstrate compliance with the Energy Code.
- ACM candidate compliance software computer runs and summary sheets. Copies of the computer runs specified in 3 Compliance Software Test Requirements of this manual on machine-readable forms as specified in to enable verification of the runs.
- User manual, or changelog or both. The compliance software vendor shall submit a complete copy of the ACM candidate compliance software user manual, including material on the use of the ACM candidate compliance software for compliance, a changelog, including a complete list of changes to the ACM compliance software, or both.

- Executable ACM candidate compliance software and weather data. A machine-readable copy of the ACM candidate compliance software for random verification of compliance analyses. The compliance software vendor shall use approved CEC weather files.
- Long-term system cost (LSC) documentation. The ACM candidate compliance software shall be able to convert modeled building energy consumption to LSC as described in Reference Appendices, Joint Appendix JA3.
- Source energy. The software shall be able to calculate source energy as described in 2.1.5 Source Energy.
- Application fee. The compliance software vendor shall provide an application fee of $1,000.00 as authorized by Section 25402.1(b) of the Public Resources Code, payable to the State of California to cover costs of evaluating the application and to defray reproduction costs.

A cover letter acknowledging the shipment of the completed application package should be emailed to ExecutiveOffice@energy.ca.gov.

Two copies of the full application package should be sent to:

Compliance Software Nonresidential Certification
California Energy Commission
715 P Street, MS-26
Sacramento, CA 95814-5512

Following submittal of the application package, the CEC may request additional information under Title 24, Part 1, Sections 10-109, 10-110, and 10-116. This additional information is often necessary due to the complexity of software. Failure to provide such information in a timely manner may be considered cause for rejection or disapproval of the application. A resubmittal of a rejected or disapproved application will be considered a new application and must include a new application fee.

1.7.2 Types of Approval

An ACM candidate compliance software application can be approved unconditionally, approved with restrictions to specified occupancies, designs, materials, or devices, or rejected.

If approved, the ACM candidate compliance software is considered compliance software and may be used to demonstrate compliance with the Energy Code through the performance compliance pathway. Demonstration of compliance may be restricted to specific occupancies, designs, materials, or devices if the compliance software was approved with restrictions.

1.7.3 Alternative Calculation Method Compliance Software Updates

Approved alternative calculation method compliance software may need to be updated throughout the current code cycle. The Energy Commission classifies updates as major updates or minor updates.

Major updates are changes that would affect compliance values, or changes to match rules established for modeling compliance software documented in the current version of the Alternative Calculation Method Reference Manual. The steps for major alternative calculation method compliance software updates are provided in Section 10-116(d)1 of the Energy Code. Examples of scenarios that may result in major updates to alternative calculation method compliance software include:

- Energy Code revisions that alter the basic compliance process.
- The Energy Commission determines that new analytic capabilities are widespread and should be a required software capability.
- The vendor of the ACM compliance software implements new algorithms into the compliance software which results in changes to building model compliance margins.

Minor updates are changes to the user interface or changes that do not result in changes to compliance values. The steps for minor updates are provided in Section 10-116(d)2.

1.7.4 Decertification of Compliance Software

Decertification is the formal process of withdrawing approval of alternative calculation method compliance software. The process for decertification of compliance software is described in the Energy Code Section 10-116(f). Compliance software can be decertified as a result of the following:

- The Energy Code undergoes substantial changes such that the software would fail to confirm compliance with the Building Efficiency Standards.
- A letter from the vendor of the alternative calculation method compliance software requests a particular version of the alternative calculation method compliance software to be decertified. The decertification request shall briefly describe the nature of the program errors or "bugs" that justify the need for decertification.
- Any "initiating party" may begin decertifying any compliance software according to the steps outlined in the Energy Code Section 10-116(f)3. The intent is to include a means whereby unfavorable compliance software tests, serious program errors, flawed numeric results, improper forms, or incorrect program

documentation not discovered in the certification process or a combination thereof can be verified, and use of the particular compliance software version discontinued. In this process, there is ample opportunity for the Energy Commission, the vendor of the compliance software, and all interested parties to evaluate any alleged problems with the compliance software program.

NOTE 1: The primary rationale for a challenge is unfavorable compliance software tests, which means that for some particular building design with a set of energy efficiency measures, the compliance software fails to meet the criteria used for testing compliance software programs described in 3 Compliance Software Test Requirements.

NOTE 2: Another challenge rationale is flawed numeric results, where the compliance software meets the test criteria in 3 Compliance Software Test Requirements, in particular, when compliance software fails to properly create the standard design building.

The following is the process for challenging compliance software or initiating a decertification procedure:

- Any party may initiate a review of compliance software approval by sending a written communication to the Executive Director. (The Energy Commission may be the initiating party for this type of review by noticing the availability of the same information listed here.)
- The initiating party shall:
  - State the name of the compliance software and the program version number(s) that contain the alleged errors.
  - Identify concisely the nature of the alleged errors in the compliance software that require review.
  - Explain why the alleged errors are serious enough in the effect on analyzing buildings for compliance to justify a decertification procedure.
  - Include appropriate data on any media compatible with Windows 7 or newer and/or information sufficient to evaluate the alleged errors.

The Executive Director shall make a copy or copies of the initial written communication available to the compliance software vendor and interested parties within 30 days.

- Within 75 days of receipt of the written communication, the Executive Director may request any additional information needed to evaluate the alleged compliance software errors from the party who initiated the decertification review. If the additional information is incomplete, this procedure will be delayed until the initiating party submits complete information.

- Within 75 days of receipt of the initial written communication, the Executive Director may convene a workshop to gather additional information from the initiating party, the compliance software vendor, and interested parties. All parties will have 15 days after the workshop to submit additional information regarding the alleged program errors.
- Within 90 days after the Executive Director receives the application or within 30 days after receipt of complete additional information requested of the initiating party, whichever is later, the Executive Director shall either:
  - Determine that the compliance software need not be decertified.
  - Submit to the Energy Commission a written recommendation that the compliance software be decertified.
- The initial written communication, all relevant written materials, and the Executive Director's recommendation shall be placed on the consent calendar and considered at the next business meeting after submission of the recommendation. The matter may be removed from the consent calendar at the request of one of the Commissioners.
- If the Energy Commission approves the compliance software decertification, it shall take effect 60 days later. During the first 30 days of the 60-day period, the Executive Director shall send out a notice to building officials and interested parties announcing the decertification.

All initiating parties have the burden of proof to establish that the review of alleged compliance software errors should be granted. The decertification process may be terminated at any time by mutual written consent of the initiating party and the Executive Director.

As a practical matter, the compliance software vendor may use the 180- to 210-day period outlined here to update the compliance software program, get it reapproved by the Energy Commission, and release a revised version that does not have the problems initially brought to the attention of the Energy Commission. The vendor of the compliance software may wish to be the initiating party to ensure that a faulty program version is taken off the market.

1.8 Guidance for the Vendor of the Compliance Software

Each vendor shall meet all of the following requirements as part of the compliance software approval and as part of an ongoing commitment to users of the particular program.

1.8.1 Availability to California Energy Commission

All compliance software vendors are required to submit at least one fully working program version of the compliance software to the CEC. An updated copy or access to the approved version of the compliance software shall be kept by the CEC to maintain approval for compliance use of the compliance software.

The CEC agrees not to duplicate the compliance software except for analyzing it, for verifying building compliance with the compliance software, or for verifying that only approved versions of the compliance software are used for compliance.

1.8.2 Enforcement Agency Support

Compliance software vendors shall provide ongoing enforcement agency support. Compliance software vendors shall provide a copy of the compliance software users' manual or help system or both to all enforcement agencies who request one in writing.

1.8.3 User Support

Compliance software vendors shall offer support to their users with regard to the use of the compliance software for compliance. Compliance software vendors shall include a users' manual or help system or both that provides appropriate guidance for specifying inputs and running a simulation for compliance. Requirements for the user manual are described in the 2025 California Building Standards Code, Title 24 Part 1._Vendors may charge a fee for user support.

1.8.4 Compliance Software Vendor Demonstration

The Energy Commission may request that compliance software vendors offer a live demonstration of the capabilities of their compliance software. One or more demonstrations may be requested before approval is granted.

2. General Compliance Software_Modeling Procedures and Requirements

This section describes the modeling procedures and requirements that must be met by all compliance software. This includes requirements for inputs, zoning, and other functionality of compliance software. Note that the application process for alternative calculation method compliance software and requirements for vendors of compliance software can be found in this ACM Reference Manual, 1.7 Alternative Calculation Method Compliance Software Approval Process and 1.8 Guidance for the Vendor of the Compliance Software. Testing requirements for compliance software can also be found in this ACM Reference Manual, 3 Compliance Software Test Requirements.

2.1 General Requirements for User-Entered Data

This document lists the building descriptors that are used in the compliance simulation. Users must provide valid data for all descriptors that do not have defaults specified and that apply to parts of the building that must be modeled.

2.1.1 Type of Project Submittal

The type of compliance for the project should be identified to ensure that the appropriate compliance requirements are used. This includes the following options:

- New building or Addition Alone. Compliance software may model the addition alone, but an addition modeled in this way shall be reported on all output forms as an addition (modeled alone).
- Addition Plus Alteration of Existing Building (if compliance software is approved for this optional capability).
- Alteration of Existing Building (if compliance software is approved for this optional capability).

2.1.2 Scope of Compliance Calculations

For each building or separately permitted space, compliance software shall require the user to identify the scope of the compliance submittal from a combination of the following list:

- Envelope
- Lighting or Partial Lighting
- Mechanical or Partial Mechanical (may include or exclude Domestic Hot Water)

Each combination requires specific assumptions, input procedures, and reporting requirements. Modeling assumptions are documented in 5 Nonresidential Building Descriptors Reference and 6 Multifamily Building Descriptors Reference. Reporting requirements are documented in 4 Content and Format of Standard Reports. Compliance software shall produce only compliance reports specific to the scope of the submittal determined for the run. For example, if the scope is envelope only, only the PRF-01 forms with envelope-only components are produced.

Lighting compliance for a partial compliance scenario may be for the entire building or may be specified for only portions of the building. When the building applies for partial lighting compliance, the space(s) where lighting for the space is unknown or undefined shall be marked as "undefined," and the compliance software shall use the standard design lighting power for the user-defined space type for both the proposed design and standard design. Under this compliance scope, the entire building shall be modeled, and the compliance forms shall indicate the spaces for which lighting compliance is not performed.

The combination of the above scopes will determine the standard design to which the proposed design is compared. When a scope is excluded from the performance calculation, the standard design will match the proposed for all features covered by that scope. Specific rules for each building model descriptor can be found in 5 Nonresidential Building Descriptors Reference and 6 Multifamily Building Descriptors Reference of this manual.

2.1.3 Climate Zones

The program shall account for variations in energy use due to the effects of the California climate zones and local weather data. Climate information for compliance simulations shall use the applicable data set in Reference Appendices, Joint Appendix JA2.

2.1.4 Long-Term System Cost (LSC)

The compliance software shall calculate the LSC for both the standard design and the proposed design by multiplying the LSC factor for each hour of the year by the predicted site energy use for that hour. LSC factors have been established by the CEC for residential and nonresidential occupancies, for each of the climate zones, and for each fuel type (electricity, natural gas, and propane). The LSC approach is documented in more detail in Reference Appendices, Joint Appendix JA3. The Total LSC for nonresidential and multifamily buildings consists of the LSC for all efficiency measures (Efficiency LSC) and the LSC for all photovoltaic systems, building energy storage systems, and demand flexibility measures as described in the following equations:

For nonresidential buildings:

$$\begin{aligned} Efficiency\ LSC &= \sum(SC_{kwh,i} \times LSC_{kWh,i}) + \sum(SC_{gas,i} \times LSC_{gas,i}) \\ &+ \sum(WH_{kwh,i} \times LSC_{kWh,i}) + \sum(WH_{gas,i} \times LSC_{gas,i}) \\ &+ \sum(MV_{kwh,i} \times LSC_{kWh,i}) + \sum(MV_{gas,i} \times LSC_{gas,i}) \\ &+ \sum(L_{regulated,i} \times LSC_{kWh,i}) \end{aligned}$$

For multifamily buildings:

$$\begin{aligned} Efficiency\ LSC &= \sum(SC_{kwh,i} \times LSC_{kWh,i}) + \sum(SC_{gas,i} \times LSC_{gas,i}) \\ &+ \sum(WH_{kwh,i} \times LSC_{kWh,i}) + \sum(WH_{gas,i} \times LSC_{gas,i}) \\ &+ \sum(MV_{kwh,i} \times LSC_{kWh,i}) + \sum(MV_{gas,i} \times LSC_{gas,i}) \\ &+ \sum(L_{regulated,i} \times LSC_{kWh,i}) + \sum(SUC_i \times LSC_{kWh,i}) \end{aligned}$$

$$Total\ LSC = Efficiency\ LSC + \sum(PV_i \times LSC_{kWh,i}) + \sum(BESS_i \times LSC_{kWh,i})$$

Where:

PV_i = The energy generation of the photovoltaic system in the i^{th} hour. Additional information for export considerations are described below.

$LSC_{kWh,\ i}$ = The LSC factor for electricity in the i^{th} hour.

$BESS_i$ = Battery energy storage system energy in the i^{th} hour.

DF_i = The demand flexibility energy in the i^{th} hour.

$SC_{kwh,i}$ = The space-conditioning electric energy used in the i^{th} hour.

$SC_{gas,i}$ = The space-conditioning gas or propane energy used in the i^{th} hour.

$LSC_{gas,\ i}$ = The LSC factor for gas or propane in the i^{th} hour.

$WH_{kwh,i}$ = The water heating electric energy used in the i^{th} hour.

$WH_{gas,i}$ = The water heating gas energy used in the i^{th} hour.

$MV_{kwh,i}$ = The mechanical ventilation electric energy used in the i^{th} hour.

$MV_{gas,i}$ = The mechanical ventilation gas energy used in the i^{th} hour.

SUC_i = The electric energy associated with the self-utilization credit in the i^{th} hour.

$L_{regulated,i}$ = Regulated lighting energy used in the i^{th} hour.

The LSCs that apply to photovoltaic and BESS systems depend on whether generated energy is used on site or exported to the grid. If energy is used on site the LSC factors are based on the LSC factors as described in Reference Appendices, Joint Appendix JA3. If energy is exported to the grid, the hourly export LSC factors provided by the CEC are used. These export LSC factors account for the LSC costs that are avoided by the exports in each hour.

To comply through the performance compliance approach, the Total LSC and Efficiency LSC of the proposed design must be equal to or less than the Total LSC and Efficiency LSC of the standard design. This applies to newly constructed buildings, additions to existing buildings, additions plus alterations of existing buildings, and alterations of existing buildings. The hourly LSC factors can be found at the Energy Commission website (https://www.energy.ca.gov/files/2025-energy-code-date-and-hourly-factors).

2.1.5 Source Energy

The compliance software shall calculate the long-run marginal, hourly source energy use for both the standard design and the proposed design as specified in the equation below.

$$Source\ Energy = \sum(Electricity\ Use_i \times SE_{kWh,i}) + \sum(Gas\ Use_i \times SE_{gas,i})$$

Where:

$Electricity\ Use_i$ = The electric energy used in the i^{th} hour.

$SE_{kWh,\ i}$ = The source energy factor for electricity in the i^{th} hour.

$Gas\ Use_i$ = The gas energy used in the i^{th} hour.

$SE_{gas,\ i}$ = The source energy factor for gas in the i^{th} hour.

The hourly source energy factors provided by the CEC are used to determine compliance. To comply through the performance compliance approach, the Source Energy of the proposed design must be equal to or less than the Source Energy of the standard design. This applies to newly constructed buildings only. The hourly source energy factors can be found at the Energy Commission website (https://www.energy.ca.gov/files/2025-energy-code-date-and-hourly-factors).

2.1.6 Reporting Requirements for Unsupported Features

The compliance software shall have the input capabilities described in 2 General Compliance Software Modeling Procedures and Requirements and meet required capabilities and pass applicable certification tests as defined in 3 Compliance Software

Test Requirements. While the vendor's ACM candidate compliance software does not need to implement every modeling rule in the Nonresidential and Multifamily ACM Reference Manual*,* all ACM candidate compliance software features, systems, components, and controls that are modeled must follow the modeling rules in the Nonresidential and Multifamily ACM Reference Manual. Vendors seeking certification for ACM candidate compliance software programs to be used for Energy Code compliance should clearly state the extent of the capabilities of their ACM candidate compliance software with respect to compliance. Support of a modeling feature includes correctly processing user input, specifying the standard design correctly, applying that information to simulation models, and processing the results.

Any building features or systems that cannot be modeled in a compliance software program shall show compliance using prescriptive forms.

2.1.7 Building Envelope Descriptions

The user shall provide accurate descriptions for all building envelope assemblies including exterior walls, demising surfaces, fenestration, doors, roofs, exterior floors, slab-on-grade floors, below-grade walls, and below-grade floors. The user shall provide data for all the required descriptors listed in 5.5 Building Envelope Data for nonresidential occupancies and 6.9.7 Exterior Surfaces for multifamily occupancies that correspond with these assemblies. However, the following exception applies:

- Exterior surfaces with an azimuth orientation and tilt differing by no more than 45° that is otherwise the same, may be described as a single surface or described using multipliers. This specification would permit a circular form to be described as an octagon.

2.1.8 Space-Use Classification

The user must designate space-use classifications that best match the uses for which the building or spaces are designed. Space-use classifications determine the default occupant density, occupant activity level, receptacle power, service water heating, lighting load, daylighting set points, and operating schedules used in the analysis. Process loads and refrigeration loads are also provided for applicable space types. Each space-use classification must be associated with a ventilation space function that sets the outdoor ventilation and/or exhaust requirement for the space. The user must choose a ventilation space function from one or more options, depending on the space function.

The user must specify the space-use classifications using the area category method. The area category method uses the area categories in the standard design, which were developed for lighting requirements. The area category method requires area category entry of floor area and space-use designations. More than one area category may be used if the building is a mixed-use facility.

The user may override the default assumptions for some building descriptors dependent on the space-use classification with supporting documentation. Details are provided in 5.4 Space Uses for nonresidential occupancies and 6.9 Zones for multifamily occupancies of this manual.

2.1.9 Treatment of Descriptors Not Fully Addressed by This Document

This document provides input and rating rules covering a full range of energy-related features encountered in commercial buildings. However, this goal is unlikely to ever be achieved due to the large number of features that must be covered and the continuous evolution of building materials and technologies. Building features or systems not covered in this manual must apply for approval through the exceptional calculation method to the CEC. This manual may be amended with provisions to model additional features or HVAC systems during the code cycle. When this occurs, it is the responsibility of the compliance software vendor to pass the necessary acceptance tests and apply for approval for the additional feature(s).

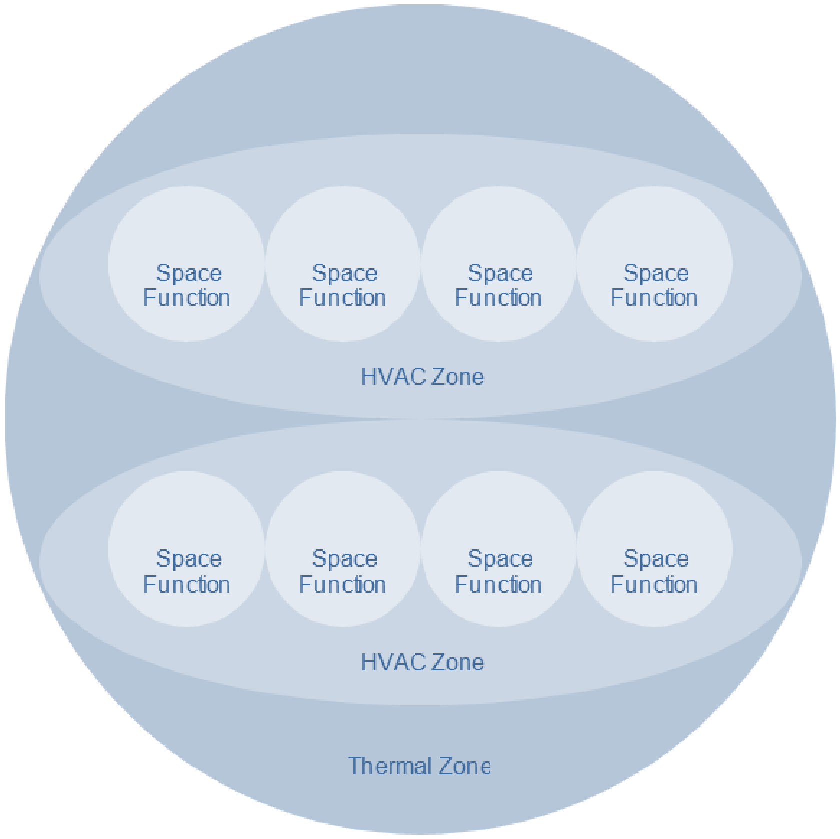
2.2 Thermal Zones, HVAC Zones, and Space Functions

2.2.1 Definitions

A *thermal zone* is a space or collection of spaces that has similar space-conditioning requirements, has the same heating and cooling set point, and is the basic thermal unit (or zone) used in modeling the building. A thermal zone will include one or more spaces. Thermal zones may be grouped together, but systems serving combined zones shall be subject to efficiency and control requirements of the combined zones.

An *HVAC zone* is a physical space within the building that has a thermostat and zonal system for maintaining temperature. HVAC zones are identified on the HVAC plans. HVAC zones should not be split between thermal zones; however, a thermal zone may include more than one HVAC zone. A *space function* is a space-use classification that has specific standard design lighting requirements and for which there are associated defaults for occupancy, receptacle loads, and hot water consumption. Space functions are associated with ventilation space functions that set outdoor air-ventilation requirements documented in the ACM appendices. An HVAC zone may contain more than one space function. Particular space functions in a building may require multiple HVAC zones to serve the needs of the space function. Appendix 5.4A lists the space functions that may be used with the compliance software. Daylit areas should be assigned to specific spaces, even if they have the same classification from Appendix 5.4A, so that lighting reductions due to daylighting can be determined at the appropriate resolution.

Figure 1: Hierarchy of Space Functions, HVAC Zones, and Thermal Zones



Source: California Energy Commission

2.3 Compliance Software Modeling Requirements for Zones

2.3.1 Required Zone Modeling Capabilities

For Energy Code compliance, compliance software shall accept input for and be capable of modeling a minimum of 50 thermal zones, each conditioned by an HVAC system that influences zone temperature. Compliance software may use zone multipliers for identical zones.

2.3.2 Modeling Requirements for Unconditioned and Indirectly Conditioned Spaces

Unconditioned space is enclosed space that is neither directly nor indirectly conditioned as specified by the definition in Section 100.1 of the Energy Code. Examples include stairways, warehouses, unoccupied adjacent tenant spaces, parking garages, attics, and crawl spaces.

Unconditioned spaces shall be modeled if they are part of the permitted space. All applicable envelope information shall be specified in a similar manner to conditioned space as designed, but is not subject to compliance with the standards.

If unconditioned space is not a part of the permitted space, the space may be either explicitly modeled or the impact thereof on the permitted space may be approximated by modeling the space as outdoor space. For unconditioned spaces that are explicitly modeled, all internal gains and operational loads (occupants, water heating, receptacle, lighting, and process loads) shall be modeled as specified in Appendix 5.4A.

Indirectly conditioned spaces are enclosed spaces that are not directly conditioned and meet the indirectly conditioned space definition in Section 100.1 of the Energy Code. These spaces can be either occupied or unoccupied. For spaces that are unoccupied, such as plenums, attics, or crawlspaces, lighting, receptacle, and occupant loads shall be zero. For spaces that can be occupied, such as stairwells or storage rooms, modeling assumptions shall be taken from Appendix 5.4A.

Return air plenums are considered indirectly conditioned spaces and shall be modeled as part of the adjacent conditioned space with equipment, lighting, and occupant loads at zero. Unconditioned spaces may not be located in the same thermal zone as conditioned spaces. Conditioned spaces and indirectly conditioned spaces may be located in the same thermal zone or in separate zones. When located in the same thermal zone, the indirectly and directly conditioned spaces are assumed to have the same space temperature schedule. When indirectly conditioned space is assigned to a thermal zone, the zone cannot have a heating/cooling system butcanhave a ventilation or exhaust system.

2.3.3 Space-Use Classification Considerations

Thermal zones may be combined only if the spaces have similar space-conditioning requirements and operating schedules. Modeling of spaces with respect to thermal zones and HVAC system analysis must be conducted as specified in the following rules:

Spaces: Building spaces are sections of a building sharing the same space function (for example, office, retail, laboratory) and serve as the structure for modeling the envelope, ventilation, exhaust, lighting, daylighting, occupancy and process loads of the building. Spaces shall have only one space function, shall be assigned to only one thermal zone, and shall not span multiple building floors.

Space Functions: Each building space shall be assigned one space function. Design internal loads and other space function input assumptions are defined in Appendix 5.4A. Appendix 5.4A also defines the schedule group associated with each space function. The schedule group and the schedule values for each space function are prescribed for compliance analysis.

Some space functions are common to many schedule groups. These space functions are defined in Appendix 5.4A as having schedule groups that are editable. This addresses the issue of conflicting schedule profiles if these common functions are combined into a single thermal zone or served by the same HVAC system as surrounding zones. In the event the user does not assign a schedule group to these common space types, a default assumption is defined in the Appendix 5.4A.

Thermal Zones: Spaces may be combined into thermal zones. In this situation, peak internal loads and other design inputs for the thermal zone may be modeled separately or weight-averaged based on floor area. The thermal zone schedules (occupancy, HVAC, lighting, space setpoint) are based on the predominant schedule group described below. Thermal zones shall not combine spaces that are associated with different building floors. Dwelling units shall be modeled using at least one thermal zone per dwelling unit, except units with the same orientation may be combined into one thermal zone. Corner dwelling units and dwelling units with roof or floor loads may only be combined with dwelling units sharing these features. If multiple floors are the same, then the modeler may use a floor multiplier to model multiple floors.

Schedule Group: There are many different schedule groups defined in Appendix 5.4B for California compliance. Each schedule group defines hourly profiles for thermostat set points, HVAC system availability, occupancy, lighting, receptacles, service hot water, gas equipment, infiltration, refrigeration, elevators, and escalators. The schedule group is based on space function.

HVAC Systems: In many cases, more than one conditioned thermal zone is served by an HVAC system, which has scheduled availability (ON or OFF) to address the occupancy and internal load patterns of the thermal zones it serves.

Predominant Schedule Group: For a building thermal zone or building floor that includes multiple schedule groups, the hourly profiles shall be determined by the compliance software according to the predominant schedule group for each thermal zone or building floor. The predominant schedule group for the thermal zone or building floor shall be determined by the schedule group, as defined above, associated with the largest floor area of the thermal zone or building floor. Residential multifamily dwelling units, hotel/motel guestrooms, and common areas associated with these residential spaces; enclosed parking garages; and covered process spaces (laboratory, data, and commercial kitchen), shall always have their own prescribed schedule group regardless of the predominant schedule group for the thermal zone.

2.4 Unmet Load Hours

This manual uses the term "unmet load hours" (UMLHs) as a criterion for determining if the proposed design heating/cooling capacities are sufficient to meet the simulated loads. The concept of unmet load hours applies to thermal zones. For a thermal zone, it represents the number of occupied hours during a year when the HVAC system serving the thermal zone is unable to maintain the set point temperatures for heating or cooling or both. During periods of unmet loads, the zone temperature drifts above the cooling set point or below the heating set point. A thermal zone is considered to have one UMLH if the zone temperature is outside a specified tolerance below the heating or above the cooling set point for the entire hour. The set-point tolerance for nonresidential occupancies is defined in 5.3.5 Space Temperature Control.

UMLHs occur only during periods when the zone is occupied as specified in Appendix 5.4A and Appendix 5.4B. UMLHs shall be accounted for in each zone of the building. No zone in the building shall exceed the maximum allowed UMLH.

UMLHs can occur because fans, terminal units, coils, furnaces, air conditioners, or other equipment are undersized. UMLHs can also occur because of user errors such as inappropriate supply air control set points. It is the responsibility of the user to address causes of UMLHs in the proposed design.

UMLHs apply to thermal zones that contain any space type that is normally occupied. Thermal zones that contain only the irregularly occupied space types listed below shall not have UMLHs criteria:

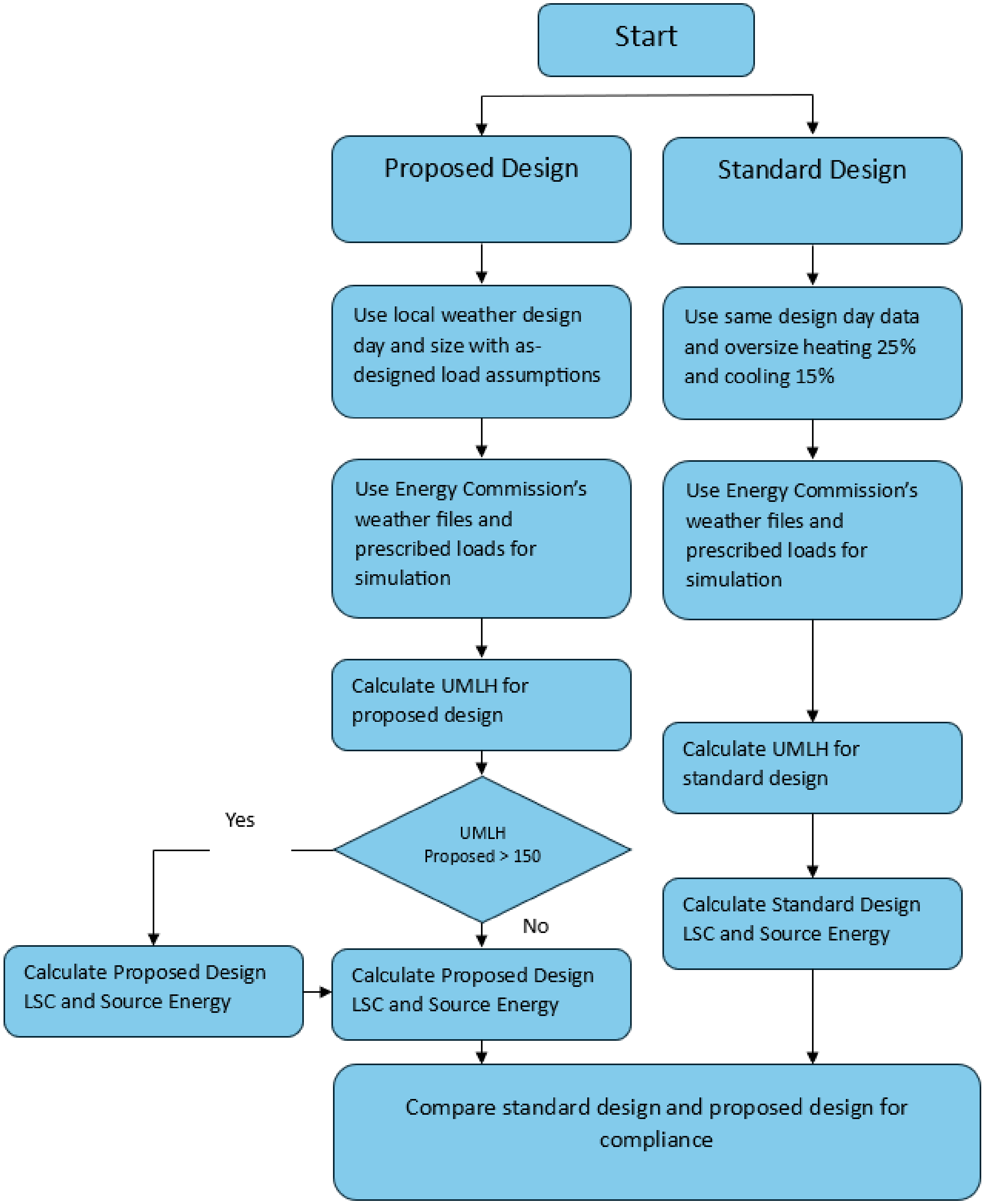
- Commercial and industrial storage areas
- Corridors, restrooms, stairs, and support areas
- Electrical, mechanical, telephone rooms
- Laundry rooms
- Locker/dressing rooms
- Parking garage areas

- Unoccupied gross floor areas
- Zones not subject to UMLHs checks or restrictions are listed in Appendix 5.4A.

2.5 Calculation Procedures

The general calculation procedure is illustrated below in Figure 2: Calculation Process for Energy Code Compliance*.* The proposed design Total LSC, Efficiency LSC, and source energy use are compared to the standard design by the compliance manager and must be equal to or less than the standard design for the project to comply through the performance method.

Figure 2: Calculation Process for Energy Code Compliance



Source: California Energy Commission

1. The process begins with a detailed description of the proposed design. Information is provided in enough detail to enable an estimate of annual energy use for a typical weather year. The required information depends on the scope of the project to be simulated by the compliance software but generally includes the building envelope, lighting systems, HVAC systems, water heating systems, and other important energy-using systems. This collection of information is referred to in this manual as *building descriptors*. Details on the building descriptors are provided in Chapter 5: Nonresidential Building Descriptors Reference and Chapter 6: Multifamily Building Descriptors Reference. Where applicable, user inputs are checked to be consistent with the guidance provided in this manual and the limitations of the simulation software.
2. Before the calculations are performed, some of the building descriptors are modified for the proposed design to incorporate prescribed modeling assumptions. Prescribed modeling assumptions include operating schedules, occupant density, equipment power density, and water-heating loads.
3. An annual simulation of the proposed design is performed to calculate hourly energy use and determine whether the heating and cooling loads are satisfied. The indicator, UMLHs, include the number of occupied hours during the year when the space temperature in one or more thermal zones is outside the throttling range. A large number of unmet load hours indicate system control issues, an undersized system, or a combination of factors.
4. If UMLHs for the proposed design are greater than 150 for the year, a warning will be presented after the simulation is complete, and the compliance report will be watermarked as not usable for compliance. No zone, except those completely comprised of the irregularly occupied space types listed in 2.4 Unmet Load Hours, may exceed 150 UMLHs. It is up to the designer to adjust system control, flow rates, or equipment sizes as necessary.
5. For comparison with the proposed design compliance simulation, the standard design is generated following the rules in this manual.
6. Sizing calculations are performed for the standard design and heating equipment shall be oversized by 25 percent and cooling equipment by 15 percent.
7. An annual simulation of the standard design is performed with the equipment capacities determined from sizing to calculate the hourly energy use. The number of unmet UMLHs for the standard design is calculated and the information is available as an optional output. It is unlikely for the standard design to have more than 150 UMLHs since the standard design system capacities are determined using a sizing run with additional oversizing multipliers, and controls are prescribed to be consistent with the system type.

8. If the UMLHs in the standard design are greater than 150, the compliance software developer should be notified for review. This situation does not impact the validity of proposed design compliance.
9. Finally, the proposed design Total LSC, Efficiency LSC, and source energy use and standard design Total LSC, Efficiency LSC and source energy use are compared for compliance depending on if the project is a newly constructed building, addition alone, addition plus alteration of existing building, or alteration of existing building.

2.6 HVAC Capacity Requirements and Sizing

To ensure that the simulated space-conditioning loads are adequately met, adequate capacity must be available in each of the components of the HVAC system, for example, supply-airflow rates, cooling coils, chillers, and cooling towers. If any component of the system is incapable of adequate performance, the simulation may understate the required energy use of space-conditioning equipment and report unmet load hours. Therefore, adequate capacities are required in the simulations of both the proposed design and standard design. The subchapters below describe the procedures that shall be followed to ensure that both versions of the design are simulated with adequate space-conditioning capacities.

The UMLHs criteria are used to prevent simulation of HVAC systems that may not adequately serve space-conditioning needs. This requirement does not mandate that a specific cooling or heating capacity be specified. With this requirement, if the proposed design appears as undersized, the user will be prompted to adjust plant, system, zonal capacities, or a combination as needed to meet the UMLHs criteria.

The special case of a building designed with no cooling system (typically, in a temperate coastal climate) is accommodated by the compliance software automatically adding a minimally compliant packaged constant-volume, single-zone system.

2.6.1 Specifying HVAC Capacities for the Proposed Design

As described in 2.5 Calculation Procedures, the proposed design shall have no more than 150 UMLHs for any thermal zone. If this limit is exceeded, the compliance software allows the user to make changes to the proposed design building description to bring the UMLHs equal to or below 150. This process is not automated by the compliance software.

If the proposed design does not meet the UMLHs criteria, the user should indicate the condition on the forms to add necessary equipment capacity to the proposed design. If the space-conditioning criteria are not met because the HVAC equipment in the proposed design lacks the capability to provide either heating or cooling, equipment capable of providing the needed space conditioning must be specified by the user.

Equipment sizes for the proposed design shall be entered into the model by the energy analyst and shall agree with the equipment sizes specified in the construction documents. When the simulations of these actual systems indicate that specified space conditions are not being adequately maintained in one or more thermal zone(s), the user shall be prompted to make changes to equipment sizes or zones as necessary. Space conditions are not being adequately met when the UMLHs exceed 150 for the year. The use of equipment sizes that do not match the actual equipment sizes as indicated on construction documents triggers an exceptional condition that is noted on the compliance forms.

2.6.2 Sizing Equipment in the Standard Design

For sizing heating and cooling equipment capacities, the compliance software shall use design day schedules as specified in 5.2 Project Data. For cooling capacity sizing, compliance software shall use the OnDay schedule from Appendix 5.4B for occupant, lighting, and equipment schedules. For heating capacity sizing, compliance software shall use the OffDay schedule from Appendix 5.4B for occupant, lighting, and equipment schedules.

Equipment in the standard design is automatically sized by the program as described below. Net coil capacities are calculated using the adjustments described in 5.7.5 Cooling Systems and 5.7.6 Heating Systems. The compliance software tabulates the zone UMLHs for the standard design in the same manner as for the proposed design.

Single-Zone Air-Source Heat Pump Systems

For standard design single-zone air-source heat pump systems, the heat pump heating and cooling capacities shall be determined by the following steps:

Step 1: Determine the gross heat pump heating capacity that can meet the heating load at the design condition. The sizing run shall be performed using an electric resistance heating coil. The autosized electric resistance coil capacity is then used as an input in the equations below to determine the gross heating capacity of the heat pump at 47°F and the heat pump supplemental heating coil.

$$GrossHPHtgCap_{sizing} = GrossERCap_{sizing} \times (1 + 0.0167 \times (47 - DesignHeatingDBT))$$

$$GrossSuppHtgCap_{sizing} = GrossERCap_{sizing}$$

Where:

$GrossHPHtgCap_{sizing}$ = the estimated gross heating capacity of the heat pump at 47°F outdoor air temperature

$GrossERCap_{sizing}$ = the autosized gross electric resistance heating capacity from the sizing run

DesignHeatingDBT = the design heating outdoor air temperature used for sizing run

$GrossSuppHtgCap_{sizing}$ = the autosized gross electric resistance supplemental heating capacity

Step 2: Determine the gross heat pump cooling capacity that can meet the cooling load at the design condition. The gross cooling capacity should be the autosized gross cooling capacity plus the calculated design fan heat.

Step 3: Determine the standard design gross cooling capacity, which should be 1.15 times the maximum of either the gross cooling capacity calculated in Step 2, or the gross heating capacity calculated in Step 1 multiplied by 0.75 less the calculated design fan heat.

$$GrossHPClgCap_{standard} = 1.15 \times max\left(GrossHPClgCap_{sizing}, 0.75 \times GrossHPHtgCap_{sizing} - FanHeat_{design}\right)$$

Where:

$GrossHPClgCap_{standard}$ = the gross cooling capacity of the heat pump in the standard design.

$GrossHPClgCap_{sizing}$ = the gross cooling capacity of the heat pump calculated in Step 2.

$GrossHPHtgCap_{sizing}$ = the gross heating capacity of the heat pump calculated in Step 1.

$FanHeat_{design}$ = the design fan heat

To avoid simulation errors, the final calculated gross cooling capacity should result in the cooling cfm/ton not less than 280 and not more than 450. The system fan capacity is 1.15 times the maximum of the autosized heating or cooling airflow, or the minimum ventilation airflow, whichever is greater. If the cfm/ton is not within the specified range, the cooling capacity shall be adjusted to bring it within the specified range.

Step 4: Define the standard design gross heating capacity, which should be the same as the gross cooling capacity calculated in Step 3.

All Other Secondary Systems: The gross coil capacity for heating at standard rating conditions is 1.25 times the autosized gross heating capacity. The gross coil capacity for cooling at standard rating conditions is 1.15 times the autosized gross cooling capacity plus the calculated design fan heat. For DX coils, the final calculated cfm/ton_{gross} shall not be less than 280 and not more than 450.

Fan capacity is 1.15 times the maximum of the autosized heating or cooling airflow, or the minimum ventilation airflow, whichever is greater. For multi-zone systems, autosized airflow is determined based on the coincident peak airflow needed by all thermal zones at the design supply air temperature.

Plant Equipment: The gross coil capacity for boilers at standard rating conditions is 1.25 times the design day peak loop load. The gross coil capacity for chillers/heat rejection at standard rating conditions is 1.15 times the design day peak loop load. Pump capacity is calculated using the final capacity and design deltaT of the primary equipment served by the pump.

2.6.3 Handling Proposed Design With No HVAC Equipment

If mechanical system compliance is included, as described in 5.2.3 Partial Compliance Model Input Classification, and a compliance model does not contain an HVAC system, the compliance software will generate an error and not run the simulation. For zones designed to not have a cooling system, the compliance software will automatically generate a minimally compliant, single-zone HVAC system to meet the cooling loads for the zone. In cases where the design has cooling but is insufficient to meet the UMLH criteria, the user can select "Add cooling system to meet load," and the compliance software will automatically generate a minimally compliant, single-zone HVAC system to meet the cooling loads for the zone. The compliance software shall make an appropriate note on compliance documentation indicating that the modeled HVAC system does not match design requirements. If the compliance software provides a means for the user to identify that the building has no cooling system, this information is reported on the compliance reports.

2.7 Ventilation Requirements

Design decisions regarding outside air ventilation shall be based on Section 120.1 of the Energy Code. If local codes do not apply, minimum values from Appendix 5.4A shall be used. 5.6 HVAC Zone Level Systems of the ACM has additional information on the ventilation requirements used in the building descriptors for the proposed and standard design. While no compliance credit can be claimed for reducing ventilation rates in the proposed design below the required levels, the user can specify higher ventilation rates in the proposed design.

3. Compliance Software Test Requirements

This chapter contains the procedures used to test and certify vendor's compliance software as acceptable for compliance with Title 24, Part 6. The compliance software shall have the input capabilities described in 2 General Compliance Software Modeling Procedures and Requirements and meet required capabilities and pass applicable certification tests as defined in 3 Compliance Software Test Requirements. Compliance software must also follow all modeling rules specified in 5 Nonresidential Building Descriptors Reference and 6 Multifamily Building Descriptors Reference. The reference method test verifies compliance software functionality and accuracy of simulation results by identifying reference method test cases and comparing the results of ACM candidate compliance software to the results of the compliance manager. The reference method test cases fall into the following categories:

- Reference method test cases to verify that the compliance software is evaluating thermal loads and the response of the HVAC systems to these loads in an acceptable manner. These tests reference *ASHRAE Standard 140-2023, Method of Test for Evaluating Building Performance Simulation Software*.
- Reference method test cases that verify that compliance software is capable of modeling envelope, lighting, HVAC, and water heating efficiency features and provides precise estimates of energy tradeoffs and reasonably accurate predictions of building energy consumption.
- Reference method test cases to verify that the standard design building is created correctly. For example, the standard design HVAC system is properly specified, other components of the standard design are correctly defined, and rules that fix and restrict inputs (such as schedules and plug loads) are properly applied. These tests do not verify simulation outputs but may require simulations to be run to specify inputs that depend on system sizing.

The reference method test cases are designed to cover representative compliance software functionality for building envelope, space uses, lighting, daylighting, HVAC, and water heating, both for simulation performance and for proper implementation of ACM rules specified in 5 Nonresidential Building Descriptors Reference. The CEC reserves the right to add ruleset implementation tests or software sensitivity tests to verify existing or future compliance software requirements. Moreover, the CEC reserves the right to adjust the passing criteria for the compliance software sensitivity tests to reflect the capabilities of commonly available energy simulation programs.

CEC approval of ACM candidate compliance software programs is intended to provide flexibility in complying with the Energy Code. In achieving this flexibility, however, the ACM candidate compliance software shall not fail to meet the Energy Code or evade the intent of the Energy Code to achieve a particular level of energy efficiency. The vendor has the burden of proof to demonstrate the accuracy and reliability of the ACM candidate compliance software relative to the reference method test cases and demonstrate the conformance of the ACM candidate compliance software to the requirements of this manual. The accuracy of simulation are evaluated based on the following:

- The ACM candidate compliance software shall demonstrate acceptable levels of accuracy by performing and passing the required certification tests discussed in 3 Compliance Software Test Requirements. The ACM candidate compliance software vendor conducts the specified certification tests in Appendix H, evaluates the results, and certifies in writing that the ACM candidate compliance software passes the tests. The CEC will perform spot checks and may require additional tests to verify that the proposed ACM candidate compliance software is appropriate for compliance.

When energy analysis techniques are compared, two potential sources of discrepancies are 1) the differences in user interpretation when entering the building specifications, and 2) the differences in the ACM candidate compliance software algorithms (mathematical models) for estimating energy use. The approval tests minimize differences in interpretation by providing explicit detailed descriptions of the test buildings that must be analyzed. For differences in the ACM candidate compliance software algorithms, the CEC allows algorithms that yield equivalent results. The vendor shall follow the procedure described in this document to certify publicly to the CEC that the ACM candidate compliance software meets the criteria in this document for:

- Accuracy and reliability when compared to the reference method test cases.
- Suitability in terms of the accurate calculation of the correct energy budget, the generation of output for transmission to standardized forms, and documentation on how the program demonstrates compliance.

In addition to specified technical criteria, CEC approval will also depend upon the CEC’s evaluation of:

- Enforceability in terms of reasonably simple, reliable, and rapid methods of verifying compliance and application of energy efficiency features modeled by the

ACM candidate compliance software and the inputs used to characterize those features by the software users.

- Dependability of the installation and energy savings of features modeled by the ACM candidate compliance software. The CEC will evaluate the probability that the measure will be installed and remain functional. The CEC shall also determine that the energy impacts of the features that the ACM candidate compliance software is capable of modeling will be reasonably and accurately reflected in real building applications of those features. It is important that the ACM candidate compliance software does not encourage the replacement of actual energy savings with theoretical energy savings due to tradeoffs allowed by the ACM candidate compliance software.

3.1 General Requirements

3.1.1 Scope

The compliance software must satisfy the requirements contained in this chapter.

The compliance software shall be capable of modeling at least 50 thermal zones.

The compliance software shall be capable of modeling at least 15 HVAC systems.

3.1.2 Calculation Methods

The compliance software shall calculate the annual consumption of all end uses in buildings, including fuel and electricity for:

- HVAC (heating, cooling, fans, and ventilation).
- Lighting (both interior and exterior).
- Receptacles and miscellaneous electric.
- Service water heating.
- Process energy uses.
- All other energy end uses that typically pass through the building meter.

The compliance software shall perform a simulation on an hourly time interval (at a minimum) over a one-year period (8,760 hours) with the ability to model changes in weather parameters, schedules, and other parameters for each hour of the year. This is achieved by specifying a 24-hour schedule for each day of the week plus holidays.

3.1.2.1 Calculating Design Loads

The compliance software shall be capable of performing design load calculations for determining required standard design HVAC equipment capacities and air and water flow rates, as described in this reference manual or using other accepted industry calculation methods showing equivalency.

3.1.2.2 Checking Simulation Output for Unmet Loads

The compliance software shall be capable of checking the annual simulation output for the proposed design to ensure that thermal zone conditions are maintained within the tolerances specified in 2.4 Unmet Load Hours. The compliance software shall post a compliance analysis error and inform the user of what zones violate the unmet load-hour criteria.

3.1.3 Climate Data

The compliance software shall perform simulations using the official CEC weather files and design conditions documented in Reference Appendices, Joint Appendix JA2*.*

The compliance software shall calculate solar radiation on exterior surfaces on an hourly basis from the values of direct normal irradiance and diffuse horizontal irradiance contained in the climate data, taking ground reflectance into account.

The compliance software shall be capable of simulating time-of-use rates and apply both demand and energy charges for each period of the rate schedule.

3.1.4 Long-Term System Cost (LSC)

The compliance software shall be capable of converting site energy to LSC applying the CEC LSC multipliers for each hour of the simulation. See CEC Reference Appendices, Joint Appendix JA3*.*

3.1.5 Source Energy

The compliance software shall be capable calculating source energy for each hour of the simulation as described in 2.1.5 Source Energy.

3.1.6 Thermal Mass

The calculation procedures used in the compliance software shall account for the effect of thermal mass on loads due to occupants, lights, solar radiation, and transmission through building envelope on the amount of heating and cooling required to maintain the specified space temperature schedules and on variation in space temperature.

3.1.7 Modeling Space Temperature

The compliance software shall incorporate a dynamic simulation of space temperature that accounts for:

- Dynamics in change in heating and cooling setpoint temperatures.
- Dead band between heating and cooling thermostat settings.
- Temperature drift in transition to setback or setup thermostat schedules.

- Temperature drift in periods when heating or cooling capability are scheduled off.
- Temperature drift when heating or cooling capability of the system is limited by heating or cooling capacity, airflow rate, or scheduled supply air temperature.
- Indirectly conditioned thermal zones, where the temperature is determined by internal loads, heat transfer through building envelope, and heat transfer between thermal zones.

3.1.8 Heat Transfer Between Thermal Zones

The compliance software shall be capable of modeling heat transfer between a thermal zone and adjacent thermal zones.

The compliance software shall account for the effect of this heat transfer on the space temperature, space-conditioning loads, and resulting energy use in the thermal zone and adjacent thermal zones.

3.1.9 Control and Operating Schedules

The compliance software shall be capable of modeling control and operating schedules that vary by:

- The hour of the day.
- The day of the week.
- Holidays, which are treated as a special day of the week.

The compliance software shall be capable of explicitly modeling all of the schedules specified in Appendix 5.4B of this manual.

3.1.9.1 Loads Calculation

The load calculations described in this chapter relate to the simulation engine, and not to the procedure used by the design engineer to size and select equipment.

3.1.9.2 Internal Loads

The compliance software shall be capable of calculating the hourly cooling loads due to occupants, lights, receptacles, and process loads.

The calculation of internal loads shall account for the dynamic effects of thermal mass.

The compliance software shall be capable of simulating schedules for internal loads in the form given in Appendix 5.4B.

The simulation of cooling load due to lights shall account for:

- The effect of the proportion of radiant and convective heat, which depends on the type of light and on the dynamic response characteristic.
- A portion of heat from lights going directly to return air. The amount depends on the type and location of fixture.

3.1.9.3 Building Envelope Loads

The compliance software shall calculate heat transfer through walls, roofs, and floors for each thermal zone, accounting for the dynamic response due to thermal characteristics of the particular construction as specified in 5 Nonresidential Building Descriptors Reference and 6 Multifamily Building Descriptors Reference.

The calculation of heat transfer through walls and roofs shall account for the effect of solar radiation absorbed on the exterior surface, which depends on orientation and absorptance of the surface.

The compliance software shall calculate heat transfer through windows and skylights, accounting for both temperature difference and transmission of solar radiation through the glazing.

Calculation of cooling load due to transmission of solar radiation through windows and skylights shall account for:

- The variation of thermal properties of the fenestration system with ambient temperature.
- Orientation (azimuth and tilt of surface).
- The effect of shading from overhangs, side fins, or exterior horizontal slats.

3.1.9.4 Infiltration

The compliance software shall be capable of simulating infiltration that varies by the time of day and day of the week. Schedules are provided in Appendix 5.4B.

3.1.10 Systems Simulation

3.1.10.1 General

The compliance software shall be capable of modeling:

- The standard design building systems specified in 5 Nonresidential Building Descriptors Reference and 6 Multifamily Building Descriptors Reference.
- The lighting, water-heating, HVAC, and miscellaneous equipment specified in 5 Nonresidential Building Descriptors Reference and 6 Multifamily Building Descriptors Reference.
- All compulsory and required features, as specified in 5 Nonresidential Building Descriptors Reference and 6 Multifamily Building Descriptors Reference.

The capability to model multiple zone systems shall allow at least 15 thermal zones to be served by one multiple-zone system.

The compliance software shall be capable of modeling plenum air return.

3.1.10.2 HVAC Zone Level Systems

The compliance software shall be capable of simulating the effect on space temperature and energy use of:

- Limited capacity of terminal heating devices.
- Limited capacity of terminal cooling devices.
- Limited rate of airflow to thermal zones.

3.1.10.3 HVAC Secondary Systems and Equipment

The compliance software shall be capable of simulating the effect on energy use and space temperature in thermal zones served by the HVAC system of:

- Limited heating capacity.
- Limited cooling capacity.

The simulation of HVAC systems shall account for:

- Temperature rise of supply air due to heat from supply fan, depending on the location of the fan.
- Temperature rise of return air due to heat from return fan.
- Temperature rise of return air due to heat from lights to return air stream.
- Fan power as a function of supply airflow in variable-air-volume systems.

3.1.10.4 HVAC Primary Systems and Equipment

The compliance software shall be capable of simulating the effect on energy use of limited heating or cooling capacity of the central plant system.

If the compliance software is not capable of simulating the effect of limited heating or cooling capacity of the central plant system on space temperature in affected thermal zones, then it shall issue a warning message when loads on the central plant system are not met.

3.1.10.5 Equipment Performance Curves

The compliance software shall be capable of modeling the part-load efficiency and variation in capacity of equipment as follows:

- Furnace efficiency as a function of part load.

- Boiler efficiency as a function of part load, supply hot water temperature, and return hot water temperature.
- Water-cooled compressors, including heat pumps and chillers, efficiencies as a function of part load, evaporator fluid, or air temperature and condensing fluid temperature.
- Air-cooled compressors, including heat pumps, direct expansion cooling and chillers, efficiencies as a function of part load, ambient dry-bulb temperature, and wet-bulb temperature returning to the cooling coil.
- Evaporative cooling system efficiency as a function of ambient wet-bulb temperature.
- Cooling tower efficiency as a function of range and ambient wet-bulb temperature.

3.1.10.6 Economizer Control

The compliance software shall be capable of modeling integrated air- and water-side economizers.

3.2 Special Documentation and Reporting Requirements

3.2.1 Building Envelope

3.2.1.1 Roof Radiative Properties

The user shall enter three-year aged roof reflectance and emittance for roofs that have been certified by the Cool Roof Rating Council. The compliance software shall report the product identification number(s) of any roofing products used on the building, so that aged reflectance and emittance can be verified by the code official.

3.2.2 Interior Lighting

3.2.2.1 Regulated Interior Lighting Power

Whenever any of the additional lighting power allowance for qualified lighting systems (the two rightmost columns in Table 140.6-C of the Energy Code) are claimed, the compliance software shall indicate on the compliance forms that verification is required.

3.2.2.2 Indoor Lighting Power (see 5.4.4 Interior Lighting)

Compliance software shall print all applicable lighting forms and report the lighting energy use and the lighting level (watts/ft^2) for the entire project. Compliance software shall report "no lighting installed" for nonresidential spaces with no installed lighting. Compliance software shall report "default residential lighting" for housing units of multifamily buildings and hotel/motel guest rooms.

Lighting power in unconditioned spaces does not receive performance standards compliance credit, but lighting in those spaces is required to meet the prescriptive requirements for regulated unconditioned spaces, such as commercial and industrial storage spaces, and parking garages. When these types of spaces are entered, the compliance software must report in the Special Features section that these spaces must comply with the prescriptive requirements for such spaces.

3.2.2.3 Design Illumination Set Point

Spaces that have low design illuminance levels, below the ranges specified in Appendix 5.4A, shall provide documentation showing the design illuminance to be used as the daylight illumination setpoint.

3.2.3 HVAC Exceptional Conditions

3.2.3.1 Equipment Sizing

When any proposed equipment size for secondary equipment or central plant equipment does not match the equipment size listed on construction documents, an exceptional condition shall be reported on compliance forms.

3.2.3.2 Process and Filtration Pressure Drop Allowance

Any nonzero values entered for supply fan process and filtration pressure drop are flagged as an exceptional condition in the compliance documentation.

3.2.3.3 Natural Ventilation Specified

When natural ventilation is specified by the user for the proposed design for Hotel/Motel guestrooms, the compliance software shall report an exceptional condition that the conditions in Section 120.1(c) of the Energy Code must be met. When natural ventilation is specified for common-use area in multifamily buildings, the compliance software shall report an exceptional condition that the conditions in Section 160.2(c) of the Energy Code must be met.

3.3 ASHRAE Standard 140-2023 Tests

This method of testing is provided for analyzing and diagnosing building energy simulation software using software-to-software and software-to-quasi-analytical-solution comparisons. The method allows different building energy simulation programs, representing different degrees of modeling complexity, to be tested by comparing the predictions from other building energy programs to the simulation results provided by the compliance software in question.

Compliance software must publish the results of ASHRAE Standard 140-2023 tests, but these tests are not part of the reference method.

The building energy simulation programs shall be tested according to ASHRAE Standard 140, except for Sections 12 of Standard 140. The required tests shall include Weather Drivers Tests (Section 6), Building Thermal Envelope and Fabric Load Tests (Section 7), Ground Coupled Slab-On-Grade Tests (Section 8), Space-Cooling Equipment Performance Tests (Section 9), Space-Heating Equipment Performance Tests (Section

10), and Air-Side HVAC Equipment Performance Tests (Section 11), along with the associated reporting.

During testing, hidden inputs that are not normally accessible to the user shall be permitted. The hidden inputs are permitted to avoid introducing source code changes that are strictly used for testing.

The software vendor or third party, authorized by either the software vendor or the AHJ, shall publish on a publicly available website the following ASHRAE Standard 140 test results, input files, and modeler reports for each tested version of a building energy simulation program:

- Test results demonstrating the building energy simulation program were tested in accordance with ASHRAE Standard 140 Annex A3 and that meet or exceed the values for "The Minimum Number of Range Cases withing the Test Group to Pass" for all test groups in ASHRAE Standard 140, Table A3-14.
- Test results of the building energy simulation program and input files used for generating the ASHRAE Standard 140 test cases, along with the results of the other simulation programs included in ASHRAE Standard 140, Annexes B8 and B16.
- The modeler report in ASHRAE Standard140 Annex 2, Attachment A2.8. Report Blocks A and G shall be completed for results exceeding the maximum or falling below the minimum of the reference values shown in ASHRAE Standard 140 Table A3-1 through Table A3-13, and Report Blocks A and E shall be completed for any omitted results.

A software vendor of the simulation user interface or a third party authorized by the software vendor or the AHJ shall also be permitted to meet the requirements for this section.

If a certification program exists for building energy simulation program tested to ASHRAE Standard 140, the building energy simulation program shall be listed in the certification program.

4. Content and Format of Standard Reports

Consult the *Nonresidential and Multifamily Compliance Manual* for the reports required to be manually generated for any project. For nonresidential compliance, the PRF-01 report is generated by the compliance software. For residential compliance, the low-rise multifamily certification of compliance (LMCC) and the nonresidential and high-rise multifamily certification of compliance (NRCC) reports are generated by the compliance software.

5. Nonresidential Building Descriptors Reference

5.1 Overview

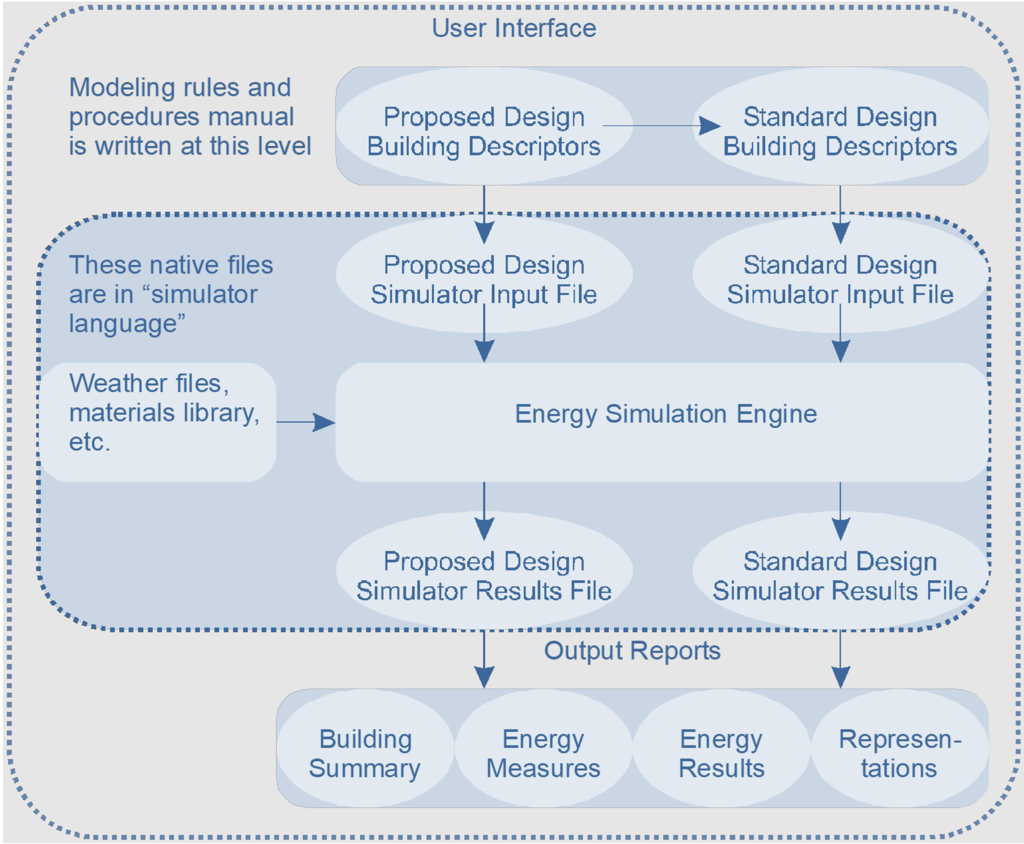
This chapter specifies, for each building descriptor, the rules that apply to the proposed design and to the standard design for nonresidential buildings. For multifamily buildings, refer to 6 Multifamily Building Descriptors Reference, for the applicable rules.

5.1.1 Definition of Building Descriptors

Building descriptors provide information about the proposed design and the standard design. In this chapter, the building descriptors are discussed in the generic terms of engineering drawings and specifications. By using generic building descriptors, this manual avoids bias toward one energy simulation engine. The building descriptors in this chapter are compatible with commonly used simulation software.

Each energy simulation program has a unique way of accepting building information. EnergyPlus™ uses a comma delimited data file called an *input data file* (IDF). DOE-2 uses BDL (building design language) to accept information. It is the responsibility of the compliance software to translate the generic terms used in this chapter into the "native language" of the simulation program. Figure 3: Information Flow illustrates the flow of information.

Figure 3: Information Flow



Source: California Energy Commission

5.1.2 Organization of Information

Building descriptors are grouped under objects or building components. A wall or exterior surface (an object) would have multiple building descriptors dealing with the geometry, thermal performance, and so forth. Each building descriptor contains the following pieces of information:

Building Descriptor Title

Applicability: Information on when the building descriptor applies to the proposed design.

Definition: A definition for the building descriptor.

Units: The units that are used to prescribe the building descriptor. A "list" indicates that a fixed set of choices applies, and the user shall be allowed to enter only one of the values in the list.

Input Restrictions: Any restrictions on information that may be entered for the proposed design.

Standard Design: This defines the value for the "standard design," or baseline building applied for this building descriptor. A value of "same as proposed" indicates that the building descriptor is neutral, that is, the value is set to match the proposed design value. In many cases, the value may be fixed or may be determined from a table lookup. In some cases, the input may not be applicable.

Standard Design: Existing Building: Standard design for existing buildings if different than for newly_constructed buildings.

5.1.3 HVAC System Map

The Nonresidential HVAC system in the standard design depends on the predominant space function types of the building, the size of the building, and the number of floors. In buildings with different space function types on different floors, the standard design depends on the predominant space function type of each floor. Details about these systems are provided in subsequent chapters.

Many of the building descriptors have a one-to-one relationship between the proposed design and the standard design; for example, every wall in the proposed design has a corresponding wall in the standard design. For HVAC systems, however, this one-to-one relationship generally does not hold. The number and type of HVAC systems serving the proposed design and the standard design may be completely different in type and components.

The HVAC systems in the standard design are determined by Table 1: Nonresidential HVAC System Map, which is based on space type, system cooling capacity, number of above-grade floors, climate zone, conditioned floor area, and, for some spaces, process load, and laboratory exhaust rate. Table 2: System Descriptions, provides additional detail for each standard design system. Unless otherwise noted, all non-residential systems are set to meet the efficiency requirements for 3-phase equipment.

For Systems 1, 3, 7, 9, 10, and 11, each thermal zone shall be modeled with a respective HVAC system. For Systems 5, 6, 14, and 15 each floor shall be modeled with a separate HVAC system. Floors with identical thermal zones and occupancies can be grouped for modeling.

Table 1: Nonresidential HVAC System Map

Space Type	Above-Grade Floors	Climate Zone	System Cooling Capacity	Standard Design
Multifamily	(See NRMFACM Chapter 6)	(See NRMFACM Chapter 6)	(See NRMFACM Chapter 6)	(See NRMFACM Chapter 6)

Space Type	Above-Grade Floors	Climate Zone	System Cooling Capacity	Standard Design
Hotel/motel guestrooms	No limit	All	No limit	System 1 – RAC
Retail or grocery[1]	Buildings ≤ 2 floors	2-15	< 65 kBtu/h	System 3b – SZHP
Retail or grocery[1]	Buildings ≤ 2 floors	2-15	≥ 65 kBtu/h	System 7b – SZVAVHP
Retail or grocery[1]	Buildings ≤ 2 floors	1, 16	< 65 kBtu/h	System 3a – SZAC
Retail or grocery[1]	Buildings ≤ 2 floors	1, 16	≥ 65 kBtu/h	System 7c – SZVAVDFHP
Retail or grocery[1] and total building conditioned floor area < 25,000 ft[2]	Buildings = 3 floors	2-15	< 65 kBtu/h	System 3b – SZHP
Retail or grocery[1] and total building conditioned floor area < 25,000 ft[2]	Buildings = 3 floors	2-15	≥ 65 kBtu/h	System 7b – SZVAVHP
Retail or grocery[1] and total building conditioned floor area < 25,000 ft[2]	Buildings = 3 floors	1, 16	< 65 kBtu/h	System 3a – SZAC
Retail or grocery[1] and total building conditioned floor area < 25,000 ft[2]	Buildings = 3 floors	1, 16	≥ 65 kBtu/h	System 7c – SZVAVDFHP
School[2] and total building conditioned floor area ≤ 150,000 ft[2]	Buildings ≤ 3 floors	2-15	< 65 kBtu/h	System 3b – SZHP
School[2] and total building conditioned floor area ≤ 150,000 ft[2]	Buildings ≤ 3 floors	2-15	≥ 65 kBtu/h	System 7b – SZVAVHP
School[2] and total building conditioned floor area ≤ 150,000 ft[2]	Buildings ≤ 3 floors	1, 16	< 65 kBtu/h	System 3c – SZDFHP

Space Type	**Above-Grade Floors**	**Climate Zone**	**System Cooling Capacity**	**Standard Design**
School[2] and total building conditioned floor area ≤ 150,000 ft^2	Buildings ≤ 3 floors	1, 16	≥ 65 kBtu/h	System 7c – SZVAVDFHP
School and total building conditioned floor area ≤ 150,000 ft^2	4 – 5 floors	2, 4, 8 – 16	No limit	System 15 – PVAVAWHP
Warehouse and light manufacturing that do not include mechanical cooling in the proposed design[3]	No limit	All	No limit	System 9 – HEATVENT
Office in buildings with warehouse and light manufacturing space[3]	Buildings ≤ 3 floors	All	< 65 kBtu/h	System 3b – SZHP
Office in buildings with warehouse and light manufacturing space[3]	Buildings ≤ 3 floors	All	≥ 65 kBtu/h	System 7b – SZVAVHP
Office, financial institution, and library and total building area < 25,000 ft^2	Buildings ≤ 3 floors	1-15	< 65 kBtu/h	System 3b – SZHP
Office, financial institution, and library and total building conditioned floor area < 25,000 ft^2	Buildings ≤ 3 floors	1-15	≥ 65 kBtu/h	System 7b – SZVAVHP
Office, financial institution, and library and total building conditioned floor area < 25,000 ft^2	Buildings ≤ 3 floors	16	< 65 kBtu/h	System 3a – SZAC
Office, financial institution, and library and total building	Buildings ≤ 3 floors	16	≥ 65 kBtu/h	System 7c – SZVAVDFHP

Space Type	**Above-Grade Floors**	**Climate Zone**	**System Cooling Capacity**	**Standard Design**
conditioned floor area < 25,000 ft^2				
Office, financial institution, and library and total building conditioned floor area < 25,000 ft^2	4 – 5 floors	All	No limit	System 15 – PVAVAWHP
Office, financial institution, and library and total building area 25,000 – 150,000 ft^2	≤ 5 floors	All	No limit	System 15 – PVAVAWHP
Covered process computer room with total process load ≤ 800kW	No limit	All	No limit	System 11 – CRAC Unit
Covered process computer room with total process load > 800kW	No limit	All	No limit	System 10 – CRAH Unit
Covered process laboratory with design maximum exhaust 20,000 cfm or less or meets an exception[5] and total building conditioned area less than 25,000 ft^2	No limit	All	No limit	System 7b – SZVAVHP
Covered process laboratory with design maximum exhaust 20,000 cfm or less or meets an exception[5] and total building conditioned floor area 25,000 ft^2 and less than 150,000 ft^2	No limit	All	No limit	System 5 – PVAV
Covered process laboratory with design maximum exhaust	No limit	All	No limit	System 6 – VAV

Space Type	Above-Grade Floors	Climate Zone	System Cooling Capacity	Standard Design
20,000 cfm or less or meets exception[5] and total building conditioned floor area ≥ 150,000 ft^2				
Covered process laboratory design maximum exhaust greater than 20,000 cfm and does not meet exception[5] with total building conditioned floor area less than 150,000 ft^2	No limit	All	No limit	System 14a – ACSZVAV
Covered process laboratory design maximum exhaust greater than 20,000 cfm and does not meet an exception[5] with total building conditioned floor area 150,000 ft^2 or greater	No limit	All	No limit	System 14b – WCSZVAV
Covered process commercial kitchen for buildings that use System 6 – VAV	No limit	All	No limit	System 13a – BKITCHMAU
Covered process commercial kitchen for buildings that don't use System 6 – VAV	No limit	All	No limit	System 13b – PKITCHMAU
Healthcare facilities	No limit	All	No limit	Same as the Proposed Design
All other spaces in buildings with < 25,000 ft^2 conditioned floor area	Buildings ≤ 3 floors	All	< 65 kBtu/h	System 3a – SZAC

Space Type	Above-Grade Floors	Climate Zone	System Cooling Capacity	Standard Design
All other spaces in buildings with < 25,000 ft^2 conditioned floor area	Buildings ≤ 3 floors	All	≥ 65 kBtu/h	System 7a – SZVAVAC
All other spaces in buildings with < 25,000 ft^2 conditioned floor area	4 - 5 floors	All	No limit	System 5 – PVAV
All other spaces in buildings with < 25,000 ft^2 conditioned floor area	> 5 floors	All	No limit	System 6 – VAV
All other spaces in buildings with 25,000 – 150,000 ft^2_ conditioned floor area	≤ 5 floors	All	No limit	System 5 – PVAV
All other spaces in buildings with 25,000 – 150,000 ft^{2-} conditioned floor area	> 5 floors	All	No limit	System 6 – VAV
All other spaces in buildings_with > 150,000 ft^2 conditioned floor area	No limit	All	No limit	System 6 – VAV

Source: California Energy Commission

Notes:

1) "Retail or grocery" building space types include "Pharmacy Area," "Retail Sales Area (Fitting Room)," "Retail Sales Area (Grocery Sales)," "Retail Sales Area (Retail Merchandise Sales)," "Concourse and Atria Area," "Exercise/Fitness Center and Gymnasium Areas" and "Beauty Salon Area." To qualify for this system, the building floor that includes these spaces must predominantly have a "Retail" function schedule group (FuncSchGrp), specified by Appendix 5.4A, and be part of a building with only three above-grade floors or less. If these are not met, the standard design system is determined using the "All other spaces" categories.
2) "School" building space types include "Classroom, Lecture, Training, Vocational Areas." To qualify for this standard design system, the building floor that includes these spaces must predominantly have a "School" function schedule group (FuncSchGrp), specified by Appendix 5.4A, and be part of a building with only three above-grade floors or less. If these are not met, the standard design system is determined using the "All other spaces" categories.
3) Warehouse and light manufacturing spaces are those identified as having a "Warehouse" or "Manufacturing" function schedule group (FuncSchGrp), specified by Appendix 5.4A.
4) Office, financial institution, and library spaces include "Copy Room," "Financial Transaction Area," "Library, Reading Areas," "Library, Stacks," "Office (Greater than 250 square feet in floor area)," "Office (250 square feet in floor area or less)," "Videoconferencing Studio," and "Waiting Area." To qualify for this system, the building floor that includes these spaces must predominantly have an "Office" function schedule group (FuncSchGrp), specified by Appendix 5.4A. If these are not met, the standard design system is determined using the "All other spaces" categories.
5) Exceptions pertaining to covered process laboratory systems include:
i) Systems in climate zone 7, 15
ii) Systems dedicated to vivarium spaces or spaces classified as biosafety level 3 or higher.

Table 2: System Descriptions

System Type	Description	Detail
System 1 – RAC	Room air conditioner	Single-phase single-zone system with constant volume fan, no economizer, direct expansion cooling, and gas furnace heating.
System 2 – RESERVED		
System 3a – SZAC	Packaged single-zone air conditioner	Single-phase single-zone system with constant-volume fan, direct expansion cooling, and gas furnace heating.
System 3b – SZHP	Packaged single-zone heat pump	Single-phase single-zone system with constant-volume fan, direct expansion heat pump cooling and heating, and electric resistance supplemental heating.
System 3c – SZDFHP	Packaged single-zone dual-fuel heat pump	Single-zone system with constant-volume fan, direct expansion heat pump cooling and heating, and gas supplemental heating.
System 4 – Reserved		
System 5 – PVAV	Packaged VAV	Multizone packaged system with variable-air-volume fan, direct expansion cooling, and hot water heating provided by central gas boiler.
System 6 – VAV	Built-up VAV	Multizone built-up system with variable-air-volume fan, chilled water cooling provided by a central water-cooled chiller and cooling tower, and hot water heating provided by central gas boiler.
System 7a – SZVAVAC	Packaged single-zone variable-air-volume air conditioner	Single-zone system with variable-air-volume fan, direct expansion variable-speed-drive cooling, and gas furnace heating. Integrated economizer for standard design cooling capacities ≥ 33 kBtu/h.

System Type	Description	Detail
System 7b – SZVAVHP	Packaged single-zone variable-air-volume heat pump	Single-zone system with variable-air-volume fan, direct expansion heat pump cooling and heating, and electric resistance supplemental heating. Minimum fan speed ratio of 0.2 for laboratory spaces and 0.5 for all other spaces.
System 7c – SZVAVDFHP	Packaged single-zone variable-air-volume dual-fuel heat pump	Single-zone system with variable-air volume fan, direct expansion heat pump cooling and heating, and gas supplemental heating.
System 8 – RESERVED		
System 9 – HEATVENT	Heating and ventilation only	Single-zone system with a constant volume fan and gas furnace heating.
System 10 – CRAH	Computer room air handler	Single-zone built-up system with variable- air-volume fan, chilled water cooling provided by a central water-cooled chiller and cooling tower, and no heating.
System 11 – CRAC	Computer room air conditioner	Single-zone packaged system with variable-air-volume fan, direct expansion cooling, and no heating
System 12 – Reserved		
System 13a – BKITCHMAU	Built-up kitchen makeup air unit	Built-up single-zone makeup air unit with dedicated exhaust fan, chilled water cooling provided by a central water-cooled chiller and cooling tower, and hot water heating provided by central gas boiler.
System 13b – PKITCHMAU	Packaged kitchen makeup air unit	Packaged single-zone makeup air unit with dedicated exhaust fan, direct expansion cooling, and gas furnace heating.
System 14a – ACSZVAV	Air-cooled single zone VAV	Single-zone built-up system with variable-air-volume fan, chilled water provided by a dedicated air-cooled chiller, and hot water provided by a dedicated air-to-water heat pump.

System Type	Description	Detail
		The air handler has a heat recovery coil as specified by Section 140.9(c)6 of the Energy Code.
System 14b – WCSZVAV	Water-cooled single zone VAV	Single-zone built-up system with variable-air-volume fan, chilled water provided by a central water-cooled chiller plant, and hot water provided by a dedicated air-to-water heat pump. The air handler has a heat recovery coil as specified by Section 140.9(c)6 of the Energy Code.
System 15 – PVAVAWHP	Packaged VAV with AWHP heating	Multi-zone packaged system with variable-air-volume fan, direct expansion cooling, and hot water heating provided by an air to water heat pump (AWHP). See Table 3: System 15 – PVAVAWHP: Standard Design Criteria for additional system details based on occupancy served and climate zone.

Source: California Energy Commission

Table 3: System 15 – PVAVAWHP: Standard Design Criteria

Design Criteria	Schools	Offices
Percentage of perimeter zone terminal units utilizing parallel fan powered boxes	All CZ: 100%	CZ 1 – 6, 16: 100% of heating capacity CZ 7-15: 25% of heating capacity
Exhaust air heat recovery	CZ 2, 4, 11 – 16: Required All Other CZs: Not required	CZ 1, 3, 5: Required All Other CZs: Not required
Fan power	CZ 2: 15% lower than Table 13: Total System Fan Power Allowance, in W/cfm by System Type All Other CZs: Table 13: Total System Fan Power Allowance, in W/cfm by System Type	CZ 3, 5: 15% lower than Table 13: Total System Fan Power Allowance, in W/cfm by System Type All Other CZs: Table 13: Total System Fan Power Allowance, in W/cfm by System Type

Design Criteria	Schools	Offices
Hot water loop supply temperature	CZ 2: 120 °F All Other CZs: 130 °F	130 °F
Hot water loop temperature drop (delta T)	CZ 2: 15 °F All Other CZs: 10 °F	10 °F
AWHP COP	CZ 2: 2.77 at 120 °F supply temperature All Other CZs: 2.31 at 140 °F supply temperature	2.31 at 140 °F supply temperature

Source: California Energy Commission

The standard design systems serving mixed-use buildings are different from the standard design systems serving nonresidential space types. Also, spaces containing covered processes are served by dedicated standard design systems separate from systems serving other nonresidential space types. Examples include hotel/motel guestroom and related spaces located over retail and other similar conditions. For example, a 100,000 ft^2 building that has retail and restaurant on Floor 1, offices on Floors 2, 3, and 4, a 600-kW process load computer room on each office floor, and guestrooms on Floors 5, 6, and 7 would have the following systems in the standard design:

- System 13a or b – BKITCHMAU or PKITCHMAU serving the restaurant commercial kitchen zone
- Separate System 11 – CRAC systems serving each computer room
- Separate System 1 – RAC systems serving each guestroom space, with a System 6 – VAV system serving corridors and other non-guestroom spaces on each floor
- System 6 – VAV serving all other conditioned spaces, including retail spaces since the building has more than three floors, as well as the dining area of the restaurant.

The standard design building shall have only one central chilled and/or hot water plant, so if there are multiple systems that incorporate a central plant (for example, CRAH and VAVs), then a single plant shall serve all plant loads.

5.1.4 Additions and Alterations System Modification

For nonresidential additions and alterations to existing buildings, the standard design HVAC system and the proposed design system will be the same for all existing systems. For new and altered HVAC systems, the standard design system is determined as described in Chapter 5.1.4 Additions and Alterations System Modification. In some cases when identifying the HVAC system, the characteristics for the entire building (existing plus any addition) must be considered. Therefore, the existing building floor area and number of floors must be entered. (See 5.2.2 Existing Building Classification.)

1. The building conditioned floor area and number of floors that are used in the HVAC system map is determined by the following rules.
   a. For an existing building that has both heating and cooling systems.
      i. Primary: If the change in cooling capacity of all new primary (plant) cooling equipment exceeds 50 percent of the total plant cooling capacity, the conditioned floor area and total above-grade floors of the entire building is used.
      ii. Non-Hydronic Secondary: If the change in cooling capacity of all new secondary cooling coils other than hydronic chilled water exceeds 50 percent of the total cooling capacity for the building, the conditioned floor area and total above-grade floors of the entire building is used.
      iii. Combined Secondary: If the combined cooling capacity of all (hydronic + non-hydronic) new secondary cooling coils exceeds 90 percent of the total building cooling capacity, the conditioned floor area and total above-grade floors of the entire building is used.
      iv. If none of the primary, non-hydronic secondary, or combined secondary condition descriptions apply, the conditioned floor area of only the addition and existing areas with new heating/cooling equipment and total above-grade floors of the entire building is used.
   b. For an existing building that has only heating-only systems.
      i. Primary: If the change in heating capacity of all new primary (plant) heating equipment exceeds 50 percent of the existing total plant heating capacity, the conditioned floor area and total above-grade floors of the entire building is used.
      ii. Non-Hydronic Secondary: If the change in heating capacity of all new secondary heating coils other than hydronic hot water or steam (if supported) exceeds 50 percent of the total heating capacity for the building, the conditioned floor area and total above-grade floors of the entire building is used.
      iii. Combined Secondary: If the combined heating capacity of all (hydronic + non-hydronic) new secondary heating coils exceeds 90 percent of the building heating capacity, the conditioned floor area and total above-grade floors of the entire building is used.
      iv. If none of these three conditions apply, the conditioned floor area of only the addition and existing areas with new heating equipment and total above-grade floors of the entire building is used.

New or replaced systems in added or altered areas of existing buildings are not subject to Section 140.4(a)2 requirements. New or replaced systems in altered areas of existing buildings must comply with Section 141.0(b)2Cii. In this case, the conditioned floor area and total above-grade floors determined in the step above are used as inputs to the revised system map below, when applicable. For all other systems Table 1: Nonresidential HVAC System Map is applicable.

Table 4: Nonresidential HVAC System Map (Alterations)

Space Type	Above-Grade Floors	Climate Zone	System Cooling Capacity	Standard Design
Retail or grocery	Buildings ≤2 floors	3-13 and 15	<65 kBtu/h	System 3b - SZHP
Retail or grocery	Buildings ≤2 floors	1,2, 14 and 16	<65 kBtu/h	System 3a - SZAC
Retail or grocery, conditioned area < 25,000 ft^2	Buildings =3 floors	3-13 and 15	<65 kBtu/h	System 3b - SZHP
Retail or grocery, conditioned area < 25,000 ft^2	Buildings =3 floors	1,2, 14 and 16	<65 kBtu/h	System 3a - SZAC
School, conditioned floor area < 150,000 ft^2	Buildings ≤ 3 floors	1-15	<65 kBtu/h	System 3b – SZHP
School, conditioned floor area < 150,000 ft^2	Buildings ≤ 3 floors	16	<65 kBtu/h	System 3b – SZAC
Office or financial institution, conditioned floor area < 25,000 ft^2	Buildings ≤ 3 floors	3-13 and 15	<65 kBtu/h	System 3b – SZHP
Office or financial institution, conditioned floor area < 25,000 ft^2	Buildings ≤ 3 floors	1,2, 14 and 16	<65 kBtu/h	System 3a - SZAC
Library, conditioned floor area < 25,000 ft^2	Buildings ≤ 3 floors	1, 3-15	<65 kBtu/h	System 3b – SZHP
Library, conditioned floor area < 25,000 ft^2	Buildings ≤ 3 floors	2 and 16	<65 kBtu/h	System 3a - SZAC

Source: California Energy Commission

5.1.5 Special Requirements for Additions and Alterations Projects

Compliance projects containing additions or alterations or both require that the user designate each building component (envelope construction assemblies and fenestration, lighting, HVAC, and water heating) as either new, altered, or existing. Many of the building descriptors in 5 Nonresidential Building Descriptors Reference of this manual do not have explicit definitions for the standard design when the project is an addition or alterations project or both. For these terms, the standard design rules for existing, altered components follow the same rule as the standard design rule for newly constructed buildings.

For example, the receptacle loads are prescribed for both the proposed design building and standard design building for a newly constructed buildings compliance project. For additions or alterations to an existing building, since the rules are not explicitly defined in the building descriptor in 5.3.3 Receptacle Loads, the same rules apply to the proposed design and standard design for the additions or alterations compliance project.

Building descriptors that are prescribed for the proposed and standard design models for newly constructed buildings projects are also prescribed for the proposed and standard design models for additions and alterations projects.

For additions and alterations projects, there are three modeling approaches that can be taken when modeling the existing building:

- Model the addition or altered portion alone. For this option, the addition or alteration is modeled as a stand-alone building, and the boundary or interface between the addition or alteration (or both) and the preexisting building is modeled as an adiabatic partition (an adiabatic wall, ceiling, roof, or floor).
- Model the entire existing building and any additions and alterations. For this option, the existing, unaltered components of the building would be modeled "as designed" (as specified by the user), with the standard design components modeled the same as the proposed design.
- Model part of the existing building and any additions and alterations. For this option, all components of the existing, unaltered building (HVAC, lighting, envelope, spaces) would have to be distinguished from the components that are added and altered. The existing building components would be modeled "as designed" (as specified by the user), with the standard design components modeled the same as the proposed design. Added or altered building components would follow the rules for additions and alterations.

When either Option 1 or Option 3 is used, the adiabatic partitions shall not be considered as part of gross exterior wall area or gross exterior roof area for the window/wall ratio (WWR) and skylight/roof ratio (SRR) calculations.

5.2 Project Data

This chapter specifies inputs for project-level information, including the location of the project and information on who is working on who is responsible for different portions of the building project.

5.2.1 General Information

The general information of the project identifies the basic information for where the project will be implemented and identifies a person to be responsible for different portions of the project. In a building project, the location of the project will help inform the climate zone applicable to the project.

The various roles that are identified can be used to coordinate between the design and modeling teams. By identifying a main lead for various parts of the building, questions regarding the design of specific building components can more quickly be answered.

Specifying the building project compliance type is important for developing the building model. The compliance type will inform assumptions made in the standard and proposed design. It is important to correctly identify the compliance type as this can have a major effect on modeling results.

PROJECT NAME

Applicability: All projects.

Definition: Name used for the project if one is applicable.

Units: Alphanumeric characters.

Input Restrictions: Input is optional for the proposed design.

Standard Design: Not applicable.

PROJECT OWNER

Applicability: All projects.

Definition: Owner(s) of the project or individual or organization for whom the building permit is sought should include name, title, organization, email, and phone number.

Units: Alphanumeric characters on each of two lines.

Input Restrictions: Input is optional for the proposed design.

Standard Design: Not applicable.

ENVELOPE DESIGNER

Applicability: All projects.

Definition: Person responsible for the building design; information should include name, title, organization, email, and phone number.

Units: Up to 50 alphanumeric characters on each of two lines.

Input Restrictions: Input is optional for the proposed design.

Standard Design: Not applicable.

Mechanical Designer

Applicability: All projects.

Definition: Person responsible for the mechanical design; information should include name, title, organization, email, and phone number.

Units: Up to 50 alphanumeric characters on each of two lines.

Input Restrictions: Input is optional for the proposed design.

Standard Design: Not applicable.

Lighting Designer

Applicability: All projects.

Definition: Person responsible for the lighting design; information should include name, title, organization, email, and phone number.

Units: Up to 50 alphanumeric characters on each of two lines.

Input Restrictions: Input is optional for the proposed design.

Standard Design: Not applicable.

Documentation Author

Applicability: All projects.

Definition: Person responsible for inputting building information and performing the compliance analysis; information should include name, title, organization, email, and phone number.

Units: Up to 50 alphanumeric characters on each of two lines.

Input Restrictions: Input is optional for the proposed design.

Standard Design: Not applicable.

Date

Applicability: All projects.

Definition: Date of completion of the compliance analysis or the date of its most recent revision.

Units: Date format.

Input Restrictions: Input is optional for the proposed design.

Standard Design: Not applicable.

COMPLIANCE TYPE

Applicability: All projects.

Definition: Type of compliance project (newly constructed buildings, partial compliance or additions and alterations).

Units: List:

- **New Complete:** Newly constructed building project assessing compliance of envelope, lighting, mechanical, domestic hot water systems, and when applicable photovoltaic and battery systems.
- **New Envelope:** Newly constructed building project, assessing compliance of building envelope systems only.
- **New Mechanical:** Newly constructed buildings project, assessing compliance of building mechanical systems only.
- **New Envelope And Lighting:** Newly constructed buildings project, assessing compliance of building envelope and lighting systems.
- **New Envelope And Partial Lighting:** Newly constructed buildings project, assessing compliance of building envelope systems. Compliance of lighting systems for some spaces are also assessed.
- **New Envelope And Mechanical:** Newly constructed buildings project, assessing compliance of building mechanical and envelope systems.
- **New Envelope And Partial Mechanical:** Newly constructed buildings project, assessing compliance of building envelope systems. Compliance of mechanical systems for some spaces are also assessed.
- **New Mechanical And Lighting:** Newly constructed buildings project, assessing compliance of building mechanical and lighting systems.
- **New Mechanical And Partial Lighting:** Newly constructed buildings project, assessing compliance of building mechanical systems. Compliance of lighting systems for some spaces are also assessed.
- **New Lighting And Partial Mechanical:** Newly constructed buildings project, assessing compliance of building lighting systems. Compliance of mechanical systems for some spaces are also assessed.

- **Existing Alteration:** Alteration of existing buildings project assessing compliance of the alteration envelope, lighting, mechanical, and domestic hot water systems.
- **Existing Addition And Alteration:** Alteration of existing buildings and additions to existing buildings project assessing compliance of the addition's and alteration's envelope, lighting, mechanical and domestic hot water systems.
- **Addition Complete:** Additions to an existing building project assessing compliance of the addition's envelope, lighting, mechanical and domestic hot water systems.
- **Addition Envelope:** Additions to an existing building project assessing compliance of the addition's envelope systems.
- **Addition Mechanical:** Additions to an existing building project assessing compliance of the addition's mechanical systems.
- **Addition Envelope And Lighting:** Additions to an existing building project assessing compliance of the addition's envelope and lighting systems.
- **Addition Envelope And Partial Lighting:** Additions to an existing building project assessing compliance of the addition's envelope systems. Compliance of lighting systems for some additions are also assessed.
- **Addition Envelope And Mechanical:** Additions to an existing building project assessing compliance of the addition's envelope and lighting systems.
- **Addition Envelope and Partial Mechanical:** Additions to an existing building project assessing compliance of the addition's envelope systems. Compliance of mechanical systems for some additions spaces are also assessed.
- **Addition Mechanical And Lighting:** Additions to an existing building project assessing compliance of the addition's mechanical and lighting systems.
- **Addition Mechanical And Partial Lighting:** Additions to an existing building project assessing compliance of the addition's mechanical systems. Compliance of lighting systems for some additions spaces are also assessed.

Input Restrictions: As designed.

Standard Design: Same as proposed.

5.2.2 Existing Building Classification

The existing building classification provides general information on the building used for information and reporting purposes. The number of floors in the existing building and area of the building, including any additions, are required inputs.

Existing Building Number of Floors

Applicability: Additions and alterations.

Definition: Total number of floors of the building (For information and reporting purposes only).

Units: Integer

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Building: Same as the proposed design.

EXISTING BUILDING FLOOR AREA

Applicability: Additions and alterations.

Definition: Total floor area of an existing building, including any additions, if present (for information and reporting purposes only).

Units: ft^2.

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Building: Not applicable.

5.2.3 Partial Compliance Model Input Classification

Earlier chapters of this reference manual have described the available partial compliance scenarios for newly constructed buildings or additions/alterations that address one or more but not all of the building systems. The compliance software that supports these scenarios must define the inputs for both the proposed design and the standard design for unpermitted portions of the building. "New" below refers to the particular partial compliance option for newly constructed buildings. "Addition" below refers to the particular partial compliance option for additions and/or alterations.

- New Envelope or Addition Envelope: The user specifies the project envelope systems, all spaces, space types, and thermal zones in the project as designed. The standard design rules are applied to the envelope systems of the standard design model. For all lighting and HVAC inputs, the proposed design values are prescribed and follow the rules for the standard design, including modeling the same HVAC systems determined using the HVAC system map in 5.1.3 HVAC System Map.
- New Mechanical or Addition Mechanical: The user specifies the project mechanical systems, and thermal zones in the project as designed. The standard design rules and system map are applied to the HVAC systems of the standard design model. This compliance option assumes that the building has already been permitted for envelope and lighting. The envelope and lighting systems for both the proposed design and the standard design are modeled as designed.

- New Envelope and Lighting or Addition Envelope and Lighting : The user specifies the project envelope systems, all spaces, space types, thermal zones, all lighting systems, and any daylighting in the project as designed. The standard design rules are applied to the envelope systems and the lighting systems of the standard design model. For all HVAC inputs, the proposed design values are prescribed and follow the rules for the standard design, including modeling the same HVAC systems determined using the HVAC system map in 5.1.3 HVAC System Map.
- New Envelope and Mechanical or Addition Envelope and Mechanical: The user specifies the project envelope, all spaces, space types, thermal zones, and mechanical systems in the project as designed. The standard design rules and system map are applied to the envelope systems and HVAC systems of the standard design model. For all lighting inputs, the proposed design values are prescribed and follow the rules for the standard design model.
- New Envelope and Partial Lighting or Addition Envelope and Partial Lighting: This option is used for projects where the building envelope is defined and where the lighting systems in some of the spaces are defined. The user specifies the project envelope systems, all spaces, space types, thermal zones, and lighting systems for spaces with defined lighting systems and any daylighting in the project as designed. For spaces where the lighting system is not defined, the proposed design and standard design models are set to prescriptive lighting power limits. The standard design rules are applied to the envelope systems and the defined lighting systems of the standard design model. For all HVAC inputs, the proposed design values are prescribed and follow the rules for the standard design, including modeling the same HVAC systems determined using the HVAC system map in 5.1.3 HVAC System Map.
- New Mechanical and Lighting or Addition Mechanical and Lighting: The user specifies the project mechanical systems, all spaces, space types, thermal zones, all lighting systems, and any daylighting in the project as designed. The standard design rules and system map are applied to the lighting systems and HVAC systems of the standard design model. This compliance option assumes that the project has already been permitted for envelope compliance. The envelope systems for both the proposed design and the standard design are modeled as designed.
- New Mechanical and Partial Lighting or Addition Mechanical and Partial Lighting: The user specifies the project mechanical systems, thermal zones, lighting systems for spaces with defined lighting systems and any daylighting in the project as designed. The standard design rules and system map are applied to the defined lighting systems and HVAC systems of the standard design model. This compliance option assumes that the building has already been permitted for Envelope and Partial Lighting. The envelope systems, all spaces, space types, and permitted lighting spaces for both the proposed design and the standard design are modeled as designed.

- New Envelope and Partial Mechanical or Addition Envelope and Partial Mechanical: This option is used for projects where the building envelope id defined and where the mechanical systems in some of the spaces are defined. The user specifies the project envelope systems, all spaces, space types, thermal zones, and mechanical systems for spaces with mechanical systems defined as designed. For spaces where the mechanical system is not defined, the proposed design and standard models follow the rules for the standard design, including modeling the same HVAC systems determined using the HVAC system map in 5.1.3 HVAC System Map. For all lighting inputs, the proposed design values are prescribed and follow the rules for the standard design model. Building descriptors with inputs for both the proposed design and standard design that are restricted to prescribed values (for example, equipment performance curves) follow the same rules for prescribed values for any of the partial compliance projects listed above.

5.2.4 Building Model Classification

The function of the building and building spaces affects a number of energy-related requirements including lighting, PV, battery, and HVAC requirements.

SPACE CLASSIFICATION

Applicability: All projects.

Definition: Appendix 5.4A lists the building classifications that are available under the Area Category method.

Units: List (See Appendix 5.4A).

Input Restrictions As designed.

Standard Design: Existing Building: Same as proposed.

5.2.5 Geographic and Climate Data

The following data needs to be specified or derived in some manner. Compliance software developers may use any acceptable method to determine the data. For California, city, state, and county are required to determine climate data from the available data in Reference Appendices, Joint Appendix JA2.

ZIP CODE

Applicability: All projects.

Definition: California postal designation.

Units: 5-digit number.

Input Restrictions: As designed.

Standard Design: Same as proposed.

LATITUDE

Applicability: All projects.

Definition: The latitude of representative city from Reference Appendices, Joint Appendix JA2.

Units: Degrees (°).

Input Restrictions: Not a user input, prescribed based on zip code.

Standard Design: Same as proposed.

LONGITUDE

Applicability: All projects.

Definition: The longitude of the representative city from Reference Appendices, Joint Appendix JA2.

Units: Degrees (°).

Input Restrictions: Not a user input, prescribed based on zip code.

Standard Design: Same as proposed.

ELEVATION

Applicability: All projects.

Definition: The elevation of the representative city from Reference Appendices, Joint Appendix JA2.

Units: Feet (ft).

Input Restrictions: Not a user input, prescribed based on weather station.

Standard Design: Same as proposed.

CALIFORNIA CLIMATE ZONE

Applicability: All projects.

Definition: One of the 16 California climate zones.

Units: List (see Reference Appendices, Joint Appendix JA2).

Input Restrictions: One of the 16 California climate zones.

Standard Design: Same as proposed.

CITY

Applicability: All projects.

Definition: The city where the project is located.

Units: Alphanumeric string.

Input Restrictions: Representative city from Reference Appendices, Joint Appendix JA2.

Standard Design: Same as proposed.

DESIGN DAY DATA

Applicability: All projects.

Definition: A data structure indicating design day information used for the sizing of the proposed system. This information may not necessarily match the information used in the annual compliance simulation.

Units: Data structure contains the following:

Design DB (0.4%), mean coincident wet-bulb, daily range, day of year.

Input Restrictions: The design day information is taken from one of the predefined California weather files for the location within the same climate zone as the location of the proposed building. (This is not input by the user.)

Standard Design: Not applicable.

WEATHER FILE

Applicability: All projects.

Definition: The hourly (that is, 8,760 hours per year) weather data to be used in performing the building energy simulations. Weather data must include outside dry-bulb temperature, outside wet-bulb temperature, atmospheric pressure, wind speed, wind direction, cloud amount, cloud type (or total horizontal solar and total direct normal solar), clearness number, ground temperature, humidity ratio, density of air, and specific enthalpy.

Units: Data file.

Input Restrictions: The weather file selected shall be in the same climate zone as the proposed design. Weather data must be based on the weather files found in CBECC.

Standard Design: Weather data shall be the same for both the proposed design and standard design.

GROUND REFLECTANCE

Applicability: All projects.

Definition: Ground reflectance affects daylighting calculations and solar gain. The reflectance can be specified as a constant for the entire period of the energy simulation or it may be scheduled, which can account for snow cover in the winter.

Units: Data structure: schedule, fraction.

Input Restrictions: Prescribed. The weather file determines the ground reflectance. The ground reflectance shall be set to 0.2 when the snow depth is 0 or undefined and set to 0.6 when the snow depth is greater than 0.

Standard Design: Same as proposed.

LOCAL TERRAIN

Applicability: All projects.

Definition: An indication of how the local terrain shields the building from the prevailing wind. Estimates of this effect are provided in the ASHRAE Handbook of Fundamentals.

Units: List: the list shall contain only the following choices:

- Flat, open country
  - Exponent (α):0.14
  - Boundary layer thickness, δ (m): 270
- Rough, wooded country, Suburbs
  - Exponent (α): 0.22
  - Boundary layer thickness, δ (m): 370
- Towns and cities
  - Exponent (α): 0.33
  - Boundary layer thickness, δ (m): 460
- Ocean
  - Exponent (α): 0.10
  - Boundary layer thickness, δ (m): 210
- Urban, industrial, forest
  - Exponent (α): 0.22
  - Boundary layer thickness, δ (m): 370

The exponent and boundary layer are used in the following equation to adjust the local wind speed:

$$V_z = V_{met}\left(\frac{\delta_{met}}{Z_{met}}\right)^{\alpha_{met}}\left(\frac{Z}{\delta}\right)^{\alpha}$$

Where:

$\boldsymbol{Z}$ - altitude, height above ground (m)
$\boldsymbol{V_z}$ - wind speed at altitude $\boldsymbol{Z}$ (m/s)
$\boldsymbol{\alpha}$ - wind speed profile exponent at the site
$\boldsymbol{\delta}$ - wind speed profile boundary layer thickness at the site (m)
$\boldsymbol{Z_{met}}$ - height above ground of the wind speed sensor at the meteorological station (m)
$\boldsymbol{V_{met}}$ - wind speed measured at the meteorological station (m/s)
$\boldsymbol{\alpha_{met}}$ - wind speed profile exponent at the meteorological station
$\boldsymbol{\delta_{met}}$ - wind speed profile boundary layer thickness at the meteorological station. (m)

The wind speed profile coefficients — α, δ, α_{met}, and δ_{met} — are variables that depend on the roughness characteristics of the surrounding terrain. Typical values for α and δ are shown in the table above.

Input Restrictions: Not a user input. "Rough, wooded country, Suburbs" is prescribed.

Standard Design: The standard design terrain should be equal to the proposed design.

5.2.6 Site Characteristics

General site characteristics, including building shading and fuel source availability, are provided for the building. Building shading from external sources are not used for compliance calculations.

SHADING OF BUILDING SITE
Applicability: All projects.

Definition: Shading of building fenestration, roofs, or walls by surrounding terrain, vegetation, and the building itself.

Units: Data structure.

Input Restrictions: The default and fixed value are for the site to be unshaded. External shading from other buildings or other objects is not modeled for Title 24 compliance in the ACM. Building self-shading is accounted for using the detailed geometry method.

Standard Design: The proposed design and standard design are modeled with identical assumptions regarding shading of the building site.

SITE FUEL SOURCE
Applicability: All projects.

Definition: The fossil fuel source that is available at the site for water heating, space heating or other fuel purposes.

Units: List.

Input Restrictions: The following choices are available:

- Natural Gas
- Propane

Standard Design: Natural gas, if applicable.

5.2.7 Calendar

The calendar year entered in the compliance software is used to coordinate weather events from the weather files to specific days of the week. The schedule of holidays will also be coordinated to the calendar year.

YEAR FOR ANALYSIS

Applicability: All projects.

Definition: The calendar year to be used for the annual energy simulations. This input determines the correspondence between days of the week and the days on which weather events on the weather tape occur and has no other impact.

Units: List: choose a year (other than a leap year).

Input Restrictions: Use year 2009.

Standard Design: Same calendar year as the proposed design.

SCHEDULE OF HOLIDAYS

Applicability: All projects.

Definition: A list of dates on which holidays are observed and on which holiday schedules are used in the simulations.

Units: Data structure.

Input Restrictions: The following 10 holidays represent the prescribed set. When a holiday falls on a Saturday, the holiday is observed on the Friday preceding the Saturday. If the holiday falls on a Sunday, the holiday is observed on the following Monday.

- New Year's Day — January 1
- Martin Luther King Day — Third Monday in January
- Presidents Day — Third Monday in February
- Memorial Day — Last Monday in May
- Independence Day — July 4
- Labor Day — First Monday in September

- Columbus Day Second Monday in October
- Veterans Day November 11
- Thanksgiving Day Fourth Thursday in November
- Christmas Day December 25

Standard Design: The standard design shall observe the same holidays specified for the proposed design.

5.3 Thermal Zones

A *thermal zone* is a space or collection of spaces having similar space-conditioning requirements, has the same heating and cooling set point, and is the basic thermal unit (or zone) used in modeling the building. A thermal zone will include one or more spaces. Thermal zones may be grouped together, but systems serving combined zones shall be subject to efficiency and control requirements of the combined zones. Nonresidential buildings with identical floors served by like systems may be modeled with floor multipliers.

5.3.1 General Information

The general information is used to identify the various thermal zones included in the building project. This information will include whether the thermal zone is directly conditioned, unconditioned, or plenum, and the floor area of the thermal zone. The HVAC system(s) used to service the specific thermal zone is also identified.

THERMAL ZONE NAME

Applicability: All projects.

Definition: A unique identifier for the thermal zone made up of 50 or fewer alphanumeric characters.

Units: Alphanumeric string.

Input Restrictions: None.

Standard Design: Same as proposed.

THERMAL ZONE DESCRIPTION

Applicability: All projects.

Definition: A brief description of the thermal zone that identifies the spaces which make up the thermal zone or other descriptive information. The description should tie the thermal zone to the building plans.

Units: Alphanumeric string.

Input Restrictions: None.

Standard Design: Same as proposed.

THERMAL ZONE TYPE

Applicability: All projects.

Definition: Designation of the thermal zone as a directly conditioned, unconditioned, or plenum. Plenum zones may be defined as either supply or return air paths for secondary systems.

Units: List: Conditioned, Unconditioned or Plenum.

Input Restrictions: The default thermal zone type is Conditioned.

Standard Design: The Conditioned and Unconditioned zones are identical for the proposed design and standard design. Supply and return plenums are not modeled in the standard design. Plenum zones included in the proposed model are modeled as Unconditioned zones in the standard design.

SYSTEM NAME

Applicability: All projects.

Definition: The name of the HVAC system(s) that serves this thermal zone.

Units: Text, unique.

Input Restrictions: None.

Standard Design: The system(s) serving the zone is defined by 5.1.3 HVAC System Map.

FLOOR AREA

Applicability: All projects.

Definition: The gross floor area of a thermal zone, including walls and minor spaces for mechanical or electrical services such as chases that may or may not be conditioned.

Units: Square feet (ft^2).

Input Restrictions: The floor area of the thermal zone is derived from the floor area of the individual spaces that make up the thermal zone.

Standard Design: Same as proposed design.

5.3.2 Interior Lighting

Inputs for interior lighting are specified at the space level. (See specification below.) In those instances, when thermal zones contain just one space, the inputs here will be identical to the inputs for the single space that is contained within the thermal zone.

For those instances when a thermal zone contains more than one space, the compliance software shall either:

- Model the lighting separate for each space and sum energy consumption and heat gain for each time step of the analysis, or
- Incorporate some procedure to sum inputs or calculate weighted averages such that the lighting power used at the thermal zone level is equal to the combination of lighting power for each of the spaces contained in the thermal zone.

In some cases, combining lighting power at the space level into lighting power for the thermal zone may be challenging and would have to be done at the level of each time step in the simulation. These cases include:

- A thermal zone that contains some spaces that have daylighting and others that do not.
- A thermal zone that contains spaces with different schedules of operation.
- A thermal zone that contains some spaces that have a schedule adjusted in some way for lighting controls and other spaces that do not.
- Combinations of the above.

5.3.3 Receptacle Loads

Inputs for receptacle and process loads are specified at the space level. (See specification below.) In those instances, when thermal zones contain just one space, the inputs here will be identical to the inputs for the single space that is contained within the thermal zone.

For those instances when a thermal zone contains more than one space, the compliance software shall either:

- Model the receptacle and process loads separate for each space and sum energy consumption and heat gain for each time step of the analysis, or
- Incorporate some procedure to sum inputs or calculate weighted averages such that the receptacle and process loads used at the thermal zone level are equal to the combination of receptacle and process loads for each of the spaces contained in the thermal zone.

When the spaces contained in a thermal zone have different schedules, combining receptacle and process loads from the space level may be challenging and would have to be done at the level of each time step in the simulation. See discussion above on lighting.

5.3.4 Occupants

Inputs for occupant loads are specified at the space level. (See specification below.) In those instances, when thermal zones contain just one space, the inputs here will be identical to the inputs for the single space that is contained within the thermal zone.

For those instances when a thermal zone contains more than one space, the compliance software shall either:

- Model the occupant loads separate for each space and the heat gain for each time step of the analysis, or
- Incorporate some procedure to sum inputs or calculate weighted averages such that the occupant loads used at the thermal zone level are equal to the combination of occupant loads for each of the spaces contained in the thermal zone.

When the spaces contained in a thermal zone have different occupant schedules, rolling up occupant loads from the space level may be challenging and would have to be done at the level of each time step in the simulation. Spaces with differences in full-load equivalent operating hours of more than 40 hours per week shall not be combined in a single zone. See discussion above on lighting.

5.3.5 Space Temperature Control

THERMAL ZONE THERMOSTAT SETPOINT TOLERANCE

Applicability: All thermal zones.

Definition: The number of degrees that the room temperature, when occupied, must be above the cooling setpoint, or below the heating setpoint, for the zone load to be considered ‘unmet’.

Units: Degrees Fahrenheit (°F).

Input Restrictions: The prescribed value is +/-1°F.

Standard Design: Same as the proposed design.

THERMOSTAT TEMPERATURE SCHEDULE

Applicability: All thermal zones.

Definition: An hourly schedule of thermostat setpoints.

Units: Data structure: temperature schedule.

Input Restrictions: Prescribed.

The schedule is based on the predominant schedule group for the building floor or zone. See Chapter 2.3.3 space use classification considerations for details. For multifamily buildings, see Chapter 6 Multifamily Building Descriptors Reference.

Standard Design: Schedules in the standard design shall be identical to the proposed design.

5.4 Space Uses

Each thermal zone discussed above may be subdivided into spaces. This chapter presents the building descriptors that relate to the space uses. Space uses and the defaults associated with them are listed in Appendix 5.4A. Every thermal zone shall have at least one space, as defined in this chapter. Daylit spaces should generally be separately defined by space type or orientation or both.

5.4.1 General Information

The general information is used to identify the various spaces included in each thermal zone. This information will include the area of each space as well as how the space will be used. The function of the space will inform certain standard design requirements such as lighting power density for the space.

SPACE FUNCTION TYPE

Applicability: All projects.

Definition: The space function type that defines occupancy, internal load, and other characteristics, as indicated in Appendix 5.4A.

The allowed space function types in area category are available from Appendix 5.4A. The building or space type determines the following standard design inputs:

- Number of occupants (occupant density)
- Equipment power density
- Lighting power density
- Hot water load
- Schedules (from Appendix 5.4B)

Units: List.

Input Restrictions: Only selections shown in Appendix 5.4A may be used. Additional inputs may be utilized to describe special space function cases that are needed to meet special rules. Examples of additional inputs requiring special rules include~~may indicate one of the following special rules~~:

- The space has a process exhaust system subject to Section 140.9(b) or Section 140.9(c).
- A space falls under the requirements of Section 140.9(c) and is a vivarium or has a specific biosafety level.
- The space is part of a 'Healthcare Facility', as defined in Title 24, Part 6.
- The space has fixed seating and ventilation requirements are based on the expected number of occupants.The space is the common area of a hotel/motel building.

Standard Design: Same as proposed design.

Standard Design: Existing Building: Same as proposed design.

VENTILATION SPACE FUNCTION

Applicability: All projects.

Definition: A unique identifier for ventilation requirements. A given function area may have different ventilation functions available, which define the design ventilation rate, minimum ventilation rates for the space if using demand control ventilation (DCV), and any exhaust air requirements.

Units: List (from Reference Manual Appendix 5.4A).

Input Restrictions: As designed (selection from list)

Standard Design: Same as proposed design.

Standard Design: Existing Building: Same as proposed design.

FLOOR AREA

Applicability: All projects.

Definition: The floor area of the space.

The area of the spaces that make up a thermal zone shall sum to the floor area of the thermal zone.

Units: Square feet (ft^2).

Input Restrictions: Area shall be measured to the outside of exterior walls and to the center line of partitions.

Standard Design: Area shall be identical to the proposed design.

Standard Design: Existing Building: Same as proposed design.

5.4.2 Infiltration

Infiltration of outside air into a building and leakage of air from inside of the building will affect the space-conditioning energy use of the building. There are several methods used to identify the air leakage or infiltration rate of the building.

AIR BARRIER

Applicability: All projects.

Definition: Air barrier specification that determines the infiltration rate.

Units: List.

- No air barrier
- Air barrier – not verified
- Air barrier – verified by visual inspection
- Air barrier – verified by air leakage testing
- *Input Restrictions:* As designed.

Standard Design: Not applicable.

INFILTRATION METHOD

Applicability: All projects.

Definition: Energy simulation programs have a variety of methods for modeling uncontrolled air leakage or infiltration. Some procedures use the effective leakage area, which is generally applicable for small, residential-scale buildings. The component leakage method requires the user to specify the average leakage through the building envelope per unit of area (ft^2). Other methods require the specification of a maximum rate, which is modified by a schedule. The airflow per unit of exterior wall area method shall be used.

Units: The infiltration method is prescribed. No input is provided.

Input Restrictions: The airflow per unit of exterior wall area calculation method is prescribed. A fixed infiltration rate shall be specified and calculated as a leakage per unit area of exterior envelope, including the gross area of exterior walls and fenestration but excluding roofs and exposed floors.

Standard Design: The infiltration method used for the standard design shall be the same as the proposed design.

INFILTRATION DATA

Applicability: All projects.

Definition: Information needed to characterize the infiltration rate in buildings.

For the airflow per unit of exterior wall area calculation method, inputs are described below.

Units: Infiltration rate shall be calculated each hour using the following equation:

$$Infiltration\ Rate = I_{design} \cdot F_{schedule} \cdot (A + B \cdot |t_{zone} - t_{odb}| + C \cdot ws + D \cdot ws^2)$$

The infiltration is then found by multiplying the infiltration rate by the area of the exterior walls in the thermal zone.

Where:

$Infiltration\ Rate$ - zone infiltration airflow per unit of wall area (cfm/ft²)

$Infiltration$ - zone infiltration airflow (cfm/ft^2)

I_{design}- zone infiltration airflow rate at reference conditions (cfm/ft²)

$F_{schedule}$- fractional adjustment from a prescribed schedule, consistent with HVAC availability schedules in Appendix 5.4B (unitless)

t_{zone} - zone air temperature (°F)

t_{odb} - outdoor dry bulb temperature (°F)

ws - the wind speed (mile/hr)

A - overall coefficient (unitless)

B - temperature coefficient (1/°F)

C - wind speed coefficient (hr/mile)

D - wind speed squared coefficient (hr²/mile²)

Input Restrictions:

The proposed design shall use the equation listed above, with coefficients A, B, and D set to 0. C shall be set to 0.10016 hr/mile (0.224 s/m). I_{design} shall be:

- 0.3696 cfm/ft^2 for buildings that do not have air barriers,
- 0.2352 cfm/ft^2 for buildings that have air barriers that are not verified,
- 0.1680 cfm/ft^2 for buildings that have air barriers verified by visual inspection
- 0.1344 cfm/ft^2 for buildings that have air barriers verified by whole building air leakage testing as described in Section 140.3(a)9Ci of the Energy Code.

For nonresidential spaces with operable windows that do not have mechanical system interlocks, the compliance software shall automatically increase the infiltration rate by 0.15 cfm/ft^2 whenever the outside air temperature is between 50°F and 90°F and when the HVAC system is operating.

Standard Design: The standard design shall use the equation listed above, with coefficients A, B, and D set to 0. C shall be set to 0.10016 hr/mile (0.224 s/m). I_{design} shall be 0.2352 cfm/ft². For Hotel/Motel Buildings in climate zone 7 and for relocatable public school buildings I_{design} shall be 0.3696 cfm/ft².

INFILTRATION SCHEDULE

Applicability: When an infiltration method is used that requires the specification of a schedule.

Definition: With the ACH method and other methods (see above), it may be necessary to specify a schedule that modifies the infiltration rate for each hour or time step of the simulation. Typically, the schedule is either on or off but can also be fractional.

Units: Data structure: schedule, fractional.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group for the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details. The infiltration schedule shall be set equal to 1 when the HVAC system is scheduled off and 0.25 when the HVAC system is scheduled on. This schedule is based on the assumption that when the HVAC system is on, it brings the pressure of the interior space above the pressure of the exterior, decreasing the infiltration of outside air. When the HVAC system is off, interior pressure drops below exterior pressure, and infiltration increases.

Standard Design:

The infiltration schedule for the standard design shall be scheduled the same as the proposed design.

5.4.3 Occupants

For space level information on occupancy, lighting, and plug load schedules, as well as occupant density and allowed lighting power density.

OCCUPANT DENSITY

Applicability: All projects.

Definition: The design egress occupant density assumed for simulation and minimum ventilation requirements of a space.

The occupancy density also affects hot water use requirements for the space.

Units: people/1,000 ft²

Input Restrictions: This is determined based on the specified space function types defined in Appendix 5.4A and corresponding list of ventilation occupancy categories, as defined in Appendix 5.4C. If the occupant density is not defined in Appendix 5.4C, the occupant density defined in Appendix 5.4A will be used.

Standard Design: Same as proposed.

Standard Design: Existing Buildings: Same as proposed.

OCCUPANCY FRACTION

Applicability: All projects.

Definition: The fraction of the design egress occupant density assumed for simulation and design ventilation requirements.

The occupancy fraction also affects hot water use requirements for the space.

Units: Unitless fraction.

Input Restrictions: For "Retail" space, default of 1 as designed with a minimum value of 1 and a maximum value of 5. For all other spaces, default of 0.5 as designed with a minimum value of 0.5 and a maximum value of 5.

Standard Design: Same as proposed.

Standard Design: Existing Buildings: Same as proposed.

FIXED SEATING IN SPACE

Applicability: All projects that have a space with designed occupancy (such as a theater or auditorium).

Definition: This is a flag that indicates the space has designed occupancy. If checked, this flag allows the user to override the default occupancy with values that comply with the California Building Code.

Units: Boolean.

Input Restrictions: As designed.

May not be used with hotel/motel guest rooms, unoccupied, and unleased tenant area spaces. The default is false.

Standard Design: Same as proposed.

Standard Design: Existing Building: The number of occupants must be identical for both the proposed and standard design cases.

OCCUPANT HEAT RATE

Applicability: All projects.

Definition: The sensible and latent heat produced by each occupant in an hour.

This depends on the activity level of the occupants and other factors. Heat produced by occupants must be removed by the air-conditioning system as well as the outside air ventilation rate and can have a significant effect on energy consumption.

Units: Btu/h specified separately for sensible and latent gains.

Input Restrictions: The occupant heat rate is prescribed by Appendix 5.4A.

Standard Design: The occupant heat rate for the standard design shall be the same as the proposed design.

Standard Design: Existing Building: Same as proposed.

OCCUPANCY SCHEDULE

Applicability: All projects.

Definition: The occupancy schedule modifies the number of occupants to account for expected operational patterns in the building. The schedule adjusts the heat contribution from occupants to the space on an hourly basis to reflect time-dependent usage patterns. The occupancy schedule can also affect other factors such as outside air ventilation, depending on the control mechanisms specified.

Units: Data structure: schedule, fractional.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group for the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

Standard Design: Occupancy schedules are identical for proposed and standard design buildings.

Standard Design: Existing Building: Same as proposed.

5.4.4 Interior Lighting

The building descriptors in this chapter are provided for each lighting system. Typically, a space will have only one lighting system but, in some cases, it could have two or more. Examples include a general and task lighting system in offices or hotel multipurpose rooms that have lighting systems for different functions. It may also be desirable to define different lighting systems for areas that are daylit and those that are not.

LIGHTING CLASSIFICATION METHOD

Applicability: Each space in the building.

Definition: The method that is used to determine the Standard Design lighting power density (LPD).

When lighting compliance is not performed, actual LPDs cannot be entered for the spaces; the LPDs of the building match the standard design.

Units: List.

Input Restrictions: Area Category Method is the only available option.

Standard Design: Same as proposed.

Standard Design: Existing Building: Same as proposed.

REGULATED INTERIOR LIGHTING POWER DENSITY

Applicability: All projects when lighting compliance is performed.

Definition: Total connected lighting power density for all regulated interior lighting power

This includes the loads for lamps and ballasts. The total regulated interior lighting power density is the sum of general lighting power and applicable custom lighting power per unit of floor area in a space. Calculation of lighting power for conditioned spaces is done separately from unconditioned spaces.

Lighting in unconditioned spaces can be modeled, but total lighting power in unconditioned spaces is not enforced in the compliance software. Lighting in unconditioned spaces must follow prescriptive compliance and must be documented on appropriate compliance forms. No tradeoffs are allowed between lighting in conditioned spaces and lighting in unconditioned spaces.

Units: W/ft^2.

Input Restrictions: Proposed value is the sum of the proposed general lighting power and the proposed general lighting exceptional power within a conditioned space or a user input value if no interior lighting systems are modeled.

When lighting compliance is not performed, the lighting power may not be entered and is set equal to the lighting level of the standard design, which is set to the levels for the selected occupancy from Appendix 5.4A.

Standard Design: For spaces without special task lighting, wall display lighting, or similar requirements, this input will be the same as the general lighting power density. See the general lighting power building descriptor for details.

Standard Design: Existing Building: For alterations where fewer than 40 luminaires have been modified the standard design is the existing lighting condition before the alteration. If 40 or more luminaires have been modified, the prescriptive requirements for newly constructed buildings apply.

GENERAL LIGHTING POWER

Applicability: All spaces or projects.

Definition: General lighting power is the power used by installed electric lighting that provides a uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect, and known as ambient lighting.

Units: Watts.

Input Restrictions: As designed.

For spaces without special task lighting, wall display lighting, or similar requirements, this input will be the same as the regulated lighting power.

Trade-offs in general lighting power are allowed between conditioned spaces.

Standard Design: General lighting power is the product of the lighting power densities for the space type from Appendix 5.4A and the floor areas for the corresponding conditioned spaces.

The standard design lighting power is modified by a factor of 1/1.20 (0.833) if the simplified geometry approach is used and if the visible transmittance of any fenestration in the space does not meet the prescriptive requirements established in Section 140.3 of the Energy Code.

Standard Design: Existing Building: When the lighting status is "existing" (and unaltered) for the space, the standard design is the same as the existing, proposed design.

When the lighting status is "altered" for the space, and at least 10 percent of existing luminaires have been altered:

- If the lighting status is "existing," then the standard design LPD is the same as the proposed design.
- If the lighting status is "new," then the standard design LPD is same as newly constructed buildings.
- If the lighting status is "altered," then the standard design LPD is the same as newly constructed buildings.

ADDITIONAL LIGHTING POWER

Applicability: For all building types except multifamily buildings, space types listed in Appendix 5.4A. Some additional lighting power allowances are applicable only to certain space types. See Table 140.6-C of the Energy Code.

Definition: The Energy Code provides an additional lighting power allowance for qualified lighting systems. The additional lighting power allowance for qualified lighting systems is treated separately as "use-it-or-lose-it" lighting — the user receives no credit (standard design matches proposed), but there is a maximum power allowance for each item. The qualified lighting systems and the respective allowed additional lighting power allowance values are listed in the two rightmost columns of Table 140.6-C of the Energy Code.

Units: Data structure. This input has the following data elements — each data element corresponds to the additional lighting allowance of the functional area types listed in Table 140.6-C of the Energy Code.

Input Restrictions: As designed.

Standard Design: The standard design additional lighting power (ALP) is given by the following equation:

$$ALP_{std} = \sum_{i-1}^{13} \min\left(ALP_{prop,i}, ALPA_i \times ALPTQ_i\right)$$

Where:

ALP_{std}
The additional lighting power (ALP) of the standard design

$ALP_{prop,i}$
The proposed ALP of the allowance is in the data structure above. If there is no proposed lighting system in the proposed design serving as the qualified lighting system, the ALPprop,i should be assigned with a zero value (no allowance permitted and given). If there is a proposed lighting system serving as the qualified lighting system, the ALPprop,i should be assigned a value of one(1).

$ALPA_i$
The additional lighting power allowance (ALPA), which is the maximum allowed additional lighting power is indicated in the two rightmost columns in Table 140.6-C of the Energy Code.

$ALPTQ_i$
The additional lighting power task quantity (ALPTQ) for the i^{th} allowance, where the task area corresponds to the functional area with the additional lighting power allowance in Table 140.6-C of the Energy Code.

Standard Design: Existing Building: When the lighting status is "existing" (and unaltered) for the space, the standard design is the same as the existing, proposed design.

When the lighting status is "altered" for the space and at least 10 percent of existing luminaires have been altered:

- If the lighting status is "existing," then the standard design LPD is the same as the proposed design.
- If the lighting status is "new," then the standard design LPD is the same as for newly constructed buildings.
- If the lighting status is "altered," then the standard design LPD is the same as for newly constructed buildings.

Additional Lighting Power Task Quantity

Applicability: Space types listed inTable 140.6-C with qualifying lighting systems that are allocated additional lighting power allowances.

Definition: The area, length, or quantity associated with each of the additional lighting allowances in the *Additional Lighting Power* (ALP) building descriptor.

Units: ft^2, linear ft of white board or chalk board; number of automated teller machine(s) (ATM(s)) or ticket machines, or number of illuminated mirror(s).

Input Restrictions: As designed but cannot exceed the floor area of the space.

Standard Design: Same as proposed.

Standard Design: Existing Building: Same as proposed.

Nonregulated Interior Lighting Power

Applicability: All projects.

Definition: For California, Section 140.6(a)3 of the Energy Code identifies excluded lighting.

Units: ft^2.

Input Restrictions: As designed.

The nonregulated lighting power should be cross-referenced to the type of exception and the construction documents. The default for nonregulated lighting power is zero.

Standard Design: The nonregulated interior lighting in the standard design shall be the same as the proposed design.

Standard Design: Existing Buildings: Same as proposed.

Lighting Schedules

Applicability: All projects.

Definition: Schedule of operation for interior lighting power used to adjust the energy use of lighting systems on an hourly basis to reflect time-dependent patterns of lighting usage.

Units: Data structure: schedule, fractional.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group of the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

Standard Design: The nonregulated interior lighting in the standard design shall be the same as the proposed design.

Standard Design: Existing Building: Same as proposed.

FIXTURE TYPE
Applicability: All interior light fixtures.

Definition: The type of lighting fixture, which is used to determine light heat gain distribution.

Units: List: one of three choices:

- Recessed with lens
- Recessed/downlight
- Not in ceiling

Input Restrictions: As designed.

Standard Design: Recessed/downlight.

Standard Design: Existing Building: Recessed/downlight.

LUMINAIRE TYPE
Applicability: All interior light fixtures.

Definition: The type of lighting luminaire used to determine the light heat gain distribution

The dominant luminaire type determines the daylight dimming characteristics when there is more than one type of luminaire in the space.

Units: List:

- Linear fluorescent
- Compact fluorescent lamp (CFL)
- Incandescent
- Light-emitting diode (LED)
- Metal halide
- Mercury vapor
- High-pressure sodium

Input Restrictions: As designed.

Standard Design: LED.

Standard Design: Existing Building: LED.

LIGHT HEAT GAIN DISTRIBUTION

Applicability: All projects.

Definition: The distribution of the heat generated by the lighting system that is directed to the space, the plenum, the HVAC return air, or to other locations

This input is a function of the luminaire type, fixture type, and location. Luminaires recessed into a return air plenum contribute more heat to the plenum or the return air stream if the plenum is used for return air, while pendant-mounted fixtures hanging in the space contribute more heat to the space. Common luminaire type/space configurations are listed in Table 3, Chapter 18, 2009 *ASHRAE Handbook of Fundamentals*, summarized in Table 5: Light Heat Gain Parameters for Typical Operating Conditions. Typically, the data will be linked to a list of common luminaire configurations so that the user chooses a luminaire type category, and heat gain is automatically distributed to the appropriate locations.

Units: List of luminaire types or data structure consisting of a series of decimal fractions that assign heat gain to various locations.

Input Restrictions: Heat gain distribution is fixed to Table 5: Light Heat Gain Parameters for Typical Operating Conditions values based on the luminaire, fixture, and distribution type.

Where lighting fixtures with different heat venting characteristics are used within a single space, the wattage weighted average heat-to-return-air fraction shall be used.

Standard Design: The standard design shall use the values in Table 5: Light Heat Gain Parameters for Typical Operating Conditions for recessed/downlight LED luminaires.

Standard Design: Existing Building: Same as newly constructed buildings.

Table 5: Light Heat Gain Parameters for Typical Operating Conditions

Based on Table 3, Chapter 18, 2009 ASHRAE Handbook of Fundamentals

Fixture Type	Luminaire Type	Return Type	Space Fraction	Radiative Fraction
Recessed with Lens	Linear Fluorescent	Ducted/Direct	1.00	0.67
Recessed with Lens	Linear Fluorescent	Plenum	0.45	0.67
Recessed/Downlight	Linear Fluorescent	Ducted/Direct	1.00	0.58
Recessed/Downlight	Linear Fluorescent	Plenum	0.69	0.58

Fixture Type	Luminaire Type	Return Type	Space Fraction	Radiative Fraction
Recessed/Downlight	CFL	Ducted/Direct	1.00	0.97
Recessed/Downlight	CFL	Plenum	0.20	0.97
Recessed/Downlight	Incandescent	Ducted/Direct	1.00	0.97
Recessed/Downlight	Incandescent	Plenum	0.75	0.97
Recessed/Downlight	LED	Ducted/Direct	1.00	0.97
Recessed/Downlight	LED	Plenum	0.20	0.97
Recessed/Downlight	Metal Halide	Ducted/Direct	1.00	0.97
Recessed/Downlight	Metal Halide	Plenum	0.75	0.97
Not in Ceiling	Linear Fluorescent	Ducted/Direct	1.00	0.54
Not in Ceiling	Linear Fluorescent	Plenum	1.00	0.54
Not in Ceiling	CFL	Ducted/Direct	1.00	0.54
Not in Ceiling	CFL	Plenum	1.00	0.54
Not in Ceiling	Incandescent	Ducted/Direct	1.00	0.54
Not in Ceiling	Incandescent	Plenum	1.00	0.54
Not in Ceiling	LED	Ducted/Direct	1.00	0.54
Not in Ceiling	LED	Plenum	1.00	0.54
Not in Ceiling	Metal Halide	Ducted/Direct	1.00	0.54
Not in Ceiling	Metal Halide	Plenum	1.00	0.54
Not in Ceiling	Mercury Vapor	Ducted/Direct	1.00	0.54
Not in Ceiling	Mercury Vapor	Plenum	1.00	0.54
Not in Ceiling	High Pressure Sodium	Ducted/Direct	1.00	0.54
Not in Ceiling	High Pressure Sodium	Plenum	1.00	0.54

Source: California Energy Commission

In this table, the *space fraction* is the fraction of the lighting heat gain that goes to the space; the *radiative fraction* is the fraction of the heat gain to the space that is due to radiation, with the remaining heat gain to the space due to convection.

LIGHTING POWER ADJUSTMENT FACTORS (PAF)

Applicability: All projects.

Definition: Automatic controls that are not already required by the Energy Code and which reduce lighting power uniformly over the day can be modeled as *power adjustment factors.* Power adjustment factors represent the percentage reduction in lighting power that will approximate the effect of the control. Models account for such controls by multiplying the controlled watts by (1–PAF).

Eligible California power adjustment factors are defined in Table 140.6-A. Reduction in lighting power using the PAF method can be used only for nonresidential controlled general lights. Only one PAF can be used for a qualifying lighting system unless multiple adjustment factors are allowed in Table 140.6-A of the Energy Code. Controls for which PAFs are eligible are listed in Table 140.6-A of the Energy Code and include:

- Daylight continuous dimming plus off controls — daylight dimming controls that automatically shut off luminaires when natural lighting provides an illuminance level of at least 150 percent of the space requirement.
- Occupant sensing controls in offices larger than 250 square feet.
- Institutional tuning — lighting tuned to not use more than 85 percent of rated power, as specified by Section 140.6 of the Energy Code.
- Demand-responsive controls — demand-responsive lighting control that reduces lighting power consumption in response to a demand-response signal for qualifying building types.
- Clerestory fenestration – luminaires in daylit areas adjacent to the clerestory.
- Horizontal slats — interior or exterior horizontal slats on fenestration adjacent to daylit areas.
- Light shelves — clerestory fenestration with interior or exterior light shelves adjacent to daylit areas.

Note that clerestory fenestration is modeled using power adjustment factors and is not modeled directly by compliance software. Compliance software shall have a means of disregarding daylight through clerestory windows when using the PAF. If handled with a PAF, daylight controls in zones with clerestory windows should be disabled.

Units: List: eligible control types (see above) linked to PAFs

Input Restrictions: PAF shall be fixed for a given control and area type.

Standard Design: PAF is zero.

Standard Design: Existing Building: PAF is zero.

5.4.5 Daylighting Control

This group of building descriptors is applicable for spaces that have daylighting controls or daylighting control requirements.

California prescribes a modified version of the split flux daylighting methods to be used for compliance. This is an *internal daylighting method* because the calculations are automatically performed by the simulation engine. For skylit daylit areas (aka top-lighted areas) or sidelit daylit areas, California compliance prescribes an internal daylighting model consistent with the split flux algorithms used in many simulation programs. With this method the simulation model has the capability to model the daylighting contribution for each hour of the simulation and make an adjustment to the lighting power for each hour, considering factors such as daylighting availability, geometry of the space, daylighting aperture, control type, and the lighting system. The assumption is that the geometry of the space, the reflectance of surfaces, the size and configuration of the daylight apertures, and the light transmission of the glazing are taken from other building descriptors.

For daylight control using a simplified geometry approach, daylight control for both the primary daylit zone and secondary daylit zone (mandatory) must be indicated on the compliance forms. If the simplified geometry approach is used and the visible transmittance of fenestration does not meet prescriptive requirements, the standard design lighting power is reduced by 20 percent to represent increased energy usage for these building features. See 5.4.4 Interior Lighting.

DAYLIGHT CONTROL REQUIREMENTS

Applicability: All spaces with exterior fenestration.

Definition: The extent of daylighting controls in skylit and sidelit areas of the space.

Units: List.

Input Restrictions: For nonresidential spaces, when the installed general lighting power in the skylit, primary sidelit, or secondary sidelit daylit zone is 75W or greater, daylighting controls are required, as specified by the Title 24 mandatory requirements. Controls are not required if total glazing area is less than 24 ft^2 or for luminaires in sidelit daylit zones in retail merchandise sales and wholesale showroom areas.

For parking garages, when the installed general lighting power in the primary sidelit and secondary sidelit daylit zone exceeds 60W, daylighting controls are required, as specified by the Title 24 mandatory requirements. Luminaires located in daylit transition zones or dedicated ramps are not required to meet this requirement. Controls are not required if total glazing and openings are less than 36 ft^2.

Standard Design: The requirements are the same as proposed.

Standard Design: *Existing Buildings*: When lighting systems in an existing altered building are not modified as part of the alteration, daylighting controls are the same as the proposed design.

When an alteration increases the area of a lighted space, increases lighting power in a space, or when luminaires are modified in a space where proposed design lighting power density is greater than 85 percent of the standard design LPD, daylighting control requirements are the same as for newly constructed buildings.

SKYLIT, PRIMARY, AND SECONDARY DAYLIT AREA

Applicability: All daylit spaces.

Definition: The floor area that is daylit.

The skylit area is the portion of the floor area that gets daylighting from a skylight. Two types of sidelit daylit areas are recognized. The primary daylit area is the portion that is closest to the daylighting source and receives the most illumination. The secondary daylit area is an area farther from the daylighting source, which still receives useful daylight.

The primary daylit area for side lighting is a band near the window with a depth equal to the distance from the floor to the top of the window and width equal to window width plus 0.5 times window head height wide on each side of the window opening. The secondary daylit area for side lighting is a band beyond the primary daylit area that extends a distance double the distance from the floor to the top of the window and width equal to window width plus 0.5 times window head height wide on each side of the window opening. Area beyond a permanent obstruction taller than 6 feet should not be included in the primary and secondary daylight area calculation.

The skylit area is a band around the skylight well that has a depth equal to 70 percent of the ceiling height from the edge of the skylight well. The geometry of the skylit daylit area will be the same as the geometry of the skylight. Area beyond a permanent obstruction taller than 50 percent of the height of the skylight from the floor should not be included in the skylit area calculation.

Double counting due to overlaps is not permitted. If there is an overlap between secondary and primary or skylit areas, the effective daylit area used for determining reference position shall be the area minus the overlap.

Units: ft^2.

Input Restrictions: Not a user input. The daylit areas in a space are derived using other modeling inputs like dimensions of the fenestration and ceiling height of the space.

Standard Design: The daylit areas in the standard design are derived from other modeling inputs, including the dimensions of the fenestration and ceiling height of the space. Daylit area calculation in the standard design is done after window to wall ratio and skylight to roof ratio rules in 5.5.7 Fenestration of this manual are applied.

Standard Design: Existing Buildings: Same as newly constructed buildings when skylights are added/replaced and general lighting altered.

INSTALLED GENERAL LIGHTING POWER IN THE SKYLIT DAYLIT ZONE

Applicability: All spaces.

Definition: The installed lighting power of general lighting in the skylit daylit zone.

The skylit daylit zone shall be defined on the plans and be consistent with the definition of the skylit daylit zone in the Energy Code. Note that a separate building descriptor, fraction of controlled lighting, defines the fraction of the lighting power in the space that is controlled by daylighting.

Units: Watts.

Input Restrictions: As designed.

Standard Design: The installed lighting power for the standard design is the product of the skylit daylit area and the LPD for general lighting in the space.

Standard Design: Existing Buildings: Same as newly constructed buildings when skylights are added/replaced and general lights are altered.

INSTALLED GENERAL LIGHTING POWER IN THE PRIMARY DAYLIT ZONE

Applicability: All spaces.

Definition: The installed lighting power of general lighting in the primary daylit zone.

The primary daylit zone shall be defined on the plans and be consistent with the definition of the primary daylit zone in the Energy Code. Note that a separate building descriptor, fraction of controlled lighting, defines the fraction of the lighting power in the space that is controlled by daylighting.

Units: Watts.

Input Restrictions: As designed.

Standard Design: The installed lighting power for the standard design is the product of the primary daylit area and the LPD for general lighting in the space.

Standard Design: Existing Buildings: Same as newly constructed buildings when windows are added/replaced and general lights are altered.

INSTALLED GENERAL LIGHTING POWER IN THE SECONDARY DAYLIT ZONE

Applicability: All spaces.

Definition: The installed lighting power of general lighting in the secondary daylit zone.

The secondary daylit zone shall be defined on the plans and be consistent with the definition of the secondary daylit zone in the Energy Code. Note that a separate building descriptor, fraction of controlled lighting, defines the fraction of the lighting power in the space that is controlled by daylighting.

Units: Watts.

Input Restrictions: As designed.

Standard Design: The installed lighting power for the standard design is the product of the secondary daylit area and the LPD for general lighting in the space.

Standard Design: Existing Buildings: Same as newly constructed buildings when windows are added/replaced and general lights are altered.

REFERENCE POSITION FOR ILLUMINANCE CALCULATIONS

Applicability: All spaces or thermal zones, depending on which object is the primary container for daylighting controls.

Definition: The position of the two daylight reference points within the daylit space.

Lighting controls are simulated so that the illuminance at the reference position is always maintained at or above the illuminance setpoint. For step switching controls, the combined daylight illuminance plus uncontrolled electric light illuminance at the reference position must be greater than the setpoint illuminance before the controlled lighting can be dimmed or tuned off for stepped controls. Similarly, dimming controls will be dimmed so that the combination of the daylight illuminance plus the controlled lighting illuminance is equal to the setpoint illuminance.

Preliminary reference points for primary and secondary daylit areas are located at the farthest end of the daylit area aligned with the center of each window. For skylit area, the preliminary reference point is located at the center of the edge of the skylit area closest to the centroid of the space. In each case, the Z – coordinate of the reference position (elevation) shall be located 2.5 feet above the floor.

Up to two final reference positions can be selected from among the preliminary reference positions identified in for each space.

Units: Data structure.

Input Restrictions: The user does not specify the reference position locations; reference positions are automatically calculated by the compliance software based on the procedure outlined below. Preliminary reference positions are each assigned a relative daylight potential (RDP) which estimates the available illuminance at each position, and the final reference position selection is made based on the RDP.

Relative Daylight Potential: An estimate of daylight potential at a specific reference position. This is NOT used directly in the energy simulation, but it used to determine precedence for selecting the final reference points. The relative daylight potential is calculated as a function of effective aperture, azimuth, illuminance setpoint and the type (skylit, primary sidelit, or secondary sidelit) of the associated daylit zone. RDP is defined as:

$$RDP = C_1 \times EA_{dz} + C_2 \times SO + C_3$$

Where: C_1,C_2, and C_3 are selected from the following table.

Table 6: Illuminance Calculation

Illuminance Setpoint	Skylit Daylit Zone C1	Skylit Daylit Zone C2	Skylit Daylit Zone C3	Primary Sidelit Daylit Zone C1	Primary Sidelit Daylit Zone C2	Primary Sidelit Daylit Zone C3	Secondary Sidelit Daylit Zone C1	Secondary Sidelit Daylit Zone C2	Secondary Sidelit Daylit Zone C3
< 200 lux	3927	0	3051	1805	-0.40	3506	7404	-3.32	1167
> 200 lux < 1000 lux	12046	0	-421	6897	-7.22	475	1512	-2.88	-22
> 1000 lux	5900	0	-516	884	-5.88	823	212	-0.93	57

Source: California Energy Commission

Illuminance Setpoint: This is defined by the user, subject to the limits specified in Appendix 5.4A, determined from the space type.

Source Orientation (SO): The angle of the outward facing normal of the daylight source's parent surface projected onto a horizontal plane, expressed as degrees from south. This is not a user input but is calculated from the geometry of the parent surface. For skylights, the source orientation is not applicable. For vertical fenestration, it is defined:

$$SO = |(180 - Azimuth)|$$

Where: Azimuth is defined as the azimuth of the parent object containing the fenestration associated with the preliminary reference point.

Effective Aperture (EA): For this calculation, effective aperture represents the effectiveness of all sources which illuminate a specific reference position in contributing to the daylight available to the associated daylit zone. In cases where daylit zones from multiple fenestration objects intersect, the effective aperture of an individual daylit zone is adjusted to account for those intersections according to the following rules:

- For skylit and primary sidelit daylit zones, intersections with other skylit or primary sidelit daylit zones are considered.
- For secondary sidelit daylit zones, intersections with any toplit or sidelit (primary or secondary) daylit zones are considered.

Effective aperture is defined as follows:

$$EA_{dz} = \left(VT_{fdz} \times A_{fdz} + \sum F_i \times VT_i \times A_i\right)/A_{dz}$$

Where:

$\boldsymbol{EA_{dz}}$ - Is the combined effective aperture of all daylight sources illuminating a specific daylit zone.
$\boldsymbol{VT_{fdz}}$ - Is the user specified visible transmittance of the fenestration object directly associated with the daylit zone.
$\boldsymbol{A_{fdz}}$ - Is the area of the fenestration object directly associated with the daylit zone.
$\boldsymbol{VT_i}$ - Is the user specified visible transmittance of the fenestration object associated with each intersecting daylit zone.
$\boldsymbol{A_i}$ - Is the area of the fenestration object directly associated with each intersecting daylit zone.
$\boldsymbol{F_i}$ - Is the fraction of intersecting area between the daylit zone in question and each intersecting daylit zone:
$\boldsymbol{F_i = A_{intersection}/A_{dzi}}$
$\boldsymbol{A_{dzi}}$ - Is the area of each intersecting daylit zone (including area that might fall outside a space or exterior boundary).
$\boldsymbol{A_{dz}}$ - Is the area of the daylit zone (including area that might fall outside a space or exterior boundary).

First Reference Position: Select the preliminary reference point with the highest relative daylight potential (RDP) from among all preliminary reference points located within either top or primary sidelit daylit zones. If multiple reference points have identical RDPs, select the reference point geometrically closest to the centroid of the space.

Second Reference Position: Select the preliminary reference point with the second highest RDP from amongst all remaining preliminary reference points located within either top or primary sidelit daylit zones. If multiple reference points have identical RDPs, select the reference point geometrically closest to the centroid of the space.

Standard Design: Reference positions for the standard design shall be selected using the same procedure as those selected for the proposed design.

Standard Design: Existing Buildings: When additions or alternations to the lighting in spaces trigger the daylighting control requirements, the reference positions shall be determined in the same manner as with newly constructed buildings.

ILLUMINATION ADJUSTMENT FACTOR

Applicability: All Daylit Spaces.

Definition: Recent studies have shown that the split flux interreflection component model used in many simulation programs overestimates the energy savings due to daylighting, particularly deep in the space. A set of two adjustment factors is provided, one for the primary daylit zone and one for the secondary daylit zone.

For simulation purposes, the input daylight illuminance setpoint will be modified by the illuminance adjustment factor as follows:

$$LightSetpoint_{adj} = LightSetpoint \times Adjustment\ Factor$$

Units: Unitless

Input Restrictions: Prescribed values for space type in Appendix 5.4A.

Standard Design: The standard design illumination adjustment factors shall match the proposed.

Standard Design: *Existing Buildings*: Same as newly constructed buildings when fenestration is added/replaced and general light is altered.

FRACTION OF CONTROLLED LIGHTING

Applicability: Daylit Spaces.

Definition: The fraction of the general lighting power in the primary and skylit daylit zone, or secondary sidelit daylit zone that is controlled by daylighting controls.

Units: Numeric fraction

Input Restrictions: As designed when the daylight control requirements building descriptor indicates that mandatory daylighting controls are not required. If daylighting controls are required, input is restricted to 1.

Standard Design: When daylight controls are required according to the daylight control requirements building descriptor in either the primary daylit and skylit zone, or the secondary daylit zone, or both, the fraction of controlled lighting shall be 1. When the daylight control requirements building descriptor indicates that they are not required, the standard design shall match the proposed design.

Standard Design: Existing Buildings: Same as for newly constructed buildings when fenestration is added/replaced, and general light is altered.

DAYLIGHTING CONTROL TYPE

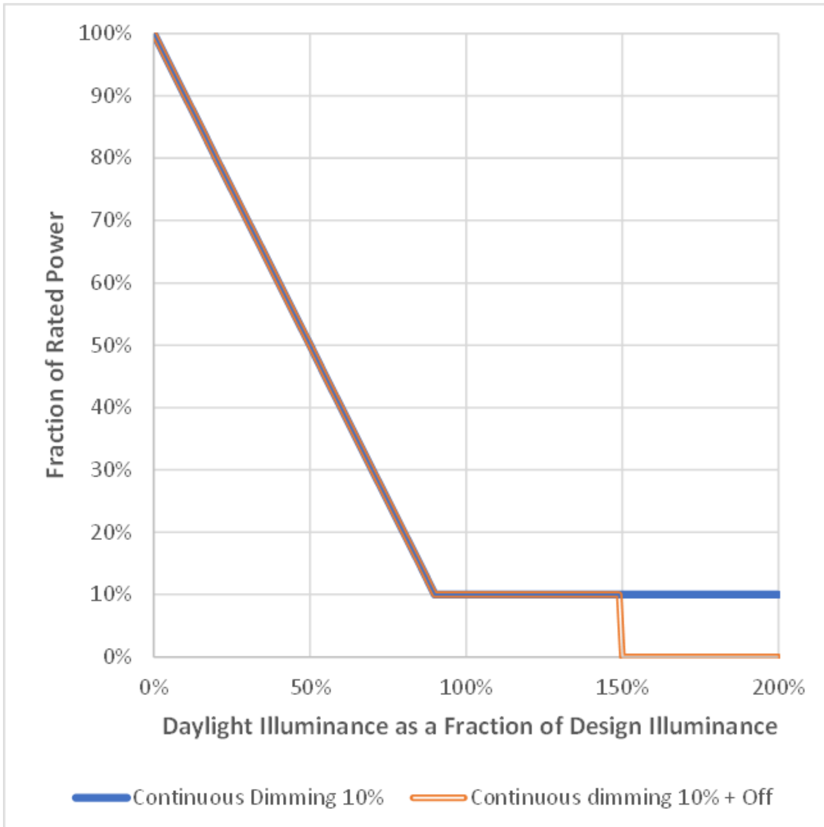
Applicability: Daylit Spaces.

Definition: The type of control that is used to control the electric lighting in response to daylight available at the reference point.

Options:

- Stepped switching controls: The electric power input and light output vary in discrete, equally spaced steps.
- Continuous dimming controls: The fraction to rated power to fraction of rated output that is a linear interpolation of the minimum power fraction at the minimum dimming light fraction to rated power at full light output. See Figure 4: Example of Lighting Power Fraction Continuous Dimming and Continuous Dimming Plus OFF Daylighting Controls (with Minimum Dimming Fraction of 10 Percent).
- Continuous dimming + off controls: Same as continuous dimming controls except that these controls can turn all the way off when none of the controlled light output is needed. The OFF stage is implemented at a daylight illuminance of 150% or higher than design illuminance.

Figure 4: Example of Lighting Power Fraction Continuous Dimming and Continuous Dimming Plus OFF Daylighting Controls (With Minimum Dimming Fraction of 10 Percent)



Source: California Energy Commission

Units: List (see above).

Input Restrictions: Daylighting control type must be specified when fraction of controlled lighting is greater than zero. For parking garage with daylighting control, the users must use continuous dimming plus off control or stepped switching control to meet the mandatory requirement.

Standard Design: Parking garage in standard design uses continuous plus off daylighting control. All other spaces in standard design use continuous daylighting control.

Standard Design: Existing Buildings: Same as for newly constructed buildings when fenestration is added/replaced, and general lighting is altered.

MINIMUM DIMMING POWER FRACTION

Applicability: Daylit spaces.

Definition: The minimum power fraction when controlled lighting is fully dimmed. Minimum power fraction = minimum power / full rated power.

Units: Numeric: fraction.

Input Restrictions: In proposed design if continuous daylighting control is used, the dimming fraction must be 0.1 or lower. No restriction if other control types are used.

Standard Design: Standard design uses a minimum dimming power fraction of 0.1.

Standard Design: Existing Buildings: Same as for newly constructed buildings when fenestration is added/replaced, and general lighting is altered.

MINIMUM DIMMING LIGHT FRACTION

Applicability: Daylighting and dimming controls.

Definition: The minimum light output when controlled lighting is fully dimmed. Minimum light fraction = minimum light output / rated light output.

Units: Numeric: fraction.

Input Restrictions: No restrictions.

Standard Design: Standard design uses a minimum dimming light fraction of 0.1.

Standard Design: Existing Buildings: Same as for newly constructed buildings when fenestration is added/replaced, and general lighting is altered.

5.4.6 Receptacle Loads

Receptacle loads contribute to heat gains in spaces and directly use energy.

RECEPTACLE POWER

Applicability: All building projects.

Definition: Receptacle power is power for typical general service loads in the building. Receptacle power includes equipment loads normally served through electrical receptacles, such as office equipment and printers, but does not include either task lighting or equipment used for HVAC purposes. Receptacle power values are slightly higher than the largest hourly receptacle load that is actually modeled because the receptacle power values are modified by the receptacle schedule, which approaches but does not exceed 1.0.

Units: Total power (W) or the space power density (W/ft^2)

Compliance software shall also use the following prescribed values to specify the latent, radiative, and convective heat gain split. If the sum of these values is less than 1, the balance is assumed to be lost from the space.

Heat Gain Fractions:

Receptacle Power

- Radiative: 0.20
- Latent: 0.00
- Convective: 0.80

Gas Equipment Power

- Radiative: 0.15
- Latent: 0.00
- Convective: 0.00

Input Restrictions: Prescribed to values from Appendix 5.4A for nonresidential buildings.

Spaces with an information technology equipment (ITE) equipment power density that is greater than 20 W/ft^2 are considered computer rooms.

Standard Design: Same as proposed.

Standard Design: Existing Buildings: Same as for newly constructed buildings.

RECEPTACLE SCHEDULE

Applicability: All projects.

Definition: Schedule for receptacle power loads used to adjust the intensity on an hourly basis to reflect time-dependent patterns of usage.

Units: Data structure: schedule, fraction.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group of the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

Standard Design: Same as proposed.

Standard Design: Existing Buildings: Same as for newly constructed buildings.

UPS EFFICIENCY

Applicability: Computer rooms and data centers with computer rooms.

Definition: The efficiency of the Uninterruptible Power Supply (UPS) systems in a computer room. This only applies to computer room process loads with an ITE equipment power density greater than 20 W/ft^2.

Units: Percentage, 0 to 100%.

Input Restrictions: For healthcare facilities, same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group of the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

Standard Design: The UPS Efficiency shall match the requirements in Table 140.9-B.

Standard Design: Existing Buildings: Same as for newly constructed buildings.

5.4.7 Commercial Refrigeration Equipment

Commercial refrigeration equipment includes the following:

- Walk-in refrigerators
- Walk-in freezers
- Refrigerated casework

Refrigeration equipment is modeled as neutral plug loads, with the standard design power matching the proposed design and no heat added to or removed from the space where the equipment is located.

Refrigeration Modeling Method

Applicability: All buildings that have commercial refrigeration for cold storage or display

Definition: The method used to estimate refrigeration energy and to model the thermal interaction with the space where casework is located.

Title 24 defaults. With this method, the power density values provided in Appendix 5.4A are used; schedules are assumed to be continuous operation.

Units: List (see above).

Input Restrictions: The Title 24 defaults shall be used.

Standard Design: Title 24 defaults.

Standard Design: Existing Buildings: Same as for newly constructed buildings.

Refrigeration Power

Applicability: All buildings that have commercial refrigeration for cold storage or display.

Definition: Commercial refrigeration power is the average power for all commercial refrigeration equipment, assuming constant year-round operation. Equipment includes walk-in refrigerators and freezers, open refrigerated casework, and closed refrigerated casework. It does not include residential type refrigerators used in kitchenettes or refrigerated vending machines. These are covered under receptacle power.

Units: Total power (W) or the space power density (W/ft²). The latent, radiative, and convective heat gain fractions are modeled as 0, resulting in no heat added to or removed from the space where the equipment is located.

Input Restrictions: With the Title 24 defaults method, the values in Appendix 5.4A are prescribed. These values are multiplied times the floor area of the rated building to estimate the refrigeration power.

Standard Design: Refrigeration power is the same as the proposed design when the Title 24 default method is used.

Standard Design: Existing Buildings: Same as for newly constructed buildings.

5.4.8 Elevators, Escalators and Moving Walkways

Elevators, escalators and moving walkways account for 3 percent to 5 percent of electric energy use in buildings.[1] Buildings up to about five to seven floors typically use hydraulic elevators because of their lower initial cost. Mid-rise buildings commonly use traction elevators with geared motors, while multifamily buildings typically use gearless systems where the motor directly drives the sheave. The energy-using components include the motors and controls as well as the lighting and ventilation systems for the cabs.

Elevators, escalators, and moving walkways are modeled as a plug loads, with the standard design power matching the proposed design.

ELEVATOR & ESCALATOR POWER

Applicability: All buildings that have commercial elevators, escalators, or moving walkways.

Definition: The power for elevators, escalators and moving walkways are modeled as plug loads.

Units: Number of units.

Input Restrictions: The power values are prescribed as 10 kW per elevator and 3.93 kW per escalator or moving walkway for the proposed design.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

ELEVATOR & ESCALATOR SCHEDULE

Applicability: All buildings that have commercial elevators, escalators, or moving walkways.

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1 Sachs, Harvey M. *Opportunities for Elevator Energy Efficiency Improvements.* American Council for an Energy Efficiency Economy, April 2005.

Definition: The schedule of operation for elevators, escalators, and moving walkways. This is used to convert elevator/escalator power to energy use.

Units: Data structure: schedule, state.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group of the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

5.4.9 Process Loads

Commercial gas and electric equipment includes the following:

- Commercial kitchen or laboratory ovens
- Commercial kitchen fryers and grills
- Other equipment

The majority of commercial equipment is located in the space and may contribute both sensible and latent heat. Gas equipment is modeled by specifying the rate of average gas consumption or a fractional schedule that is prescribed in Appendix 5.4B which represents full load hours. The procedure consists of prescribed power and energy values for use with both the proposed and standard design buildings. No credit for commercial gas energy efficiency features is offered. For all electric buildings, the electric equipment power is the same as the gas equipment power but is modeled as electric load, see "Gas Equipment Schedule" for more details.

The prescribed average load values are provided in Appendix 5.4A. The full load schedules in Appendix 5.4B are used as the default.

GAS EQUIPMENT POWER

Applicability: All spaces with commercial gas equipment.

Definition: Commercial gas power is the annual average power for all commercial gas equipment, such as gas-powered commercial cooking equipment, assuming constant year-round operation.

Units: Btu/h-ft^2.

Compliance software shall also use the following prescribed values to specify the latent heat gain fraction and the radiative/convective heat gain split.

For compliance software that specifies the fraction of the heat gain that is lost from the space, this fraction shall be prescribed at 0.

Gas Equipment Power Heat Gain Fractions:

Radiative = 0.15, Latent = 0, Convective = 0

Input Restrictions: The values in Appendix 5.4A are prescribed. However, these values may be overridden with a "0" value for buildings that are designed to use only electricity as the source.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Same as the proposed design.

GAS EQUIPMENT SCHEDULE

Applicability: All spaces with commercial gas equipment.

Definition: The schedule of operation for commercial gas equipment. This is used to convert gas power to energy use. Since the gas equipment power is an annual average value the hourly energy use is calculated as follows.

$$GasEnergyUse_i = Power_{avg} \times \frac{8760}{FLH_{sch}} \times Schedule(i)$$

Where

$GasEnergyUse_i$ is the gas energy use per square foot of the building space at the i^{th} hour of the year

$Power_{avg}$ is the annual average gas equipment power in Btu/hr-ft^2

FLH_{sch} is the full load hour of the schedule in a year, and

$Schedule(i)$ is the schedule value at the i^{th} hour.

Units: Data structure: schedule, fractional.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group of the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

GAS PROCESS LOADS

Applicability Spaces with gas process loads.

Definition: Process load is the gas energy consumption in the conditioned space of a building resulting from an activity or treatment not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy. Process load may include sensible and/or latent components.

Compliance software shall model and simulate process loads only if the amount of the process energy and the location and type of process equipment are specified in the construction documents. This information shall correspond to specific special equipment shown on the building plans and detailed in the specifications.

Units: Data structure: Peak load (Btu/h-ft^2), radiant fraction, latent fraction, and loss fraction.

Input Restrictions: Compliance software shall receive input for total load, radiant fraction, latent fraction, and loss fraction for each zone in the proposed design. The radiant, latent, and loss fraction are defaulted to zero. The process load input shall be the peak of the process load (Btu/h-ft2) and the thermal zone where the process equipment is located. The modeled information shall be consistent with the plans and specifications of the building.

Standard Design: The standard design shall use the same gas process loads and sensible and latent contribution and radiative/convective split for each zone as the proposed design.

Standard Design: Existing Buildings: Same as newly constructed buildings.

GAS PROCESS LOAD SCHEDULE

Applicability: All buildings that have commercial gas equipment.

Definition: The schedule of process load operation. Used to convert gas power to energy use.

Units: Data structure: schedule, fractional.

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

ELECTRIC EQUIPMENT POWER

Applicability: All spaces with commercial electric equipment.

Definition: The average power for all commercial electric equipment, such as electric commercial cooking appliances, assuming constant year-round operation.

Units: W/ft^2.

Compliance software shall also use the following prescribed values to specify the latent heat gain fraction and the radiative/convective heat gain split.

For compliance software that specifies the fraction of the heat gain that is lost from the space, this fraction shall be prescribed at 0.

Electric Equipment Power Heat Gain Fractions:

Radiative = 0.15, Latent = 0, Convective = 0

Input Restrictions: The value is prescribed and derived from the gas equipment power value defined in Appendix 5.4A, converted to W/ft2. The electric equipment value will be “0” for buildings that have fossil fuel gas as an available source.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Same as the proposed design.

ELECTRIC EQUIPMENT SCHEDULE

Applicability: All buildings that have commercial electric equipment.

Definition: The schedule of operation for commercial electric equipment. This is used to convert the gas equipment power defined in Appendix 5.4A to hourly energy consumption. Since the gas equipment power is an annual average value the hourly energy use is calculated as follows.

$$ElecEquipUse_i = Power_{avg} \times \frac{8760}{FLH_{sch}} \times Schedule(i)$$

Where:

$ElecEquipUse_i$ is the electric energy use per square foot of the building space at the i^{th} hour of the year

$Power_{avg}$ is the annual average electric equipment power in W/ft^2

FLH_{sch} is the full load hour of the schedule in a year, and

$Schedule(i)$ is the schedule value at the i^{th} hour.

Units: Data structure: schedule, fractional.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group of the building floor or thermal zone. See 2.3.3 Space-Use Classification Considerations for details.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

ELECTRIC PROCESS LOADS

Applicability: Spaces with electric process loads.

Definition: Process load is the electrical energy consumption in the conditioned space of a building resulting from an activity or treatment not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

Data center loads including transformers, uninterruptible power supplies, power delivery units, server fans and power supplies are considered receptacle loads, not process loads, and the equipment schedules are given in Appendix 5.4B.

Compliance software shall model and simulate process loads only if the amount of the process energy and the location and type of process equipment are specified in the construction documents. This information shall correspond to specific special equipment shown on the building plans and detailed in the specifications. The compliance software shall inform the user that the compliance software will output process loads including the types of process equipment and locations on the compliance forms.

Units: Data structure: load (kW).

For electric process loads, the radiative, latent, and loss fractions shall be defaulted by the compliance software to 0.0 resulting in a convective fraction of 1.0. The user may enter other values for the radiative/convective split, but the compliance software shall verify that the values add to 1.

Input Restrictions: Compliance software shall receive input for sensible and/or latent process load for each thermal zone in the proposed design. The process load input shall be the peak of the process load (W/h-ft^2) and the thermal zone where the process equipment is located. The modeled information shall be consistent with the plans and specifications of the building.

Standard Design: The standard design shall use the same process loads and radiative/convective split for each zone as the proposed design.

Standard Design: Existing Buildings: Same as newly constructed buildings.

ELECTRIC PROCESS LOAD SCHEDULE

Applicability: Spaces with electric process loads.

Definition: The schedule of electric process load operation.

Units: Data structure: schedule, fractional.

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

5.4.10 Water Heating Use

This chapter defines the water heating load (use rate) and system requirements on a space level.

SPACE WATER HEATING USE RATE

Applicability: All spaces.

Definition: The water heating use rate for a space in a building.

Units: Gal/h per person.

Input Restrictions: The values in Appendix 5.4A are prescribed.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

SPACE WATER HEATING FUEL TYPE

Applicability: All spaces.

Definition: A mapping that defines the standard design water heating fuel type for a space.

Units: List; gas or electric.

Input Restrictions: As designed.

Standard Design: Prescribed from the table in Appendix 5.4A.

Standard Design: Existing Buildings: Not applicable.

5.5 Building Envelope Data

5.5.1 Materials

Energy simulation programs commonly define construction assemblies by listing a sequence of material layers that make up the construction assembly. Appendix 5.5 has a list of standard materials that may be referenced by construction assemblies. Alternate methods may be used to define construction assemblies such as specifying the U-factor and optionally, a metric describing thermal mass such as heat capacity (HC). These alternate methods may not require identification of materials. When a material is defined, all of the properties listed below must be defined. Some materials listed in Appendix 5.5 are non-homogeneous, for instance, framing members with insulation in the cavity. The properties of each material layer can be found in ACM Appendix 5.5.

MATERIAL NAME

Applicability: Opaque constructions.

Definition: The name of a construction material used.

Units: Text: unique.

Input Restrictions: Material name is a required input for materials not available from the standard list in ACM Appendix 5.5. The user may not modify entries for predefined materials.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

DENSITY

Applicability: Opaque constructions.

Definition: The density, mass per unit volume, of the construction material as documented in Appendix 5.5A.

Units: lb/ft^3.

Input Restrictions: Prescribed from Appendix 5.5.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

SPECIFIC HEAT

Applicability: Opaque constructions.

Definition: The specific heat capacity of a material is numerically equal to the quantity of heat that must be supplied to a unit mass of the material to increase its temperature by 1°F.

Units: Btu/lb·°F.

Input Restrictions: Prescribed from Appendix 5.5.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

THERMAL CONDUCTIVITY

Applicability: All non-standard materials.

Definition: The thermal conductivity of a material of unit thickness is numerically equal to the quantity of heat that will flow through a unit area of the material when the temperature difference through the material is 1°F.

Units: Btu/lb·°F.

Input Restrictions: Prescribed from Appendix 5.5.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

THICKNESS

Applicability: All non-standard materials.

Definition: The thickness of a material.

Units: Inches.

Input Restrictions: Prescribed from Appendix 5.5.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

5.5.2 Construction Assemblies

For California compliance, construction assemblies for the proposed design shall be created by selecting from a library of building construction layers in ACM Appendix 5.5. The compliance software shall specify composite layers that consist of both framing and insulation. It shall use established methods defined in the ASHRAE Handbook of Fundamentals for calculating effective R-values of composite layers.

MASS WALLS

For mass walls, the user first chooses the mass layer from Appendix 5.5. After that, the user may select an insulating layer from Appendix 5.5 for outside and/or inside the mass wall.

BALLASTED ROOFS, VEGETATED ROOFS, CONCRETE PAVERS, AND OTHER MASS ROOFS

An additional layer may be added to the roof construction assembly when thermal mass is used above the roof membrane. This exception is intended to allow ballasted roofs, concrete pavers, and other massive elements to be explicitly modeled. To qualify, the weight of the stone ballast, the concrete pavers or other elements must exceed 25 lb/ft². The thickness, heat capacity, conductance and density of the additional mass layer shall be based on the measured physical properties of the material. If the surface properties of the additional mass material have been verified through the Cool Roof Rating Council (CRRC), the CRRC reported properties may be used for the proposed design. Otherwise, the mass layer shall be modeled with an aged reflectance of 0.10 and an emittance of 0.75.

ASSEMBLY NAME

Applicability: All projects.

Definition: The name of a construction assembly that describes a roof, wall, or floor assembly. The name generally needs to be unique so it can be referenced precisely by surfaces.

Units: Text.

Input Restrictions: Required input and name must be unique.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

SPECIFICATION METHOD

Applicability: All projects.

Definition: The method of describing a construction assembly. The common method is to describe the construction assembly as a series of layers, each layer representing a material. For slab-on-grade constructions, exterior insulation levels are specified, and the compliance software determines the corresponding F-factor from Reference Appendix JA4 tables.

Units: List: layers, F-factor.

Input Restrictions: The layers method shall be used for all above-grade constructions.

Standard Design: For each construction, the proposed design specification method shall be used.

Standard Design: Existing Buildings: Same as newly constructed buildings.

LAYERS

Applicability: All construction assemblies that use the layers method of specification

Definition: A structured list of material names that describe a construction assembly, beginning with the exterior finish and progressing through the assembly to the interior finish. Material names must be from the standard list (Appendix E) or defined (see above) ACM Appendix 5.5A.

Units: List: layers of construction assembly

Input Restrictions: The user is required to describe all layers in the actual assembly and model the proposed design based the layer descriptions.

Standard Design: See building descriptors for roofs, exterior walls, exterior floors, doors, fenestration, and below-grade walls.

Standard Design: Existing Buildings: Same as newly constructed buildings

5.5.3 Roofs

ROOF NAME

Applicability: All roof surfaces.

Definition: A unique name or code that identifies the roof and ties it to the construction documents submitted for energy code review. It is not mandatory to name roofs.

Units: Text.

Input Restrictions: Name must be unique.

Standard Design: N/A.

Standard Design: Existing Buildings: N/A.

ROOF TYPE

Applicability: All roof surfaces.

Definition: A roof classification defined in the Energy Code. This descriptor can be derived from other building descriptors, and it may not be necessary for the compliance software user to specify it directly.

Units: List: metal building roofs, wood framed or other; residential or non-residential; steep or low-slope roof.

Input Restrictions: As designed for existing buildings.

Standard Design: All roofs in the standard design are modeled as wood-framed and other.

Standard Design: Existing Buildings: Same as proposed.

ROOF GEOMETRY

Applicability: All roofs.

Definition: Roof geometry defines the position, orientation, azimuth, tilt, and dimensions of the roof surface. The details of how the coordinate system is implemented may vary between compliance software programs. The data structure for surfaces is described in the reference section of this chapter.

Units: Data structure: surface.

Input Restrictions: There are no restrictions other than that the surfaces defined must agree with the building being modeled, as represented on the construction drawings or as-built drawings.

Standard Design: Roof geometry is identical in the proposed and standard design building designs.

Standard Design: Existing Buildings: Roof geometry will be identical in the proposed and standard design building designs. For alterations, roof geometry will be fixed based on one of the building prototypes.

ROOF SOLAR REFLECTANCE

Applicability: All opaque exterior roof surfaces exposed to ambient conditions.

Definition: The solar reflectance of a material. For roofing materials, the three-year aged reflectance value from CRRC testing should be used if available.

Units: Unitless.

Input Restrictions: Must be in the range of 0 to 1.

For roofs that are part of newly constructed buildings, if asphalt shingles or composition shingles are not rated by the CRRC, the default aged solar reflectance shall be equal to 0.08 for asphalt roofs and 0.10 for all other roof types. The default value may be overridden when roof materials are used that the CRRC has tested and are called for in the construction documents. In cases where the default value is overridden, the user is required to submit documentation identifying the test procedure that was used to establish the non-default values. If the aged CRRC reflectance is not known, the aged CRRC reflectance may be calculated from the initial CRRC reflectance using the following equation:

ρaged = 0.2 + β · (ρinit – 0.2)ρ_{aged}

Where,

$\boldsymbol{\rho_{aged}}$ - the calculated aged reflectance

β - 0.65 for field-applied coatings, 0.7 for all other roof surfaces

$\boldsymbol{\rho_{init}}$ - the initial CRRC reflectance

As a compliance option, low-sloped roofs that use aggregate may specify an aged reflectance of 0.50 if the product meets the following criteria:

- Conforms to material standard ASTM D1863.
- Conforms to ASTM D448, size number equal between No.6 and No.7.
- Has a CRRC-tested initial solar reflectance that meets or exceeds 0.55 using the ASTM E1918 test procedure with aggregate passing a No. 4 sieve and is retained by a No. 8 sieve that conforms to ASTM D448, conducted by a CRRC-accredited

independent laboratory meeting the requirement of Section 10-113(d)4 of the Energy Code.

- Has a label on bags or containers of aggregate stating that the materials conform to ASTM D1863 and ASTM D448.

Standard Design: For newly constructed buildings, the standard design reflectance is defined in Table 140.3-B for nonresidential buildings, Table 140.3-C for guest rooms of hotel/motel buildings containing guestrooms, Table 140.3-D for relocatable classroom buildings, and Table 170.2-A for multifamily buildings.

For alterations to more than 50 percent of the roof area or roof areas above 2,000 ft^2, the standard design shall be modeled as the more efficient of either the existing conditions or the values required for cool roofs under Section 141.0 and Section 180.2 of the Energy Code.

Standard Design: Existing Buildings: For alterations to more than 50 percent of the roof area or roof areas above 2,000 ft^2, the standard design shall be modeled as the more efficient of either the existing conditions or the values required for cool roofs under Section 141.0 and Section 180.2.

ROOF THERMAL EMITTANCE

Applicability: All opaque exterior roof surfaces exposed to ambient conditions.

Definition: The thermal emittance of a material. For roofing materials, the three-year aged emittance value from CRRC testing should be used if available.

Units: Unitless.

Input Restrictions: Must be in the range of 0 to 1.

For roofs, newly constructed buildings: as designed, from CRRC values. If CRRC rating information is not available, the default thermal emittance shall be 0.85. Aggregate that meets the following criteria may specify a thermal emittance of 0.85:

- Conforms to material standard ASTM D1863.
- Conforms to ASTM D448, size number equal between No.6 and No.7.
- Has a CRRC-tested initial solar reflectance that meets or exceeds 0.55 using the ASTM E1918 test procedure with aggregate passing a No. 4 sieve and is retained by a No. 8 sieve that conforms to ASTM D448, conducted by a CRRC accredited independent laboratory meeting the requirement of Section 10-113(d) 4 of the Energy Code.
- Has a label on bags or containers of aggregate stating that the materials conform to ASTM D1863 and ASTM D448.

Standard Design: For roofs, newly constructed buildings, the standard design thermal emittance shall be 0.85.

For alterations to more than 50 percent of the roof area or roof areas above 2,000 ft^2, the standard design shall be modeled as the more efficient of either the existing conditions or a thermal emittance of 0.85.

Standard Design: Existing Buildings: If the existing roof is unaltered, same as proposed. For alterations, the standard design is 0.85.

For alterations to more than 50 percent of the roof area or roof areas above 2,000 ft^2, the standard design shall be modeled as the more efficient of either the existing conditions or a thermal emittance of 0.80.

ROOF CONSTRUCTION

Applicability: All roofs.

Definition: A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for roof construction type.

Units: List: layers.

Input Restrictions: The area-weighted average of the roof construction assembly U-factors, defined by a series of layers, must be equal to or more efficient than the mandatory U-factor requirements of Section 120.7 and Section 160.1 of the Energy Code for newly constructed buildings, and Section 141.0 and Section 180.2 of the Energy Code for alterations. Note that these U-Factor requirements assume an exterior air film of R-0.17 and an interior air film of R-0.61. Each layer specified must be listed in the materials database in the ACM Appendix 5.5.

Newly constructed buildings

- Metal Building: U – 0.098
- Wood Framed and Others: U – 0.075

Additions and Alterations

- Roof / Ceiling Insulation: See Section 141.0(b)2Biii and Section 180.2(b)2B of the Energy Code

Appropriate R-values for insulation can be calculated using the formula below.

$$R_{insulation} = (1/UFactor) - R_{Layer(1)} - R_{Layer(2)} - R_{Layer(3)} - R_{Layer(n)}$$

$$R_{insulation} = R_{ins_{continuous}} + R_{ins_{framing}}$$

Ceilings that form the boundary between the modeled building of an additions and alterations project and the existing, un-modeled portion of the building may be modeled as adiabatic roofs (no heat transfer).

Standard Design: Roofs in the standard design are of the type "insulation entirely above deck." The insulation requirement is determined by climate zone. The standard design building roof construction shall be modeled as layers as defined. See Appendix 5.5for details.

For newly constructed buildings, the standard design roof type is wood framed and other, and the roof is a standing seam metal roof, with the R-value of continuous insulation adjusted to match the prescriptive standards for wood-framed and other roofs. The U-factor required for roof construction is defined in Table 140.3-B, 140.3-C, 140.3-D, or Table 170.2-A of the Energy Code. Programs that model a U-factor shall include an exterior and interior air film resistance. The standard design construction is based on JA4 Table 4.2.7 and assumes an exterior air film of R-0.17 and an interior air film of R-0.61.

The standard design construction shall include the following layers:

- Layer 1: Metal Standing Seam 1/16 in. (R - 0.00)
- Layer 2: Continuous Insulation (R - Based on Climate Zone)
- Layer 3: Open Framing + No Insulation (R - 0.00)

The value of the continuous insulation layer entirely above framing shall be set to achieve the following R-values:

Nonresidential Buildings: Continuous Insulation

- Climate Zones 6, 7, 8: R-20.49 (U – 0.047)
- All Other Climate Zones: R-34.93 (U – 0.028)

Hotel/Motel Guestrooms: Continuous Insulation

- Climate Zones 1, 2,4,8-16: R - 34.93 (U – 0.028)
- Climate Zone 7: R - 24.86 (U– 0.039)
- Climate Zones 3, 5, 6: R - 28.63 (U– 0.034)

For mixed-use buildings, the roof standard design requirements shall be determined by which space type (nonresidential or residential) is the majority of the floor area of the adjoining conditioned spaces.

For re-locatable classroom buildings, the standard design shall use the construction assembly corresponding to the most stringent of requirements in any climate zone, or R-28.63 continuous insulation.

For alterations, any approved roof type may be used. The U-factor in the standard design shall be modeled as the more efficient of either the existing conditions or the values stated in Section 141.0 and Section 180.2 of the Energy Code. Where applicable, selection shall be based on building type, assembly, and climate zone. A construction of layers shall be defined to yield an equivalent U-factor.

Standard Design: Existing Buildings: For existing buildings, if the roof component is not altered, the standard design roof construction shall match the proposed design roof construction of the existing building. If the roof is altered, the roof component shall meet the prescriptive requirements for newly constructed buildings for the roof type of the existing building.

The roof type of the existing building is either a metal building roof or a wood-framed or other roof. The standard design roof assemblies for altered roofs are shown below for the appropriate climate zones.

Alterations Roof Standard Design:

For alterations, any approved roof type may be used. The U-factor in the standard design shall be modeled as the more efficient of either the existing conditions or the values stated in Section 141.0 and Section 180.2 of the Energy Code. Where applicable, selection shall be based on building type, assembly, and climate zone. A construction of layers shall be defined to yield an equivalent U-factor.

5.5.4 Exterior Walls

WALL NAME

Applicability: All walls.

Definition: A unique name or code that relates the exterior wall to the design documents. This is an optional input since there are other acceptable ways to key surfaces to the construction documents.

Units: Text.

Input Restrictions: Must be unique.

Standard Design: None.

Standard Design: Existing Buildings: None.

WALL TYPE

Applicability: All walls.

Definition: One of four categories of above-grade wall assemblies used to determine minimum insulation requirements for walls. The five wall type categories are as follows:

- Mass Light
- Mass Heavy
- Metal building
- Metal framing
- Wood framing and other walls

A mass light wall is defined as a wall with total heat capacity greater than 7 but less than 15 Btu/ft^2-. A mass heavy wall is defined as a wall with a total heat capacity of 15 Btu/ft^2-°F or greater. (Heat capacity is defined as the product of the specific heat in Btu/lb-°F, the thickness in ft, and the density in lb/ft^3.)

Units: List: mass light, mass heavy, metal building walls, metal framing walls, and wood framing and other walls

Input Restrictions: This input is required for existing buildings when any wall is altered. This input is not required for newly constructed buildings.

Standard Design: All walls in the standard design building are modeled as "metal framed."

Standard Design: Existing Buildings: Same as proposed.

WALL GEOMETRY

Applicability: All walls

Definition: Wall geometry defines the position, orientation, azimuth, and tilt of the wall surface. The data structure for surfaces is described in the reference section of this chapter.

Units Data structure: surface

Input Restrictions: As designed

Standard Design: Same as proposed

Standard Design: Existing Buildings: Same as proposed

WALL FIRE RATING

Applicability: All walls in multifamily buildings.

Definition: The fire rating for the exterior walls in the building.

Units: hr (integer – typically, 1 hr, 2 hr).

Input Restrictions: This input is required for existing buildings when any wall is altered. This input is not required for newly constructed buildings.

Standard Design: Not required.

Standard Design: Existing Buildings: Same as proposed.

Wall Solar Reflectance

Applicability: All opaque exterior walls exposed to ambient conditions.

Definition: The solar reflectance of a material.

Units: Unitless ratio.

Input Restrictions: For walls and other non-roof surfaces, the value is prescribed to be 0.3.

Standard Design: For walls and other non-roof surfaces, the value is prescribed to be 0.3.

Standard Design: Existing Buildings: 0.3.

Wall Thermal Emittance

Applicability: All opaque exterior walls exposed to ambient conditions.

Definition: The thermal emittance of a material.

Units Unitless ratio.

Input Restrictions: For walls and other non-roof surfaces, the value is prescribed to be 0.9.

Standard Design: For walls and other non-roof surfaces, the thermal emittance is 0.9.

Standard Design: Existing Buildings: For walls and other non-roof surfaces, the thermal emittance is 0.9.

Wall Construction

Applicability: All walls that use the layers method.

Definition: A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for wall construction type.

Units: List: Layers.

Input Restrictions: The area weighted-average of the construction assembly U-factors, defined by a series of layers, must be equal to or more efficient than the mandatory U-factor requirements of Section 120.7 of the Energy Code for newly constructed buildings. Note that these U-Factor requirements assume an exterior air film of R-0.17 and an interior air film of R-0.68. Each layer specified, with the exception of composite layers, must be listed in the materials database in the ACM Appendix 5.5A.

Newly Constructed

Metal Building

- U – 0.113

Metal Framed

U – 0.151 Light Mass Walls

- U – 0.440

Heavy Mass Walls

- U – 0.690

Wood Framed and Others

U – 0.110 Spandrel Panels / Glass Curtain Walls

- U – 0.280

Additions and Alterations

Metal Building

- U – 0.113

Metal Framed

- U – 0.217

Wood Framed and Others

- U – 0.110

Spandrel Panels / Glass Curtain Walls

- U – 0.280

Appropriate R-values for insulation can be calculated using the formula below.

$$R_{insulation} = (1/UFactor) - R_{Layer(1)} - R_{Layer(2)} - R_{Layer(3)} - R_{Layer(n)}$$
$$R_{insulation} = R_{ins_{continuous}} + R_{ins_{framing}}$$

Walls that form the boundary between the modeled building of an additions and alterations project and the existing, un-modeled portion of the building may be modeled as adiabatic walls (no heat transfer).

Standard Design: The U-factor required for wall construction of the standard design building is defined in Table 140.3-B, 140.3-C, 140.3-D, or 170.2-A of the Energy Code. Programs that model a U-factor shall use an exterior and interior air film resistance. The standard design construction is based on JA4 Table 4.3.3 and assumes an exterior air film of R-0.17 and an interior air film of R-0.68.

For metal framed walls, the standard design construction shall include the following layers:

Layer 1

- Stucco – 7/8 in.
- R - 0.18

Layer 2

- Building Paper
- R – 0.06

Layer 3

- Continuous Insulation
- R - Based on Climate Zone

Layer 4

- Closed Framing and No Ins.
- R – 0.65

Layer 5

- Gypsum Board – 1/2 in.
- R – 0.45

Standard Design: Existing Buildings: The value of the continuous insulation layer entirely outside framing shall be set to achieve the following R-values:

Nonresidential Buildings: Continuous Insulation

Climate Zones 1, 6, and 7

- R – 14.47

Climate Zones 2, 4, 5, and 8 – 16

- R – 15.99

Climate Zone 3

- R – 11.90

Hotel/Motel Guestrooms: Continuous Insulation

Climate Zones 1 - 6, and 8-16

- R – 12.30

Climate Zone 7

- R – 7.33

For mixed-use buildings that contain both nonresidential and residential spaces, walls adjacent to nonresidential spaces shall use the Nonresidential Buildings standard design construction, and walls adjacent to residential and multifamily spaces shall use the multifamily standard design construction.

For relocatable classroom buildings, the standard design shall use the construction assembly corresponding to the most stringent of requirements in any climate zone, or R-13.94 continuous insulation.

Table 7: Wall Construction

	CZ2,10-16	**CZ 1**	**CZ 4**	**CZ 3**	**CZ 5-9**
JA4 U-factor	0.170	0.196	0.227	0.278	0.440
Layer 1	4 in MW CMU, 115 lb/sf 4.3.6-B5	4 in MW CMU, 115 lb/sf 4.3.6-B5	4 in MW CMU, 115 lb/sf 4.3.6-B5	4 in MW CMU, 115 lb/sf 4.3.6-B5	8 in NW CMU, 125 lb/ft^2, partly grouted, reinforced with insulated cells 4.3.6-C10
Layer 2*	3″ furring space with R-21 insulation and metal clips 4.3.14-V15 (equiv R-4.8 c.i.)	2.5″ furring space with R-13 insulation and metal clips 4.3.14-R13 (equiv R-3.8 c.i.)	2″ furring space with R-13 insulation and metal clips 4.3.14-N11 (equiv R-3.3 c.i.)	1.5″ furring space with R-9 insulation and metal clips 4.3.14-J9 (equiv R-2.5 c.i.)	N/A
Layer 3	N/A	N/A	N/A	N/A	N/A
…	N/A	N/A	N/A	N/A	N/A
Layer n	N/A	N/A	N/A	N/A	N/A

Source: California Energy Commission

Table 8: Heavy Mass Wall (Heat Capacity >= 15 Btu/ft^2-F)

	CZ2,10-16	**CZ 1**	**CZ 4**	**CZ 3**	**CZ 5-9**	
JA4 U-factor	0.160	0.184	0.211	0.253	0.650	0.690
Layer 1	8 in. NW CMU, 125 lb/ft^2, solid grout, reinforced 4.3.5-A10	8 in. NW CMU, 125 lb/ft^2, solid grout, reinforced 4.3.5-A10	8 in. NW CMU, 125 lb/ft^2, solid grout, reinforced 4.3.5-A10	8 in. NW CMU, 125 lb/ft^2, solid grout, reinforced 4.3.5-A10	8 in NW CMU, 125 lb/ft^2, solid grout, reinforced 4.3.5-A9	8 in. NW CMU, 125 lb/ft^2, solid grout, reinforced 4.3.5-A10
Layer 2*	3″ furring space with R-21 insulation and metal clips 4.3.14-V15	2.5″ furring space with R-13 insulation	2″ furring space with R-13 insulation and metal clips	1.5″ furring space with R-9 insulation	N/A	N/A

	CZ2,10-16	CZ 1	CZ 4	CZ 3	CZ 5-9	
	(equiv R-4.8 c.i.)	and metal clips 4.3.14-R13 (equiv R-3.8 c.i.)	4.3.14-N11 (equiv R-3.3 c.i.)	and metal clips 4.3.14-J9 (equiv R-2.5 c.i.)		
Layer 3	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A
Layer n	N/A	N/A	N/A	N/A	N/A	N/A

Source: California Energy Commission

Table 9: Metal Building Walls

	CZ15	CZ 2,4,5,8,9,10-14,16	CZ 1,3,6,7
JA4 U-factor	0.057	0.061	0.113
Layer 1	R-13 batt insulation draped over purlins and compressed	R-13 batt insulation draped over purlins and compressed	R-13 batt insulation draped over purlins and compressed Rlayer=8.85
Layer 2*	Second layer R-13 batt insulation	Second layer R-10 batt insulation	N/A
Layer 3	N/A	N/A	N/A
…	N/A	N/A	N/A
Layer n	N/A	N/A	N/A

Source: California Energy Commission

Table 10: Wood-Framed Walls

	CZ15	CZ 2,4,9-14,16	CZ 4	CZ 3
JA4 U-factor	0.042	0.059	0.102	0.110
Layer 1	2x4, 16″ o.c., with R-13 batt ins	2x4, 16″ o.c., with R-11 batt ins	2x4, 16″ o.c. with R-13 batt ins	2x4, 16″ o.c. with R-11 batt ins
Layer 2*	R-14 continuous insulation	R-8 continuous insulation	N/A	N/A

Source: California Energy Commission

5.5.5 Exterior Floors

FLOOR NAME

Applicability: All floor surfaces.

Definition: A unique name or code that relates the exposed floor to the design documents.

Exposed floors include floors exposed to the outdoors and floors over unconditioned spaces, but do not include slab-on-grade floors, below grade floors, or interior floors.

Units: Text.

Input Restrictions: Must be unique.

Standard Design: None.

Standard Design: Existing Buildings: None.

FLOOR TYPE

Applicability: All exterior floor surfaces, optional.

Definition: The category that defines the standard design prescriptive floor requirements.

Units: List: mass or other.

Input Restrictions:

Standard Design: The standard design building floors shall be of type "other".

Standard Design: Existing Buildings: Same as proposed.

FLOOR GEOMETRY

Applicability: All exterior floors.

Definition: Floor geometry defines the position, orientation, azimuth, and tilt of the floor surface. The details of how the coordinate system is implemented may vary between compliance software programs. The data structure for surfaces is described in the reference section of this chapter.

Units: Data structure: surface.

Input Restrictions: As designed. Required input.

Standard Design: Standard design building floor geometry is identical to the proposed design.

Standard Design: Existing Buildings: Same as proposed.

Floor Construction

Applicability: All floors.

Definition: A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for floor construction type.

Units: List: Layers.

Input Restrictions: The area weighted-average of the floor construction assembly U-factors, defined by a series of layers, must be equal to or more efficient than the mandatory U-factor requirements of Section 120.7 and Section 160.1 of the Energy Code for newly constructed buildings, and Section 141.0 and Section 180.2 of the Energy Code for alterations. Note that these U-factor requirements assume an exterior air film of R-0.17 and an interior air film of R-0.92. Each layer specified must be listed in the materials database in the ACM Appendix 5.5A.

Newly constructed buildings

Raised Mass Floors

- U – 0.269

Other Floors

- U – 0.071

Heated Slab Floors

- Climate Zone (see Section 120.7 and Section 160.1)

Additions and Alterations

Metal Building

- U – 0.113

Metal Framed

- U – 0.217

Wood Framed and Others

- U – 0.110

Spandrel Panels / Glass Curtain Walls

- U – 0.280

Appropriate R-values for insulation can be calculated using the formula below.

$$R_{insulation} = (1/UFactor) - R_{Layer(1)} - R_{Layer(2)} - R_{Layer(3)} - R_{Layer(n)}$$
$$R_{insulation} = R_{ins_{continuous}} + R_{ins_{framing}}$$

Floors that form the boundary between the modeled building of an addition and alteration project and the existing, un-modeled portion of the building may be modeled as adiabatic floors (no heat transfer).

Standard Design: The U-factor required for floor construction is defined in Table 140.3-B, 140.3-C, 140.3-D, or 170.2-A of the Energy Code. Programs that model a U-factor shall use an exterior and interior air film resistance. The standard design construction is based on JA4 Table 4.4.5 and assumes an exterior air film of R-0.17 and an interior air film of R-0.92.

For metal framed floors, the standard design construction shall include the following layers:

Layer 1

- Open Framing + No Ins.
- R – 0.00

Layer 2

- Continuous Insulation
- R – Based on Climate Zone

Layer 3

- Plywood – 5/8 in.
- R – 0.78

Layer 4

- Carpet and Pad – 3/4 in.
- R – 1.30

Standard Design: Existing Buildings: The value of the continuous insulation layer entirely above or below framing shall be set to achieve the following R-values:

Nonresidential Buildings: Continuous Insulation

- Climate Zones 1
  - R – 17.66
- Climate Zones 2, 11, and 14 -16
  - R – 22.47
- Climate Zones 3 – 10, 12, and 13
  - R – 10.91

Hotel/Motel Guestrooms: Continuous Insulation

- Climate Zones 1, 2, 14, and 16
  - R – 26.24
- Climate Zones 3 – 6, 8 – 13, and 15
  - R – 22.47
- Climate Zones 7
  - R – 10.91

The standard design floor that serves as the boundary between the modeled additions and alterations building and the existing, unmodeled portion of the building is modeled as an adiabatic floor, to match the proposed design. The standard design floor construction for existing buildings depends on the floor type.

5.5.6 Doors

DOOR NAME

Applicability All exterior doors, optional input.

Definition A unique name or code that relates the door to the design documents submitted. Doors that are more than 50 percent glass are treated as windows and must be determined and entered by using the Fenestration building descriptors.

Units: Text: unique.

Input Restrictions: None.

Standard Design: None.

Standard Design: Existing Buildings: None.

DOOR TYPE

Applicability: All exterior doors, required input.

Definition: One of two door classifications of either: swinging or non-swinging. Non-swinging are generally roll-up doors. The prescriptive U-factor requirements depend on door type and climate. This building descriptor may be derived from other building descriptors, in which case a specific input is not necessary.

Units: List: swinging or non-swinging.

Input Restrictions: The door type shall be consistent with the type of door represented on the construction documents or as-built drawings.

Standard Design: The standard design building door type shall be the same as the proposed design.

Standard Design: Existing Buildings: Same as newly constructed buildings.

DOOR GEOMETRY

Applicability: All exterior doors.

Definition: Door geometry defines the position and dimensions of the door surface relative to its parent wall surface. The azimuth and tilt (if any) of the door is inherited from the parent surface. The position of the door within the parent surface is specified through (X, Y) coordinates. The size is specified as a height and width (all doors are generally assumed to be rectangular in shape). The details of how the geometry of doors is specified may vary for each energy simulation program.

Units: Data structure: opening.

Input Restrictions: As designed.

Standard Design: Door geometry in the standard design building is identical to the proposed design.

Standard Design: Existing Buildings: Same as newly constructed buildings.

DOOR CONSTRUCTION

Applicability: All exterior doors.

Definition: The thermal transmittance of the door, including the frame.

Units: Btu/h·ft^2·°F.

Input Restrictions: The construction assembly must be equal to or more efficient than the mandatory U-factor requirements of Section 110.6 of the Energy Code for newly constructed buildings. There are no restrictions for alterations.

Standard Design: For newly constructed buildings, the U-factor required for door construction is defined in Table 140.3-B, 140.3-C, or 140.3-D of the Energy Code.

- Nonresidential Buildings – U Factor:
    - Non-Swinging Doors:
        - Climate Zones 1, and 16
            - U – 0.50
        - Climate Zones 2 – 15
            - U – 1.45
    - Swinging Doors:
        - Climate Zones 1 – 16
            - U – 0.70
- Hotel/Motel Guestrooms – U Factor:
    - Non-Swinging Doors:
        - Climate Zones 1, and 16
            - U – 0.50
        - Climate Zones 2 – 15
            - U – 1.45
    - Swinging Doors:
        - Climate Zones 1 – 16
            - U – 0.70
- Relocatable Public School Building (for all climate zones)
    - Non-Swinging Doors:
        - U-0.50
    - Swinging Doors:
        - U-0.70

Standard Design: Existing Buildings: For alterations, the U-factor in the standard design is either the same standard design as the newly constructed buildings standard design if the door is replaced, or the equal to the existing door construction, if the door is unaltered. Where applicable, selection shall be based on building type, assembly, and climate zone.

OPERABLE DOOR OPENING TYPE

Applicability: All exterior doors.

Definition: The opening type that determines whether interlocks with mechanical cooling and heating are required, as specified by Section 140.4(n) and Section 170.2(c)4L. If manual, then interlocks are required when operable windows are present in any nonresidential space, excluding multifamily and healthcare spaces and buildings. If self-closing or a glazed door, interlocks are not required and are not present in the standard design.

Units Btu/h·ft^2·°F.

Input Restrictions: List: Self-Closing, Manual, Glazed Door.

Standard Design: Same as Proposed.

5.5.7 Fenestration

Note that fenestration includes windows, doors that have 25 percent or more glazed area, and skylights. A skylight is fenestration that has a tilt of less than 60 degrees from horizontal.

FENESTRATION NAME

Applicability: All fenestration, optional input.

Definition: A unique name or code that relates the fenestration to the design documents and a parent surface.

Units: Text: unique.

Input Restrictions: None.

Standard Design: None.

Standard Design: Existing Buildings: None.

FENESTRATION TYPE (VERTICAL FENESTRATION)

Applicability: All vertical fenestration.

Definition: This is a classification of vertical fenestration that determines the thermal performance and solar performance requirement for vertical fenestration.

Units: List: Fixed, Operable, Curtain Wall, Glazed Doors.

Input Restrictions: As designed

Standard Design: Same as the proposed design

Standard Design: Existing Buildings: Same as newly constructed buildings

FENESTRATION TYPE (SKYLIGHTS)

Applicability: All skylights

Definition: This is a classification of skylights that determines the thermal performance and solar performance requirement for vertical fenestration

Units List:

- Glass, Curb-mounted
- Glass, Deck-mounted
- Plastic, Curb-mounted
- Plastic, Deck-mounted

Input Restrictions: As designed

Standard Design: Same as the proposed design

Standard Design: Existing Buildings: Same as newly constructed buildings

DEFAULT FENESTRATION TYPE

Applicability: All fenestration that uses default thermal performance factors

Definition: This is a classification of fenestration that determines the thermal performance for fenestration using defaults from the Energy Code Section 110.6, Table 110.6-A. This is used for fenestration without National Fenestration Rating Council (NFRC) ratings or for fenestration for altered buildings that includes window films.

Units: List: fixed, operable, greenhouse/garden, doors, or skylight

Input Restrictions: As designed. The default value shall be fixed.

Standard Design: Not applicable

DEFAULT GLAZING TYPE

Applicability: All fenestration that uses default thermal performance factors

Definition: This is a classification of fenestration that determines the thermal performance for fenestration using defaults from the Energy Code Section 110.6, Table 110.6-A. This is used for fenestration without NFRC ratings or for fenestration for altered buildings that includes window films.

Units: List: single pane, double pane, glass block

Input Restrictions: As designed. The default value shall be single-pane.

Glass block is only allowed if the default fenestration type is operable or fixed.

Standard Design: Not applicable.

DEFAULT FRAMING TYPE

Applicability: All fenestration that uses default thermal performance factors.

Definition: This is a classification of fenestration that determines the thermal performance for fenestration using defaults from the Energy Code Section 110.6, Table 110.6-A. This is used for fenestration without NFRC ratings or for fenestration for altered buildings that includes window films. This is also used for skylight products where the thermal performance is determined by the equations from the Reference Appendix NA6.

Units: List: metal, metal with thermal break, or nonmetal.

Input Restrictions: As designed. The default value shall be metal.

Standard Design: Not applicable.

DEFAULT DIVIDER TYPE

Applicability: All double-pane fenestration that uses default thermal performance factors.

Definition: This is a classification of fenestration that determines the thermal performance for fenestration using defaults from the Energy Code Section 110.6, Table 110.6-A. This is used for fenestration without NFRC ratings or for fenestration for altered buildings that includes window films.

Units: List: no divider, true divided lite, divider between panes less than 7/16 inch, or divider between panes greater than or equal to 7/16 inch.

Input Restrictions: As designed. The default value shall be no divider.

Standard Design: Not applicable.

DEFAULT TINT TYPE

Applicability: All fenestration that uses default thermal performance factors.

Definition: This is a classification of fenestration that determines the thermal performance for fenestration using defaults from the Energy Code Section 110.6, Table 110.6-B. This is used for fenestration without NFRC ratings or for fenestration for altered buildings that includes window films.

Units: List: clear glazing, tinted glazing.

Input Restrictions: As designed. The default value shall be clear.

Standard Design: Not applicable.

DEFAULT OPERABLE CONFIGURATION

Applicability: All operable fenestration that uses default thermal performance factors.

Definition: This is a classification of fenestration that determines the visible transmittance (VT) for fenestration using defaults from the Energy Code Appendix NA6. This is used for fenestration without NFRC ratings, for fenestration for altered buildings that includes window films, or skylights.

Units: List: casement or awning, sliding.

Input Restrictions: As designed. The default value shall be sliding.

Standard Design: Not applicable.

FENESTRATION GEOMETRY

Applicability: All fenestration.

Definition: Fenestration geometry defines the position and dimensions of the fenestration surface within its parent surface and the identification of the parent surface. The orientation and tilt are inherited from the parent surface. The details of how the coordinate system is implemented may vary between compliance software programs.

Display Perimeter:

Display perimeter is the length of an exterior wall in a B-2 occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each floor that abuts a public sidewalk. The compliance software shall allow the user to specify a value for the length of display perimeter, in feet, for each floor or floor of the building. The user entry for display perimeter shall have a default value of zero. Note: Any non-zero input for display perimeter is an exceptional condition that shall be reported on the PRF-1 exceptional condition list and shall be reported on the ENV forms. The value for display perimeter is used as an alternate means of establishing maximum wall fenestration area in the standard design (Section 140.3 of the Energy Code).

The display perimeter shall be calculated separately for west-facing fenestration, and for non-west facing fenestration.

Floor Number:

The compliance software shall also allow the user to specify the display perimeter associated with each floor of the building.

Units: Data structure: opening

Geometry is defined relative to the parent surface and can include setbacks.

Inputs include:

Geometry of opening (window or skylight), parent surface, display perimeter (optional), percent of roof area that is not required to meet the skylight requirements in Section 140.3(a)6A of the Energy Code.

Input Restrictions: As designed

Specification of the fenestration position within its parent surface is required for the following conditions:

- Exterior shading is modeled from buildings, vegetation, or other objects; or
- If daylighting is modeled within the adjacent space.

Standard Design: The standard design calculates the window wall ratio (WWR) for each orientation and the overall window wall ratio for the building. The window wall ratio is the total fenestration area (including framing) divided by the gross exterior wall area (excluding wall area that is underground). Note that exterior wall area that is below grade, but has exposure to ambient conditions, and any associated fenestration, is included in the WWR calculation.

The standard design vertical fenestration area and horizontal fenestration area for spaces that are specified as computer rooms or data centers (with an ITE equipment power density greater than 20 W/ft^2) shall be zero.

For all other buildings, the geometry of the fenestration in the standard design shall be identical to the proposed design with the following exceptions:

Exception 1: Either the whole building window wall ratio or west window wall ratio exceeds 40 percent.

Exception 2: If display perimeter is entered, the fenestration area exceeds the greater of 40 percent of the gross wall area (excluding adiabatic walls) and six times the display perimeter.

Exception 1: The fenestration is adjusted based on the following conditions:

Case 1. $WWR_o > 0.40$, $WWR_w \leq 0.40$

In this case, the fenestration area of all windows is reduced by multiplying the fenestration area by the ratio $0.40/WWR_o$. The dimensions of each window are reduced by increasing the sill height so that the window height is modified by the multiplier (0.40/WWRo) so that the same window width is maintained.

Case 2: $WWR_o < 0.40$. $WWR_w > 0.40$

In this case, the fenestration area of all windows on the west orientation is reduced by multiplying the fenestration area by the ratio 0.40/WWRo. The dimensions of each window are reduced by multiplying the proposed window dimension by increasing the sill height so that the window height is modified by the multiplier (0.40/WWRo), so that the window width is maintained.

Case 3: $WWR_o > 0.40$. $WWR_w > 0.40$

If both the west window wall ratio and the overall window wall ratio exceed the prescriptive limit of 0.40, the fenestration areas must be reduced by:

Adjust the west window area multiplying the west window area by the ratio $0.4/WWR_w$.

Calculate the WWR of the north, east and south facades:

$$WWR_{nes} = \text{Window Area}_{nes} / \text{Gross Wall Area}_{nes}$$

Adjust the window area of the windows on the north, east and south facades by the following ratio:

$$WindowArea_{N,std} = WindowArea_{N,prop} \times 0.4 / WWR_{nes}$$

$$WindowArea_{E,std} = WindowArea_{E,prop} \times 0.4 / WWR_{nes}$$

$$WindowArea_{S,std} = WindowArea_{S,prop} \times 0.4 / WWR_{nes}$$

Adjust each window geometry for the west façade by multiplying the window height by ($0.4/WWR_w$) by adjusting the sill height and by maintaining the same window width.

Adjust each window geometry for the north, east and south façade by multiplying the window height by ($0.4/WWR_{nes}$) by adjusting the sill height and by maintaining the same window width.

Exception 2: If the display perimeter is entered and the window area exceeds the prescriptive limit, the window area for the standard design is calculated by multiplying the proposed window area by the following ratio:

$$WindowArea_{std} = 6 \times DisplayPerimeter$$

The geometry of each window is modified by the following, and by modifying the sill height but not the head height position relative to the floor:

$$WindowHeight_{std} = WindowHeight_{prop} \times (WindowArea_{std}/WindowArea_{prop})$$

$$WindowWidth_{std} = WindowWidth_{prop}$$

The following rules apply for calculating geometry of skylights. For the calculation of the standard design skylight area, the gross roof area is defined as the total roof area, including skylights, that is directly over conditioned space.

The skylight area of the standard design is set:

- For buildings without atria or with atria having a height less than 55 feet over conditioned space, the smaller of the proposed skylight area and 5 percent of the gross roof area that is over conditioned space.
- For buildings with atria at a height of 55 ft or greater over conditioned spaces, the smaller of the proposed skylight area and 10 percent of the gross roof area that is over conditioned space.
- For buildings with atria or other roof area directly over unconditioned spaces, the smaller of the proposed skylight area or 5 percent of the roof area excluding the atria area and excluding any adiabatic walls, if present in the modeled building. The skylight area of the atria or roof area directly over unconditioned space is not included in the skylight area limit in this case.

The skylight area for atria over unconditioned space is not included in determining the skylight to roof ratio (SRR) for the building.

Depending on the following conditions, adjustments to the SRR as described shall be made.

- For open spaces other than auditoriums, churches, movie theaters, museums and refrigerated warehouses, for buildings in climate zones 2 through 15, and when spaces have ceiling heights greater than 15 ft and floor areas greater than 5000 ft^2, the skylight area shall be the greater of 3 percent or the area required to provide daylight coverage through skylights or primary side lighting to 75 percent of the floor area in the space. See 5.4.5 Daylighting Control for detail description on primary daylit area and skylit daylit area.
- If the above condition is met and SRR ≤ 0.05, no adjustments are needed.
- If the condition is met and SRR > 0.05, skylight dimensions = Existing Dimension x [1- √ (0.05/SRR of Proposed Building)]
- If the condition is not met triggering the need for additional skylights, the standard design case shall be modeled with new skylights irrespective of the skylight location of the proposed case. The new skylights shall be distributed uniformly such that there is no overlapping of primary daylit areas from skylights or sidelights. The dimension of the new skylights shall be the same as the proposed design if calculated new SRR ≤ 0.05. If SRR > 0.05, skylight dimensions = existing dimension x [1- √ (0.05/SRRfof proposed building)].

Note that the adjustments to SRR are done after adjustments to WWR if any are completed.

For compliance software that cannot make the adjustments described above, the compliance software should enforce the proposed design to provide daylight coverage using skylights or primary side lighting to 75 percent of the space floor area.

Standard Design: Existing Buildings: For alterations of existing vertical fenestration or skylights, where no fenestration area is added, the fenestration geometry of the standard design shall be the same as the proposed for the existing building.

For additions of vertical fenestration or skylights, where the additional fenestration causes the fenestration area to exceed the limit of 40 percent window to wall ratio (WWR) for the building, 40 percent WWR for the west orientation of the building, 5 percent skylight to roof ratio (SRR) for existing buildings without atria 55 feet or higher, or 10 percent SRR for existing buildings with atria 55 feet or higher, the fenestration geometry for the standard design shall be adjusted from the proposed design according to the rules set forth under the standard design rules.

For additions of vertical fenestration and/or skylights, where the existing fenestration already exceeds any of these limits, the new fenestration shall be removed.

For additions of vertical fenestration and/or skylights that do not cause the fenestration area to exceed any of these limits, the fenestration geometry of the standard design shall be the same as the proposed design.

SKYLIGHT REQUIREMENT EXCEPTION FRACTION

Applicability: All buildings with interior ceiling heights greater than 15 feet.

Definition: The fraction of floor area that is not required to meet the minimum skylight area requirement for spaces with high ceilings.

Identifying areas subject to Section 140.3 of the Energy Code:

When a proposed space has ceiling heights greater than 15 ft, with exterior surfaces having a tilt angle less than 60 degrees (roofs) and no more than three floors above grade, the user shall enter the fraction of the modeled space that is not required to meet the requirements of Section 140.3 of the Energy Code. If the proposed design has skylights, the user shall also indicate the area of the proposed design daylight area under skylights in this space. When the user enters a value greater than zero percent for the fraction of the space area that is not required to meet Section 140.3 of the Energy Code, the compliance software shall require that the user indicate at least one of the following exceptions:

- The building is not located in Climate Zone 1 or Climate Zone 16
- Designed general lighting is less than 0.5 W/ft^2
- Existing walls on plans result in enclosed spaces less than 5,000 ft^2
- Future walls or ceilings on plans result in enclosed spaces less than 5,000 ft^2 or ceiling heights less than 15 ft
- Plans or documents show that space is an auditorium, religious building of worship, movie theater, museum, or refrigerated warehouses

Units: Unitless fraction of area.

Input Restrictions: Must be in the range of 0 to 1 and should match the as-built drawings.

Standard Design: Same as the proposed design.

Standard Design: Existing Buildings: Not applicable.

FENESTRATION CONSTRUCTION

Applicability: All fenestration.

Definition: A collection of values that together describe the performance of a fenestration system.

The values that are used to specify the criteria are U-factor, SHGC, and VT. U-factor and SHGC inputs are whole-window values.

Units: Data structure: shall include at a minimum the following properties as specified by NFRC ratings:

U-factor: whole window U-factor (Btu/h ft^2 °F).

SHGC: whole window solar heat gain coefficient (unitless).

VT: visible transmittance (unitless).

Input Restrictions: For newly constructed buildings, performance information for fenestration shall be obtained from NFRC test results or shall be developed from procedures outlined in Section 110.6 of the Energy Code, as specified below. Values entered shall be consistent with the specifications and the construction documents.

For manufactured products:

- U-factor, SHGC, and VT shall be equivalent to NFRC rated values.

For products not rated by NFRC, U-factor, SHGC and VT shall be determined from CEC default tables (110.6 A and B).

For site-built products:

- U-factor, SHGC, and VT shall be equivalent to NFRC rated values.
- For products not rated by NFRC, up to 200 ft^2 of skylight area or alteration of any area in a skylight product may use center of glass properties and Reference Appendix NA6 equations to calculate U-factor, SHGC, and VT. Any site-built fenestration in excess of 200 ft^2 must use the default values in Table 110.6-A and 110.6-B.

For buildings with fenestration area that meets requirements for use of center-of-glass U-factor and SHGC, the fenestration overall U-factor, SHGC, and VT shall be determined by the following equations from the Reference Appendix NA6:

UT = C1 + (C2 · Uc)

SHGCT = 0.08 + (0.86 · SHGCc)

VTT = VTF · VTC

Where:

UT - U-factor is the total performance of the fenestration including glass and frame

C1 - Coefficient selected from Table NA6-5 in Reference Appendix NA6

C2 - Coefficient selected from Table NA6-5 in Reference Appendix NA6

UC - Center of glass U-factor calculated in accordance with NFRC 100 Section 4.5.3.1

SHGCT - Total SHGC performance including glass and frame SHGCC = Center of glass SHGC calculated in accordance with NFRC 200 Section 4.5.1.1

VTT - Is the total performance of the fenestration including glass and frame

VTF - 0.53 for projecting windows, such as casement and awning windows

VTF - 0.67 for operable or sliding windows

VTF - 0.77 for fixed or non-operable windows

VTF - 0.88 for curtain wall/storefront, site-built and manufactured non-curb mounted skylights

VTF - 1.0 for curb mounted manufactured skylights

VTC - Center of glass VT is calculated in accordance with NFRC 200 Section 4.5.1.1 or NFRC 202 for Translucent Products or NFRC 203 for Tubular Daylighting Devices and Hybrid Tubular Daylighting Devices or ASTM E972

For vertical fenestration the area weighted-average U-factors, must be equal to or more efficient than the mandatory U-factor requirements of Section 120.7 of the Energy code for newly constructed buildings. The area weighted-average of the construction assembly U-factors, must be equal to or more efficient than the mandatory U-factor requirements of Section 141.0(b)E of the Energy Code for altered buildings.

Newly Constructed Buildings

U-0.47

Additions and Alterations

U-0.58

For skylights, the default values shall be the alternate default U-factor and SHGC using default calculations specified above and in Reference Appendix NA6 or the U-factor and SHGC listed in Table 110.6-A and Table 110.6-B in the Energy Code.

Standard Design: For newly constructed buildings, the requirements for vertical fenestration U factor, SHGC, and visible light transmission by window or skylight type and framing type are specified in Table 140.3-B, C, or D of the Energy Code. For plastic skylights, SHGC of 0.50 is assumed.

Standard Design: Existing Buildings: The U-factor, SHGC, and VT in the standard design shall be modeled as design if unchanged, as the values stated in Table 141.0-A of the Energy Code when the existing window area is unchanged (different than the newly constructed buildings performance requirement), or Table 140.3-B, C, or D of the Energy Code for all other cases.

The standard design does not include window films.

EXTERNAL SHADING DEVICES

Applicability: All fenestration.

Definition: Devices or building features that are documented in the construction documents and shade the glazing, such as overhangs, fins, shading screens, and setbacks of windows from the exterior face of the wall.

The Title 24 compliance software shall be capable of modeling vertical fins, horizontal slats, and overhangs. Recessed windows may also be modeled with side fins, horizontal slats, and overhangs.

Units: Data structure: surface.

Input Restrictions: No restrictions other than that the inputs must match the construction documents.

Standard Design: The standard design building is modeled without external shading devices.

Standard Design: Existing Buildings: No shading devices.

INTERNAL SHADING DEVICES

Applicability: All fenestration.

Definition: Curtains, blinds, louvers, or other devices that are applied on the room side of the glazing material.

Glazing systems that use blinds between the glazing layers are also considered internal shading devices. Glass coatings, components, or treatments of the glazing materials are addressed through the fenestration construction building descriptor.

Units: Not applicable – not modeled for compliance.

Input Restrictions: Not applicable – interior shading is not modeled for compliance.

Standard Design: Not applicable – interior shading is not modeled for compliance.

Standard Design: Existing Buildings: No interior shades.

DYNAMIC GLAZING PRESENT

Applicability: All fenestration that has dynamic glazing.

Definition: This is a flag used for reporting purposes only. Dynamic glazing is not modeled directly in compliance software.

Units: Boolean.

Input Restrictions: None.

Standard Design: False (not present).

Standard Design: Existing Buildings: Not Applicable.

5.5.8 Below-Grade Walls

BELOW-GRADE WALL NAME

Applicability: All projects, optional input.

Definition: A unique name that keys the below-grade wall to the construction documents.

Units: Text: unique.

Input Restrictions: None.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Same as proposed.

BELOW-GRADE WALL GEOMETRY

Applicability: All projects.

Definition: A geometric construct that describes the dimensions and placement of walls located below grade. Below-grade walls have soil or crushed rock on one side and interior space on the other side. Some simulation models take the depth below grade into account when estimating heat transfer so the geometry may include height and width.

Units: Data structure: below-grade wall geometry.

Input Restrictions: As designed.

Standard Design: The geometry of below-grade walls in the standard design building is identical to the below-grade walls in the proposed design.

Standard Design: Existing Buildings: Same as proposed.

BELOW-GRADE WALL CONSTRUCTION

Applicability: All projects, required input.

Definition: A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for below-grade wall construction type.

Units: Data structure: construction assembly.

The construction can be described as a C-factor which is similar to a U-factor, except that the outside air film is excluded, or the construction can be represented as a series of layers, like exterior constructions.

Input Restrictions: The construction assembly, defined by a series of layers, must be equal to or more efficient than the mandatory R-value and C-factor requirements of Section 120.7 of the Energy Code for newly constructed buildings, and Section 141.0 of the Energy Code for alterations. Note that these requirements only apply when the slab floor connected to the below-grade wall is heated.

For newly constructed buildings, the inputs shall agree with the construction documents. Values for the C-factor shall be taken from Table 4.3.5, 4.3.6, or 4.3.7 of Reference Appendices, Joint Appendix JA4.

For alterations there are no restrictions.

Standard Design: For newly constructed buildings, see Table 11: Standard Design Building Below-Grade Wall Construction Assemblies. The standard design building shall use default values for C-factor. The height shall be the same as specified in the proposed design.

For below-grade walls, the standard design construction shall include the layers described in Appendix 5.7 and in the table below.

For alterations, the C-factor in the standard design shall be modeled as the more efficient of either the existing conditions, or the values stated above for newly constructed buildings standard design.

For below-grade walls, the alteration standard design assembly shall include the appropriate existing layers.

Standard Design: Existing Buildings: Same as proposed.

Table 11: Standard Design Building Below-Grade Wall Construction Assemblies

Construction	Layer	Thickness (inch)	Conductivity (Btu/h ft°F)	Density (lb./ft²)	Specific Heat (Btu/lb°F)	R-value (ft²·°F ·h/Btu)	C-factor (Btu/ft²·°F ·h)
NR	115 lb./ft³ CMU, solid grout	8	0.45	115	0.20	0.87	1.140
R-7.5 c.i.	115 lb./ft³ CMU, solid grout	8	0.45	115	0.20	0.87	
	R-10 continuous insulation	1.8	0.02	1.8	0.29	7.50	
	Total assembly					8.37	0.119
R-10 c.i.	115 lb./ft³ CMU, solid grout	8	0.45	115	0.20	0.87	
	R-10 continuous insulation	2.4	0.02	1.8	0.29	10.00	
	Total assembly					10.87	0.092
R-12.5 c.i.	115 lb./ft³	8	0.45	115	0.20	0.87	

Construction	Layer	Thickness (inch)	Conductivity (Btu/h ft°F)	Density (lb./ft²)	Specific Heat (Btu/lb°F)	R-value (ft²·°F ·h/Btu)	C-factor (Btu/ft²·°F ·h)
	CMU, solid grout						
	R-10 continuous insulation	3.0	0.02	1.8	0.29	12.50	
	Total assembly					13.37	0.075

Source: California Energy Commission

5.5.9 Slab Floors in Contact With Ground

These building descriptors apply to slab-on-grade or below-grade floors that are in direct contact with the ground.

SLAB FLOOR NAME

Applicability: All slab floors, optional.

Definition: A unique name or code that relates the exposed floor to the construction documents.

Units: Text: unique.

Input Restrictions: None.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

SLAB FLOOR TYPE

Applicability: All slab floors, required.

Definition: One of two types and two subtypes of floors in contact with ground:

- Heated slab-on-grade floors,
- Unheated slab-on-grade floors
- Heated below-grade floors
- Unheated below-grade floors.

Heated slab-on-grade floors include all floors that are heated directly in order to provide heating to the space. Unheated slab-on-grade floors are all other floors in contact with ground.

Units: List: restricted to the four selections listed above.

Input Restrictions: None.

Standard Design: The slab for type is unheated (either unheated slab-on-grade for slab-on-grade floors or unheated below-grade for below-grade floors).

Standard Design: Existing Buildings: Same as proposed.

SLAB FLOOR GEOMETRY

Applicability: All slab floors, required.

Definition: A geometric construct representing a slab floor in contact with the earth.

The geometric representation can vary depending on how the energy simulation compliance software models slabs-on-grade. Some models require that only the perimeter of the slab be entered. Other models divide the slab into a perimeter band within 2 ft of the edge and the interior portion or core area, such that the perimeter area and the core area sum to the total area of the slab.

Units: Data structure: surface.

This may include area, perimeter exposed.

Input Restrictions: None.

Standard Design: The geometry of the slab floor in the standard design building is identical to the slab floor in the proposed design.

Standard Design: Existing Buildings: Same as proposed.

SLAB FLOOR CONSTRUCTION

Applicability: All slab floors, required.

Definition: A specification containing a series of layers that result in a construction assembly for the proposed design.

The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for slab floor construction type.

A description of how the slab is insulated (or not)

How the construction is described will depend on the energy simulation model. The construction can be represented by an F-factor that represents the entire construction (floor and insulation).

Simple models may include just an F-factor, representing an instantaneous heat loss/gain to outside air. The F-factor could be related to the configuration of insulation in the proposed design. Other slab loss models may require that the surface area of the slab floor be divided between the perimeter and the interior. The insulation conditions then define heat transfer between both outside air and ground temperature.

The insulation condition for slabs includes the R-value of the insulation and the distance it extends into the earth at the slab edge and how far it extends underneath the slab.

Units: F-factor from Reference Appendices, Joint Appendix JA4; this is one selection from list 1 and one selection from list 2. Note that some combinations from list 1 and list 2 are not allowed, see Reference Appendices, Joint Appendix JA4 Table 4.4.8 and Table 4.4.7 for details.

List 1:

- None / 12 in vertical
- 12 in horizontal / 24 in vertical
- 24 in horizontal / 36 in vertical
- 36 in horizontal / 48 in vertical
- 48 in horizontal / Fully insulated slab

List 2:

- R-0 / R-20 / R-45
- R-5 / R-25 / R-50
- R-7.5 / R-30 / R-55
- R-10 / R-35
- R-15 / R-40

The compliance software shall also provide the following slab insulation options:

- Horizontal+Vertical, R-5 vertical down to the horizontal insulation and R-5 horizontal insulation extending 4 feet inwards from the perimeter
- Horizontal+Vertical, R-10 vertical down to the horizontal insulation and R-7 horizontal insulation extending 4 feet inwards from the perimeter

These two combinations of slab insulation are mapped to an F-factor in Appendix 5.4B.

Input Restrictions: The construction assembly, defined by an F-factor, must be equal to or more efficient than the mandatory F-factor requirements of Section 120.7 of the Energy Code for newly constructed buildings, and Section 141.0 of the Energy Code for alterations.

For newly constructed buildings, F-factors shall be taken from Table 4.4.8 of Reference Appendices, Joint Appendix JA4 for heated slab floors and Table 4.4.7 for unheated slab floors. For all methods, inputs shall be consistent with the construction documents. For heated slab floors, the F-factor shall be determined by the mandatory R-value and installation requirements in Section 110.8 of the Energy Code. That information is used in Table 4.4.8 of Reference Appendices, Joint Appendix JA4 to determine the required F-factor. The same requirements apply for alterations.

Standard Design: Slab loss shall be modeled with the simple method (F-factor).

The standard design construction shall include the following layer:

Layer 1: Concrete 140lb/ft^3 – 6 in. (R - 0.44)

The standard design shall include no insulation, equivalent to an F-factor of 0.73.

For alterations, the F-factor in the standard design shall be modeled as the more efficient of either the existing conditions, or the values stated above for newly constructed buildings standard design.

Standard Design: Existing Buildings: Same as proposed.

5.5.10 Heat Transfer between Thermal zones

PARTITION NAME

Applicability: All partitions, optional.

Definition: A unique name or code that relates the partition to the construction documents.

Units: Text: unique.

Input Restrictions: The text should provide a key to the construction documents.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

PARTITION GEOMETRY

Applicability: All partitions.

Definition: A geometric construct that defines the position and size of partitions that separate one thermal zone from another.

The construct shall identify the thermal zones on each side of the partition. Since solar gains are not generally significant for interior partitions, the geometry of partitions is sometimes specified as an area along with identification of the thermal zones on each side.

Units: Data structure: surface with additional information identifying the two thermal zones that the partition separates.

Input Restrictions: No restrictions other than agreement with the construction documents.

Standard Design: The geometry of partitions in the standard design building shall be identical to the proposed design.

Standard Design: Existing Buildings: Same as proposed.

PARTITION CONSTRUCTION

Applicability: All partitions.

Definition: A description of the construction assembly for the partition.

Units: Data structure: construction assembly.

Input Restrictions: As designed.

Standard Design: Partitions in the standard design shall be steel framed walls with 5/8-inch gypsum board on each side. For walls, partitions in the standard design building shall be steel-framed walls with 5/8-inch gypsum board on each side. For interior floors and ceilings, standard design construction shall be a metal deck, 4 inches of heavyweight (140 lb./ft^3) concrete, and 3/4" thick carpet.

Standard Design: Existing Buildings: Same as proposed.

DEMISING PARTITION CONSTRUCTION

Applicability: All demising walls and demising partitions (ceilings, floors) that separate conditioned spaces from unconditioned spaces.

Definition: A description of the construction assembly for the partition.

Units: Data structure: construction assembly.

Input Restrictions: As designed.

Standard Design: For walls, when the proposed design demising partition is metal-framed or other, the standard design shall be a metal-framed wall meeting the mandatory U-factor requirements of Section 120.7 (b) of the Energy Code.

For walls, when the proposed design demising partition is wood-framed, the standard design shall be a wood-framed wall with the opaque portions of the wall meeting the mandatory U-factor requirements of Section 120.7 (b) of the Energy Code.

For windows in demising walls, the fenestration area shall equal the fenestration area of the proposed design. The window U-factor for fenestration in demising walls shall equal the fixed window prescriptive U-factor requirement of 5.5.7 Fenestration. Neither solar heat gain nor daylighting through interior demising windows will be modeled.

Demising ceiling partitions, separating conditioned space from unconditioned space and attics, shall be insulated to the same levels as exterior roofs in 5.5.3 Roofs. Demising floor partitions shall be insulated to the same levels as exterior floors in 5.5.5 Exterior Floors.

Standard Design: Existing Buildings: Demising ceiling partitions, separating conditioned space from unconditioned space and attics shall be insulated to the same levels as exterior roofs in 5.5.3 Roofs. Demising floor partitions shall be insulated to the same levels as exterior floors in 5.5.5 Exterior Floors.

5.5.11 Simplified Geometry Simulation Option

The compliance software may have an option to model a building with simplified two-dimensional (2D) geometry. This is an optional capability as an alternative to modeling the three-dimensional (3D) geometry of a building. If the compliance software only provides a 2D building model, the following features cannot be modeled:

- Daylighting controls and dimming
- Exterior shading or self-shading

All mandatory and prescriptive daylight controls must be present when submitting a compliance project using compliance software that only models a building with 2D geometry.

The compliance software must pass all reference method tests corresponding to 2D geometry to meet certification requirements as compliance software. Consult Appendix 3B of the *ACM Reference Manual* for additional information. The compliance software must pass the rule set implementation tests, and for the sensitivity tests that verify simulation accuracy, there are 2D tests specified for building envelope, but for other building components such as lighting and HVAC, the compliance software is compared against the results of the reference method, which uses a 3D geometry model.

The compliance software must have sufficient information to specify each exterior surface when modeling a building with 2D geometry. At a minimum, building surface azimuth, elevation, and area are required and the tilt, azimuth and area is specified for roof components. The model must use only vertical walls for the analysis. The model follows all other ACM requirements for space and zone definitions, lighting, and HVAC specifications, and follows the same rules for the standard design and proposed design constraints.

The model also requires the following explicit inputs from the user:

- Total Building Floor Count – the total number of floors
- Total Above Grade Floors – the total number of floors above grade, used in determination of multifamily classification

5.6 HVAC Zone-Level Systems

This group of building descriptors relate to HVAC systems at the zone level. There is not a one-to-one relationship between HVAC components in the proposed design and the standard design since the standard design system is determined from building type, and size. The applicability of each building descriptor for each of the standard design systems is indicated in tables under the building descriptor standard design rules. Additions and alterations should follow the same requirements stated for newly constructed buildings proposed designs and newly constructed buildings standard designs unless otherwise noted in the descriptor.

5.6.1 General System Information

COUNT

Applicability: HVAC zone level systems.

Definition: The number of duplicate systems represented by the current system. All system attributes must be identical for multiple system assignment.

Units: None.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

DESIGN SUPPLY AIR TEMPERATURE (COOLING)

Applicability: HVAC zone level systems.

Definition: Design SAT in cooling for the zone.

Units: Deg F.

Input Restrictions: As Designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

DESIGN SUPPLY AIR TEMPERATURE (HEATING)

Applicability: HVAC zone level systems.

Definition: Design SAT in heating for the zone.

Units: Deg F.

Input Restrictions: As Designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

NET COOLING CAPACITY

Applicability: HVAC zone level systems.

Definition: Net cooling capacity of the zone system (one system if count>1), which includes all cooling to the zone but excludes any fan motor heat.

Units: Btu/h.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design with adjustment to account for Standard Design fan heat. For all other cases, not applicable.

NET HEATING CAPACITY

Applicability: HVAC zone level systems.

Definition: Net heating capacity of the zone system (one system if count>1), which includes all cooling to the zone but excludes any fan motor heat.

Units: Btu/h.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design with adjustment to account for Standard Design fan heat. For all other cases, not applicable.

SUPPLY FAN CAPACITY FOR COOLING

Applicability: HVAC zone level systems.

Definition: The supply fan flow rate when the zone requires cooling.

Units: cfm (for each mode).

Input Restrictions: Not applicable. The cooling airflow is set to be the same as the system design airflow.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

SUPPLY FAN CAPACITY FOR HEATING

Applicability: HVAC zone level systems.

Definition: The supply fan flow rate when the zone requires heating.

Units: cfm (for each mode).

Input Restrictions: Not applicable. The heating airflow is set to be the same as the system design airflow.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

SUPPLY TEMP CONTROL

Applicability: HVAC zone level systems.

Definition: The method of controlling the system supply air temperature.

Units: List (Constant, reset by outside air, reset by demand).

Input Restrictions: No Supply Air Temperature Control.

Standard Design: No supply air temperature control.

5.6.2 Terminal Device Data

TERMINAL TYPE

Applicability: All thermal zones.

Definition: A terminal unit includes any device serving a zone (or group of zones collected in a thermal zone) that can vary airflow or reheat or recool or all three in response to the zone thermostat. This includes:

- None or Uncontrolled (applicable for single zone systems only)
- VAV reheat box
- VAV no-reheat box
- Series fan powered VAV box (with reheat)
- Parallel fan powered VAV box (with reheat)
- Active Beam

Units: List (see above).

Input Restrictions: As designed.

Standard Design: Multi-zone systems use VAV reheat boxes except perimeter zone terminal units that use parallel fan powered boxes, see Table 3: System 15 – PVAVAWHP: Standard Design Criteria. All single-zone systems are assumed to use None or Uncontrolled.

For healthcare facilities, same as the Proposed Design.

Standard Design: Existing Buildings: Same as proposed design. For unaltered components; same as newly constructed buildings rules for new secondary systems or terminal units.

5.6.3 Terminal Heating

This group of building descriptors applies to proposed design systems that have reheat coils at the zone level. The building descriptors are applicable for standard design systems 5 and 6.

TERMINAL HEAT TYPE

Applicability: Systems that have heating coils in the zone terminal unit.

Definition: The heating source for the terminal unit. This includes:

- Electric resistance
- Gas furnace
- Hot water

Units: List (see above).

Input Restrictions: For all others, as designed.

Standard Design: Hot water, when applicable.

For healthcare facilities, same as the Proposed Design except electric resistance is not allowed.

TERMINAL HEAT CAPACITY

Applicability: Systems that have heating coils in the zone terminal unit.

Definition: The heating capacity of the terminal heating source.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: The compliance software shall automatically size the terminal heating gross capacity to be 25 percent greater than the design loads.

For healthcare facilities, same as the Proposed Design.

REHEAT DELTA T (ΔT_{reheat})

Applicability: Systems that have heating coils in the zone terminal unit.

Definition: This is an alternate method to enter the terminal heat capacity, which can be calculated as follows:

$$\Delta T_{reheat} = T_{reheat} - T_{cool\_supply}$$
$$\Delta T_{reheat} = Q_{coil}/1.09 \times CFM$$

Where:

- $\Delta \boldsymbol{T}_{reheat}$ - Heat rise across the terminal unit heating coil F)
- $\boldsymbol{T}_{reheat}$ - Heating air temperature at design (F)
- $\boldsymbol{T}_{cool\_supply}$ - Supply air temperature at the heating coil (F)
- $\boldsymbol{Q}_{coil}$ - Heating coil load (Btu/h)
- $\boldsymbol{CFM}$ - Airflow (ft^3/min)

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed but may need to be increased if zone unmet load hours are greater than 150.

Standard Design: Method not used for standard design.

For healthcare facilities, same as the Proposed Design.

5.6.4 Terminal Cooling

This group of building descriptors applies to proposed design systems that have recool coils at the zone level. The building descriptors are applicable for standard design systems 14 and 15.

TERMINAL COOLING TYPE

Applicability: Systems that have heating coils in the zone terminal unit.

Definition: The cooling source for the terminal unit. This includes:

- Chilled Water

Units: List (see above).

Input Restrictions: As designed.

Standard Design: Chilled water, when applicable.

For healthcare facilities, same as the Proposed Design.

TERMINAL COOLING CAPACITY

Applicability: Systems that have heating coils in the zone terminal unit.

Definition: The Cooling capacity of the terminal heating source.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: The compliance software shall automatically size the terminal Cooling gross capacity to be 15 percent greater than the design loads.

For healthcare facilities, same as the Proposed Design.

5.6.5 Baseboard Heat

BASEBOARD CAPACITY

Applicability: All thermal zones.

Definition: Total heating capacity of the baseboard unit(s).

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: Not applicable.

BASEBOARD HEAT CONTROL

Applicability: All thermal zones with baseboard heating.

Definition: Defines the control scheme of base board heating as controlled by a space thermostat.

Units: List (fixed as By Space Thermostat).

Input Restrictions: Controlled by space thermostat is the only type allowed if baseboard heating is used.

Standard Design: Not applicable.

BASEBOARD HEAT SOURCE

Applicability: All thermal zones with furnaces or baseboard heating at the zone.

Definition: Heating source.

Units: List

- Electric heat
- Gas furnace
- Hot water

Input Restrictions: Electric resistance baseboard shall not be used for healthcare facilities space heating unless it meets one of the exceptions to Section 140.4(g) in the Energy Code.

Standard Design: Not applicable, except for healthcare facilities, same as the Proposed Design.

5.6.6 Variable Refrigerant Flow (VRF) Zone Systems (Indoor Units)

The following inputs are required when zone systems are connected to a VRF system (condensing unit).

Acceptance Test Required

Applicability: VRF.

Definition: Flag if acceptance test is required.

Units: Boolean.

Input Restrictions: None.

Standard Design: Not applicable.

Supply Fan Capacity for Deadband

Applicability: VRF.

Definition: Identify the supply fan airflow rate in deadband (floating) mode.

Units: cfm (for each mode).

Input Restrictions: If the fan control is continuous, and if a multi-speed or variable speed fan is defined for the VRF fan coil, this will be set to the minimum fan flow. Otherwise, it is set to the design airflow.

If the fan control is Cycling, 0 cfm.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

Auxiliary Power When On

Applicability: VRF.

Definition: The parasitic electrical energy use of the zone terminal unit when either terminal unit coil is operating.

Units: Watts or Btu/h.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

AUXILIARY POWER WHEN OFF

Applicability: VRF.

Definition: The parasitic electrical energy use of the zone terminal unit when the terminal unit coils are off.

Units: Watts or Btu/h.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

SUPPLY FAN AIRFLOW CAPACITY CONTROL

Applicability: VRF.

Definition: The supply fan airflow shall be capable of specifying one (constant volume), two, or variable speed control and power relationships for each fan unit.

Units: List: Subset of fan capacity control options: constant volume, two speed, and variable speed.

Input Restrictions: As designed. Minimum airflow capacity to be no less than 50% flow.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, not applicable.

5.6.7 Terminal Airflow

5.6.7.1 Variable Air Volume (VAV) Airflow

This group of building descriptors applies to proposed systems that vary the volume of air at the zone level.

DESIGN AIRFLOW

Applicability: Systems that vary the volume of air at the zone level.

Definition: The air delivery rate at design conditions.

Units: CFM.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. Otherwise, the compliance software shall automatically size the terminal airflow to meet both:

- The standard design peak cooling load based on a supply-air-to-room-air temperature difference of 20°F for exterior zones or 15°F for interior zones, the required ventilation air from Table 120.1-A of the Energy Code, or makeup air, whichever is greater.
- The standard design peak heating load assuming a 95°F supply air temperature.

An exterior zone is a thermal zone that has any exterior walls and a non-zero amount of vertical exterior glazed fenestration (windows). Any zone that does not meet the definition of an exterior zone is an interior zone.

TERMINAL MINIMUM AIRFLOW

Applicability: Systems that vary the volume of air at the zone level

Definition: The minimum airflow that will be delivered by a terminal unit.

Units: Unitless fraction of airflow

Input Restrictions: Input must be greater than or equal to the outside air ventilation rate.

For VAV systems where the Control System Type Certified Guideline 36 Libraries specify that certified Guideline 36 libraries are not being used, the modeled minimum airflow shall be the maximum of 2 times the minimum airflow input and 2 times the minimum outside air ventilation rate.

For laboratories, users may input separate minimum ventilation rates for occupied and unoccupied periods. The unoccupied rates shall be used when the occupancy schedule indicates an occupancy fraction below 0.10. The terminal minimum airflow shall be equivalent to the greater of the proposed design occupied minimum exhaust requirements or the occupied minimum ventilation rate.

Standard Design: For healthcare facilities, same as the Proposed Design. For VAV systems, set the minimum airflow to be the maximum of the minimum outside air ventilation rate or 10% of the design airflow.

For laboratories, the occupied minimum airflow fraction shall be fixed at a value equivalent to the greater of the proposed design occupied minimum exhaust requirements or the occupied minimum ventilation rate.

TERMINAL HEATING CONTROL TYPE

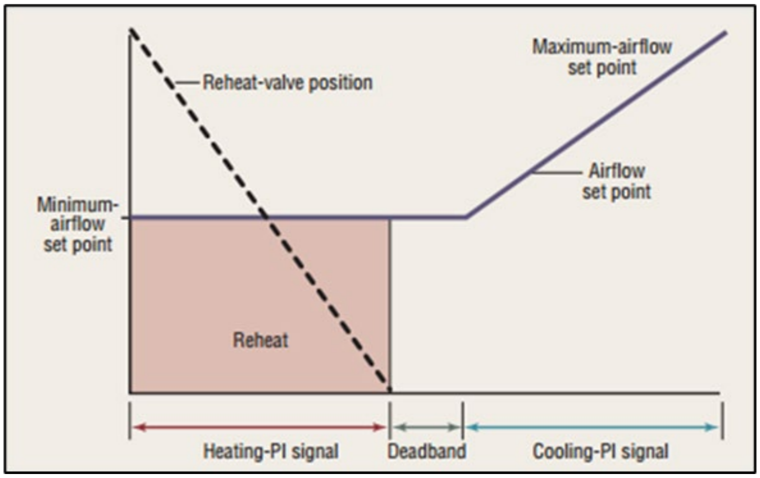
Applicability: VAV boxes with reheat

Definition: The control strategy for the heating mode.

Single Maximum:

In the single maximum control mode, the airflow is set to a minimum constant value in both the deadband and heating mode. This airflow can vary but is typically 30 to 50 percent of maximum. This control mode typically has a higher minimum airflow than the minimum used in the dual maximum below, resulting in more frequent reheat.

Figure 5: Single Maximum VAV Box Control



Source: California Energy Commission

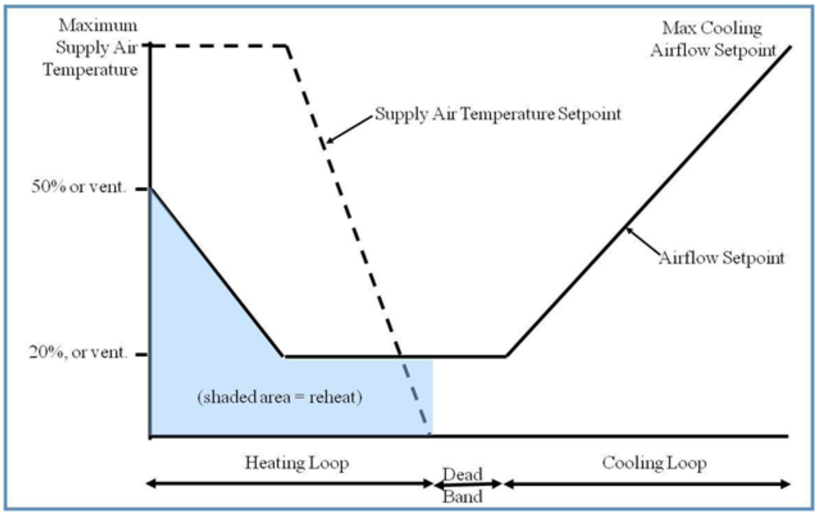
Dual Maximum:

Raises the supply air temperature (SAT) as the first stage of heating and increases the airflow to the zone as the second stage of heating.

The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint no larger than 95°F while the airflow is maintained at the dead band flow rate.

The second stage of heating consists of modulating the airflow rate from the dead band flow rate up to the heating maximum flow rate (50 percent of design flow rate or minimum ventilation rate whichever is greater).

Figure 6: Dual Maximum Control Sequence



Source: California Energy Commission

Units: List:

- Single maximum
- Dual maximum

Input Restrictions: Fixed at single maximum if control system type is not direct digital control (DDC) control to the zone level.

Standard Design: For healthcare facilities, same as the Proposed Design. For all other cases, dual maximum.

5.6.8 Fan-Powered Boxes

FAN-POWERED BOX TYPE

Applicability: Thermal zones that have fan powered boxes.

Definition: Defines the type of fan-powered induction box.

Units: List:

- Series
- Parallel

Input Restrictions: As designed.

Standard Design: Parallel, when applicable.

For healthcare facilities, same as the proposed design.

Terminal Fan Power

Applicability: Thermal zones that have fan powered boxes.

Definition: Rated power input of the fan in a fan-powered box.

Units: W/cfm.

Input Restrictions: As designed.

Standard Design: 0.3 W/cfm, when applicable.

For healthcare facilities, same as the Proposed Design.

Fan Powered Box Induced Air Zone

Applicability: Thermal zones that have fan powered boxes.

Definition: Zone from which a series or parallel fan-powered box draws its air.

Units: List: name of thermal zones included in the building model.

Input Restrictions: As designed.

Standard Design: The thermal zone where the terminal unit is located, when applicable.

For healthcare facilities, same as the Proposed Design.

Parallel Powered Induction Unit (PIU) Induction Ratio

Applicability: Thermal zones that have fan-powered boxes.

Definition: Ratio of induction-side airflow of a fan-powered box at design heating conditions to the primary airflow.

Units: Ratio.

Input Restrictions: As designed.

Standard Design: 50%, when applicable.

For healthcare facilities, same as the proposed design.

Parallel Fan Box Control Method

Applicability: Thermal zones that have parallel fan powered boxes.

Definition: The control scheme used to define when a parallel fan-powered box fans operate.

Units: List: Flow Fraction, Thermostat Offset.

Input Restrictions: None.

Standard Design: Flow Fraction, when applicable.

For healthcare facilities, same as the proposed design.

PARALLEL FAN BOX FLOW FRACTION

Applicability: Thermal zones that have parallel fan powered boxes with 'Flow Fraction' control method.

Definition: If the primary airflow to the box is above this fraction, the parallel fan is off. If the fraction is set to 0, the fan will only run when there is a call for heating in the zone. Otherwise, the parallel box fan will run according to the system availability schedule, or if activated by night-cycle control.

Units: Ratio.

Input Restrictions: 0 to 1.

Standard Design: 0 when, applicable.

For healthcare facilities, same as the proposed design.

5.6.9 Zone Exhaust

This group of building descriptors describes the rate of exhaust and the schedule or control for this exhaust. An exhaust system can serve one thermal zone or multiple thermal zones. Energy is summed for the exhaust system level, not the thermal zone level.

This chapter also contains unique inputs for kitchen exhaust systems that must meet requirements of Section 140.9 of the Energy Code.

KITCHEN EXHAUST HOOD LENGTH

Applicability: Exhaust fans in spaces of type kitchen, commercial food preparation.

Definition: The exhaust hood length.

Units: ft.

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

KITCHEN EXHAUST HOOD STYLE

Applicability: Exhaust fans in spaces of type kitchen, commercial food preparation.

Definition: The hood style as defined in Table 140.9-C of the Energy Code.

Units: List:

- Wall-mounted canopy
- Single island
- Double island
- Eyebrow
- Backshelf or Passover

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

KITCHEN EXHAUST HOOD COOKING DUTY

Applicability: Exhaust fans in spaces of type kitchen, commercial food preparation.

Definition: The hood cooking duty as defined in Table 140.9-C of the Energy Code.

Units: List:

- Light-duty
- Medium-duty
- Heavy-duty
- Extra heavy-duty

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

EXHAUST FAN NAME

Applicability: All thermal zones.

Definition: A reference to an exhaust fan system that serves the thermal zone.

Units: Text or other unique reference to an exhaust fan system defined in the secondary systems section.

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

EXHAUST AIRFLOW RATE

Applicability: All thermal zones.

Definition: Rate of exhaust from a thermal zone.

Units: Cfm.

Input Restrictions: For nonresidential and hotel/motel spaces, Proposed exhaust airflow rate must meet the minimum exhaust requirements of Section 120.1(c)4 for applicable spaces in Table 120.1-B.

For laboratory spaces and zones, the design exhaust airflow rate is specified by the user, but a warning shall be posted if less than 1 cfm/ft^2.

Standard Design: Same as the proposed design but not above the maximum design exhaust rates listed in Appendix 5.4A for spaces that do not include covered processes. For buildings with over 5,000 cfm of kitchen exhaust; the design exhaust rate is a function of the kitchen exhaust hood length, kitchen exhaust hood style, and kitchen exhaust hood cooking duty, and is determined by Title 24 Energy Code, Table 140.9-A.

For laboratory exhaust systems, the design (occupied) exhaust flow rate is the same as the proposed.

For healthcare facilities, same as the Proposed Design.

ZONE EXHAUST MINIMUM AIRFLOW RATE

Applicability: All laboratory zones.

Definition: Minimum rate of exhaust from a zone.

Units: cfm/ft^2.

Input Restrictions: As designed for non-process zones.

For laboratory zones, the exhaust airflow rate is the maximum of the hood scheduled exhaust airflow rate and the minimum ventilation rate. A warning is posted if the minimum exhaust rate is 2 ACH or less. Users shall have the capability to input separate rates for occupied and unoccupied.

Standard Design: For laboratory systems the occupied exhaust minimum airflow rate is the proposed design occupied minimum exhaust airflow rate. The unoccupied exhaust minimum airflow rate is the proposed design unoccupied minimum exhaust airflow rate.

EXHAUST FAN SCHEDULE

Applicability: All thermal zones.

Definition: Schedule indicating the pattern of use for exhaust air from the thermal zone.

Units: Data structure: schedule, fraction.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group for the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

Exhaust schedules for commercial kitchen exhaust and laboratory processes are prescribed in Appendix 5.4B. For laboratory systems the compliance software shall automatically use either the fume hood manual sash control or auto sash control variable exhaust schedule or a volume-weighted interpolated average of the two schedules if only a fraction of the fume hoods have automatic sash control. The resulting exhaust fan schedule fraction shall be no less than the ratio of user specified unoccupied to occupied (design) airflow, regardless of the resulting fume hood sash control airflow schedule.

Standard Design: Same as the proposed design for non-covered process spaces.

For commercial kitchen spaces, exhaust schedules for kitchen exhaust hoods are prescribed and specified in Appendix 5.4B. For sizing heating and cooling equipment, exhaust schedules and corresponding make-up airflow schedules shall be assumed to be 100% during occupied hours, and equal to the design unoccupied flow during unoccupied hours. For laboratory spaces, the standard design is variable volume. If the proposed laboratory space is fume hood intense (as defined in Table 140.9-D of the Energy Code) then the standard design will use a modified VAV schedule for hoods with sash controls, volume-weighted by the fraction of exhaust that is served by exhaust hoods with vertical-only sashes. If the proposed space is not fume hood intense then the standard design shall use the VAV exhaust schedule for manual sash control. For sizing heating and cooling equipment, exhaust schedules and corresponding make-up airflow schedules shall be assumed to be 100% during occupied hours, and the ratio of unoccupied to occupied (design) airflow during unoccupied hours.

For healthcare facilities, same as the proposed design.

EXHAUST FAN FRACTION SASH CONTROL

Applicability: Zones with laboratory exhaust hoods with vertical sashes.

Definition: The airflow-weighted fraction of exhaust hoods with vertical sashes that have automatic sash controls. This input is needed to appropriately model cases where only a fraction of the exhaust hoods that have automatic sash controls.

Units: Fraction.

Input Restrictions: As Designed (between 0 and 1).

Standard Design: 1 if sash controls are required for the laboratory space (per Table 140.9-D of the Energy Code).

For healthcare facilities, same as the Proposed Design.

Standard Design: Existing Buildings: As Designed (between 0 and 1).

EXHAUST SOURCE

Applicability: Zones with exhaust system.

Definition: The source of exhaust makeup air.

Units: List.

- Transfer From Adjacent Zones assumes the exhaust makeup air is provided as outside air by a system either directly to the local zone or from adjacent zones by transfer openings. This option does not change the user's model or impact the simulation.
- Direct Outside Air indicates a louver or other means of allowing untempered, outside air to enter from the exterior to make up for the exhaust. This results in the zone exhaust air to be modeled with an equivalent amount of outdoor air infiltrated into the zone in the simulation.

Input Restrictions: As designed, but if the total outside air brought into the building floor is less than the total exhaust air of the same building floor the compliance software should add infiltration to the zone with exhaust system.

Standard Design: Same as the Proposed Design.

Standard Design: Existing Buildings: As Designed.

5.6.10 Outdoor Air Ventilation

VENTILATION SOURCE

Applicability: All thermal zones.

Definition: The source of ventilation for a thermal zone. The choices are:

- None (ventilaion not provided directly to the zone)
- Natural (by operable openings)
- Forced (by fan)

Units: List: None, Natural, or Forced.

Input Restrictions: For hotel/motel guest rooms, can be 'Natural' or 'Forced'.

For all other occupancies, must be 'Forced'.

Standard Design: For hotel/motel guest rooms, same as the proposed.

For other occupancies, "Forced" if the proposed design is also "Forced", otherwise "None".

VENTILATION STANDARD

Applicability: Thermal zones with special ventilation requirements, such as a process space, which have no defined requirements in Title 24.

Definition: Minimum ventilation rates for:

- Title 24 (default)
- Other

Units: List: See above.

Input Restrictions: None.

User should be prepared to show justification for not using Title 24 ventilation source. If 'Other' is used, the user must enter a description of which standard applies, such as OSHPD3, Animal Shelter, etc.

Standard Design: Same as proposed.

Standard Design: Existing Buildings: Same as proposed.

DESIGN VENTILATION RATE

Applicability: All thermal zones.

Definition: The quantity of ventilation air that is provided to the space for the specified thermal zone at the design condition.

Units: CFM.

Input Restrictions:

As defined by the user.

To accommodate transfer air requirements for makeup air for exhaust from other zones, the design ventilation rate may be between 95 percent and 110 percent of code required ventilation rates for a building floor before simulated energy usage is effected.

If any space ventilation rate is below 95% of the code required ventilation rate, additional ventilation must be provided to other spaces on the same building floor to meet the transfer air requirements, that is, the total design ventilation flow rates for all spaces on a building floor must be equal or greater than 95% of the code required ventilation rates.

If the ventilation source is natural ventilation for hotel/motel guestroom spaces, then the proposed design ventilation will be modeled as infiltration.

Standard Design: For laboratories and healthcare facilities, same as the Proposed Design.

If the total design ventilation rate of the building floor does not exceed 110% of the total ventilation requirement, then the standard design outside air ventilation rate shall be the same as the proposed. If the proposed ventilation rate exceeds the limit above, the standard design ventilation rate for each space shall be the proposed rate uniformly reduced such that the total ventilation air delivered to the building floor is equal to the maximum allowed ventilation air rate:

Design Ventilation Rate$_{std}$ = Design Ventilation Rate$_{prop}$ x (BFVent$_{std}$ / BFVent$_{prop}$)

Where:

BFVent$_{std}$ is the building floor ventilation requirement, as described in the descriptor below, and

BFVent$_{prop}$ is the building floor design ventilation flow for the proposed design.

Standard Design: Existing Buildings: Same as the proposed, if unaltered. If space type is altered such that different ventilation rate requirements apply, the outside air ventilation rate should follow the same rules as for newly constructed buildings.

BUILDING FLOOR VENTILATION REQUIREMENT

Applicability: Internal variable, calculated for each building floor.

Definition: The total outside air ventilation airflow requirement for all spaces on a building floor.

This is calculated by summing the ventilation levels for each space and comparing it to the minimum required ventilation rate and the design exhaust airflow requirements.

Units: cfm (ft^3/min).

Input Restrictions: Not a user input; derived by summing the ventilation and exhaust airflows from all spaces on the building floor.

Standard Design: For laboratories and healthcare facilities, same as the Proposed Design.

For all other spaces:

This is calculated by the following procedure:

- Calculate the proposed ventilation for the building floor as the sum of design ventilation flow for each space included on a building floor, including all conditioned spaces except space designated as laboratory.
- Calculate the proposed exhaust for the building floor as the sum of design exhaust flow for each space on the building floor, including all conditioned spaces except spaces designated as laboratory.
- Calculate the code minimum ventilation requirement as the sum of all minimum required ventilation airflows, as defined by Appendix 5.4A, for all spaces in the building floor.

- Calculate the code minimum exhaust requirement as the sum of all minimum required exhaust airflows, as defined by Appendix 5.4A, for all spaces in the building floor.
- If the proposed exhaust is greater than the code minimum ventilation rate, then:
  - Total standard design building floor ventilation requirement shall be: Standard ventilation = Min (proposed ventilation, code minimum exhaust x 1.2)

Otherwise:

- Standard ventilation = Min (code minimum ventilation x 1.1, proposed ventilation)

MINIMUM VENTILATION RATE

Applicability: All thermal zones that have variable ventilation control.

Definition: The minimum quantity of ventilation air that must be provided to the space when it is occupied.

Units: cfm (ft^3/min).

Input Restrictions: As designed but not lower than code minimum (default value).

The default value shall be the conditioned floor area times the applicable ventilation rate from Appendix 5.4A unless the exception for designed occupancy is used where the larger of 15 cfm times the number of occupants or conditioned floor area times the applicable ventilation rate.

For spaces where demand control ventilation is installed, the minimum ventilation rate is specified by the greater of the rate in Table 120.1-A or 15 cfm times the scheduled occupancy for that hour.

For hotel/motel guestroom spaces where the proposed design ventilation source is natural ventilation, the minimum ventilation rate will be modeled as infiltration.

Standard Design: For laboratories and healthcare facilities, same as the Proposed Design.

For spaces where demand control ventilation is required, the minimum ventilation rate is specified by the greater of the rate in Appendix 5.4A or 15 cfm times the scheduled occupancy for that hour.

VENTILATION CONTROL METHOD

Applicability: All thermal zones

Definition: The method used to determine outside air ventilation needed for each hour in the simulation.

This information is reported to the system serving the zone. The method of controlling outside air at the system level in response to this information is discussed under secondary systems. Options at the zone level are: CO2 sensors in the space: The outside air is varied to maintain a maximum CO2 concentration in the space. This shall be approximated by multiplying the ventilation rate per occupant times the number of occupants for that hour. (When turnstile counts are used to automatically adjust ventilation levels based on occupancy, this method may also be used.)Fixed ventilation rate: Outside air is delivered to the zone at a constant rate and is equal to the design ventilation rate (see above).

Units: List (see above)

Input Restrictions: As designed. If the space includes a design occupant density greater than or equal to 25 persons per 1,000 ft^2, and the system includes an airside economizer, or if the design airflow rate for the system exceeds 3,000 cfm, the input is restricted to CO2 sensors in the space.

Note: a classroom space greater than 750 ft^2must have an occupancy sensor for ventilation control and setback to meet the mandatory Title 24 Energy Code requirements of Section 120.2(e)3. This requirement should be indicated on the appropriate compliance form submittal.

Standard Design: For healthcare facilities, same as the Proposed Design.

If the default occupancy for the specified space function from Appendix 5.4B is greater than or equal to 25 persons per 1,000 ft^2 and the system includes an airside economizer, set control method to CO2 sensors in the space. Otherwise, set to fixed ventilation rate.

DEMAND CONTROL VENTILATION (DCV) MINIMUM VENTILATION SCHEDULE

Applicability: All projects.

Definition: The DCV minimum schedule modifies the ventilation airflow rate for a given space based on the controllability of a ventilation system and the allowance of the energy standard for the space to modulate outdoor air. The schedule is dependent on the occupancy schedule for a space type and shall include a lower limit to airflow based on spaces where minimum ventilation air has a lower limit greater than 0.

Units: Data Structure: schedule, fractional.

Input Restrictions: The DCV minimum ventilation schedule is prescribed for California compliance based on a space type.

Standard Design: DCV minimum ventilation schedules shall be used in all spaces where DCV is a mandatory requirement. DCV minimum ventilation schedules can be different between the proposed and standard design buildings based on a proposed building adopting DCV control in spaces the energy standard does not require.

Standard Design: Existing Buildings: Same as proposed.

5.7 HVAC Secondary Systems

This group of building descriptors relate to the secondary HVAC systems. There is not a one-to-one relationship between secondary HVAC system components in the proposed and standard design since the standard design system is determined from building type, size, and number of floors. The standard design for a given building descriptor indicates the appropriate value for each applicable system type.

5.7.1 Basic System Information

HVAC SYSTEM NAME

Applicability: All system types.

Definition: A unique descriptor for each HVAC system.

Units: Text, unique.

Input Restrictions: When applicable, input should match the tags that are used on the plans.

Standard Design: None.

Standard Design: Existing Buildings: None.

SYSTEM TYPE

Applicability: All system types.

Definition: A unique descriptor which identifies the HVAC system type. The System Type indicates the cooling and heat source, and whether the system serves a single zone or multiple zones.

Units: List from the choices below.

Input Restrictions:

PTAC – Packaged Terminal Air Conditioner

PTHP – Packaged Terminal Heat Pump

SZAC – Single-zone Air Conditioner

SZHP – Single-zone Heat Pump

SZDFHP – Single-zone Dual Fuel Heat Pump

PVAV* – Packaged Variable Air Volume (VAV) with Reheat

VAV* – Built-up VAV with Reheat

SZVAV-AC – Single Zone VAV Air Conditioner

SZVAV-HP – Single Zone VAV Heat Pump

SZVAV-DFHP – Single Zone VAV Dual Fuel Heat Pump

HV – Heating and Ventilation Only

CRAC – Computer Room Air Conditioner

CRAH – Computer Room Air Handler

FPFC – Four-pipe Fan Coil

WSHP – Water-source Heat Pump

SPVAC – Single package vertical air conditioner

SPVHP – Single package vertical heat pump

DOASVAV – Dedicated Outdoor Air System with Variable Air Volume Airflow

DOASCAV – Dedicated Outdoor Air System with Constant Air Volume Airflow

Chilled Beam – Active or Passive chilled beams

Dual Duct – Mixing box (constant volume and VAV)

* Choice includes series and parallel fan-powered boxes as zone terminal units

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, based on the prescribed system type in the HVAC system map. (See 5.1.3 HVAC System Map).

SYSTEM CONFIGURATION

Applicability: Computer room air conditioner.

Definition: A unique descriptor which identifies the system class and configuration. This descriptor is used to determine the minimum system efficiency. The valid options are:

- Floor-Mounted (Downflow)
- Floor-Mounted (Upflow – Ducted)
- Floor-Mounted (Upflow — Nonducted)
- Floor-Mounted (Horizontal)
- Ceiling-Mounted (Ducted Discharge and Ducted Return)

- Ceiling-Mounted (Ducted Discharge and Free Air Return)
- Ceiling-Mounted (Free Air Discharge and Ducted Return)
- Ceiling-Mounted (Free Air Discharge and Free Air Return)

Units: None.

Input Restrictions: None.

Standard Design: When the standard design system is a computer room air conditioner the configuration is "Floor-Mounted (Downflow)."

5.7.2 System Controls

5.7.2.1 Control System Type

CONTROL SYSTEM TYPE

Applicability: All HVAC systems that serve more than one control zone, as well as the hydronic systems that serve building HVAC systems.

Definition: The type of control system for multi-zone HVAC systems and their related equipment.

This input affects the proposed design system specification for zone level controls, supply air temperature reset controls, ventilation controls and fan and pump static pressure part-load curves. See the following building descriptors:

- Ventilation control method
- Terminal heating control type
- Pump part-load curve
- Fan part-load curve
- Optimal start

Units: List.

- Direct digital control (DDC) to the zone level – DDC systems with control to the zone level.
- Other – other control systems, including pneumatic and DDC systems without control to the zone level.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, DDC control to the zone level.

5.7.2.2 Schedules

AIR HANDLER SCHEDULE

Applicability: All systems that do not cycle with loads.

Definition: A schedule that indicates when the air handler operates continuously.

Units: Data structure: schedule, on/off.

Input Restrictions: For healthcare facilities, the schedule is the same as the proposed design. For all nonresidential buildings, the schedule is based on the predominant schedule group for the building floor or zone. See 2.3.3 Space-Use Classification Considerations for details.

The fan schedules and HVAC operations are defined so that the air handlers provide the necessary outside air 1 hour prior to scheduled occupancy.

Standard Design: Same as the proposed design.

AIR HANDLER FAN CYCLING

Applicability: All fan systems.

Definition: This building descriptor indicates whether the system supply fan operates continuously or cycles with building loads when the HVAC schedule indicates the building is occupied. (See night cycle control input for fan operation during unoccupied hours.) The fan systems in most commercial buildings operate continuously.

Units: List continuous or cycles with loads.

Input Restrictions: As designed if the HVAC system serves zones with a dedicated outside air source for ventilation; otherwise, continuous.

Standard Design: For healthcare facilities, same as the Proposed Design. For air-to-water room air conditioner, cycles with loads; continuous for all other standard design system types.

OPTIMAL START CONTROL

Applicability: Systems with the control capability for flexible scheduling of system start time based on building loads.

Definition: Optimal start control adjusts the start time of the HVAC unit such that the space is brought to setpoint just prior to occupancy. Modeling input is used for reporting only and does not affect simulation results.

Units: Boolean (Yes/No).

Input Restrictions: Fixed at yes if control system type is DDC to the zone level; otherwise, as designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, fixed at yes if control system type is DDC to the zone level.

NIGHT-CYCLE HVAC FAN CONTROL

Applicability: All air systems – not applicable for zone systems.

Definition: The control of an HVAC system that is triggered by the heating or cooling temperature setpoint for thermal zones during periods when the heating, cooling and fan systems are scheduled to be off. For this control, the space is controlled to the setback or setup temperature only; this control is not equivalent to a night purge control. The choices are:

- Cycle on call from any zone.
- Cycle on call from the primary control zone.
- Stay off.
- Cycle zone fans only (for systems with fan-powered boxes). Restart fans below given ambient temperature.
- Cycle on any cooling.
- Cycle on any heating.

Units: None.

Input Restrictions: For multizone systems, "Cycle on call from any zone," except for systems with fan-powered boxes, where either "Cycle on call from any zone" or "Cycle zone fans only" is allowed. For DOAS, "Stay off" unless the DOAS is identified as a heating or cooling system for any zone. For single-zone heating/cooling systems, "Cycle on call from primary zone."

Standard Design: For healthcare facilities, same as the Proposed Design. For multizone systems, "Cycle on call from any zone." For single-zone heating/cooling systems, "Cycle on call from primary zone."

CERTIFIED GUIDELINE 36 LIBRARIES

Applicability: Packaged VAV, built-up VAV and built-up VAV with AWHP heating with Control Type DDC to the zone.

Definition: Indicates whether certified ASHRAE Guideline 36 programming libraries are used in proposed HVAC control system design.

The input affects the proposed design system specification for zone level controls and fan static pressure part-load curves. See the following building descriptors:

- Terminal minimum airflow
- Fan part-load curve

Units: Boolean

Input Restrictions: None

Standard Design: Not applicable

5.7.2.3 Supply Air Temperature Control

COOLING SUPPLY AIR TEMPERATURE

Applicability: All cooling systems.

Definition: The supply air temperature setpoint at design cooling conditions.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, 15°F below the space temperature setpoint for interior zones that are served by multiple zone systems and for computer rooms without air containment (where space temperature equals return air temperature); for all other zones, 20°F below the space temperature. Setpoint

HEATING SUPPLY AIR TEMPERATURE

Applicability: All heating systems.

Definition: The supply air temperature leaving the air handler when the system is in a heating mode (not the air temperature leaving the reheat coils in VAV boxes).

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, 95°F for all system types with heating, except 60°F for multiple zone systems; no heating for data centers and computer rooms.

SUPPLY AIR TEMPERATURE CONTROL

Applicability: All cooling or heating systems or both.

Definition: The method of controlling the supply air temperature. Choices are:

- No control — For this scheme the coils cycle on/off based on control zone thermostat signal for heating/cooling. There is no controller to maintain a specific supply air temperature (SAT).
- Fixed — The coils cycle on/off to maintain a constant SAT setpoint.
- Warmest Reset – Resets the cooling supply air temperature of a central forced air HVAC system according to the cooling demand of the warmest zone.
- Outside air dry-bulb temperature — The SAT is adjusted based on the outdoor air temperature. The SAT is varied linearly between the max/min limits in proportion to the outside air max/mix limits, and constant above/below the outside air limits.
- Scheduled setpoint — The coils cycle on/off to maintain a SAT setpoint specified by schedules.

Units: List (see above).

Input Restrictions: Warmest zone reset controls not applicable for single-zone systems. Otherwise, as designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, for standard design systems 1 through 4 and 7 through 13, the SAT control is No Control. For systems 5, 6 and 15 the SAT control shall be reset by warmest reset.

RESET SCHEDULE BY OUTDOOR AIR TEMPERATURE

Applicability: When the proposed design resets SAT by outside air dry-bulb temperature.

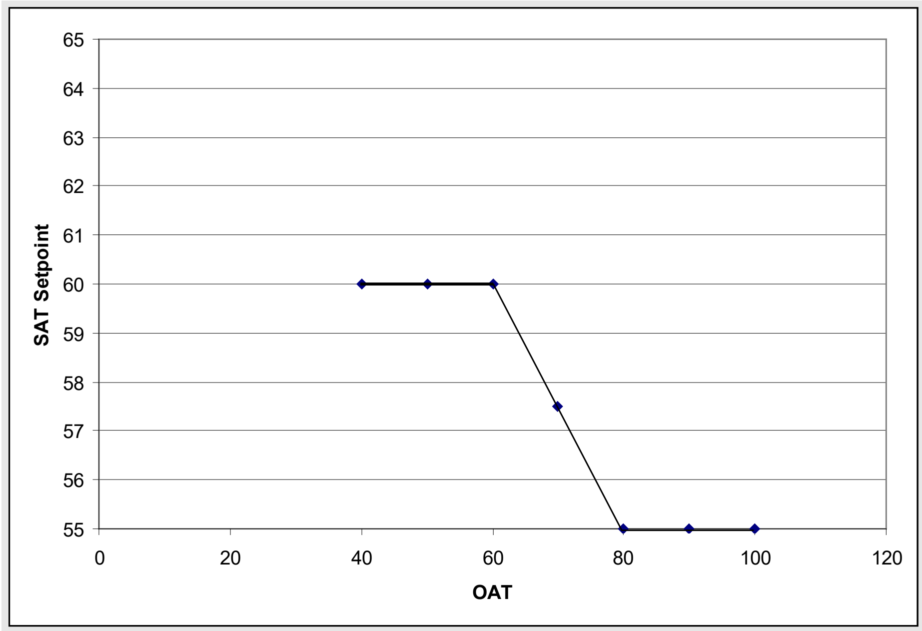
Definition: A linear reset schedule that represents the SAT setpoint as a function of outdoor air dry-bulb temperature.

This schedule is defined by at minimum the following four data points (see Figure 7: SAT Cooling Setpoint Reset Based on Outdoor Air Temperature OAT):

- The coldest supply air temperature
- The corresponding (hot) outdoor air dry-bulb setpoint
- The warmest supply air temperature
- The corresponding (cool) outdoor air dry-bulb setpoint

There may be one reset schedule for the system, or may be individual reset schedules for heating and cooling coils, as may be the case for DOAS systems.

Figure 7: SAT Cooling Setpoint Reset Based on Outdoor Air Temperature (OAT)



Source: California Energy Commission

Units: Data structure (two matched pairs of SAT and OAT, see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

DUAL SETPOINT SUPPLY AIR TEMPERATURE CONTROL

Applicability: All cooling and/or heating systems. This strategy is most applicable to ventilation only (DOAS) systems with tempering coils and/or heat recovery.

Definition: The maximum and minimum supply air temperature setpoints for the system. Cooling coils will be energized to maintain the system supply air temperature at the maximum setpoint, and heating coils will be energized to maintain the setpoint at the minimum temperature. If the mixed air temperature of the system is between these two values, the coils are not energized and the supply air temperature “floats” within this range.

Units: Data structure (a pair of minimum and maximum supply air temperatures).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

5.7.3 Fan and Duct Systems

5.7.3.1 Standard Design Fan System Summary

The standard design fan system is summarized in this chapter. See 5.1.3 HVAC System Map, for the HVAC standard design system mapping. At the end of the Fans, General section below, the standard design fan power allowance and available credits is described. There are also sections on Supply, Return/Relief, and Exhaust systems with additional guidance.

5.7.3.2 Fans, General

The following descriptors are common to all fans.

FAN MODELING METHOD

Applicability: All fan systems.

Definition: Fans can be modeled in one of three ways. The simple method is for the user to enter the electric power per unit of flow (W/cfm). This method is commonly used for zonal equipment and other small fan systems. A more detailed method is to model the fan as a system whereby the static pressure, fan efficiency, part-load curve, and motor efficiency are specified at design conditions. A third method is to specify brake horsepower at design conditions instead of fan efficiency and static pressure. This is a variation of the second method whereby brake horsepower is specified in lieu of static pressure and fan efficiency. The latter two methods are commonly used for VAV and fan systems with significant static pressure.

Units: List power-per-unit-flow, static pressure, or brake horsepower.

Input Restrictions: As designed.

Standard Design: For healthcare facilities with total system fan power less than 1 kW and system is not a DOAS, same as the Proposed Design. For all others, power-per-unit-flow.

FAN CONTROL METHOD

Applicability: All fan systems with supply or relief fans or both.

Definition: A description of how the supply (and return/relief) fan(s) are controlled.

The options include:

- Constant volume
- Variable-flow, inlet, or discharge dampers
- Variable-flow, inlet guide vanes
- Variable-flow, variable speed drive (VSD)
- Variable-flow, variable pitch blades

- Two-speed

For variable-speed fans, the fan control method determines which part-load performance curve to use.

Units: List (see above).

Input Restrictions: As designed. The user shall not be able to select VSD with static pressure reset if the building does not have DDC controls to the zone level.

Standard Design: For healthcare facilities, same as the Proposed Design. Based on the prescribed system type. Refer to the 5.1.3 HVAC System Map.

FAN BRAKE HORSEPOWER

Applicability: All fan systems.

Definition: The design shaft brake horsepower of a fan.

This input does not need to be supplied if the supply fan power (kW or W/cfm) is supplied.

Units: Horsepower (hp).

Input Restrictions: As designed. Required if the fan modeling method is 'brake horsepower', otherwise this input is calculated for other methods.

The compliance software shall apply the following rule to ensure the proposed design bhp is consistent with the user input motor nameplate horsepower.

The user entered brake horsepower for the proposed design is compared against the next smaller standard motor size, as defined by Table 12: Minimum Nominal Efficiency for Electric Motors (Percent), from the user entered supply fan nameplate motor horsepower. The proposed design supply fan brake horsepower (bhp) is set to the maximum of the user entered or calculated bhp and 95 percent of the next smaller motor horsepower:

Proposed bhp = max(User bhp, 95 percent ×MHPi-1)

Where User bhp is the user entered supply fan brake horsepower:

MHPi is the proposed (nameplate) motor horsepower

MHPi-1 is the next smaller motor horsepower from the Standard Motor Size table.

For example, if the user entered fan brake horsepower is 18 and the proposed motor horsepower is 25, the next smaller motor horsepower from the table above is 20, and 95 percent of the next smaller motor horsepower is 19. Then, the brake horsepower in the proposed model should be 19.

Standard Design: For healthcare facilities with total system fan power less than 1 kW and system is not a DOAS, same as the Proposed Design. For all others, not applicable (the standard design maps to a HVAC system type, which has a power-per-unit-flow allowance based on the components in the given system type).

Standard Design: Existing Buildings: Same as proposed if existing and unaltered.

FAN MOTOR HORSEPOWER

Applicability: All fan systems.

Definition: The motor nameplate horsepower of the supply fan.

Units: List: choose from standard motor sizes: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200

Alternatively, the nameplate horsepower can be entered as a numeric value.

Input Restrictions: As designed.

This building descriptor is required for all fan power modeling methods.

Standard Design: For healthcare facilities with total system fan power less than 1 kW and system is not a DOAS, same as the Proposed Design. For all others, set to the standard motor efficiency for the nominal motor size, from NEMA standards, for calculated supply fan input power.

Standard Design: Existing Buildings: Same as proposed if existing and unaltered.

FAN TOTAL STATIC PRESSURE

Applicability: All fan systems using the static pressure method.

Definition: The design total static pressure for the supply fan. This includes both the internal and external static pressure drop for an air handler.

Units: Inches of water column (in. H20).

Input Restrictions: As designed.

The design static pressure for the supply fan does not need to be specified if the supply fan power index or brake horsepower (bhp) is specified.

Standard Design: For healthcare facilities with total system fan power less than 1 kW and system is not a DOAS, same as the Proposed Design. For all others, not applicable.

Standard Design: Existing Buildings: Same as proposed if existing and unaltered.

FAN EFFICIENCY

Applicability: All fan systems using the static pressure method.

Definition: The efficiency of the fan at design conditions; this is the static efficiency and does not include motor losses.

Units: Unitless.

Input Restrictions: As designed.

The supply fan efficiency does not need to be specified if the supply fan brake horsepower (bhp) is specified.

Standard Design: For healthcare facilities with total system fan power less than 1 kW and system is not a DOAS, same as the Proposed Design. For all others, 65%.

Not applicable for the four-pipe fan coil system.

Standard Design: Existing Buildings: Not applicable.

MOTOR EFFICIENCY

Applicability: All fans.

Definition: The full-load efficiency of the motor serving the fan.

Units: Unitless.

Input Restrictions: As designed.

Standard Design: For healthcare facilities with total system fan power less than 1 kW and system is not a DOAS, same as the Proposed Design. For all others, determined from Table 12: Minimum Nominal Efficiency for Electric Motors (Percent) using the nameplate motor size.

Existing Buildings: Same as proposed.

Table 12: Minimum Nominal Efficiency for Electric Motors (Percent)

Motor Horsepower	Efficiency (%)
1	85.5
1.5	86.5
2	86.5
3	89.5
5	89.5
7.5	91.7

10	91.7
15	92.4
20	93.0
25	93.6
30	93.6
40	94.1
50	94.5
60	95.0
75	95.4
100	95.4
125	95.4
150	95.8
200	96.2
250	96.2
300	96.2
350	96.2
400	96.2
450	96.2
500	96.2

Source: California Energy Commission

MOTOR POSITION

Applicability: All fans.

Definition: The position of the supply fan motor relative to the cooling or heating air stream or both.

The choices are:

- In the air stream.
- Out of the air stream.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: In the air stream.

FAN PART-FLOW POWER CURVE

Applicability: All variable-flow fan systems.

Definition: A part-load power curve that represents the percentage full-load power draw of the supply fan as a function of the percentage full-load airflow.

The curve is typically represented as a quadratic equation with an absolute minimum power draw specified.

Units: Unitless ratio.

Input Restrictions: Prescribed, use curves in Appendix 5.7 based on fan control. When certified Guideline 36 libraries are not being used, the fan curve in the proposed design shall be fanVSDLimited SpResetPwrRatio_fCFMRatio.

The default fan curve shall be selected from Appendix 5.7 for the type of fan specified in the proposed design.

$$PLR = (a) + (b \times FanRatio) + (c \times FanRatio^2) + (d \times FanRatio^3)$$
$$PLR = PowerMin$$

Where:

$\boldsymbol{PLR}$ - Ratio of fan power at part load conditions to full load fan power
$\boldsymbol{PowerMn}$ - Minimum fan power ratio
$\boldsymbol{FanRatio}$ - Ratio of cfm at part-load to full-load cfm
$\boldsymbol{a, b, c, and\ d}$ - Constants from the table below

For exhaust fans modeled as zone fans, the part-flow power curve can be described by a curve from Appendix 5.7 for the type of fan specified, or as a linear curve.

Standard Design: For healthcare facilities with total system fan power less than 1 kW where system is not a DOAS, same as the Proposed Design. For all others, not applicable for standard design constant volume systems. The curve VSD with static pressure reset fans shall be used for variable volume systems. For exhaust fans, if a linear curve is used, the same fan curve, in the proposed design is used.

FAN POWER INDEX

Applicability: Fan systems that use the power-per-unit-flow method.

Definition: The fan power (at the motor) per unit of flow.

Units: W/cfm.

Input Restrictions: As designed or specified in the manufacturers' literature.

Standard Design: For healthcare facilities with total system fan power greater than or equal to 1 kW and the system is not DOAS, power-per-unit-flow allowance based on the components in the proposed system according to 140.4(c)1 of the Energy Code. For healthcare facilities with DOAS and total system fan power less than 1 kW, 1.0 W/CFM. For all other health care facilities, same as Proposed Design.

For all other buildings:

- Hotel/motel guestroom room air conditioner: 0.45 W/CFM
- Computer room air conditioner and computer room air handler systems: 0.58 W/CFM (approximate value of 27 W/kBtu-h of net sensible cooling capacity assuming design air flow rate is based on 20°F temperature differential between supply air and room air)
- System 15 – Parallel fan-powered box fan: 0.3 W/cfm.

Other systems: The fan electrical power input of the standard design will be based on which components are present in the given HVAC system type, and what the prescriptive fan power budget allows for each airflow range.

The standard design fan input electrical power will be determined by the system type and airflow range described in the table below:

Table 13: Total System Fan Power Allowance, in W/cfm by System Type

System No.	≤ 5,000 cfm	> 5,000 cfm; ≤ 10,000 cfm	> 10,000 cfm
3a – SZAC	0.800	0.780	0.748
3b – SZHP (no furnace)	0.742	0.720	0.676
3c – SZDFHP (with furnace)	0.800	0.780	0.748
7a – SZVAVAC	0.800	0.780	0.748
7b – SZVAVHP	0.742	0.720	0.676

System No.	**≤ 5,000 cfm**	**> 5,000 cfm; ≤ 10,000 cfm**	**> 10,000 cfm**
7c – SZVAVDFHP (with furnace)	0.800	0.780	0.748
5 – PVAV	0.978	1.013	0.946
6 – VAV	0.978	1.013	0.946
9 – HEATVENT	0.616	0.620	0.605
13a – BKICHMAU	0.602	0.586	0.540
13b – PKITCHMAU	0.614	0.596	0.558
14 – AC/WCSZVAV[1]	0.666	0.681	0.623
15 – PVAVAWHP[2]	1.000	1.022	0.964

Source: California Energy Commission

Notes

1) System 14 fan power is determined using the total supply flow rate of all System 14 units on the same building floor.
2) This fan power shall be reduced by 15% for schools in climate zone 2 and offices in climate zones 3 and 5.

Standard Design: Existing Buildings: Same as proposed if existing and unaltered; otherwise use newly constructed buildings values with the following additional credits (includes supply and return/relief/exhaust):

Table 14: Additional System Fan Power Allowance, in W/cfm by System Type

System No.	**≤ 5,000 cfm**	**> 5,000 cfm; ≤ 10,000 cfm**	**> 10,000 cfm**
MZ-VAV (Systems 5 and 6)	0.205	0.174	0.159

System No.	≤ 5,000 cfm	> 5,000 cfm; ≤ 10,000 cfm	> 10,000 cfm
All other (Systems 1, 3, 7, and 9)	0.209	0.182	0.162

Source: California Energy Commission

FAN POWER ADJUSTMENT

Applicability: Any system with special requirements for filtration or other process requirements.

Definition: Additional system fan power related to application-specific filtration requirements or other process requirements.

An exceptional condition shall be included on compliance documentation when the user selects one of these adjustment conditions.

Units: List.

Input Restrictions: The user chooses one or more fan power adjustment credits from the list below. For the credits that are indicated as 'calculation required the user enters the pressure drop for each device.

Table 15: Adjustment Credits (Multizone VAV) (W/cfm)

Device	≤ 5,000 cfm	> 5,000 cfm; ≤ 10,000 cfm	> 10,000 cfm
Return of exhaust systems required by code to be fully ducted	0.089	0.100	0.116
Exhaust filters, scrubbers, or other exhaust treatment (calculation required, see note)	0.177	0.198	0.231
Particulate filtration credit: MERV 16 or greater and	0.265	0.280	0.333

Device	≤ 5,000 cfm	> 5,000 cfm; ≤ 10,000 cfm	> 10,000 cfm
electronically enhanced filters			
Carbon and other gas-phase air cleaners (calculation required, see note)	0.176	0.188	0.224
Biosafety cabinet (calculation required, see note)	0.177	0.198	0.231
Energy Recovery (included only if standard design requires heat recovery)	0.374	0.318	0.289

Source: California Energy Commission

Table 16: Adjustment Credits, All Other Fan Systems (W/cfm)

Device	≤ 5,000 cfm	> 5,000 cfm; ≤ 10,000 cfm	> 10,000 cfm
Return of exhaust systems required by code to be fully ducted	0.091	0.102	0.116
Exhaust filters, scrubbers, or other exhaust treatment (calculation required, see note)	0.179	0.202	0.232
Particulate filtration credit: MERV 16 or greater and	0.264	0.292	0.342

Device	≤ 5,000 cfm	> 5,000 cfm; ≤ 10,000 cfm	> 10,000 cfm
electronically enhanced filters			
Carbon and other gas-phase air cleaners (calculation required, see note)	0.177	0.197	0.231
Biosafety cabinet (calculation required, see note)	0.179	0.202	0.232
Energy Recovery (Included only if standard design requires heat recovery)	0.381	0.329	0.293
Single Zone VAV Systems that are capable of turning down to 50% of full load airflow at a maximum of 30% design wattage	0.070	0.100	0.089

Source: California Energy Commission

For any row with "calculation require," include a field that allows the user to enter static pressure and multiply by the value in the cell. The value in the cell is based on 1.0 in. w.c. pressure drop.

Standard Design: Same as proposed. The adjustment credit for energy recovery is independent of the proposed design. When energy recovery is present in the standard design, the adjustment credit is added to the standard design fan. For laboratory systems, System 14, the adjustment credits shall be applied separately to the supply fan and exhaust fan using the credits in Table 17: Supply Fan Adjustments Credits, System 14 (W/cfm) and Table 18: Exhaust Fan Adjustments Credits, System 14 (W/cfm). For all other systems, the adjustment credit is applied to the supply fan based on Table 15: Adjustment Credits (Multi-zone VAV) (W/cfm) and Table 16: Adjustment Credits, All Other Fan Systems (W/cfm). For all other systems, the exhaust fan adjustment credit is calculated based on Table 15: Adjustment Credits (Multi-zone VAV) (W/cfm) and Table 16: Adjustment Credits, All Other Fan Systems (W/cfm) and distributed to the exhaust fans based on the proposed system fan power ratio .

Table 17: Supply Fan Adjustments Credits, System 14 (W/cfm)

Device	<= 5,000 cfm	> 5,000 cfm; <= 10,000 cfm	> 10,000 cfm
Coil Runaround Loop (Multi-zone VAV)[1]	0.135	0.114	0.105

Source: California Energy Commission

1. The adjustment credit is determined using the total supply flow rate of all System 14 on the same building floor.

Table 18: Exhaust Fan Adjustments Credits, System 14 (W/cfm)

Device	<= 5,000 cfm	> 5,000 cfm; <= 10,000 cfm	> 10,000 cfm
Coil Runaround Loop (Multizone VAV)[1]	0.139	0.120	0.102

Source: California Energy Commission

1. The adjustment credit is determined using the total exhaust flow rate of all laboratory exhaust on the same building floor.

Standard Design: Existing Buildings: Same as proposed for new HVAC equipment; not applicable for existing, unaltered systems.

FAN ENERGY INDEX (FEI)

Applicability: All fans with a motor nameplate horsepower greater than 1.00 hp or with an electrical input power greater than 0.89 kW.

Definition: FEI is a ratio of the baseline electrical power divided by the fan's actual electrical input power calculated in accordance with ANSI/AMCA 208-18 Annex C.

This input is currently only used for mandatory minimum efficiency checks.

Units: Unitless ratio.

Input Restrictions: As designed.

The applicable fan shall have a FEI of 1.00 or higher. The applicable fan used for a variable-air-volume system that meets the requirements of Section 140.4(c)2 shall have an FEI of 0.95 or higher. If the fan FEI does not meet one of the requirements above, the compliance run shall fail unless the fan meets one of the EXCEPTIONs to Section 120.10(a).

Standard Design: Not applicable.

MULTISPEED FAN POWER RATIO

Applicability: Two-speed fans.

Definition: The ratio of part-load power to full-load power at the given fan flow.

Units: Unitless.

Input Restrictions: Not input. Same as standard design.

Standard Design:

Two-speed fans: 30 percent power at 50 percent flow.

5.7.3.3 Supply Fans

The standard design HVAC systems have supply fans.

SUPPLY FAN POWER RATIO

Applicability: All fan systems.

Definition: The standard design fan power requirements apply to all fans that operate at design conditions. To apportion the fan power to the supply, return/relief fan and exhaust fans, a ratio is defined that is the ratio of supply fan power to total system fan power.

Units: Unitless ratio.

Input Restrictions: Not a user input.

This is the ratio of the supply fan power to total system fan power, which includes supply, return/relief, and exhaust fans in zones served by a proposed HVAC system. If the proposed design does not have a return, relief or exhaust fan in the zones served by the system, this ratio is 1.0.

Standard Design: Same as proposed.

Standard Design: Existing Buildings: Same as proposed.

SUPPLY FAN DESIGN AIRFLOW

Applicability: All fan systems

Definition: The airflow rate of the supply fan(s) at design conditions.

This building descriptor sets the 100 percent point for the fan part-load curve.

Units: CFM (ft^3/min)

Input Restrictions: As designed*

* For systems with DX cooling coils, the airflow is typically between 250 and 500 cfm/$ton_{cooling}$. If the compliance software simulation engine limits the final calculated cfm/$ton_{cooling}$ to a certain range, the compliance software shall inform the user of this limitation.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others,

The program shall automatically size the airflow at each thermal zone to meet the loads. The design airflow rate calculation for exterior zones shall be based on a 20°F temperature differential between supply air and room air and a 15°F temperature differential for interior zones served by multiple zone systems. The design supply airflow rate is the larger of the flow rate required to meet space conditioning requirements and the required ventilation flow rate.

For multi-zone systems, the supply fan design airflow rate shall be the system airflow rate that satisfies the coincident peak of all thermal zones at the design supply air temperature.

For systems with cooling coils, a 115% multiplier is applied to the autosized airflow rate to be consistent with the cooling coil sizing multiplier.

FAN POSITION

Applicability: All supply fans.

Definition: The position of the supply fan relative to the cooling coil.

The configuration is either:

- Draw through (fan is downstream of the coil) or
- Blow through (fan is upstream of the coil).

Units List (see above).

Input Restrictions: As designed.

Standard Design: Draw through.

5.7.3.4 Return/Relief Fans

The standard design HVAC systems has a return or relief fan if any of the zone(s) in the proposed design are served by HVAC systems with return or relief fan. If the standard design is required to include exhaust air heat recovery, and the proposed design does not include a return and/or a relief fan, the standard design will be modeled with a return fan.

PLENUM ZONE

Applicability: Any system with return ducts or return air plenum.

Definition: A reference to the thermal zone that serves as return plenum or where the return ducts are located.

Units: Text, unique.

Input Restrictions: As designed.

Standard Design: Not applicable.

RETURN AIR PATH

Applicability: Any system with return ducts or return air plenum.

Definition: Describes the return path for air.

Can be:

- Ducted return,
- Via plenum zone(s), or
- Direct-to-unit.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For standard design systems, the return air path shall be direct-to-unit.

RETURN/RELIEF FAN POWER RATIO

Applicability: All thermal zones.

Definition: This is the ratio of the return or relief fan power divided by the total system fan power for the thermal zone. If the proposed design does not have a return or relief fan in the zones served by the system, this ratio is 0:0. This ratio is used to apportion the standard design fan power allowance to the standard design return/relief fan in a similar manner as the proposed design.

Units: Unitless ratio.

Input Restrictions: As designed, not a user input.

Standard Design: Same as proposed. When compliance scope does not include Mechanical or includes Partial Mechanical and a zone is specified as "HVAC Is Unknown," the return/relief fan power ratio shall be 0.

Standard Design: Existing Buildings: Same as proposed.

RETURN/RELIEF FAN DESIGN AIRFLOW

Applicability: All systems with a return or relief fan

Definition: The design airflow fan capacity of the return or relief fan(s).

This sets the 100 percent fan flow point for the part-load curve (see below).

Units: Cfm

Input Restrictions: As designed

Standard Design: For healthcare facilities, same as the Proposed Design. Otherwise, if the standard design has a return or relief fan, the design airflow will be equal to the standard design supply fan airflow less the system minimum outdoor air, or 90% of the standard design supply fan airflow, whichever is larger.

5.7.3.5 Exhaust Fans

The standard design shall track the proposed design exhaust flow rate up to the prescribed outside exhaust rate by space type. (See Appendix 5.4A for the standard design maximum exhaust rate.) Covered process exhaust includes garage ventilation, laboratory exhaust and exhaust from kitchens with more than 5,000 cfm of exhaust. Rules for the standard design covered process exhaust rate and fan power are discussed in the following chapters.

EXHAUST FAN POWER RATIO

Applicability: All thermal zones.

Definition: This is the ratio of the proposed exhaust fan power included in zones served by a proposed HVAC system, divided by the total proposed system fan power, which includes: supply, return/relief, and exhaust fans. If the proposed design does not have exhaust fans in zones served by an HVAC system, this ratio is 0.

Units: Unitless ratio.

Input Restrictions: As designed, not a user input.

Standard Design: Same as proposed. When compliance scope does not include Mechanical, or includes Partial Mechanical and a zone is specified as 'HVAC Is Unknown', the exhaust fan power ratio for both the proposed and standard design systems will be based on the ratio of exhaust flow to total system flow (supply + exhaust), unless the exhaust fan power is defined for a covered process that does not depend on the proposed exhaust fan power ratio, in which case the standard design exhaust fan power is set to the covered process defined level.

Standard Design: Existing Buildings: Same as proposed.

EXHAUST FAN DESIGN AIRFLOW

Applicability: All exhaust fan systems.

Definition: The rated design airflow rate of the exhaust fan system. This building descriptor defines the 100 percent flow point of the part-flow curve. Actual airflow is the sum of the flow specified for each thermal zone, as modified by the schedule for each thermal zone.

Units: Cfm.

Input Restrictions: As designed, but required if the space ventilation function results in a minimum exhaust rate to be provided. The total design exhaust flow capacity for building floor (conditioned space) shall not exceed the sum of building floor total outdoor airflow. The outdoor air can be brought into the building mechanically or drawn by the exhaust system through louvers at the zone. To specify air drawn through louvers users should set the exhaust air source as Direct Outside Air.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, same as proposed design unless the space ventilation function results in a minimum exhaust rate to be provided. In this case, the standard design shall be the code minimum exhaust. The design supply air ventilation rate for zone(s) may need to be adjusted by the compliance software, so that the total design outside air ventilation rate supplied to all zones on a floor equals the total exhaust fan design airflow for all zones on the floor.

EXHAUST FAN CONTROL METHOD

Applicability: All exhaust fan systems.

Definition: A description of how the exhaust fan(s) are controlled. The options include:

- Constant-flow, constant speed fan.
- Variable-flow, constant speed fan.
- Variable-flow, variable speed fan.

For laboratories the options are:

- Constant-flow, constant speed fan with bypass damper.
- Constant-flow, constant speed fan without bypass damper.
- Variable-flow, constant speed fan with bypass damper.
- Variable-flow, variable volume fan without bypass damper.

- Variable-flow, variable volume fan with bypass damper.

Units: List (see above)

Input Restrictions: As designed, when exhaust fan flow at the thermal zone level is varied through a schedule, one of the variable-flow options shall be specified.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others,

The standard design exhaust fan control shall be the same as the proposed design, but subject to the conditions described above.

For exhaust fans serving kitchen spaces, the fan control method is constant volume for fans with flow rate of 5,000 cfm and below, and variable flow, variable speed drive for fans with flow rate greater than 5,000 cfm.

For exhaust fans serving laboratory spaces, the fan control method is variable-flow, constant speed fan with bypass damper. The airflow entering the exhaust fans is constant even though the exhausted conditioned airflow from the lab spaces varies in accordance with the larger of schedules of fume hood fraction, minimum ACH (circulation rate), and airflow required for heating and cooling. As exhaust airflow from the lab spaces decreases, bypass air correspondingly increases, and as a result, the airflow out of the stack is constant and the exhaust fan draws design power continuously when it is on.

EXHAUST FAN EFFICIENCY

Applicability: Any exhaust fan system that uses the static pressure method.

Definition: The efficiency of the exhaust fan at rated capacity.

This is the static efficiency and does not include losses through the motor.

Units: Unitless.

Input Restrictions: None.

Standard Design: For healthcare facilities covered process exhaust, same as the Proposed Design. For all other healthcare facility fans 65%.

For kitchen exhaust fans, the fan efficiency is 50%, while for lab exhaust it is 62%.

For all other exhaust fans, the standard design efficiency is 65%.

EXHAUST FAN POWER INDEX

Applicability: All exhaust systems.

Definition: The fan power of the exhaust fan per unit of flow.

This building descriptor is applicable only with the power-per-unit-flow method.

Units: W/CFM.

Input Restrictions: As designed. When an anemometer and/or contaminant controls are used in the proposed design the fan power is reduced by 0.2 W/cfm.

Standard Design: For healthcare facilities with total system fan power greater than or equal to 1 kW and the system is not DOAS, power-per-unit-flow allowance based on the components in the proposed system according to 140.4(c)1 of the Energy Code. For all other health care facilities, same as the Proposed Design.

For laboratory exhaust, where the building lab design exhaust flow exceeds 10,000 cfm, 0.65 W/cfm. If the user designates that the system includes scrubbers or other air treatment devices, the standard design exhaust fan power shall be 0.85 W/cfm.

For kitchen exhaust, 0.65 W/CFM.

For hotel/motel guestrooms, 0.58 W/CFM.

5.7.3.6 Garage Exhaust Fan Systems

When garage exhaust fan systems are modeled the fans shall be modeled as constant volume fans, with the fan power determined by whether or not the fan has CO controls.

GARAGE EXHAUST FAN RATED CAPACITY

Applicability: All garage exhaust systems.

Definition: The rated design airflow rate of the garage exhaust fan system.

Units: Cfm.

Input Restrictions: As designed.

Standard Design: Same as proposed design.

GARAGE EXHAUST FAN CONTROL METHOD

Applicability: All garage exhaust fan systems.

Definition: The control method for the garage exhaust fan.

This input determines the fan power for the exhaust fan. No other fan inputs are required.

Units: List No CO control, or CO control.

Input Restrictions: None.

If constant volume is selected, proposed fan power is as designed.

If CO control is selected, proposed fan power is 12.5 percent of the design fan power.

Standard Design: Same as proposed.

5.7.3.7 Duct Systems in Unconditioned Space

DUCT LEAKAGE ECC FAN POWER ADJUSTMENT

Applicability: Single zone, constant volume systems with ducts in unconditioned space, serving < 5000 ft^2 conditioned floor area.

Definition: Fan power energy usage adjusted based on the testing performed when ducts are in unconditioned spaces.

Units: List: Penalty, No Change Credit.

Input Restrictions: Not a user input.

If the ECC duct leakage testing isn't done when required, or if the testing fails the duct leakage rate criteria the fan power is simulated with a 30% increase to represent increased energy usage from duct leakage.

Although testing is not required, if ECC testing is performed and leakage rates are verified, the fan power is simulated with a 14% decrease to represent decreased energy usage from low duct leakage.

For all other cases the fan power is simulated with no change.

Standard Design: No Change.

5.7.4 Outdoor Air Controls and Economizers

5.7.4.1 Outside Air Controls

MAXIMUM OUTSIDE AIR RATIO

Applicability: All systems with modulating outside air dampers.

Definition: The descriptor is used to limit the maximum amount of outside air that a system can provide as a percentage of the design supply air. It is used where the installation has a restricted intake capacity.

Units: Ratio.

Input Restrictions: 1.0 for 100% outdoor air systems. As designed for all systems above 33,000 Btu/h net cooling capacity. As designed up to 0.9 for other systems.

Standard Design: 1.0 for all systems above 33,000 Btu/h net cooling capacity; 0.9 for other systems.

DESIGN OUTSIDE AIRFLOW

Applicability: All systems with outside air dampers.

Definition: The rate of outside air that needs to be delivered by the system at design conditions. This input may be derived from the sum of the design outside airflow for each of the zones served by the system.

Units: Cfm.

Input Restrictions: As designed but no lower than the ventilation rate of the standard design.

Standard Design: For healthcare facilities, same as the Proposed Design.

For systems serving laboratory spaces, the system shall be 100 percent outside air.

OUTDOOR AIR CONTROL METHOD

Applicability: All HVAC systems that deliver outside air to zones.

Definition: The method of determining the amount of outside air that needs to be delivered by the system.

Each of the zones served by the system report their outside air requirements on an hourly basis. The options for determining the outside air at the zone level are discussed above. This control method addresses how the system responds to this information on an hourly basis. Options include:

Average Flow — The outside air delivered by the system is the sum of the outside air requirement for each zone, without considering the position of the VAV damper in each zone. The assumption is that there is mixing between zones through the return air path.

Units: List (see above).

Input Restrictions: Average Flow.

Standard Design: Average Flow.

5.7.4.2 Air Side Economizers

ECONOMIZER CONTROL TYPE

Applicability: All systems with an air-side economizer

Definition: An air-side economizer increases outside air ventilation during periods when system cooling loads can be reduced from increased outside airflow. The control types include:

- No economizer: No air-side economizer.
- Fixed dry-bulb: The economizer is enabled when the dry-bulb temperature of the outside air is equal to or lower than dry-bulb temperature fixed setpoint (e.g., 75°F).

- Differential dry-bulb: The economizer is enabled when the dry-bulb temperature of the outside air is lower than the return air dry-bulb temperature.
- Differential enthalpy: The economizer is enabled when the enthalpy of the outside air is lower than the return air enthalpy.
- Differential dry-bulb and enthalpy: The system shifts to 100 percent outside air or the maximum outside air position needed to maintain the cooling SAT setpoint, when the outside air dry-bulb temperature is less than the return air dry-bulb temperature AND the outside air enthalpy is less than the return air enthalpy. This control option requires additional sensors.

Units: List (see above)

Input Restrictions: As designed

Standard Design: The control should be no economizer when the standard design net cooling capacity is less than 33,000 Btu/h and when the standard design cooling system is not a computer room system. Otherwise, the standard design shall assume an integrated fixed dry-bulb economizer.

If the following exceptions apply, the standard design system shall not include an economizer:

- Systems serving multifamily dwelling units or hotel/motel guestroom occupancies.
- Systems serving healthcare facilities with Standard Design net cooling capacity less than 54,000 Btu/h where ventilation is provided by a DOAS with heat recovery.
- When the proposed design includes a mechanical system for an individual computer room zone with an information technology equipment (ITE) design load under 18 kW and all other cooling systems in the proposed design do not have an economizer. If the compliance scope is Partial Mechanical this exception only applies if the computer room zone has a proposed system and all cooling systems included in the proposed mechanical scope (including the computer room) do not have economizers. If the computer room zone does not have a proposed system specified, both the proposed and standard design have an integrated fixed dry-bulb economizer.
- Single zone unitary air conditioner and heat pumps with rated cooling capacity less than 54,000Btu/hr if the compliance scope is Addition and/or Alteration.

For healthcare facilities, DOAS with heat recovery shall be assumed to have a fixed dry-bulb economizer.

ECONOMIZER INTEGRATION LEVEL

Applicability: Airside economizers.

Definition: This input specifies whether or not the economizer is integrated with mechanical cooling. It is up to the compliance software to translate this into software-specific inputs to model this feature. The input could take the following values:

- Nonintegrated — The system runs the economizer as the first stage of cooling. When the economizer is unable to meet the load, the economizer returns the outside air damper to the minimum position and the compressor turns on as the second stage of cooling.
- Integrated — The system can operate with the economizer fully open to outside air and mechanical cooling active (compressor running) simultaneously, even on the lowest cooling stage.

Units: List (see above).

Input Restrictions: List non-integrated or integrated.

Standard Design: Integrated for systems above capacity 33,000 Btu/h net cooling capacity.

ECONOMIZER HIGH TEMPERATURE LOCKOUT

Applicability: Systems with fixed dry-bulb economizer.

Definition: The outside air setpoint temperature above which the economizer will return to minimum position.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: The required high temperature lockout is based on Table 140.4-G for fixed dry bulb device types. For computer rooms with containment, the economizer shall have a fixed dry-bulb high limit of 80°F.

- Climate Zones 1, 3, 5, 11-16 –75 °F
- Climate Zones 2, 4, 10 –73 °F
- Climate Zones 6, 8, 9 - 71 °F
- Climate Zone 7 - 69 °F

ECONOMIZER LOW TEMPERATURE LOCKOUT

Applicability: Systems with air-side economizers

Definition: A feature that permits the lockout of economizer operation (return to minimum outside air position) when the outside air temperature is below the lockout setpoint.

Units: Degrees Fahrenheit (F°)

Input Restrictions: As designed

Standard Design: Not applicable.

ECONOMIZER HIGH ENTHALPY LOCKOUT

Applicability: Systems with differential enthalpy economizers.

Definition: The outside air enthalpy above which the economizer will return to minimum position.

Units: Btu/lb.

Input Restrictions: As designed.

The default is 28 Btu/lb (high altitude locations may require different setpoints.) The compliance software shall apply a fixed offset and add 2 Btu/lb to the user-entered value.

Standard Design: Not applicable.

5.7.4.3 Pumped Refrigerant Economizers

COMPUTER ROOM PUMPED REFRIGERANT ECONOMIZER

Applicability: Computer room air conditioner systems with pumped refrigerant economizers (PRE).

Definition: PRE systems provide partial cooling without the use of the computer room air conditioner system's compressor(s). If enabled, the economizer effect is embedded in PRE specific performance curves for cooling capacity and efficiency (Appendix 5.7).

Units: Boolean, true or false.

Input Restrictions: Only systems with PRE serving computer rooms may enable this function. No other economizer types may be used in combination with PRE and all other economizer inputs in this section are not applicable to PRE systems.

Standard Design: Not applicable.

5.7.5 Cooling Systems

5.7.5.1 General

This group of building descriptors applies to all cooling systems.

COOLING SOURCE

Applicability: All systems.

Definition: The type of cooling for the system.

Units: List

- Chilled water,
- Direct expansion (DX), or
- VRF.

Input Restrictions: As designed. When a system has a 'heat pump' heating coil type, the system shall also include a DX cooling coil. For VRF systems, the VRF coil type should be specified.

Standard Design: For healthcare facilities, same as the proposed design. For all others refer to the HVAC system map in 5.1.3 HVAC System Map for the prescribed type.

Standard Design: Existing Buildings: Same as proposed for existing, unaltered systems.

GROSS TOTAL COOLING CAPACITY

Applicability: All cooling systems.

Definition: The total gross cooling capacity (both sensible and latent) of a cooling coil or packaged DX system at AHRI conditions. The building descriptors defined in this chapter assume that the fan is modeled separately, including any heat it adds to the air stream. The cooling capacity specified by this building descriptor should not consider the heat of the fan.

Units: Btu/h.

Input Restrictions: As designed for systems with chilled water coils. For DX coils, calculated by program from net capacity.

For computer room air conditioners, (CRAC) gross total cooling capacity is equal to gross sensible cooling capacity.

For other packaged or VRF equipment with the fan motor in the air stream such that it adds heat to the cooled air, the compliance software shall calculate the net total cooling capacity as follows:

$$Q_{t,net,rated} = Q_{t,gross,rated} - Q_{fan,rated}$$

Where:

> $\boldsymbol{Q_{t,net,rated}}$ – The net total cooling capacity of a packaged unit as rated by AHRI (Btu/h)
> $\boldsymbol{Q_{t,gross,rated}}$ – The gross total cooling capacity of a packaged unit (Btu/h)
> $Q_{fan,rated}$; - The heat generated by the fan and fan motor (if fan motor is in airstream) at AHRI rated conditions

For CRAC systems, the fan heat at AHRI 1360 rated conditions is calculated based on the user input fan power at rated conditions as follows:

$$Q_{fan,rated}(Btu/hr) = FanPower_{rated,user}(kW) \times 3412$$

For all other DX coils, the fan heat at rated conditions shall be accounted for by using the equation below:

$$Q_{fan,rated} = Q_{t,gross,rated} \times 0.0415$$

This equation is based on an AHRI rated fan power of 0.365 W/cfm, and a cooling airflow of 400 cfm/ton.

Standard Design: For healthcare facilities, the gross total cooling capacity is the same as the Proposed Design with an adjustment to account for fan heat of the Standard Design. For all others, the capacity of the systems in the standard design is determined from a sizing run. See Chapter 2.6.2. Sizing Equipment in Standard Design.

GROSS SENSIBLE COOLING CAPACITY

Applicability: Computer room air conditioner (CRAC).

Definition: The gross sensible cooling capacity of the coil or packaged equipment at AHRI 1360 rated conditions. The building descriptors defined in this chapter assume that the fan is modeled separately, including any heat it adds to the air stream. The cooling capacity specified by this building descriptor should be adjusted to calculate the net sensible cooling capacity, which includes the effect of fan motor heat.

The sensible heat ratio (SHR) used by some energy simulation tools can be calculated from the sensible cooling capacity and total cooling capacity:

SHR = sensible cooling capacity/total cooling capacity

Units: Btu/h.

Input Restrictions: Not input.

The compliance software calculates the gross sensible cooling capacity to account for the effect of fan motor heat as follows:

$$Q_{s,gross,rated} = Q_{s,net,rated} + Q_{fan,rated}$$

Where:

$Q_{s,net,rated}$: The AHRI rated net sensible cooling capacity (Btu/h)
$Q_{t,gross,rated}$: The AHRI rated gross sensible cooling capacity (Btu/h)
$Q_{fan,rated}$: The heat generated by the fan motor at AHRI rated conditions (Btu/h). Calculated as fan power at AHRI rated conditions times 3.412. See rated fan power building descriptor for details.

Because the rating condition of CRAC units is based on AHRI 1360 and the performance curves in Appendix 5.7, used by CRAC and other HVAC system types, are normalized to AHRI 210/240 conditions, the CRAC gross capacity must be adjusted as follows:

$$Q_{s,gross,sim} = \frac{Q_{s.gross.rated}}{Curve_{cap,temp}(AHRI\ 1360\ condition)}$$

Where:

$Q_{s,gross,sim}$: The simulated gross sensible cooling capacity (Btu/h)

$Curve_{cap,temp}$: The output of capacity adjustment curve as a function of temperature.

Standard Design: The capacity of the systems in the standard design is determined from a sizing run. See 2.6.2 Sizing Equipment in the Standard Design.

NET TOTAL COOLING CAPACITY

Applicability: All systems with DX coils except computer room air conditioners.

Definition: The total net cooling capacity (both sensible and latent) of a cooling coil or packaged DX system at AHRI rated conditions from manufacturers' literature. The cooling capacity specified by this building descriptor should account for fan heat.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: Not applicable.

NET SENSIBLE COOLING CAPACITY

Applicability: Computer room air conditioner (CRAC).

Definition: The net sensible cooling capacity of a computer room air conditioner at the AHRI 1360 rated condition from manufacturers' literature. The cooling capacity specified by this building descriptor should account for fan heat.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: Not applicable.

GROSS TOTAL COOLING CAPACITY CURVE

Applicability: All cooling systems.

Definition: A curve that represents the available total cooling capacity as a function of cooling coil and/or condenser conditions. The common form of these curves is given as follows:

$Q_{t,available} = CAP_{FT} \times Q_{t,adj}$

For air-cooled direct expansion:

$$CAP_{FT} = a + b(t_{wb}) + c(t_{wb})^2 + d(t_{odb}) + e(t_{odb})^2 + f(t_{wb} \times t_{odb})$$

For water-cooled direct expansion:

$$CAP_{FT} = a + b(t_{wb}) + c(t_{wb})^2 + d(t_{wt}) + e(t_{wt})^2 + f(t_{wb} \times t_{wt})$$

For chilled water coils:

$$CAP_{FT} = a + b(t_{wb}) + c(t_{wb})^2 + d(t_{db}) + e(t_{db})^2 + f(t_{wb} \times t_{db})$$

Where:

- $\boldsymbol{Q_{t,available}}$ – Available cooling capacity at specified evaporator and/or condenser conditions (MBH)
- $\boldsymbol{Q_{t,adj}}$ – Adjusted capacity at AHRI conditions (Btu/h)
- $\boldsymbol{CAP_{FT}}$ – A multiplier to adjust $Q_{t,adj}$
- $\boldsymbol{t_{wb}}$ – The entering coil wet-bulb temperature (°F)
- $\boldsymbol{t_{db}}$ – The entering coil dry-bulb temperature (°F)
- $\boldsymbol{t_{wt}}$ – The water supply temperature (°F)
- $\boldsymbol{t_{odb}}$ – The outside air dry-bulb temperature (°F)

Note: If an air-cooled unit employs an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.

Compliance software may represent the relationship between cooling capacity and temperature in ways other than the equations given above.

Units: Data structure.

Input Restrictions: Where applicable, curves are prescribed based on system type, see Appendix 5.7.

Standard Design: Use the default curves or equivalent data for other models.

COIL LATENT MODELING METHOD

Applicability: All DX cooling systems.

Definition: The method of modeling coil latent performance at part-load conditions.

Units: List.

Input Restrictions: One of the following values:

Bypass factor – used by DOE-2 based programs.

NTU-effectiveness – used by EnergyPlus™.

Standard Design: Same as proposed.

RATED FAN POWER

Applicability: Computer room air conditioner (CRAC).

Definition: The power of the supply fan of the computer room air conditioner at the AHRI 1360 rated condition.

Units: kW.

Input Restrictions: Same as the reported value in the product document.

Standard Design: When the standard design system is a computer room air conditioner the rated fan power is 0.58 W/CFM (approximate value of 27 W/kBtu-h of net sensible cooling capacity assuming design air flow rate is based on 20°F temperature differential between supply air and room air).

5.7.5.2 Hydronic/Water-Source Cooling Coils

DESIGN WATER FLOW RATE

Applicability: Chilled water coils and water cooled DX coils.

Definition: The design flow rate of the chilled water coil or the condenser coil of a water-source heat pump.

Units: Gallons per minute (gpm).

Input Restrictions: None. Default based on gross capacity of the chilled water coil or heat rejection load of a water-source heat pump coil at the design deltaT of the attached hydronic loop.

Standard Design: For healthcare facilities, same as the Proposed Design. For all baseline systems with chilled water coils, default based on gross capacity at the design deltaT of the attached hydronic loop as follows.

$$FlowRate_{coil} = \frac{Capacity_{coil}}{500.19 \times \Delta T_{loop}}$$

Where:

- $FlowRate_{coil}$ – Chilled water coil water flow rate (gpm)
- $Capacity_{coil}$ – Chilled water coil gross capacity (Btu/h)
- ΔT_{loop} – the design deltaT of the attached hydronic loop (°F)

DESIGN PRESSURE DROP

Applicability: Chilled water coils and water cooled DX coils.

Definition: The design pressure drop through the chilled water coil or the condenser coil of a water-source heat pump. For coils with water-source condensers, the pressure drop is used to calculate the simulated energy input ratio (EIR) by removing the power consumed by pumps from the rated Energy Efficiency Ratio (EER). For all other water coils, this property does not affect the simulation of the coil or fluid system, it is used as a reference or reporting only.

Units: Feet of water (ftH2O).

Input Restrictions: None. Default to 5ft.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

5.7.5.3 Direct Expansion

ENERGY EFFICIENCY RATIO (EER/EER2)

Applicability: All DX cooling systems except variable refrigerant flow (VRF) systems.

Definition: The Energy Efficiency Ratio (EER) is the cooling efficiency of a direct expansion (DX) cooling system at AHRI rating conditions as a ratio of output over input in Btu/h per W, excluding fan energy. For all unitary and applied equipment where the fan energy is part of the equipment efficiency rating, the EER shall be adjusted as follows:

$$EER_{adj} = \frac{Q_{t,net,rated} + Q_{fan,rated}}{\frac{Q_{t,net,rated}}{EER} - \frac{Q_{fan,rated}}{3.413} - PumpPwr_{rated}}$$

Where:

$\boldsymbol{EER_{adj}}$ - The adjusted EER for simulation purposes

$\boldsymbol{EER}$ - The rated EER

$\boldsymbol{Q_{t,net,rated}}$ - The AHRI rated total net cooling capacity of a packaged unit (kBtu/h)

$\boldsymbol{Q_{fan,rated}}$ - The AHRI rated fan energy, specified in the gross total cooling capacity building descriptor (Btu/h).

$PumpPwr_{rated}$ – The AHRI rated pump power (Watts). Only applicable to packaged water-source heat pumps

Units: Btu/h-W.

Input Restrictions: As designed, except that the user-entered value must meet mandatory minimum requirements of the Energy Code for the applicable equipment type. For packaged equipment with cooling capacity less than 65,000 Btu/h, specify the EER/EER2 along with the SEER/SEER2 when available from manufacturer's literature or AHRI certificate. For equipment with capacity above 65,000 Btu/h that are required to have a EER/EER2 rating, the EER/EER2 must be specified.

When EER/EER2 is not available for packaged equipment with SEER/SEER2 ratings (AHRI cooling capacity of 65,000 Btu/h or smaller), it shall be calculated as follows:

$$EER = MIN(-0.0194 \times SEER^2 + 1.0864 \times SEER, 13)$$

The default EER/EER2 shall be calculated by the equation above but constrained to be no greater than 13. For SEER2 rated systems, SEER2 is first converted to SEER using conversions listed below, and then SEER is used in the equation above for calculating EER. Evaporative cooling systems that pass the requirements of the Western Cooling Challenge may be modeled with an EER/EER2 as if the equipment were packaged unitary equipment. See 5.7.5.4 Evaporative Cooler.

A conversion factor is used to convert EER2 to EER ratings for modeling. For all cooling equipment the conversion factor is 1/0.96 to convert EER2 to EER. A conversion factor is used to convert SEER2 to SEER ratings for modeling. For split-system equipment the conversion factor is 1/0.95; for single-package equipment the conversion factor is 1/0.96; for small-duct high-velocity the conversion factor is 1.00; and for space-constrained equipment the conversion factor is 1/0.99 to convert SEER2 to SEER.

Standard Design: Use the minimum cooling efficiency (EER/EER2) from the Energy Code for the applicable equipment type.

SEASONAL ENERGY EFFICIENCY RATIO (SEER/SEER2)

Applicability: DX equipment with AHRI cooling capacity of 65,000 Btu/h or smaller

Definition: The seasonal energy efficiency ratio (SEER/SEER2) is a composite rating for a range of part-load conditions at specific ambient conditions.

Units: Btu/h-W.

Input Restrictions: As designed.

This input is required for packaged DX systems less than 65,000 Btu/h that are required to have a SEER/SEER2 rating. A conversion factor is used to convert SEER2 to SEER ratings for modeling. For split-system equipment the conversion factor is 1/0.95; for single-package equipment the conversion factor is 1/0.96; for small-duct high-velocity the conversion factor is 1.00; and for space-constrained equipment the conversion factor is 1/0.99 to convert SEER2 to SEER.

Standard Design: Use the minimum SEER. The standard design system 1 is assumed to use 1-phase power, otherwise the standard design uses 3-phase power.

INTEGRATED ENERGY EFFICIENCY RATIO (IEER)

Applicability: DX equipment with AHRI cooling capacity of 65,000 Btu/h or greater.

Definition: IEER is a composite rating for a range of part-load conditions and different ambient conditions. The rating is determined according to AHRI procedures. Equipment with this rating is subject to mandatory minimum requirements.

This input is currently only used for mandatory minimum efficiency checks.

Units: Btu/h-W.

Input Restrictions: As designed, the user-entered value must meet mandatory minimum requirements of the Energy Code for the applicable equipment type.

Standard Design: Not applicable.

DIRECT EXPANSION COOLING EFFICIENCY TEMPERATURE ADJUSTMENT CURVE

Applicability: DX equipment.

Definition: A curve that varies the cooling efficiency of a direct expansion (DX) coil as a function of evaporator conditions, and condenser conditions.

For air-cooled DX systems:

$$EIR_{FT} = a + b(t_{wb}) + c(t_{wb})^2 + d(t_{odb}) + e(t_{odb})^2 + f(t_{wb})(t_{odb})$$

For water-cooled DX systems:

$$EIR_{FT} = a + b(t_{wb}) + c(t_{wb})^2 + d(t_{wt}) + e(t_{wt})^2 + f(t_{wb})(t_{wt})$$

$$P_{operating} = P_{rated}(EIR_{FPLR})(EIR_{FT})(CAP_{FT})$$

Where:

- $\boldsymbol{EIR_{FPLR}}$ - Part-load ratio based on available capacity (not rated capacity)
- $\boldsymbol{EIR_{FT}}$ - A multiplier on the EIR to account for the wet-bulb temperature entering the coil and the outdoor dry-bulb temperature, or the wet-bulb temperature entering the coil and the water supply temperature.
- $\boldsymbol{t_{wb}}$ - The entering coil wet-bulb temperature (F)
- $\boldsymbol{t_{wt}}$ - The water supply temperature (F)

- t_{odb} - The outside-air dry-bulb temperature (F)
- P_{rated} - Rated power draw at AHRI conditions (kW)
- $P_{operating}$ - Power draw at specified operating conditions (kW)
- CAP_{FT} - A multiplier to adjust cooling capacity

Units: Data structure.

Input Restrictions: Where applicable, curves are prescribed based on system type, see Appendix 5.7.

For all systems except packaged DX units with cooling capacity equal to or less than 65,000 Btu/h, use default curves from Appendix 5.7. For packaged DX units with cooling capacity equal to or less than 65,000 Btu/h that have SEER/SEER2 ratings, the user inputs EER/EER2 and SEER/SEER2, or if EER/EER2 is not known, it is calculated using the equation in 5.7.5.3 Direct Expansion. The compliance software generates the nine bi-quadratic equipment performance curve points (67, 95, 1.0*; 57, 82, $NEIR_{57,82}$; 57, 95, $NEIR_{57,95}$; 57,110,$NEIR_{57,110}$; 67, 82, $NEIR_{67,82}$; 67,110, $NEIR_{67,110}$; 77, 82, $NEIR_{77,82}$; 77, 95, $NEIR_{77,95}$; and 77,110, $NEIR_{77,110}$) based on SEER/SEER2 and EER/EER2 inputs and the following formulas.

*At ARI Test Condition, the curve output should be 1.0

$NEIR_{WBT,ODB}$ represents the normalized energy input ratio (EIR) for various entering wet-bulb (EWB) and outside dry-bulb (ODB) temperatures. The value represents the EIR at the specified EWB and ODB conditions to the EIR at standard ARI conditions of 67°F wet-bulb and 95°F dry-bulb. The COOL-EIR-FT curve is normalized at ARI conditions of 67°F entering wet-bulb and 95°F outside dry-bulb so NEIR67,95 is one or unity, by definition. For other EWB and ODB conditions, values of NEIR are calculated with Equation below.

$$NEIR_{EWB,ODB} = \frac{EIR_{EWB,ODB}}{EIR_{67,95}}$$

The energy input ratio (EIR) is the unitless ratio of energy input to cooling capacity. EIR includes the compressor and condenser fan, but not the supply fan. If the energy efficiency ratio EERnf (EER excluding the fan energy) is known for a given set of EWB and ODB conditions, the EIR for these same conditions is given by Equation below.

$$EIR_{EWB,ODB} = \frac{3.413}{EERnf_{EWB,ODB}}$$

If the EER (including fan energy) is known for a given set of EWB and ODB conditions, then the EERnf (no fan) can be calculated from Equation N2-1below.

Equation N2-1 $$EERnf_{EWB,ODB} = 1.0452 \times EER_{EWB,ODB}$$

$$+0.0115 \times EER_{EWB,ODB}{}^2$$
$$+0.000251 \times EER_{EWB,ODB}{}^3$$

The EER for different EWB and ODB conditions. These are given by the following equations.

Equation N2-2 $EER_{67,82} = SEER$

Equation N2-3 $EER_{67,95} = From\ Manufacuters\ Data$ [when available]

$EER_{67,95} = 10 - (11.5 - SEER) \times 0.83$ [Default for SEER < 11.5]

$EER_{67,95} = 10$ [default for SEER>11.5]

Equation N2-4 $EER_{67,110} = EER_{67,95} - 1.8$

Equation N2-5 $EER_{57,008} = 0.877 \times EER_{67,008}$

Equation N2-6 $EER_{77,008} = 1.11 \times EER_{67,008}$

A conversion factor is used to convert EER2 to EER ratings for modeling. For all air conditioners the conversion factor is 1/0.96 to convert EER2 to EER. A conversion factor is used to convert SEER2 to SEER ratings for modeling. For split-system equipment the conversion factor is 1/0.95; for single package equipment the conversion factor is 1/0.96; for small-duct high-velocity the conversion factor is 1.00; and for space-constrained equipment the conversion factor is 1/0.99 to convert SEER2 to SEER.

Standard Design: Use prescribed curves as described above.

Number of Cooling Stages

Applicability: Single-zone VAV systems and DX systems with multiple stages.

Definition: This applies to single-zone VAV and any HVAC systems with multiple compressors or multiple discrete stages of cooling. This system is a packaged unit with multiple compressors and a two-speed or variable-speed fan.

Units: None (Integer).

Input Restrictions: As designed, but systems with more than two stages will be modeled with two stages.

Standard Design: The standard design shall be two for the single-zone VAV baseline and packaged VAV baseline.

Total Cooling Capacity Ratio by Stage

Applicability: Single-zone VAV systems and DX systems with multiple stages.

Definition: This provides the total cooling capacity of each cooling stage, at AHRI rated conditions. The capacity is expressed as an array, with each entry a fraction of the total rated cooling capacity for the unit. For example, if the stage cooling capacity is 4 tons (48,000 Btu/h) and the total cooling capacity is 8 tons (96,000 Btu/h), the capacity is expressed as "0.50" for that stage.

Units: Array of fractions.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, the default shall be (0.50, 1) for the single zone VAV baseline.

CONDENSER TYPE

Applicability: All direct expansion systems including heat pumps.

Definition: The type of condenser for a DX cooling system.

The choices are:

- Air-cooled
- Water-cooled

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, based on the prescribed system type.

Refer to the HVAC System Map in 5.1.3 HVAC System Map.

CRANK CASE HEATER KW

Applicability: Air conditioners.

Definition: The capacity of the electric resistance heater in the crank case of a direct expansion (DX) compressor. The crank case heater operates only when the compressor is off.

Units: Kilowatts (kW).

Input Restrictions: Where applicable, the value is prescribed to be 10 W per ton (rated net cooling capacity).

Standard Design: Where applicable, the value is prescribed to be 10 W per ton (rated net cooling capacity).

CRANK CASE HEATER SHUTOFF TEMPERATURE

Applicability: All air source heat pumps and air conditioners.

Definition: The outdoor air dry-bulb temperature above which the crank case heater is not permitted to operate.

Units: Degrees Fahrenheit (°F).

Input Restrictions: Where applicable, the value is prescribed to be 50°F.

Standard Design: Where applicable, the value is prescribed to be 50°F.

SUPPLEMENTARY DX COOLING UNIT

Applicability: Required when no cooling system is specified, or can be added by the user when a zone has excessive unmet cooling load hours.

Definition: A supplementary DX cooling system that only operates when the thermostat cooling setpoint is not maintained by the proposed space conditioning equipment.

Units: None.

Input Restrictions: The compliance software shall define the following prescribed system characteristics:

Cooling capacity – Auto-sized by compliance software.

System airflow – Auto-sized by compliance software.

Fan power – None, system is assumed to cycle on fan/compressor only when cooling is needed.

Efficiency – Minimum value specified by the Energy Code for a packaged DX system, based on the calculated net cooling capacity and assuming 3-phase equipment. No adjustment of efficiency for rated fan heat because system fan cycles on only when cooling coil is energized.

Economizer - none

Design supply air temperature - 55°F

Supply air temperature control - None

Standard Design: Not applicable. With the exception of a qualified heating only system which is modeled with a system sized to meet the cooling load.

NET SENSIBLE COEFFICIENT OF PERFORMANCE (NSENCOP)

Applicability: Computer room air conditioner (CRAC)

Definition: A dimensionless ratio of the Net Sensible Cooling Capacity to the total power input (excluding reheaters and humidifiers) at AHRI 1360 rated conditions. NSenCOP must be adjusted as follows to determine the simulated COP:

$$COP_{sim} = \frac{Q_{s,net,rated} + Q_{fan,rated}}{\frac{Q_{s,net,rated}}{NSenCOP} - Q_{fan,rated}} \times Curve_{EIR,temp}(AHRI\ 1360\ condition)$$

Where:

COP_{sim}: The coefficient of performance for simulation purposes

$Q_{s,net,rated}$: The net sensible cooling capacity, see the corresponding descriptor.

$Q_{fan,rated}$: The heat generated by the fan and fan motor at AHRI 1360 rated conditions (Btu/h). Which is calculated as fan power at AHRI 1360 rated conditions times 3.412. See the rated fan power building descriptor.

$Curve_{EIR,temp}$: The output of Energy Input Ratio (EIR) adjustment curve as a function of temperature.

Units: Unitless.

Input Restrictions: As designed.

Standard Design: Federal minimum efficiency for floor-mounted (downflow) configuration.

5.7.5.4 Evaporative Cooler

This is equipment that cools without the use of a vapor compression cycle. This equipment is not applicable for the standard design.

A supplementary DX cooling unit will be added to the zone if evaporative cooling is the only cooling source. See 5.7.5.3 Direct Expansion.

EVAPORATIVE COOLING TYPE

Applicability: Systems with evaporative cooling.

Definition: The type of evaporative cooler, including:

- Direct
- Indirect

An integrated cooler can operate together with compressor or chilled water (CHW) cooling. A non-integrated cooler will shut down the evaporative cooling whenever it is unable to provide 100 percent of the cooling required.

Units: List, see above.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

DIRECT STAGE EFFECTIVENESS

Applicability: Systems with evaporative cooling.

Definition: The effectiveness of the direct stage of an evaporative cooling system. Effectiveness is defined as:

$$Direct_{EFF} = \frac{T_{db} - T_{direct}}{T_{db} - T_{wb}}$$

Where:

$\boldsymbol{Direct_{EFF}}$ - The direct stage effectiveness
$\boldsymbol{T_{db}}$ - The entering air dry-bulb temperature
$\boldsymbol{T_{wb}}$ - The entering air wet-bulb temperature
$\boldsymbol{T_{direct}}$ - The direct stage leaving dry-bulb temperature

Units: Numeric (0 ≤ EFF ≤1).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

INDIRECT STAGE EFFECTIVENESS

Applicability: Systems with evaporative cooling.

Definition: The effectiveness of the indirect stage of an evaporative cooling system. Effectiveness is defined as:

$$Indirect_{EFF} = \frac{T_{db} - T_{indirect}}{T_{db} - T_{wb}}$$

Where:

- $\boldsymbol{Indirect_{EFF}}$ - The indirect stage effectiveness
- $\boldsymbol{T_{db}}$ - The entering air dry-bulb temperature
- $\boldsymbol{T_{wb}}$ - The entering air wet-bulb temperature
- $\boldsymbol{T_{indirect}}$ - The indirect stage leaving dry-bulb temperature

Units: Numeric (0 ≤ EFF ≤1).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

EVAPORATIVE COOLING PERFORMANCE CURVES

Applicability: Systems with evaporative cooling.

Definition: A curve that varies the evaporative cooling effectiveness as a function of primary air stream airflow. The default curves are given as:

$$PLR = \frac{CFM_{operating}}{CFM_{design}}$$

$$EFF_{FFLOW} = a + b(PLR) + c(PLR)^2$$

Where:

- $\boldsymbol{PLR}$ - Part load ratio of airflow based on design airflow
- $\boldsymbol{EFF_{FFLOW}}$ - A multiplier on the evaporative cooler effectiveness to account for variations in part load
- $\boldsymbol{CFM_{operating}}$ - Operating primary air stream airflow (cfm)
- $\boldsymbol{CFM_{design}}$ - Design primary air stream airflow (cfm)

Units: Data structure.

Input Restrictions: User may input curves or use default curves. If defaults are overridden, the compliance software must indicate that supporting documentation is required on the output forms.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

AUXILIARY EVAPORATIVE COOLING POWER

Applicability: Systems with evaporative cooling.

Definition: The auxiliary energy of the indirect evaporative cooler fan, and the pumps for both direct and indirect stages.

Units: Watts.

Input Restrictions: As designed.

Standard Design: Not applicable.

DEWPOINT EFFECTIVENESS

Applicability: Systems with indirect evaporative cooling.

Definition: The effectiveness of the evaporative cooler based on dewpoint depression. This is an optional input which determines the maximum leaving air temperature based on dewpoint depression rather than wet-bulb depression. The leaving air temperature calculated with the dewpoint effectiveness will be the entering temperature minus the difference between the entering dry-bulb and dewpoint temperatures multiplied by the effectiveness,

$$T_{indirect} = T_{db} - \left(T_{db} - T_{dp}\right) \times \ Dewpoint_{EFF}$$

Where:

- $\boldsymbol{Dewpoint_{EFF}}$ - The dewpoint effectiveness
- $\boldsymbol{T_{db}}$ - The entering air dry-bulb temperature
- $\boldsymbol{T_{dp}}$ - The entering air dewpoint temperature
- $\boldsymbol{T_{indirect}}$ - The indirect stage leaving dry-bulb temperature

The actual leaving temperature will be the warmer of the two temperatures calculated from the wet-bulb and dewpoint effectiveness values.

Units: Unitless.

Input Restrictions: As designed.

Standard Design: Not applicable.

SECONDARY FAN FLOW RATE

Applicability: Systems with indirect evaporative cooling.

Definition: The flow rate of any integrated fan providing air to the secondary (wet) side of the indirect evaporative cooler.

Units: cfm.

Input Restrictions: As designed.

Standard Design: Not applicable.

SECONDARY FAN TOTAL EFFICIENCY

Applicability: Systems with indirect evaporative cooling.

Definition: The overall efficiency of any integrated fan providing air to the secondary (wet) side of the indirect evaporative cooler. This efficiency includes that of the fan, motor and drive.

Units: Unitless.

Input Restrictions: As designed.

Standard Design: Not applicable.

SECONDARY FAN STATIC PRESSURE

Applicability: Systems with indirect evaporative cooling.

Definition: The total static pressure of any integrated fan providing air to the secondary (wet) side of the indirect evaporative cooler.

Units: inH2O.

Input Restrictions: As designed.

Standard Design: Not applicable.

SECONDARY AIR SOURCE

Applicability: Systems with indirect evaporative cooling.

Definition: The primary source of air supplied to the secondary (wet) side of the indirect evaporative cooler. If return is selected and the air system return air cannot meet the airflow desired by the evaporative cooler, the difference will be made up using outdoor air.

Units: List. The options are

- Return
- Outdoor

Input Restrictions: As designed.

Standard Design: Not applicable.

5.7.5.5 Four-Pipe Fan Coil Systems

This chapter contains building descriptors required to model four-pipe fan coil systems.

Additional HVAC components (chiller, boiler, pumps) are needed to fully define this system. If a water-side economizer is specified with this system, refer to 5.8.4 Water-side Economizers for a list of applicable building descriptors.

CAPACITY CONTROL METHOD

Applicability: Four-pipe fan coil systems.

Definition: The control method for the fan coil unit used to meet zone heating or cooling loads.

The following choices are available:

- Constant Speed Fan, Variable Fluid Flow - The fan speed produces a fixed air flow rate whenever the unit is scheduled on. The hot/chilled water flow rate is varied so that the unit output matches the zone heating/cooling requirement.
- Cycling Fan - The fan is cycled to match unit output with the load.

- Variable Speed Fan, Constant Fluid Flow - The water flow rate is at full flow and the fan speed varies to meet the load.
- Variable Speed Fan, Variable Fluid Flow - both air and water flow rates are varied to match the load.

Units: List (with choices above).

Input Restrictions: Not a user input. It comes from building descriptors for fan control and chiller loop flow control.

Standard Design: Not applicable.

RATED GROSS CAPACITY

Applicability: Four-pipe fan coil systems.

Definition: The gross cooling capacity of the cooling coil.

Units: Btu/h.

Input Restrictions: None.

Standard Design: For healthcare facilities, the same as the Proposed Design with an adjustment to account for fan heat of the Standard Design. For all others, not applicable.

COOLING COIL DESIGN FLOW RATE

Applicability: Four-pipe fan coil systems and chilled beams.

Definition: The design flow rate of the cooling coil

Units: Gallons per minute (gpm).

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

5.7.5.6 Chilled Beams

Active and passive chilled beam systems may be modeled as four-pipe fan coils or similar system type if the compliance software does not explicitly support chilled beams. In this case, the FPFC fan flow rate is based on the induced airflow rate of the beam and modeled with no fan power.

CHILLED BEAM NAME

Applicability: Chilled beams.

Definition: A unique name designating the chilled beam.

Units: None.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the proposed design. For all others, not applicable.

CHILLED BEAM TYPE

Applicability: Chilled beams.

Definition: Specification of the beam as active or passive.

Units: List:

- Active
- Passive

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the proposed design. For all others, not applicable.

DESIGN COOLING CAPACITY

Applicability: Chilled beams.

Definition: The designed cooling capacity of the chilled beam.

Units: Btu/h.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

DESIGN CHILLED WATER TEMPERATURE

Applicability: Chilled beams.

Definition: The minimum supplied chilled water temperature to the beam.

This is typically at least 2°F higher than the space dewpoint temperature at design conditions, to prevent condensation.

Units: °F.

Input Restrictions: Not a user input. Based on building descriptors for chiller loop control.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

Maximum Chilled Water Temperature

Applicability: Chilled beams.

Definition: The maximum supplied chilled water temperature to the beam. This allows for chilled water temperature reset at the source.

Units: °F.

Input Restrictions: Should be equal to or greater than the design chilled water temperature.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

Active Beam Maximum Primary Flow Rate

Applicability: Chilled beams.

Definition: The design flow rate of the active fan.

Units: Cfm.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

Active Beam Induced Air Rate

Applicability: Active chilled beams.

Definition: The rate at which induced air is drawn through the chilled beam.

The total airflow across the beam is the sum of the maximum primary flow rate and the active beam induced airflow rate.

Units: Cfm.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, Not applicable.

Chilled Beam Heating Capacity

Applicability: Chilled beams.

Definition: The heating capacity of the chilled beam.

Units: Btu/h.

Input Restrictions: None; defaults to 1 if no heating.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

CHILLED BEAM HEATING SOURCE

Applicability: Chilled beams.

Definition: Defaults to electric resistance, whether there is heating provided by the beam or not.

Units: None.

Input Restrictions: Electric resistance.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

5.7.6 Heating Systems

5.7.6.1 General

HEATING SOURCE

Applicability: All systems that provide heating.

Definition: The source of heating for the heating coils. The choices are:

- Hot water
- Electric resistance
- Electric heat pump
- Gas furnace
- VRF

Units: List (see above).

Input Restrictions: As designed. Electric heat pumps may have an additional coil to be used as supplemental heat. See section below.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, based on the prescribed system type. Refer to 5.1.3 HVAC System Map. For Alterations, see 5.1.4 Additions and Alterations System Modification.

GROSS HEATING COIL CAPACITY

Applicability: All systems with a heating coil.

Definition: The heating capacity of a heating coil or packaged heat pump at AHRI conditions.

For packaged or VRF equipment that has the fan motor in the air stream such that it adds heat to the supply air, the compliance software shall calculate the net heating capacity as follows:

Net Heating Capacity = CapTotGrossRtd + FanHtRtd

Where:

- Net Heating Capacity — The net total heating capacity of a packaged unit as rated by AHRI (Btu/h).
- CapTotGrossRtd — The gross heating capacity of a packaged unit (Btu/h)
- FanHtRtd — The heat generated by the fan. See "Gross Cooling Capacity."

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, the gross total cooling capacity is the same as the Proposed Design with an adjustment to account for fan heat of the Standard Design. For all other cases, the capacity is auto sized, see 2.6.2 Sizing Equipment in the Standard Design.

Standard Design: Existing Building: Same as proposed if unaltered

5.7.6.2 Hydronic/Water-Source Heating Coils

DESIGN WATER FLOW RATE

Applicability: Hot water coils and water-cooled DX coils.

Definition: The design flow rate of the hot water coil or the condenser coil of a water-source heat pump.

Units: Gallons per minute (gpm).

Input Restrictions: None. Default based on gross capacity of the hot water coil or cooling heat rejection load of a water-source heat pump coil at the design deltaT of the attached hydronic loop.

Standard Design: For healthcare facilities, same as the Proposed Design. For baseline systems with hot water coils, default based on gross capacity at the design deltaT of the attached hydronic loop as follows.

$$FlowRate_{coil} = \frac{Capacity_{coil}}{500.19 \times \Delta T_{loop}}$$

Where:

$FlowRate_{coil}$ – Hot water coil water flow rate (gpm)

$Capacity_{coil}$ – Hot water coil gross capacity (Btu/h)

ΔT_{loop} – the design deltaT of the attached hydronic loop (°F)

DESIGN PRESSURE DROP

Applicability: Hot water coils and water-cooled DX coils.

Definition: The design pressure drop through the hot water coil or the condenser coil of a water-source heat pump.

Units: Feet of water (ftH2O).

Input Restrictions: None. Default to 5ft.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

5.7.6.3 Furnace

FURNACE FUEL HEATING EFFICIENCY

Applicability: Systems with a furnace.

Definition: The full load thermal efficiency of either a gas or oil furnace at design conditions. The compliance software must accommodate input in either thermal efficiency (Et) or annual fuel utilization efficiency (AFUE). Where AFUE is provided, Et shall be calculated as:

$$E_t = 0.0051427 \times (AFUE \times 100) + 0.3989$$

Where:

$\boldsymbol{AFUE}$ - The annual fuel utilization efficiency (%)
$\boldsymbol{E_t}$ - The thermal efficiency (fraction)

Units: Fraction.

Input Restrictions: As designed.

Standard Design: Use the minimum heating efficiency from the Energy Code for the applicable equipment type and capacity.

FURNACE FUEL HEATING PART LOAD EFFICIENCY CURVE

Applicability: Systems with a furnace.

Definition: An adjustment factor that represents the percentage of full load fuel consumption as a function of the percentage full load capacity. This curve shall take the form of a quadratic equation as follows:

$$Fuel_{partload} = Fuel_{rated} \times FHeatPLC$$

$$FHeatPLC = a + b(Q_{partload}/Q_{rated}) + c(Q_{partload}/Q_{rated})^2$$

Where:

$\boldsymbol{FHeatPLC}$ - The fuel heating part load efficiency curve
$\boldsymbol{Fuel_{rated}}$ - The fuel consumption at part load conditions (Btu/h)
$\boldsymbol{Q_{partload}}$ - The capacity at part load conditions (Btu/h)
$\boldsymbol{Q_{rated}}$ - The capacity at rated conditions (Btu/h)

Units: Data structure.

Input Restrictions: Where applicable, curves are prescribed based on system type, see Appendix 5.7.

Standard Design: Use prescribed curves as described above.

FURNACE IGNITION TYPE

Applicability: Systems that use a furnace for heating.

Definition: The method used to start combustion in fuel-fired furnaces. The options are:

- Intermittent ignition device.
- Pilot light.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: Intermittent Ignition Device.

FURNACE FUEL HEATING PILOT

Applicability: Systems that use a furnace with pilot light ignition for heating.

Definition: The fuel input for a pilot light on a furnace.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: Zero (pilotless ignition).

FURNACE FUEL HEATING FAN/AUXILIARY

Applicability: Systems that use a furnace for heating.

Definition: The fan energy in forced draft furnaces and the auxiliary (pumps and outdoor fan) energy in fuel-fired heat pumps.

Units: Kilowatts (kW).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

5.7.6.4 Electric Heat Pump

ELECTRIC HEAT PUMP SUPPLEMENTAL HEATING SOURCE

Applicability: All heat pumps.

Definition: The auxiliary heating source for a heat pump heating system.

The common control sequence is to lock out the heat pump compressor when the supplemental heat is activated. Other building descriptors may be needed if this is not the case. Choices for supplemental heat include:

- Electric resistance.
- Gas furnace.
- Hot water.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, refer to the HVAC system map in 5.1.3 HVAC System Map for the prescribed type.

ELECTRIC HEAT PUMP HEATING EFFICIENCY

Applicability: All heat pumps except AWHPs.
Definition: The heating efficiency of a heat pump at AHRI rated conditions as a dimensionless ratio of output over input. The compliance software must accommodate user input of either the coefficient of performance (COP) or the heating season performance factor (HSPF/HSPF2). Where HSPF/HSPF2 is provided, COP shall be calculated as:

$$COP = (0.2778 \times HSPF) + 0.9667$$

For all unitary and applied equipment where the fan energy is part of the equipment efficiency rating, the COP shall be adjusted as follows to remove the fan energy:

$$COP_{adj} = \frac{\frac{HCAP_{rated} - Q_{fan,rated}}{3.413}}{\frac{HCAP_{rated}}{COP \times 3.413} - \frac{Q_{fan,rated}}{3.413}}$$

Where:

$\boldsymbol{COP_{adj}}$ — The adjusted coefficient of performance for simulation purposes
$\boldsymbol{COP}$ — The AHRI rated coefficient of performance
$\boldsymbol{HCAP_{rated}}$ — The AHRI rated heating capacity of a packaged unit (Btu/h)
$\boldsymbol{Q_{fan,rated}}$ – The heat generated by the fan at AHRI rated conditions. See Gross Cooling Capacity

Units: Unitless.

Input Restrictions: As designed. A conversion factor is used to convert HSPF2 to HSPF ratings for modeling. For split system, small-duct high-velocity, and space-constrained equipment, the conversion factor is 1/0.85 to convert HSPF2 to HSPF. For single-package equipment, the conversion factor is 1/0.84 to convert HSPF2 to HSPF.

Standard Design: Minimum heating efficiency from the Energy Code for the applicable equipment type.

ELECTRIC HEAT PUMP HEATING CAPACITY ADJUSTMENT CURVE(S)

Applicability: All heat pumps.

Definition: A curve or group of curves that represent the available heat-pump heating capacity as a function of evaporator and condenser conditions. The default curves are given as:

$$Q_{available} = CAP\_FT \times Q_{rated}$$

For air-cooled heat pumps:

$$CAP\_FT = a + b(t_{odb}) + c(t_{odb})^2 + d(t_{odb})^3$$

For water-cooled heat pumps:

$$CAP\_FT = a + b(t_{db}) + d(t_{wt})$$

Where:

$\boldsymbol{Q_{available}}$ — Available heating capacity at present evaporator and condenser conditions (kBtu/h)
$\boldsymbol{t_{db}}$ — The entering coil dry-bulb temperature (°F)
$\boldsymbol{t_{wt}}$ — The water supply temperature (°F)
$\boldsymbol{t_{odb}}$ — The outside-air dry-bulb temperature (°F)

$\boldsymbol{Q_{rated}}$ — Rated capacity at AHRI conditions (in kBtu/h)

Units: Data structure.

Input Restrictions: Where applicable, curves are prescribed based on system type, see Appendix 5.7.

Standard Design: Use prescribed curves as described above.

ELECTRIC HEAT PUMP HEATING EFFICIENCY ADJUSTMENT CURVE(S)

Applicability: All heat pumps except AWHPs.

Definition: A curve or group of curves that varies the heat pump heating efficiency as a function of evaporator conditions, condenser conditions and part-load ratio. The default curves are given as:

$$PLR = \frac{Q_{operating}}{Q_{available}(t_{db}, t_{odb/wt})}$$

$$EIR_{FPLR} = a + b(PLR) + c(PLR)^2 + d(PLR)^3$$

Air-Source Heat Pumps:

$$EIR_{FT} = a + b(t_{odb}) + c(t_{odb})^2 + d(t_{odb})^3$$

Water-Source Heat Pumps:

$$EIR_{FT} = a + b(t_{wt}) + d(t_{db})$$

$$P_{operating} = P_{rated}(EIR_{FPLR})(EIR_{FT})(CAP_{FT})$$

Where:

$\boldsymbol{PLR}$ — Part-load ratio based on available capacity (not rated capacity)
$\boldsymbol{EIR_{FPLR}}$ — A multiplier on the EIR of the heat pump as a function of part-load ratio
$\boldsymbol{EIR_{FT}}$ — A multiplier on the EIR of the heat pump as a function of the wet-bulb temperature entering the coil and the outdoor dry-bulb temperature
$\boldsymbol{Q_{operating}}$ — Present load on heat pump (Btu/h)
$\boldsymbol{Q_{available}}$ — Heat pump available capacity at present evaporator and condenser conditions (Btu/h)
$\boldsymbol{t_{db}}$ — The entering coil dry-bulb temperature (°F)
$\boldsymbol{t_{wt}}$ — The water supply temperature (°F)
$\boldsymbol{t_{odb}}$ — The outside air dry-bulb temperature (°F)
$\boldsymbol{P_{rated}}$ — Rated power draw at AHRI conditions (kW)
$\boldsymbol{P_{operating}}$ — Power draw at specified operating conditions (kW)

Units: None.

Input Restrictions: Where applicable, curves are prescribed based on system type, see Appendix 5.7.

Standard Design: Use prescribed curves as described above.

Electric Heat Pump Supplemental Heating Capacity

Applicability: All heat pumps.

Definition: The design heating capacity of a heat pump supplemental heating coil.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all systems with heat pumps, auto-size, refer to 2.6.2 Sizing Equipment in the Standard Design.

Electric Supplemental Heating Control Temp

Applicability: All heat pumps.

Definition: The outside dry-bulb temperature below which the heat pump supplemental heating is allowed to operate.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed; default to 40°F.

Standard Design: For healthcare facilities, same as the Proposed Design. For buildings with heat pumps, no lockout, supplemental heat is allowed to operate whenever the heat pump cannot meet the load (supplemental gas heat), 40°F. For all other heat pumps 40°F.

Heat Pump Compressor Minimum Operating Temp

Applicability: All heat pumps.

Definition: The outside dry-bulb temperature below which the heat pump compressor is disabled.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For dual-fuel heat pumps, 45 °F. For all others heat pumps, 17 °F.

Coil Defrost

Applicability: Air-cooled electric heat pump.

Definition: The defrost control mechanism for an air-cooled heat pump.

The choices are:

- Hot-gas defrost, on-demand
- Hot-gas defrost, timed 3.5 minute cycle
- Electric resistance defrost, on-demand
- Electric resistance defrost, timed 3.5 minute cycle

Defrost shall be enabled whenever the outside air dry-bulb temperature drops below 40°F.

Units: List (see above).

Input Restrictions: Default to use hot-gas defrost, timed 3.5 minute cycle. User may select any of the above.

Standard Design: For healthcare facilities, same as the proposed design. For all other heat pumps, hot-gas defrost, timed 3.5 minute cycle.

COIL DEFROST KW

Applicability: Heat pumps with electric resistance defrost.

Definition: The capacity of the electric resistance defrost heater.

Units: Kilowatts (kW).

Input Restrictions: As designed; defaults to 0 if nothing is entered.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

CRANK CASE HEATER KW

Applicability: All air source heat pumps.

Definition: The capacity of the electric resistance heater in the crank case of a direct expansion (DX) compressor. The crank case heater operates only when the compressor is off.

Units: Kilowatts (kW).

Input Restrictions: Where applicable, the value is prescribed to be 10 W per ton (rated net cooling capacity).

Standard Design: Where applicable, the value is prescribed to be 10 W per ton (rated net cooling capacity)

CRANK CASE HEATER SHUTOFF TEMPERATURE

Applicability: All air source heat pumps.

Definition: The outdoor air dry-bulb temperature above which the crank case heater is not permitted to operate.

Units: Degrees Fahrenheit (°F).

Input Restrictions: Where applicable, the value is prescribed to be 50°F.

Standard Design: Where applicable, the value is prescribed to be 50°F.

5.7.7 Exhaust Air Heat Recovery

RECOVERY TYPE

Applicability: All systems with airside heat recovery.

Definition: The type of heat recovery system.

Units: List: sensible, latent, or total (sensible and latent).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design.

For all others, sensible if impacted based on requirements in 140.4(q) or 140.9(c)6. Exhaust air heat recovery is not required when:

- Spaces are not cooled and are heated to less than 60 F.
- More than 60 percent of outdoor air heating energy is provided from site-recovered energy in Climate Zone 16.
- Sum of airflow rates exhausted and relieved within 20 feet of each other is less than 75 percent of the design outdoor airflow rate as described in Exception 4 to Section 140.4(q).
- Or the system is expected to operate less than 20 hours per week.

For laboratory exhaust systems, exhaust air heat recovery is not required:

- Additions or alterations to existing laboratory systems that do not include exhaust air heat recovery.
- Total laboratory exhaust rates exceeds 20 cfm/ft2 of roof area.
- Locations in Climate Zone 6 or 7 and in a jurisdiction where gas heating is allowed.
- Buildings with exhaust air heat recovery system and heat recovery chillers designed to provide at least 40 percent of the peak heating load from exhaust heat recovery.
- For exhaust systems requiring wash down systems.

Not applicable for all systems.

Standard Design: *Existing Buildings:* For healthcare facilities, same as the proposed design.

For all others, sensible if impacted based on requirements in 140.4(q) or 140.9(c)6. Exhaust air heat recovery is not required when:

- Spaces are not cooled and are heated to less than 60 F.
- More than 60 percent of outdoor air heating energy is provided from site-recovered energy in Climate Zone 16.
- Sum of airflow rates exhausted and relieved within 20 feet of each other is less than 75 percent of the design outdoor airflow rate as described in Exception 4 to Section 140.4(q).
- Or the system is expected to operate less than 20 hours per week.

For laboratory exhaust systems, exhaust air heat recovery is not required:

- Additions or alterations to existing laboratory systems that do not include exhaust air heat recovery.
- Total laboratory exhaust rates exceeds 20 cfm/ft2 of roof area.
- Locations in Climate Zones 6 or 7 and in a jurisdiction where gas heating is allowed.
- Buildings with exhaust air heat recovery system and heat recovery chillers designed to provide at least 40 percent of the peak heating load from exhaust heat recovery.
- For exhaust systems requiring wash down systems.

RECOVERY AIRFLOW RATE

Applicability: All systems with airside heat recovery.

Definition: The design airflow rate through the heat recovery system.

Units: CFM.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design.

Equal to the design outdoor airflow rate, and assume balanced flow if impacted by requirements in 140.4(q). Equal to the design outdoor airflow and exhaust rate consistent with the requirements in 140.9(c)6. Not applicable for all systems.

Standard Design: Existing Buildings: Assume balanced flow if impacted based on requirements in 140.4(q). Equal to the design outdoor airflow and exhaust rate consistent with the requirements in 140.9(c)6. Not applicable for all systems.

EXHAUST AIR SENSIBLE HEAT RECOVERY EFFECTIVENESS

Applicability: Any system with outside air heat recovery.

Definition: The effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams. Effectiveness is defined as:

Where:

$\boldsymbol{HREFF}$ — The air-to-air heat exchanger effectiveness
$\boldsymbol{EEA_{db}}$ — The exhaust air dry-bulb temperature entering the heat exchanger
$\boldsymbol{ELA_{db}}$ — The exhaust air dry-bulb temperature leaving the heat exchanger
$\boldsymbol{OSA_{db}}$ — The outside air dry-bulb temperature

Units: Two unitless numbers (ratio between 0 and 1), separate for cooling and heating.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, the sensible effectiveness is 60% if the Proposed Design has heat recovery.

For all others, the sensible effectiveness is 60% if using for HVAC systems consistent with the requirements in requirements in 140.4(q) and 45% at heating design conditions and 25% at cooling design conditions if using HVAC systems consistent with the requirements in requirements in 140.9(c)6. Not applicable for all systems.

Standard Design: Existing Buildings: The sensible effectiveness is 60% if using for HVAC systems impacted based on requirements in 140.4(q) and 45% at heating design conditions and 25% at cooling design conditions if using for HVAC systems consistent with the requirements in requirements in 140.9(c)6. Not applicable for all systems.

EXHAUST AIR SENSIBLE PART-LOAD EFFECTIVENESS

Applicability: Any system with outside air heat recovery.

Definition: The effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams at 75 percent of design airflow. Effectiveness is defined as:

$$HREFF = \frac{EEA_{db} - ELA_{db}}{EEA_{db} - OSA_{db}}$$

Where:

$HREFF$ — The air-to-air heat exchanger effectiveness

EEA_{db} — The exhaust air dry-bulb temperature entering the heat exchanger

ELA_{db} — The exhaust air dry-bulb temperature leaving the heat exchanger

OSA_{db} — The outside air dry-bulb temperature

Units: Two unitless numbers (ratio between 0 and 1), separate for cooling and heating.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, the sensible effectiveness is 60% if the Proposed Design has heat recovery.

For all others, the sensible effectiveness is 65% if using for HVAC systems impacted based on requirements in 140.4(q) and 45% at heating design conditions and 25% at cooling design conditions if using HVAC systems impacted based on requirements in 140.9(c)6. Not applicable for all systems.

Standard Design: Existing Buildings: The sensible effectiveness is 65% if using for HVAC systems impacted based on requirements in 140.4(q) and 45% at heating design conditions and 25% at cooling design conditions if using HVAC systems consistent with the requirements in requirements in 140.9(c)6. Not applicable for all systems.

EXHAUST AIR LATENT HEAT RECOVERY EFFECTIVENESS

Applicability: Any system with outside air enthalpy heat recovery.

Definition: The latent heat recovery effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams. Effectiveness is defined as:

$$HREFF = \frac{EEA_w - ELA_w}{EEA_w - OSA_w}$$

Where:

- $\boldsymbol{HREFF}$ — The air-to-air heat exchanger effectiveness
- $\boldsymbol{EEA_w}$ — The exhaust air humidity ratio (fraction of mass of moisture in air to mass of dry air) entering the heat exchanger
- $\boldsymbol{ELA_w}$ — The exhaust air humidity ratio leaving the heat exchanger
- $\boldsymbol{OSA_w}$ — The outside air humidity ratio

Note: For sensible heat exchangers, this term is not applicable

Units: Two unitless numbers (ratio between 0 and 1), separate for cooling and heating.

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Not applicable.

EXHAUST AIR LATENT PART-LOAD EFFECTIVENESS

Applicability: Any system with outside air enthalpy heat recovery.

Definition: The latent heat recovery effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams at 75 percent of design airflow. Effectiveness is defined as:

$$HREFF = \frac{EEA_w - ELA_w}{EEA_w - OSA_w}$$

Where:

$\boldsymbol{HREFF}$ — The air-to-air heat exchanger effectiveness
$\boldsymbol{EEA_w}$ — The exhaust air humidity ratio (fraction of mass of moisture in air to mass of dry air) entering the heat exchanger
$\boldsymbol{ELA_w}$ — The exhaust air humidity ratio leaving the heat exchanger
$\boldsymbol{OSA_w}$ — The outside air humidity ratio

Note: For sensible heat exchangers, this term is not applicable.

Units: Two unitless numbers (ratio between 0 and 1), separate for cooling and heating.

Input Restrictions: As designed.

Standard Design: Not applicable.

HEAT RECOVERY ECONOMIZER LOCKOUT

Applicability: All systems with airside heat recovery.

Definition: A flag to indicate whether or not the heat recovery is bypassed when economizer is enabled.

Units: Boolean.

Input Restrictions: As designed.

Standard Design: For healthcare facilities heat recovery, energy recovery bypass during economizer operation.

For all others, heat recovery bypass during economizer operation for HVAC systems impacted based on requirements in 140.4(q) and 140.9(c)6. Not applicable for all systems.

Standard Design: Existing Buildings: The economizer is disabled for HVAC systems impacted based on requirements in 140.4(q) and 140.9(c)6. Not applicable for all systems.

5.8 HVAC Primary Systems

5.8.1 Hydronic System Heating Equipment

BOILER NAME

Applicability: All boilers.

Definition: A unique descriptor for each boiler, heat pump, central heating heat-exchanger, or heat recovery device.

Units: None.

Input Restrictions: User entry.

Where applicable, this should match the tags that are used on the plans for the proposed design.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, Boilers are only designated in the standard design if the baseline system type uses hot water for space heating.

BOILER FUEL SOURCE

Applicability: All boilers. Not applicable to AWHP's.

Definition: The fuel source for the central heating equipment.

The choices are:

- Gas
- Electricity

Units: List (see above).

Input Restrictions: As designed.

This input is restricted, based on the choice of boiler type, according to the following rules:

- Steam Boiler
  - Electricity — n/a
  - Gas — n/a
  - Steam — Allowed
- Hot Water Boiler
  - Electricity — n/a
  - Gas — Allowed
  - Steam — n/a

Standard Design: If the boiler serves as a supplemental heating source, for an AWHP meeting the requirements of 140.4(a)3, electricity. For all others, gas.

Standard Design: Existing Buildings: Same as proposed for existing, unaltered; same as newly constructed buildings if altered.

BOILER TYPE

Applicability: All boilers.

Definition: Type of fluid used for heat transfer.

The choices are:

- Hot water.
- Steam.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as Proposed Design. For all others, Hot Water boiler.

Standard Design: Existing Buildings: Same as proposed for existing, unaltered; same as newly constructed buildings if altered.

BOILER DRAFT TYPE

Applicability: All boilers.

Definition: How combustion airflow is drawn through the boiler.

The choices are Natural, Mechanical Noncondensing, or Condensing.

Natural draft boilers use natural convection to draw air for combustion through the boiler. Natural draft boilers are subject to outside air conditions and the temperature of the flue gases.

Condensing boilers reclaim heat of condensation from water in the flue gas to achieve efficiencies of 90 percent. However, if the water entering the boiler (return water temperature) is too hot, then condensing does not occur, and the boiler operates at efficiencies below 82 percent. Condensing boilers require a draft fan to ensure airflow through the complex flue gas passages.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design.

For gas-fired boilers in climate zones 1 through 6, 9 through 14 and 16 with rated capacity above 1 MMBtu/h and less than 10 MMBtu/h, condensing boilers.

For all others, non-condensing.

NUMBER OF IDENTICAL BOILER UNITS

Applicability: All boilers.

Definition: The number of identical units for staging.

Units: Numeric: integer.

Input Restrictions: As designed; default is 1.

Standard Design: For healthcare facilities, same as the Proposed Design. For AWHP meeting the requirements of 140.4(a)3, one boiler to provide supplemental heat. For all others, the Standard Design shall have one boiler when the standard design plant serves a conditioned floor area of 15,000 ft^2 or less and have two equally sized boilers for plants serving more than 15,000 ft^2.

BOILER DESIGN CAPACITY

Applicability: All boilers.

Definition: The heating capacity at design conditions.

Units: Btu/h.

Input Restrictions: As designed.

If unmet load hours exceed 150, the user may need to manually adjust boiler design capacity.

Standard Design: For buildings with both healthcare and other occupancies, the proposed boiler capacity is scaled based on the ratio of the capacity of heating coils serving healthcare areas. For all others, the Standard Design boiler is sized to be 25 percent larger than the peak loads of the standard design. Standard design boilers shall be sized using weather files containing 99.6 percent heating design temperatures and 0.5 percent dry-bulb and 1 percent wet-bulb cooling design temperatures.

BOILER EFFICIENCY TYPE

Applicability: All boilers.

Definition: The full load efficiency of a boiler is expressed as one of the following:

- Annual fuel utilization efficiency (AFUE) is a measure of the boiler's efficiency over a predefined heating season.
- Thermal efficiency (Et) is the ratio of the heat transferred to the water divided by the heat input of the fuel.
- Combustion efficiency (Ec) is the measure of how much energy is extracted from the fuel and is the ratio of heat transferred to the combustion air divided by the heat input of the fuel.

Units: List (see above).

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design.

For all others, AFUE for all gas fired hot water boilers with less than 300,000 Btu/h capacity.

Thermal efficiency (Et) for all gas fired hot water boilers with capacities between 300,000 and 2,500,000 Btu/h, all gas-fired steam water boilers with capacities above 225,000 Btu/h, and all electric boilers.

Combustion efficiency (Ec), for all gas fired hot water boilers with capacities above 2,500,000 Btu/h.

BOILER EFFICIENCY

Applicability: All boilers.

Definition: The full load efficiency of a boiler at rated conditions (see efficiency type above) expressed as a dimensionless ratio of output over input. The compliance software must accommodate input in either thermal efficiency (E_t), combustion efficiency (E_c), or AFUE. The compliance software shall make appropriate conversions to thermal efficiency if either AFUE or combustion efficiency is entered as the rated efficiency.

Where AFUE is provided, E_t shall be calculated as follows:

- $\mathbf{0.75 \leq AFUE < 0.80 — E_t = (0.1 \times AFUE) + 0.725}$
- $\mathbf{0.80 \leq AFUE \leq 1.00 — E_t = (0.875 \times AFUE) + 0.105}$

If combustion efficiency is entered, the compliance software shall convert the efficiency to thermal efficiency by the relation:

$$E_t = E_c - 0.015$$

All electric boilers will have an efficiency of 98 percent.

Units: Ratio.

Input Restrictions: The boiler efficiency should meet the minimum efficiency requirements as specified by Table 110.2-J.

Standard Design: Boilers with rated capacity below 1 MMBtu for the standard design have the minimum efficiency listed in Table E-4 of the *California Appliance Efficiency Regulations*.

Gas-fired boilers in climate zones 1 through 6, 9 through 14 and 16 with rated capacity 1 MMBtu/h to 10 MMBtu/h have a standard design efficiency of 90 percent.

BOILER PART-LOAD PERFORMANCE CURVE

Applicability: All boilers.

Definition: An adjustment factor that represents the percentage full load fuel consumption as a function of the percentage full load capacity. This curve shall take the form of a quadratic equation as follows:

$$Fuel_{partload} = Fuel_{design}\left[FHeatPLC(Q_{partload,}Q_{rated})\right]$$

$$FHeatPLC = \left(a + b\left(\frac{Q_{partload}}{Q_{rated}}\right) + c\left(\frac{Q_{partload}}{Q_{rated}}\right)^2\right)$$

Where:

$\boldsymbol{FHeatPLC}$ — The fuel heating part-load efficiency curve
$\boldsymbol{Fuel_{partload}}$ — The fuel consumption at part-load conditions (Btu/h)
$\boldsymbol{Fuel_{design}}$ — The fuel consumption at design conditions (Btu/h)
$\boldsymbol{Q_{partload}}$ — The boiler capacity at part-load conditions (Btu/h)
$\boldsymbol{Q_{rated}}$ — The boiler capacity at design conditions (Btu/h)
$\boldsymbol{a}$ — Constant
$\boldsymbol{b}$ — Constant
$\boldsymbol{c}$ — Constant

Units: Ratio.

Input Restrictions: Prescribed to the part-load performance curve in the ACM Appendix 5.7, based on the boiler draft type.

Standard Design: The standard design uses the mechanical draft fan curve in Appendix 5.7.

BOILER FORCED DRAFT FAN POWER

Applicability: All mechanical draft boilers.

Definition: The fan power of the mechanical draft fan at design conditions.

Units: Nameplate horsepower.

Input Restrictions: As designed.

The compliance software shall convert the user entry of motor horsepower to fan power in watts by the following equation:

Fan Power=Motor HP(746)(0.5)

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, Sized for an energy input ratio of 0.0000008 HP per Btu/h (0.2984 W per kBtu/h heat input).

BOILER MINIMUM UNLOADING RATIO

Applicability: All boilers.

Definition: The minimum unloading capacity of a boiler expressed as a percentage of the rated capacity. Below this level, the boiler must cycle to meet the load.

Units: Percent (%).

Input Restrictions: As designed.

If the user does not use the default values of 1 percent for electric boilers and 25 percent for gas boilers, the compliance software must indicate that supporting documentation is required on the output forms.

Standard Design: For healthcare facilities, same as the Proposed Design. For electric boilers, 1 percent. For all others, 25 percent.

Boiler Minimum Flow Rate

Applicability: All boilers.

Definition: The minimum flow rate recommended by the boiler manufacturer for stable and reliable operation of the boiler.

Units: Gpm.

Input Restrictions: As designed.

If the boiler(s) is piped in a primary only configuration in a variable flow system then the compliance software shall assume there is a minimum flow bypass valve that allows the hot water pump to bypass water from the boiler outlet back to the boiler inlet to maintain the minimum flow rate when boiler is enabled.

Note: The boiler entering water temperature must accurately reflect the mixed temperature (colder water returning from the coil(s) and hotter bypass water) to accurately model boiler efficiency as a function of boiler entering water temperature.

Standard Design: For buildings with both healthcare and other occupancies, the proposed boiler minimum low rate is scaled based on the ratio to the capacity of heating coils serving healthcare areas. For all others, 0 gpm.

Air to Water Heat Pump Rated Heating Capacity

Applicability: All AWHPs.

Definition: The heating capacity of the AWHP at rated conditions.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: Sized to 25% larger than 50% of the load at heating design conditions or 17°F whichever is greater [Design Load x 0.5 x 1.25].

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed buildings rules if altered or replacement.

AIR TO WATER HEAT PUMP CAPACITY RATIO CURVES

Applicability: All AWHPs.

Definition: A curve or group of curves that varies the heating efficiency of an AWHP as a function of evaporator conditions and condenser conditions.

Multipass:

$$EIR_{FT} = a + b(t_{hwr}) + c(t_{hwr})^2 + d(t_{owb}) + e(t_{owb})^2 + f(t_{hwr})(t_{owb})$$

Non-modular:

$$EIR_{FT} = a + b(t_{hws}) + c(t_{hws})^2 + d(t_{odb}) + e(t_{odb})^2 + f(t_{hws})(t_{odb})$$

Where:

t_{hwr} — The hot water return temperature (°C)

t_{hws} — The hot water supply temperature (°C)

t_{wdb} — The outside air wet-bulb temperature (°C)

t_{odb} — The outside air dry-bulb temperature (°C)

Units: Data structure.

Input Restrictions: Curve coefficients are prescribed in Appendix 5.7 given the AWHP type.

Standard Design: Use Packaged curves specified in Appendix 5.7.

AIR TO WATER HEAT PUMP SUPPLEMENTAL BOILER RATED HEATING CAPACITY

Applicability: All AWHPs.

Definition: The heating capacity of the AWHP's supplemental boiler at rated conditions.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: Sized to 25 percent larger than the full heating design load at design conditions.

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed building rules if altered or replacement.

AIR TO WATER HEAT PUMP RATED HEATING COP

Applicability: All AWHPs.

Definition: The heating efficiency of the AWHP at rated full-load conditions.

Units: COP.

Input Restrictions: As designed. User entered COP is adjusted based on Appendix 5.7 performance curve.

Standard Design: Offices, 2.31 at 140°F leaving water temperature. Schools in climate zone 2, 2.77 at 120°F leaving water temperature. Schools in all other climate zones, 2.31 at 140°F leaving water temperature. COP is adjusted based on Appendix 5.7 AWHP performance curve.

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed buildings rules if altered or replacement.

AIR TO WATER HEAT PUMP COP RATIO CURVES

Applicability: All AWHPs.

Definition: A curve or group of curves that varies the heating efficiency of an AWHP as a function of evaporator conditions and condenser conditions.

Multipass:

$$EIR_{FT} = a + b(t_{hwr}) + c(t_{hwr})^2 + d(t_{owb}) + e(t_{owb})^2 + f(t_{hwr})(t_{owb})$$

Non-modular:

$$EIR_{FT} = a + b(t_{hws}) + c(t_{hws})^2 + d(t_{odb}) + e(t_{odb})^2 + f(t_{hws})(t_{odb})$$

Where:

t_{hwr} — The hot water return temperature (°C)

t_{hws} — The hot water supply temperature (°C)

t_{wdb} — The outside air wet-bulb temperature (°C)

t_{odb} — The outside air dry-bulb temperature (°C)

Units: Data structure.

Input Restrictions: Curve coefficients are prescribed in Appendix 5.7 given the AWHP type.

Standard Design: Use Packaged curves specified in Appendix 5.7.

AIR TO WATER HEAT PUMP RATED INLET AIR DRYBULB

Applicability: All AWHPs.

Definition: The dry-bulb temperature at rated full-load conditions.

Units: Degrees Fahrenheit (°F).

Input Restrictions: The dry-bulb temperature for full-load rating condition of designed equipment.

Standard Design: 47 °F.

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed buildings rules if altered or replacement.

AIR TO WATER HEAT PUMP RATED OUTLET WATER TEMPERATURE

Applicability: All AWHPs.

Definition: The condenser outlet water temperature at rated full-load conditions.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: For schools in climate zone 2, 120°F. All other climate zones, 140 °F.

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed buildings rules if altered or replacement.

AIR TO WATER HEAT PUMP MINIMUM OUTDOOR TEMPERATURE FOR COMPRESSOR OPERATION

Applicability: All AWHPs.

Definition: The minimum outdoor air temperature where the compressor operates.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: 17 °F.

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed buildings rules if altered or replacement.

AIR TO WATER HEAT PUMP MINIMUM PART-LOAD RATIO

Applicability: All AWHPs.

Definition: The minimum operating part load ratio.

Units: Unitless.

Input Restrictions: As designed.

Standard Design: 0.20.

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed buildings rules if altered or replacement.

HOT WATER SUPPLY TEMPERATURE

Applicability: All boilers and AWHPs.

Definition: The temperature of the water produced by the boiler or AWHP and supplied to the hot water loop.

Units: Degrees Fahrenheit (°F).

Input Restrictions: Less than 130 °F

Standard Design: Use 130°F for standard design boiler. If the standard design is an AWHP, 120°F for schools in climate zone 2. All other AWHP standard designs, 130°F.

HOT WATER TEMPERATURE DIFFERENCE

Applicability: All boilers and AWHPs.

Definition: The difference between the temperature of the water returning to the boiler from the hot water loop and the temperature of the water supplied to the loop.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: Use 25°F when the standard design is a gas boiler. AWHP's serving offices, 10°F. AWHP's serving schools in climate zone 2, 15°F. AWHP's serving schools in all other climate zones, 10°F.

HOT WATER SUPPLY TEMPERATURE RESET

Applicability: All boilers and AWHPs.

Definition: Variation of the hot water supply temperature with outdoor air temperature.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: The hot water supply temperature is fixed to match the temperature reset of the proposed design.

5.8.2 Chillers

CHILLER NAME

Applicability: All chillers.

Definition: A unique descriptor for each chiller.

Units: Text, unique.

Input Restrictions: User entry: where applicable, this should match the tags that are used on the plans.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, Chillers are only designated when the standard design system uses chilled water. The chiller plan will include a heat recovery chiller sized as specified by 140.4(s)1 if the proposed design meets the 140.4(s)1A or 140.4(s)1B.

CHILLER TYPE

Applicability: All chillers.

Definition: The type of chiller, either a vapor-compression chiller or an absorption chiller.

Vapor compression chillers operate on the reverse Rankine cycle, using mechanical energy to compress the refrigerant, and include:

- Reciprocating*
- Scroll*
- Screw*
- Centrifugal — uses rotating impeller blades to compress the air and impart velocity
- Single effect absorption

Units: List (see above). The compliance software shall support all chiller types listed above.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For System 14a, Screw. For all others, the standard design chiller is based on the design capacity of the standard design as follows:

Table 19: Type and Number of Chillers

Building Peak Cooling Load	Number and type of chiller(s)
< 300 tons	One water-cooled screw chiller
>300 tons < 1600 tons	Two water-cooled screw chillers, sized equally

Building Peak Cooling Load	Number and type of chiller(s)
≥ 1600 tons	A minimum of two water-cooled centrifugal chillers, sized to keep the unit size below 800 tons

Source: California Energy Commission

NUMBER OF IDENTICAL CHILLER UNITS

Applicability: All chillers.

Definition: The number of identical units for staging.

Units: None.

Input Restrictions: As designed; default is 1.

STANDARD DESIGN: **FOR HEALTHCARE FACILITIES, SAME AS THE PROPOSED DESIGN. FOR ALL OTHERS, FROM THE NUMBER INDICATED IN CHILLER TYPE.CHILLER FUEL SOURCE**

Applicability: All chillers.

Definition: The fuel source for the chiller.

The choices are:

- Electricity (for all vapor-compression chillers).
- Indirect (absorption units only).
- Hot water (absorption units only, designated as indirect-fired units).

Units: List (see above).

Input Restrictions: As designed.

This input is restricted, based on the choice of chiller type, according to the following rules:

Reciprocating

- Electricity — Allowed
- Indirect – n/a
- Gas — n/a
- Hot Water — n/a
- Steam — n/a

Scroll

- Electricity — Allowed
- Indirect – n/a
- Gas — n/a
- Hot Water — n/a
- Steam — n/a

Screw

- Electricity — Allowed
- Indirect – n/a
- Gas — n/a
- Hot Water — n/a
- Steam — n/a

Centrifugal

- Electricity — Allowed
- Indirect – n/a
- Gas — n/a
- Hot Water — n/a
- Steam — n/a

Single-Effect Absorption

- Electricity — n/a
- Indirect - Allowed
- Gas — Allowed
- Hot Water — Allowed
- Steam — Allowed

Direct-Fired Double Effect Absorption

- Electricity — n/a
- Gas — Allowed
- Hot Water — Allowed
- Steam — Allowed

Indirect-Fired Absorption

- Electricity — n/a
- Gas — Allowed

- Hot Water — Allowed
- Steam — Allowed

Standard Design: For healthcare facilities, same as the proposed design. For all others, Electricity.

CHILLER RATED CAPACITY

Applicability: All chillers.

Definition: The cooling capacity of a piece of heating equipment at rated conditions.

Units: Btu/h or tons.

Input Restrictions: As designed.

The user may need to manually adjust the capacity if the number of unmet load hours exceeds 150.

Standard Design: For buildings with both healthcare and other occupancies, the proposed chiller capacity is scaled based on the ratio to the capacity of cooling coils serving healthcare areas. For all others, the Standard Design chiller is sized to be 15 percent larger than the peak loads of the Standard Design.

CHILLER RATED EFFICIENCY

Applicability: All chillers.

Definition: The efficiency of the chiller (EER for air-cooled chillers, kW/ton for water-cooled electric chillers, and COP for fuel-fired and heat-driven chillers) at AHRI 550/590 rated full-load conditions.

Units: Ratio (kW/ton, COP, EER, depending on chiller type and condenser type).

Water-cooled electric chiller — kW/ton.

Air-cooled or evaporatively-cooled electric chiller — EER

All non-electric chillers – COP

Input Restrictions: As designed.

Must meet the minimum requirements of Table 110.2-D.

Standard Design: Use the minimum efficiency requirements from Tables 110.2-D Path B.

If chiller type is reciprocating, scroll, or screw, use the efficiency for positive displacement chillers from Table 110.2-D.

Standard Design: Existing Buildings: Same as proposed if unaltered; same as newly constructed buildings rules if altered or replacement.

Integrated Part-Load Value

Applicability: All chillers except single effect absorption chillers.

Definition: The part-load efficiency of a chiller developed from a weighted average of four rating conditions, as specified by AHRI 550/590.

Units: Ratio.

Input Restrictions: As designed; must meet the minimum requirements of Table 110.2-D.

Standard Design: For healthcare facilities, use the minimum efficiency requirements from Tables 110.2-D Path B. For all others, not used.

When the standard design system has a chiller, the standard design will always use Path B performance curves.

Chiller Minimum Unloading Ratio

Applicability: All chillers.

Definition: The minimum unloading capacity of a chiller expressed as a fraction of the rated capacity. Below this level the chiller must either cycle to meet the load or false-load the compressor (such as with hot gas bypass).

Table 20: Default Minimum Unloading Ratios

Chiller Type	Default Minimum Unloading Ratio
Reciprocating	25%
Screw	15%
Centrifugal	10%
Scroll	25%
Single Effect Absorption	10%
Double Effect Absorption	10%

Source: California Energy Commission

Units: Percent (%).

Input Restrictions: As designed but constrained to a minimum value of 10 percent and must be equal to or greater than the minimum part load ratio. If the user does not employ the default values, supporting documentation is required.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, use defaults listed above.

CHILLER MINIMUM PART LOAD RATIO

Applicability: All chillers.

Definition: The minimum part load capacity of a chiller expressed as a fraction of the rated capacity. Below this level the chiller must cycle to meet the load.

If the chiller minimum part-load ratio (PLR) is less than the chiller minimum unloading ratio, then the compliance software shall assume hot gas bypass operation between the minimum PLR and the minimum unloading ratio.

Units: Percent (%).

Input Restrictions: As designed but constrained to a minimum value of 10 percent and must be equal to or greater than the minimum unloading ratio. If the user does not employ the default values, supporting documentation is required.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, When the standard design has a screw chiller, the minimum PLR is 15 percent. When the standard design has a centrifugal chiller, the minimum PLR is 10 percent.

CHILLER COOLING CAPACITY ADJUSTMENT CURVE

Applicability: All chillers.

Definition: A curve or group of curves or other functions that represent the available total cooling capacity as a function of evaporator and condenser conditions and perhaps other operating conditions. The default curves are given as:

$$Q_{available} = CAP_{FT}(Q_{rated})$$

For air-cooled chillers:

$$CAP_{FT} = a + b(t_{chws}) + c(t_{chws})^2 + d(t_{odb}) + e(t_{odb})^2 + f(t_{chws})(t_{odb})$$

For water-cooled chillers:

$$CAP_{FT} = a + b(t_{chws}) + c(t_{chws})^2 + d(t_{cws}) + e(t_{cws})^2 + f(t_{chws})(t_{cws})$$

Where:

$\boldsymbol{Q_{available}}$ — Available cooling capacity at present evaporator and condenser conditions (MBH)

$\boldsymbol{t_{chws}}$ — The chilled water supply temperature (°F)
$\boldsymbol{t_{cws}}$ — The condenser water supply temperature (°F)
$\boldsymbol{t_{odb}}$ — The outside air dry-bulb temperature (°F)
$\boldsymbol{Q_{rated}}$ — Rated capacity at AHRI conditions (MBH)

Note: If an air-cooled unit employs an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.

Separate curves are provided for Path A and Path B chillers in Appendix 5.7.

Units: Data structure.

Input Restrictions: Prescribed curves are provided in Appendix 5.7 for the proposed design chiller type and the compliance path (A or B). If the default curves are overridden, supporting documentation is required.

Standard Design: Use prescribed curve for Path B chiller as applicable to the standard design chiller type.

ELECTRIC CHILLER COOLING EFFICIENCY ADJUSTMENT CURVES

Applicability: All chillers.

Definition: A curve or group of curves that varies the cooling efficiency of an electric chiller as a function of evaporator conditions, condenser conditions and part-load ratio.

Note: For variable-speed chillers, the part-load cooling efficiency curve is a function of both part-load ratio and leaving condenser water temperature. The default curves are given as:

$$PLR = \frac{Q_{operating}}{Q_{available}(t_{chws}, t_{cws/odb})}$$

Variable Speed:

$$EIR_{FPLR} = a + b(PLR) + c(PLR)^2$$

Air-Cooled:

$$EIR_{FT} = a + b(t_{chws}) + c(t_{chws})^2 + d(t_{odb}) + e(t_{odb})^2 + f(t_{chws})(t_{odb})$$

Water-Cooled:

$$EIR_{FT} = a + b(t_{chws}) + c(t_{chws})^2 + d(t_{cws}) + e(t_{cws})^2 + f(t_{chws})(t_{cws})$$

$$P_{operating} = P_{rated}(EIR_{FPLR})(EIR_{FT})(CAP_{FT})$$

Where:

$\boldsymbol{PLR}$ — Part-load ratio based on available capacity (not rated capacity)

$\boldsymbol{Q_{operating}}$ — Present load on chiller (Btu/h)

$\boldsymbol{Q_{available}}$ — Chiller available capacity at present evaporator and condenser conditions (Btu/h)

$\boldsymbol{t_{chws}}$ — The chilled water supply temperature (°F)

$\boldsymbol{t_{cws}}$ — The condenser water supply temperature (°F)

$\boldsymbol{t_{odb}}$ — The outside air dry-bulb temperature (°F)

$\boldsymbol{P_{rated}}$ — Rated power draw at AHRI conditions (kW)

$\boldsymbol{P_{operating}}$ — Power draw at specified operating conditions (kW)

Note: If an air-cooled chiller employs an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.

Units: Data structure.

Input Restrictions: Curves are prescribed in Appendix 5.7 given the chiller capacity and type. A separate set of curves are provided for Path A chillers and Path B chillers. The path is determined by comparing compliance software inputs of full-load efficiency and integrated part-load value with the requirements of Table 110.2-D of the Energy Code.

Standard Design: Use Path B curves specified in Appendix 5.7.

FUEL AND STEAM CHILLER COOLING EFFICIENCY ADJUSTMENT CURVES

Applicability: All chillers.

Definition: A curve or group of curves that varies the cooling efficiency of a fuel-fired or steam chiller as a function of evaporator conditions, condenser conditions, and part-load ratio. The default curves are given as follows:

Default curves for steam-driven single and double effect absorption chillers:

$$PLR = \frac{Q_{operating}}{Q_{available}(t_{chws}, t_{cws/odb})}$$

$$FIR_{FPLR} = a + b(PLR) + c(PLR)^2$$

$$FIR_{FT} = a + b(t_{chws}) + c(t_{chws})^2 + d(t_{cws}) + e(t_{cws})^2 + f(t_{chws})(t_{cws})$$

$$Fuel_{partload} = (Fuel_{rated})(FIR_{FPLR})(FIR_{FT})(CAP_{FT})$$

Default curves for direct-fired double effect absorption chillers:

$$PLR = \frac{Q_{operating}}{Q_{available}(t_{chws}, t_{cws/odb})}$$

$$FIR_{FPLR} = a + b(PLR) + c(PLR)^2$$

$$FIR_{FT1} = a + b(t_{chws}) + c(t_{chws})^2$$

$$FIR_{FT2} = d + e(t_{cws}) + f(t_{cws})^2$$

$$Fuel_{partload} = (Fuel_{rated})(FIR_{FPLR})(FIR_{FT1})(FIR_{FT2})(CAP_{FT})$$

The default curves for engine driven chillers are the same format as those for the steam-driven single and double effect absorption chillers but there are three sets of curves for different ranges of operation based on the engine speed.

Where:

$\boldsymbol{PLR}$ — Part-load ratio based on available capacity (not rated capacity)
$\boldsymbol{FIR_{FPLR}}$ — A multiplier on the fuel input ratio (FIR) to account for part-load conditions
$\boldsymbol{FIR_{FT}}$ — A multiplier on the fuel input ratio (FIR) to account for the chiller water supply temperature and the condenser water temperature
$\boldsymbol{FIR_{FT1}}$ — A multiplier on the fuel input ratio (FIR) to account for chilled water supply temperature
$\boldsymbol{FIR_{FT2}}$ — A multiplier on the fuel input ratio (FIR) to account for condenser water supply temperature
$\boldsymbol{CAP_{FT}}$ — A multiplier on the capacity of the chiller (Equation 45)
$\boldsymbol{Q_{operating}}$ — Present load on chiller (in Btu/h)
$\boldsymbol{Q_{available}}$ — Chiller available capacity at present evaporator and condenser conditions (in Btu/h)
$\boldsymbol{t_{chws}}$ — The chilled water supply temperature (in °F)
$\boldsymbol{t_{cws}}$ — The condenser water supply temperature (in °F)
$\boldsymbol{t_{odb}}$ — The outside air dry-bulb temperature (°F)
$\boldsymbol{Fuel_{rated}}$ — Rated fuel consumption at AHRI conditions (in Btu/h)
$\boldsymbol{Fuel_{partload}}$ — Fuel consumption at specified operating conditions (in Btu/h)

Units: Data structure.

Input Restrictions: Restricted to curves specified in Appendix 5.7.

Standard Design: Use prescribed curves specified in Appendix 5.7.

CHILLED WATER SUPPLY TEMPERATURE

Applicability: All chillers.

Definition: The chilled water supply temperature of the chiller at design conditions.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, the standard design chilled water supply temperature is set to 44°F.

CHILLED WATER RETURN TEMPERATURE

Applicability: All chillers.

Definition: The chilled water return temperature setpoint at design conditions.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, the standard design chilled water return temperature is set to 64°F.

CHILLED WATER SUPPLY TEMPERATURE CONTROL TYPE

Applicability: All chillers.

Definition: The method by which the chilled water setpoint temperature is reset.

The chilled water setpoint may be reset based on demand or outdoor air temperature.

Units: List fixed, scheduled, outsideairreset, wetbulbreset, fixeddualsetpoint.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, outside air-based reset.

CHILLED WATER SUPPLY TEMPERATURE RESET

Applicability: All chillers.

Definition: The reset schedule for the chilled water supply temperature. The chilled water setpoint may be reset based on demand or outdoor air temperature.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, 10°F from design chilled water supply temperature.

The chilled water supply temperature reset follows an outside air reset scheme, where the setpoint is 44°F at outside air conditions of 80°F dry-bulb and above; the setpoint is 54°F at outside air conditions of 60°F dry-bulb and below; and ramps linearly from 44°F to 54°F as the outside air dry-bulb temperature varies between 80°F and 60°F.

CONDENSER TYPE

Applicability: All chillers.

Definition: The type of condenser for a chiller.

The choices are:

- Air-cooled.
- Water-cooled.

Air-cooled chillers use air to cool the condenser coils. Water-cooled chillers use cold water to cool the condenser and additionally need either a cooling tower or a local source of cold water. Evaporatively-cooled chillers are similar to air-cooled chillers, except a water mist is used to cool the condenser coil, making them more efficient.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For System 14a, Air-cool condenser. For all others, water-cooled condenser.

5.8.3 Cooling Towers

Standard Design Summary. Standard design system 6, 14b and 15has one or more cooling towers. One tower is assumed to be matched to each standard design chiller. Each standard design chiller has its own condenser water pump that operates when the chiller is brought into service.

COOLING TOWER NAME

Applicability: All cooling towers.

Definition: A unique descriptor for each cooling tower.

Units: Text, unique.

Input Restrictions: User entry: where applicable, this should match the tags that are used on the plans.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others descriptive name that keys the standard design building plant.

COOLING TOWER TYPE

Applicability: All cooling towers.

Definition: Type of cooling tower employed.

The choices are:

- Open tower, centrifugal fan.
- Open tower, axial fan.
- Closed tower, centrifugal fan.
- Closed tower, axial fan.
- Closed tower evaporative, centrifugal fan.
- Closed tower evaporative, axial fan.

Open cooling towers collect the cooled water from the tower and pump it directly back to the cooling system. Closed towers circulate the evaporated water over a heat exchanger to indirectly cool the system fluid.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, if the open tower design condenser flow rate is greater than 900 gpm, the fan is axial, otherwise same as the proposed design. For all others, the standard design cooling tower is an open tower axial fan device.

COOLING TOWER CAPACITY

Applicability: All cooling towers.

Definition: The tower thermal capacity per cell adjusted to Cooling Technology Institute (CTI) rated conditions of 95°F condenser water return, 85°F condenser water supply, and 78°F wet-bulb with a 3 gpm/nominal ton water flow. The default cooling tower curves below are at unity at these conditions.

Units: Btu/h.

Input Restrictions: As designed.

Standard Design: For buildings with both healthcare and other occupancies, the proposed cooling tower capacity is scaled based on the ratio to the capacity of chillers serving healthcare areas. For all others, the Standard Design tower is sized to supply 85°F condenser water at design conditions for the oversized chiller.

COOLING TOWER NUMBER OF CELLS

Applicability: All cooling towers.

Definition: The number of cells in the cooling tower.

Each cell will be modeled as equal size. Cells are subdivisions in cooling towers into individual cells, each with their own fan and water flow, that allow the cooling system to respond more efficiently to lower load conditions.

Units Numeric: integer.

Input Restrictions: As designed.

Standard Design: One cell per tower and one tower per chiller.

Cooling Tower Total Fan Horsepower

Applicability: All cooling towers.

Definition: The sum of the nameplate rated horsepower (hp) of all fan motors on the cooling tower. Pony motors should not be included.

Units: hp.

Input Restrictions: As designed, but the cooling towers shall meet minimum performance requirements in Table 110.2-E of the Energy Code.

Standard Design: Cooling towers with a design condenser water flow greater than 900 gpm shall have a fan horsepower calculated based on the water flow rate (3.0 gpm per nominal cooling ton) of between 42.1 and 80 gpm/hp in, as specified in Table 140.4-H-2 or 170.2-I of the Energy Code. Cooling towers with a design condenser water flow of 900 gpm or less shall have a fan horsepower of 42.1 gpm/hp.

Standard Design: Existing Buildings: 42.1 gpm/hp.

Cooling Tower Design Wet-Bulb

Applicability: All cooling towers.

Definition: The design wet-bulb temperature that was used for selection and sizing of the cooling tower.

Units: Degrees Fahrenheit (°F).

Input Restrictions: Specified from design wet-bulb conditions from Reference Appendix JA2 for the city where the building is located, or the city closest to where the building is located.

Standard Design: Specified from design wet-bulb conditions from Reference Appendix JA2 for the city where the building is located, or from the city closest to where the building is located.

Cooling Tower Design Leaving Water Temperature

Applicability: All cooling towers.

Definition: The design condenser water supply temperature (leaving tower) that was used for selection and sizing of the cooling tower.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed; default to 85°F.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, 85°F or 10°F above the design wet-bulb temperature, whichever is lower.

Cooling Tower Design Return Water Temperature

Applicability: All cooling towers.

Definition: The design condenser water return temperature (entering tower) that was used for selection and sizing of the cooling tower.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed; default to 95°F.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, set to a range of 10°F (10°F above the cooling tower design entering water temperature).

Cooling Tower Capacity Adjustment Curve

Applicability: All cooling towers.

Definition: A curve or group of curves that represent the available tower capacity (tower approach) as a function of tower air flow ratio, condenser water flow ratio, outdoor air wet-bulb temperature, and condenser water temperature range between supply and return temperature.

The default curves are given as follows:

$$\begin{aligned} Approach = {} & Coeff_1 + Coeff_2 \cdot Fr_{air} + Coeff_3 \cdot Fr_{air}^2 + Coeff_4 \cdot Fr_{air}^3 + Coeff_5 \cdot Fr_{water} \\ & + Coeff_6 \cdot Fr_{air} \cdot Fr_{water} + Coeff_7 \cdot Fr_{air}^2 \cdot Fr_{water} + Coeff_8 \cdot Fr_{water}^2 + Coeff_9 \\ & \cdot Fr_{air} \cdot Fr_{water}^2 + Coeff_{10} \cdot Fr_{water}^3 + Coeff_{11} \cdot T_{wb} + Coeff_{12} \cdot Fr_{air} \cdot T_{wb} \\ & + Coeff_{13} \cdot Fr_{air}^2 \cdot T_{wb} + Coeff_{14} \cdot Fr_{water} \cdot T_{wb} + Coeff_{15} \cdot Fr_{air} \cdot Fr_{water} \cdot T_{wb} \\ & + Coeff_{16} \cdot Fr_{water}^2 \cdot T_{wb} + Coeff_{17} \cdot T_{wb}^2 + Coeff_{18} \cdot Fr_{air} \cdot T_{wb}^2 + Coeff_{19} \\ & \cdot Fr_{water} \cdot T_{wb}^2 + Coeff_{20} \cdot T_{wb}^3 + Coeff_{21} \cdot Tr + Coeff_{22} \cdot Fr_{air} \cdot Tr + Coeff_{23} \\ & \cdot Fr_{air}^2 \cdot Tr + Coeff_{24} \cdot Fr_{water} \cdot Tr + Coeff_{25} \cdot Fr_{air} \cdot Fr_{water} \cdot Tr + Coeff_{26} \\ & \cdot Fr_{water}^2 \cdot Tr + Coeff_{27} \cdot T_{wb} \cdot Tr + Coeff_{28} \cdot Fr_{air} \cdot T_{wb} \cdot Tr + Coeff_{29} \cdot Fr_{water} \\ & \cdot T_{wb} \cdot Tr + Coeff_{30} \cdot T_{wb}^2 \cdot Tr + Coeff_{31} \cdot Tr^2 + Coeff_{32} \cdot Fr_{air} \cdot Tr^2 + Coeff_{33} \\ & \cdot Fr_{water} \cdot Tr^2 + Coeff_{34} \cdot T_{wb} \cdot Tr^2 + Coeff_{35} \cdot Tr^2 \end{aligned}$$

Where:

- $\boldsymbol{Fr_{air}}$ – ratio of airflow to airflow at design conditions
- $\boldsymbol{Fr_{water}}$ – ratio of water flow to water flow at design conditions
- $\boldsymbol{Tr}$ – tower range (°F)
- $\boldsymbol{T_{wb}}$ – wet-bulb temperature

Coefficients for this performance curve are provided in Appendix 5.7.

Units: Data structure.

Input Restrictions: User must use one of the prescribed curves defined in Appendix 5.7.

Standard Design: Use one of the prescribed curves defined in Appendix 5.7.

COOLING TOWER SET POINT CONTROL

Applicability: All cooling towers.

Definition: The type of control for the condenser water supply.

The choices are:

- Fixed.
- Scheduled.
- Outside air reset.
- Wet bulb reset.
- Fixed dual setpoint.

A fixed control will modulate the tower fans to maintain the design condenser water supply temperature. A wet-bulb reset control will reset the condenser water supply temperature setpoint to a fixed approach to outside air wet-bulb temperature. The approach defaults to 10°F. A lower approach may be used with appropriate documentation.

Units: List (see above).

Input Restrictions: As designed; default to fixed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, fixed at the 0.4 percent design wet-bulb temperature, which is prescribed and specified for each of the 86 weather data files.

COOLING TOWER CAPACITY CONTROL

Applicability: All cooling towers.

Definition: Describes the modulation control employed in the cooling tower.

Choices include the following:

- Fluid Bypass provides a parallel path to divert some of the condenser water around the cooling tower at part-load conditions.
- Fan Cycling is a simple method of capacity control where the tower fan is cycled on and off. This is often used on multiple-cell installations.
- Two-Speed Fan/Pony Motor is another method of capacity control that saves fan energy. A lower horsepower pony motor is an alternative to a two-speed motor. The pony motor runs at part-load conditions (instead of the full-sized motor) and saves fan energy when the tower load is reduced. Additional building descriptors are triggered when this method of capacity control is selected.

- Variable-Speed Fan has a variable frequency drive installed on the tower fan for fan speed control and capacity modulation.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, if the fan motor hp is 7.5 or larger, variable-speed fan, otherwise, same as the proposed design. For all others, variable-speed fan.

COOLING TOWER LOW-SPEED AIRFLOW RATIO

Applicability: All cooling towers with two-speed, pony motors or variable-speed fan.

Definition: The percentage full-load airflow that the tower has at low speed or with the pony motor operating; equivalent to the percentage full-load capacity when operating at low speed.

Units: Ratio.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, 0.5.

COOLING TOWER LOW-SPEED KW RATIO

Applicability: All cooling towers with two-speed/pony motors or variable-speed fan.

Definition: The percentage full-load power that the tower fans draw at low speed or with the pony motor operating.

Units: Ratio.

Input Restrictions: Calculated, using the as-designed flow ratio and the cooling tower power adjustment curve below.

Standard Design: For healthcare facilities, same as the proposed design. For all others, 0.25.

COOLING TOWER POWER ADJUSTMENT CURVE

Applicability: All cooling towers with VSD control.

Definition: A curve that varies the cooling tower fan energy usage as a function of part-load ratio for cooling towers with variable speed fan control. The default curve is given as:

$$PLR = \frac{Q_{operating}}{Q_{available}(t_R, t_A, t_{OWB})}$$

$$TWR_{Fan-FPLR} = a + b(PLR) + c(PLR)^2 + d(PLR)^3$$

$$P_{operating} = P_{rated}(TWR_{Fan-FPLR})$$

Where:

- $\boldsymbol{PLR}$ — Part-load ratio based on available capacity (not rated capacity)
- $\boldsymbol{Q_{operating}}$ — Present load on tower (in Btu/h)
- $\boldsymbol{Q_{available}}$ — Tower available capacity at present range, approach, and outside wet-bulb conditions (in Btu/h)
- $\boldsymbol{t_{OWB}}$ — The outside air wet-bulb temperature (°F)
- $\boldsymbol{t_R}$ — The tower range (°F)
- $\boldsymbol{t_A}$ — The tower approach (°F)
- $\boldsymbol{P_{rated}}$ — Rated power draw at CTI conditions (kW)
- $\boldsymbol{P_{operating}}$ — Power draw at specified operating conditions (kW)

Refer to Appendix 5.7 for the fixed cooling tower curve coefficients.

Units: Data structure.

Input Restrictions: User shall use only default curves.

Standard Design: Use default curves given above.

COOLING TOWER MINIMUM SPEED

Applicability: All cooling towers with a VSD control.

Definition: The minimum fan speed setting of a VSD controlling a cooling tower fan expressed as a ratio of full load speed.

Units: Ratio.

Input Restrictions: As designed; default is 0.50.

Standard Design: For healthcare facilities, if the fan motor hp is 7.5 or larger, 0.5, otherwise, same as the proposed design. For all others, 0.5.

5.8.4 Water-side Economizers

None of the standard design building systems use a water-side economizer.

WATER-SIDE ECONOMIZER NAME

Applicability: All water-side economizers.

Definition: The name of a water-side economizer for a cooling system.

Units: Text, unique.

Input Restrictions: Descriptive reference to the construction documents.

Standard Design: For healthcare facilities, same as the proposed design. For all others, no water economizer.

WATER ECONOMIZER TYPE

Applicability: All water-side economizers.

Definition: The type of water-side economizer. Choices include:

- None.
- Heat exchanger in parallel with chillers. This would be used with an open cooling tower and is often referred to as a nonintegrated economizer because the chillers are locked out when the plant is in economizer mode.
- Heat exchanger in series with chillers. This would be used with an open cooling tower and is often referred to as integrated because the chillers can operate simultaneously with water economizer operation.
- Direct water economizer. This would be used with a closed cooling tower. In this case, a heat exchanger is not needed. This type works only as a non-integrated economizer (also known as strainer-cycle).

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, no water economizer.

WATER-SIDE ECONOMIZER HX EFFECTIVENESS

Applicability: Water-side economizers with an open cooling tower.

Definition: The effectiveness of a water-side heat exchanger at design conditions.

This is defined as:

$$Q_{econ} = (m_{CHW})(Cp_{CHW})(\varepsilon)\left(T_{CHW,R} - T_{CW,S}\right)$$

Where:

$\boldsymbol{Q_{econ}}$ — The maximum load that the economizer can handle (Btu/hr)
$\boldsymbol{m_{CHW}}$ — The chilled water flow rate (lb/hr)
$\boldsymbol{Cp_{CHW}}$ — The chilled water specific heat (BTU/lb-°F)
$\boldsymbol{T_{CHW,R}}$ — The chilled water return temperature (°F)
$\boldsymbol{T_{CW,S}}$ — The condenser water supply temperature (°F)

ε — The effectiveness of the water-side economizer heat exchanger

Units: Ratio

Input Restrictions: Not a user input.

Standard Design: For healthcare facilities, same as the proposed design. For all others, no water economizer.

WATER-SIDE ECONOMIZER HEAT EXCHANGER HEAT TRANSFER COEFFICIENT

Applicability: Water-side economizers with an open cooling tower.

Definition: The heat transfer coefficient of the plate-and-frame heat exchanger with the waterside economizer.

Units: Btu/h-°F.

Input Restrictions: Not a user input. It is calculated based on other user inputs as follows:

$$UA = Cap_{Rtd}/LMTD$$

Where:

UA – The heat transfer coefficient (Btu/hr- °F)

Cap_{Rtd} – The design cooling capacity of the heat exchanger (Btu/hr)

$LMTD$ – The log mean temperature difference of the heat exchanger at the design conditions.

And $LMTD$ is calculated as:

$$LMTD = Tchw_{Lvg} - Tcw_{Ent}$$

When $Tchw_{Lvg} - Tcw_{Eng} = Tchw_{Ent} - Tcw_{Lvg}$. Otherwise

$$LMTD = \frac{\left((Tchw_{Lvg} - Tcw_{Ent}) - (Tchw_{Eng} - Tcw_{Lvg})\right)}{\ln\left((Tchw_{Lvg} - Tcw_{Ent})/(Tchw_{Eng} - Tcw_{Lvg})\right)}$$

Where:

$Tchw_{Ent}$ – The temperature of water entering the exchanger on the chilled water side of the system at design conditions (°F).

$Tchw_{Lvg}$ – The temperature of water leaving the exchanger on the chilled water side of the system at design conditions (°F).

Tcw_{Ent} – The temperature of water entering the exchanger on the condenser water side of the system at design conditions (°F).

Tcw_{Lvg} – The temperature of water leaving the exchanger on the condenser water side of the system at design conditions (°F).

Standard Design: For healthcare facilities, same as the proposed design. For all others, not applicable.

Water-Side Economizer Approach

Applicability: All water-side economizers (WSE).

Definition: The design temperature difference between the chilled water temperature leaving the WSE heat exchanger and the condenser water *entering* the WSE heat exchanger.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed; default is 4°F.

Standard Design: For healthcare facilities, same as the proposed design. For all others, no water economizer.

Water-Side Economizer Maximum CWST

Applicability: All water-side economizers.

Definition: The control temperature (condenser water supply temperature, CWST) above which the water-side economizer is disabled.

Units: Degrees Fahrenheit (°F).

Input Restrictions: As designed; default is 50°F.

Standard Design: For healthcare facilities, same as the proposed design. For all others, no water economizer.

Water-Side Economizer Availability Schedule

Applicability: All water-side economizers.

Definition: A schedule which represents the availability of the water-side economizer.

Units: Data structure: schedule, on/off.

Input Restrictions: Not a user input. Always available.

Standard Design: For healthcare facilities, same as the proposed design. For all others, no water economizer.

5.8.5 Pumps

Standard Design Summary — Hot water pumping in the standard design shall be modeled as a variable flow, primary only system. Two-way valves are assumed at the heating coils.

Chilled water pumping in the standard design is a primary only system. Each water-cooled chiller has its own variable speed chilled water pump and constant speed condenser water pump. Both water pumps operate when the chiller is activated.

General Notes — The building descriptors in this chapter are repeated for each pumping system. See the pump service building descriptor for a list of common pump services.

PUMP NAME

Applicability: All pumps.

Definition: A unique descriptor for each pump.

Units: Text, unique.

Input Restrictions: User entry: where applicable, should match the tags that are used on the plans.

Standard Design: For healthcare facilities, same as proposed design. For all others, Pumps are only designated in the standard design if the baseline system type includes primary systems. Assign a sequential tag to each piece of equipment. The sequential tags should indicate the pump service as part of the descriptor (e.g., CW for condenser water, CHW for chilled water, or HHW for heating hot water).

PUMP SERVICE

Applicability: All pumps.

Definition: The service for each pump.

Choices include:

- Chilled water.
- Chilled water (primary).
- Chilled water (secondary).
- Heating water.
- Heating water (primary).
- Heating water (secondary).
- Service hot water.
- Condenser water (for heat rejection or water-source heat pump loops).
- Loop water (for hydronic heat pumps).

Units: List (see above).

Input Restrictions: As designed.

Standard Design: As needed by the standard design system. See 5.1.3 HVAC System Map.

NUMBER OF PUMPS

Applicability: All pumps.

Definition: The number of identical pumps in service in a particular loop, e.g., the heating hot water loop, chilled water loop, or condenser water loop.

Units: Numeric: integer.

Input Restrictions: As designed.

Standard Design: There will be one heating hot water pump for each boiler, one chilled water pump, and one condenser water pump for each chiller.

Water Loop Design

Applicability: All pumps.

Definition: The heating and cooling delivery systems can consist of a simple primary loop system, or more complicated primary/secondary loops or primary/secondary/tertiary loops.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, assume primary loops only for heating hot water and chilled water loops.

Pump Motor Modeling Method

Applicability: All pumps.

Definition: Compliance software commonly models pumps in one of two ways. The simple method is for the user to enter the electric power per unit of flow (W/gpm). This method is commonly used for smaller systems. A more detailed method requires a specification of the pump head, design flow, impeller, and motor efficiency.

Units: List power-per-unit-flow or detailed.

Input Restrictions: Detailed.

Standard Design: Detailed for chilled water and condenser water pumps; power-per-unit-flow for heating hot water and service hot water pumps.

Pump Motor Power-Per-Unit-Flow

Applicability: All pumps that use the power-per-unit-flow method.

Definition: The electric power of the pump divided by the flow at design conditions.

Units: W/gpm.

Input Restrictions: Not a user input for proposed model. Value is calculated based on other user input pump performance values.

Standard Design: For healthcare facilities, same as the proposed design. For all others, not applicable for chilled water and condenser water pumps; 19 W/gpm for heating hot water and service hot water pumps.

Pump Motor Horsepower

Applicability: All pumps.

Definition: The nameplate motor horsepower.

Units: Horsepower (hp).

Input Restrictions: Constrained to be a value from the following standard motor sizes:

1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200

Alternatively, the nameplate horsepower can be entered as a numeric value.

Standard Design: For buildings with both healthcare and other occupancies, the proposed pump horsepower is scaled based on the ratio of plant equipment serving healthcare areas. Otherwise, set to the next larger nominal motor size, from Table 12: Minimum Nominal Efficiency for Electric Motors (Percent), for the calculated input brake horsepower.

PUMP DESIGN HEAD

Applicability: All standard and proposed design pumps that use the detailed method.

Definition: The head of the pump at design flow conditions.

Units: ft of water.

Input Restrictions: As designed but subject to an input restriction. The user inputs of pump design head, impeller efficiency, and pump design flow shall be used to calculate the proposed brake horsepower. This shall be compared to the pump motor.

Horsepower for the next smaller motor size (MHP_{i-1}) than the one specified by the user (MHP_i).

The proposed pump design head shall be constrained so that the resulting brake horsepower is no smaller than 95 percent of the next smaller motor size:

$$design\ bhp_{prop} = \max\left[design\ bhp_{prop-user-head}, 0.95(MHP_{i-1})\right]$$

Where:

- $\boldsymbol{design\ bhp_{prop}}$ — The brake horsepower used in the simulation
- $\boldsymbol{design\ bhp_{prop-user-head}}$ — The brake horsepower resulting from the user input of design head
- $\boldsymbol{MHP_i}$ — The pump motor horsepower specified by the user
- $\boldsymbol{i}$ — The index into the standard motor size table for the user motor horsepower
- $\boldsymbol{MHP_{i-1}}$ — The motor horsepower for the next smaller motor size. For example, if the user-specified pump motor horsepower is 25, the next smaller motor size in the table above is 20

Since all other user inputs that affect the proposed design brake horsepower are not modified, the proposed design pump design head is adjusted in the same proportion as the pump brake horsepower in the equation above. If the user-entered pump design head results in a brake horsepower that is at least 95 percent of the horsepower of the next smaller motor size, no modification of the user input is required.

Standard Design: For healthcare facilities, same as the proposed design. For all others, for chilled water pumps:

$$Head_{CHW} = (40ft) + 0.03\frac{ft}{ton} \times [chiller\ plant\ nominal\ capacity\ (tons)]$$

(not to exceed 100 ft)

For chilled water pumps serving four pipe fan coil systems:

For condenser water pumps: 45 ft

IMPELLER EFFICIENCY

Applicability: All pumps in proposed design that use the detailed modeling method.

Definition: The full load efficiency of the impeller.

Units: Unitless.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, 70%.

MOTOR EFFICIENCY

Applicability: All pumps in proposed design that use the detailed modeling method.

Definition: The full load efficiency of the pump motor.

Units: Unitless.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. The motor efficiency is taken from Table 12: Minimum Nominal Efficiency for Electric Motors (Percent), using the calculated nameplate motor size.

PUMP MINIMUM FLOW

Applicability: All variable-speed pumps.

Definition: The minimum pump flow for a variable-speed pump.

For variable speed pumps, the minimum flow is set to be 10% of the design flow rate.

Units: gpm.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the proposed design. For all others, 0 gpm.

PUMP DESIGN FLOW

Applicability: All pumps.

Definition: The flow rate of the pump at design conditions; derived from the load, and the design supply and return temperatures.

Units: gpm or gpm/ton for condenser and primary chilled water pumps.

Input Restrictions: As designed.

Standard Design: For buildings with both healthcare and other occupancies, the proposed pump flow is scaled based on the ratio to the capacity of plant equipment serving healthcare areas. For all others, the temperature change on the evaporator side of the chillers is 20°F (64°F less 44°F) and this equates to a flow of 1.2 gpm/ton. The temperature change on the condenser side of the chillers is 12°F, which equates to a flow of 2.0 gpm/cooling ton. For hot water pumps servicing boilers, the temperature change on the boilers is 30°F (135°F less 105°F), which equates to a flow of 0.067 gpm/kBtuh. For air-to-water heat pumps, the temperature change on the space heating side is 10°F (105°F less 95°F), which equates to 0.2 gpm/kBtuh.

PUMP CONTROL TYPE

Applicability: All pumps.

Definition: The type of control for the pump.

Choices are:

- Constant speed.
- Variable speed.

Units: List, see above.

Input Restrictions: As designed; default is "constant speed", which models the action of a constant speed pump riding the curve against two-way control valves.

Standard Design: For healthcare facilities, same as the proposed design. For all others, the chilled water and hot water pumps shall be modeled as variable-speed, condenser water pumps shall be modeled as constant speed.

PUMP OPERATION

Applicability: All pumps.

Definition: The type of pump operation can be either on-demand, standby, or scheduled. On-demand operation means the pumps are only pumping when their associated equipment is cycling. Chiller and condenser pumps are on when the chiller is on and the heating hot water pump operates when its associated boiler is cycling. Standby operation allows hot or chilled water to circulate through the primary loop of a primary/secondary loop system or through a reduced portion of a primary-only system, assuming the system has appropriate three-way valves. Scheduled operation means that the pumps and their associated equipment are turned completely off according to occupancy schedules, time of year, or outside conditions. Under scheduled operation, when the systems are on, they are assumed to be in on-demand mode.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: The standard design system pumps are assumed to operate in on-demand mode. The chilled water and condenser pumps are tied to the chiller operation, cycling on and off with the chiller, and the heating hot water pumps are tied to the boiler operation.

PUMP PART-LOAD CURVE

Applicability: All pumps.

Definition: A part-load power curve for the pump:

$$CIRC - PUMP - FPLR = a + b(PLR) + c(PLR)^2 + d(PLR)^3$$

$$P_{pump} = P_{design}(CIRC - PUMP - FPLR)$$

Where:

$\boldsymbol{PLR}$ — Part-load ratio (the ratio of operating flow rate in gpm to design flow rate in gpm)
$\boldsymbol{P_{pump}}$ — Pump power draw at part-load conditions (W)
$\boldsymbol{P_{design}}$ — Pump power draw at design conditions (W)

Refer to Appendix 5.7 for a specification of the default pump part-load curve, and the pump part-load curve if there is differential pressure reset (if DDC controls are present).

Units: Data structure.

Input Restrictions: Where applicable, curves are prescribed based on system type, see Appendix 5.7.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, DP Reset curve for chilled water pumps; heating hot water pump power is assumed to be constant even though the pump is riding the curve.

5.8.6 Variable Refrigerant Flow (VRF) Systems

Variable refrigerant flow systems consist of an outdoor unit and one or more zonal systems as indoor units. The required system level inputs are shown below. Refer to the HVAC zone level systems chapter for zonal (indoor) units connected to a VRF system. Equipment performance curves are prescribed and defined in Appendix 5.4B for VRF systems.

VRF SYSTEM NAME

Applicability: VRF.

Definition: A unique name designating the VRF System.

Units: None.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

HEAT RECOVERY

Applicability: VRF.

Definition: Identification if heat recovery (refrigerant loop) is present.

Units: Boolean.

Input Restrictions: None (default : No).

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

CONTROL PRIORITY

Applicability: VRF.

Definition: A control parameter used to determine when outdoor unit is in heating or cooling mode.

Choices include:

- Load Priority — The total zone load is used to choose the operating mode as either cooling or heating.
- Master Thermostat Priority — The system operates according to the zone load where the master thermostat is located.

Units: List (see above).

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

Control Zone

Applicability: Master Thermostat Control Zone.

Definition: The name of the control zone that controls the outdoor unit, when the Control Priority is Master Thermostat Priority.

Units: None.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

Minimum Part-Load Ratio

Applicability: VRF.

Definition: The minimum part-load ratio for the heat pump. Below this ratio the unit will cycle to meet the load.

Units: Unitless.

Input Restrictions: 0.25 to 1.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

Efficiency Rating

Applicability: VRF.

Definition: The applicable test standard for the designed system.

Choices include:

- AHRI Standard 1230-2014.
- AHRI Standard 1230-2021/2023.

Units: List (see above).

Input Restrictions: As designed. Changes to AHRI Standard 1230 in 2021/2023 affect VRF EER ratings. To account for this, equipment rated under AHRI Standard 1230 2021/2023 or newer must select 2021/2023. Systems rated under older procedures must select 2014.

Standard Design: For healthcare facilities, same as proposed. For all others, not applicable.

RATED EER

Applicability: VRF.

Definition: Full load cooling efficiency (Btu/h of net cooling output divided by the electrical energy consumption in Watts) as specified by AHRI 1230 rated conditions.

Units: Btu/h-W.

Input Restrictions: As designed, the user-entered value must meet mandatory minimum requirements of the Appliance Standards for the applicable equipment type.

Because Appendix 5.7 VRF performance curves are normalized to AHRI Standard 1230-2014, VRF systems rated under the AHRI Standard 1230-2021 or AHRI Standard 1230-2023 must have the rated EER adjusted as follows before simulation:

$$EER_{sim} = EER_{rated} \times VRF2023Factor$$

$$VRF2023Factor = [(-1.60926\ x\ 10^{-7}) \times System\ Capacity\ (Btu/h)] + 1.14394$$

Standard Design: For healthcare facilities, the minimum heating efficiency from the Energy Code for the applicable equipment type. For all others, not applicable.

RATED COP

Applicability: VRF.

Definition: Full load heating efficiency (net heating output divided by the electrical energy consumption, both in the same units) at AHRI rating conditions.

Units: None.

Input Restrictions: As designed, the user-entered value must meet mandatory minimum requirements of the Appliance Standards for the applicable equipment type.

Standard Design: For healthcare facilities, the minimum heating efficiency from the Energy Code for the applicable equipment type. For all others, not applicable.

EQUIVALENT PIPE LENGTH

Applicability: VRF.

Definition: The equivalent pipe length between the farthest terminal unit and the condensing unit, including liquid refrigerant line length, fitting losses, and other losses.

Units: ft.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

MAX VERTICAL HEIGHT

Applicability: VRF.

Definition: The vertical height difference between the highest or lowest terminal unit and outdoor unit.

Units: ft.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

DEFROST HEAT SOURCE

Applicability: VRF.

Definition: The defrost heat source type.

Units: List – electric or gas.

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

DEFROST CONTROL STRATEGY

Applicability: VRF.

Definition: The control method for enabling defrost.

Units: List – Timed Cycle or On Demand.

Input Restrictions: Not a user input.

Standard Design: Not applicable.

MAX DEFROST TEMP

Applicability: VRF.

Definition: The maximum outdoor dry-bulb temperature at which defrost will occur.

Units: Degree Fahrenheit (°F).

Input Restrictions: None.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

COMPRESSOR QUANTITY

Applicability: VRF.

Definition: The number of compressors represented by the unit.

Units: Unitless integer.

Input Restrictions: None.

Standard Design: Not applicable.

CRANKCASE HEATER CAPACITY

Applicability: VRF.

Definition: The capacity of the resistive heating element in or around the crank case of a compressor. The crank case heater operates only when the compressor is off.

Units: W.

Input Restrictions: The value is prescribed to be 10 W per ton (rated net cooling capacity).

Standard Design: Not applicable

CRANKCASE HEATER SHUTOFF TEMPERATURE

Applicability: VRF.

Definition: The outdoor air dry-bulb temperature above which the crankcase heater is not permitted to operate.

Units: Degree Fahrenheit (°F).

Input Restrictions: The value is prescribed to be 50°F.

Standard Design: Not applicable

5.8.7 Plant Management

Plant management is a method of sequencing equipment. Separate plant management schemes may be entered for chilled water systems, hot water systems, etc. The following building descriptors are specified for each load range, e.g., when the cooling load is below 300 tons, between 300 tons and 800 tons, and greater than 800 tons.

EQUIPMENT TYPE MANAGED

Applicability: All plant systems.

Definition: The type of equipment under a plant management control scheme.

Choices include:

- Chilled water cooling.
- Hot water space heating.
- Condenser water heat rejection.
- Service water heating.

Units: List (see above).

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

EQUIPMENT SCHEDULE

Applicability: All plant equipment.

Definition: A schedule that identifies when the equipment is in service.

Units: Data structure.

Input Restrictions: Prescribed to be on 24/7, the whole year.

Standard Design: Prescribed to be on 24/7, the whole year.

EQUIPMENT OPERATION

Applicability: All plant equipment.

Definition: Equipment operation can be either on-demand or always-on.

On-demand operation means the equipment cycles on when it is scheduled to be in service and when it is needed to meet building loads. Otherwise, it is off.

Always-on means that equipment runs continuously when it is scheduled to be in service. For the purpose of the compliance model, always-on is used for equipment such as chillers that are base-loaded, and on-demand equipment is scheduled to be on only when the base-loaded equipment (one or more) cannot meet the load.

Units: None.

Input Restrictions: Not a user input.

Standard Design: Assume on-demand operation.

EQUIPMENT STAGING SEQUENCE

Applicability: All plant equipment.

Definition: The staging sequence for plant equipment (chillers and boilers) indicates how multiple pieces of equipment will be staged on and off when a single piece of equipment is unable to meet the load. In both the proposed and standard design, the compliance software uses the optimal sequence to determine plant staging based on part-load performance. This descriptor is used to identify sequencing when the plant contains unequal equipment, where the order in which the plant equipment is enabled affects plant energy use.

Units: Structure – an array, where each element includes a) the load range, in minimum tons and maximum tons; and b) a list of equipment that is enabled to operate. The equipment will run in the priority matching the order of the equipment listed.

Input Restrictions: As designed; user may specify load ranges for staging each plant equipment.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

The standard design chiller and boiler plant each consist of one or more equal chillers or boilers, so the loading order is not applicable.

5.8.8 Thermal Energy Storage

The compliance model inputs below document the requirements to model a chilled water thermal energy storage system with compliance software. Some systems (ice storage, eutectic salts) cannot be modeled with compliance software.

THERMAL ENERGY STORAGE SYSTEMS NAME

Applicability: All thermal energy storage systems.

Definition: A unique descriptor for thermal energy storage systems.

Units: Text, unique.

Input Restrictions: Where applicable, this should match the tags that are used on the plans such that a plan reviewer can make a connection.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

THERMAL ENERGY STORAGE SYSTEMS TYPE

Applicability: All thermal energy storage systems.

Definition: The type of thermal energy storage system being used.

Chilled water storage system is the only currently supported option.

Units: List, chilled water.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

DISCHARGE PRIORITY

Applicability: All thermal energy storage systems.

Definition: A descriptor determines whether the storage system or a chiller will operate first to meet cooling loads during the discharge period. Storage priority will normally provide larger demand charge savings but requires a larger storage system. Chiller priority allows use of a significantly smaller storage system, but demand reduction will be smaller.

Units: List storage or chiller.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

OPERATION MODE SCHEDULE

Applicability: All thermal energy storage systems.

Definition: A schedule which controls operating mode of the thermal energy storage system.

A thermal energy storage system can be discharging (supplying chilled water to meet cooling loads), charging (receiving chilled water to be stored for later use), or off. The operation mode schedule specifies one of these modes for each of the 8,760 hours in a year.

Units: Data structure — thermal energy storage mode schedule, specifies charging, discharging, or off on an hourly basis.

Input Restrictions: Not a user input.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

RATED CAPACITY

Applicability: All thermal energy storage systems.

Definition: The design cooling capacity of the thermal energy storage system.

The rated cooling capacity of the thermal energy storage system is determined by design flow rate of the thermal energy storage system and the temperature difference between the fluid system supply and return water temperature during discharging.

Units: Btu/hr.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

TANK LOCATION

Applicability: All thermal energy storage systems.

Definition: The location of the heat pump water heater for determining losses and heat energy interaction with the surroundings.

Units: List zone, outdoors, or underground.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

TANK SHAPE

Applicability: All thermal energy storage systems.

Definition: The shape of the energy storage system tank used to calculate surface area of the tank for heat gain/loss calculations.

Units: List: Vertical cylinder, Horizontal cylinder, or rectangular.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

TANK VOLUME

Applicability: All thermal energy storage systems.

Definition: The volume of water held in the thermal energy storage system tank.

The tank volume and the rated capacity will determine how long the storage system can meet the load.

Units: Gallons.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

TANK HEIGHT

Applicability: All thermal energy storage systems.

Definition: For vertical cylinder or rectangular tank, the height will be the maximum internal height of water held in the upright storage tank. For horizontal cylinder tank, the height of the storage tank will be the inner diameter of the storage tank.

Units: Feet.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

TANK LENGTH TO WIDTH RATIO

Applicability: All thermal energy storage systems.

Definition: The length to width ratio of a rectangular storage tank in plan view. It is required only if tank shape is rectangular.

If the tank is square, the length to width ratio is one. For a rectangular tank, the ratio will be greater than one since the length of the tank is always greater than the width of the tank. This is used to determine the surface area of the tank.

Units: Unitless ratio.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

TANK R-VALUE

Applicability: All thermal energy storage systems.

Definition: The insulation applied to the tank used in calculating the tank U-factor.

Units: R-value (h-ft^2-F/Btu).

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, not applicable.

5.9 Miscellaneous Energy Uses

Miscellaneous energy uses are defined as those that may be treated separately since they have little or no interaction with the conditioned thermal zones or the HVAC systems that serve them.

5.9.1 Service Water Heating System Loads and Configuration

WATER HEATING SYSTEM NAME

Applicability: All water heating systems.

Definition: A unique descriptor for each water heating system.

A system consists of one or more water heaters, a distribution system, an estimate of hot water use, and a schedule for that use. Nonresidential buildings will typically have multiple systems, perhaps a separate electric water heater for each office break room, etc. Other building types such as hotels and hospitals may have a single system serving the entire building.

Units: Text, unique.

Input Restrictions: Where applicable, this should match the tags that are used on the plans such that a plan reviewer can make a connection.

Standard Design: The naming convention for the standard design system shall be similar to the proposed design.

WATER HEATING PEAK USE

Applicability: All water heating systems, required.

Definition: An indication of the peak hot water usage (e.g., service to sinks, showers, kitchen appliances, etc.). When specified per occupant, this value is multiplied by design occupancy density values and modified by service water heating schedules to obtain hourly load values which are used in the simulation.

Peak consumption is commonly specified as gallons per hour (gph) per occupant, dwelling unit, hotel room, patient room, or floor area. If consumption is specified in gph, then additional inputs would be needed such as supply temperature, cold water inlet temperature, etc.

Compliance software that specifies peak use as a thermal load in Btu/h can apply ACM rules for the mains (cold water inlet) temperature and supply temperature to convert the prescribed peak use from gph/person to Btu/h-person. The thermal load does not include conversion efficiencies of water heating equipment.

Units: gph/person.

Input Restrictions: For nonresidential spaces and residential living spaces of hotels and motels (guestrooms), prescribed values from Appendix 5.4A if a service hot water heating system is installed; otherwise, all values are 0.

Standard Design: Prescribed values from Appendix 5.4A if a service hot water heating system is installed; otherwise, all values are 0.

WATER HEATING SCHEDULE

Applicability: All water heating systems.

Definition: A fractional schedule reflecting the time pattern of water heating use.

This input modifies the water heating peak use described above.

Units: Data structure — schedule, fractional.

Input Restrictions: The schedules from Appendix 5.4A shall be used.

Standard Design: The schedules from Appendix 5.4A shall be used.

WATER HEATING SYSTEM CONFIGURATION

Applicability: All water heating systems.

Definition: The configuration and layout of the water heating system including the number of water heaters; the size, location, length, and insulation of distribution pipes; recirculation systems and pumps; and any other details about the system that would affect the energy model.

Units: Data structure.

Input Restrictions: None.

Standard Design: For healthcare facility spaces, the same as proposed.

For all other spaces, the standard design shall have one gas storage water heater if any of the spaces have a Space Water Heating Fuel Type of Gas (from Appendix 5.4A), and the standard design building will have on electric water heater if the any of the spaces have a Space Water Heating Fuel Type of Electric.

Standard Design: Existing Buildings: Same as proposed if proposed system is existing.

WATER MAINS TEMPERATURE SCHEDULE

Applicability: All water heating systems.

Definition: A monthly temperature schedule indicating the water mains temperature.

This temperature and the setpoint temperature are used to convert the load into a water flow rate.

Units: Data structure — schedule, °F.

Input Restrictions: For nonresidential spaces and residential living spaces of hotels and motels (guestrooms), the schedules from Appendix 5.4A shall be used. The water mains temperature schedule shall be fixed for a given climate zone.

Standard Design: For nonresidential spaces and residential living spaces of hotels and motels (guestrooms), the schedules from Appendix 5.4A shall be used. The water mains temperature schedule shall be fixed for a given climate zone.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

5.9.2 Water Heaters

This chapter describes the building descriptors for water heaters. Typically, a building will have multiple water heating systems and each system can have multiple water heaters, so these building descriptors may need to be specified more than once.

WATER HEATER NAME

Applicability: All water heaters.

Definition: A unique descriptor for each water heater in the system.

Some systems will have multiple pieces of equipment. For instance, a series of water heaters plumbed in parallel or a boiler with a separate storage tank.

Units: Text, unique.

Input Restrictions: Where applicable, this should match the tags that are used on the plans such that a plan reviewer can make a connection.

Standard Design: The naming convention for the standard design system shall be similar to the proposed design.

WATER HEATER TYPE AND SIZE

Applicability: All water heaters.

Definition: This building descriptor includes information needed to determine the criteria from baseline standards. The choices and the associated rated capacity (heat input rate) are listed in the *2015 Appliance Efficiency Regulations*, except that oil-fired water heaters and boilers are not supported.

Units: List conventional, heat pump split, or heat pump packaged.

Input Restrictions: As designed.

Standard Design: For healthcare facility spaces, the same as proposed. For all other spaces, the standard design shall have one gas storage water heater if any of the spaces have a space water heating fuel type of gas (from Appendix 5.4A), and the standard design building will have on electric water heater if the any of the spaces have a space water heating fuel type of electric.

For school buildings less than 25,000 square feet and less than four floors in climate zones 2 through 15, the standard design shall have a heat pump water heating system.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

RATED CAPACITY

Applicability: All water heaters.

Definition: For gas and electric resistance water heaters, the heating capacity of a water heater (input rate) at the rated conditions specified in DOE 10 CFR Part 430 or ANSI Z21.10. For heat pump water heaters, the rated heating capacity supplied to the water (output rate).

Units: Thousands of British thermal units per hour (MBH).

Input Restrictions: As designed.

Standard Design: The capacity of the standard design water heaters will be based on the larger of the total design hot water consumption rate (gallons/hr) of all the spaces in the building or 75 gallons per hour. The consumption rate is converted to Btu/hr (x (design supply temp – 55) x 8.2877 pounds/gallon x 1 Btu/pound-F). That value is multiplied by 0.60 to find the heat that must be supplied to the water.

All of the water heaters in the proposed design are similarly converted to a total Btu/hr heat output, summed across the water heaters, and multiplied by 0.60.

The standard design uses the smaller of these values and divides by thermal efficiency to find energy input.

If the standard design has both a gas water heater and an electric water heater, the total capacity will be pro-rated between the two based on the total hot water consumption rate of the spaces with water heating fuel type of electric or gas.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

STORAGE VOLUME

Applicability: Storage water heaters.

Definition: The volume of a storage water heater used in the standby loss calculations and standard design calculations of energy factor and uniform energy factor.

Units: Gallons.

Input Restrictions: As designed.

Standard Design: The volume of the standard design water heaters will be based on the larger of the total design hot water consumption rate (gallons/hr) of all the spaces in the building or 75 gallons per hour. That value is multiplied by 1 hour and 0.40 to determine the storage volume.

All of the water heaters in the proposed design are similarly converted to a total Btu/hr heat output, summed across the water heaters. This value is multiplied by 0.40 and converted to gallons (design supply temp – 55) / 8.2877 pounds/gallon / 1 Btu/pound-F x 1 hr).

The standard design uses the smaller of these values.

For school buildings less than 25,000 square feet and less than 4 floors in climate zones 2 through 15, the standard design shall have at a minimum 1 heat pump water heater with a storage volume calculated based on the total design hot water consumption rate of all spaces in the building.

If the standard design has both a gas water heater and an electric water heater, the total volume will be pro-rated between the two based on the total hot water consumption rate of the spaces with water heating fuel type of electric or gas.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

INPUT POWER

Applicability: Heat pump water heaters.

Definition: The total design electrical input to a heat pump water heater at design conditions.

This power includes the input to the compressor, controls, evaporator fan, and pump (if present).

Units: Kilowatts (kW).

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

STORAGE TANK LOCATION

Applicability: Heat pump water heaters.

Definition: The location of a heat pump water heater.

Units: List:

- Conditioned
- Unconditioned

Input Restrictions: List see above.

Standard Design:

ENERGY FACTOR

Applicability: Equipment covered by the National Appliance Energy Conservation Act (NAECA), which includes small storage and instantaneous water heaters.

Definition: The energy factor (EF) is the ratio of the energy delivered by the water heater divided by the energy used, in the same units. EF is calculated according to the DOE 10 CFR Part 430 test procedure, which specifies a 24-hour pattern of draws, a storage temperature, inlet water temperature, and other test conditions. These conditions result in the energy delivered for the test period. Energy inputs are measured for the same test period and the EF ratio is calculated.

Units: Unitless ratio.

Input Restrictions: Building descriptors for the proposed design should be consistent with equipment specified on the construction documents or observed in the candidate building.

For storage water heaters manufactured after June 1, 2017, that contain a Uniform Energy Factor, the EF shall not be input by the user, but shall be calculated by:

$$F = \frac{(N^2PUa) - (NUb)}{d(U - N) + c(N^2P - NPU) - Ub + NPUa}$$

Where:

$\boldsymbol{F}$ = Energy Factor
$\boldsymbol{N}$ = Recovery Efficiency
$\boldsymbol{P}$ = Power Input (W)
$\boldsymbol{U}$ = UEF

Draw Pattern (see the following descriptors)

Very Small

- a — 0.250266
- b — 57.5
- c — 0.039864
- d — 67.5

Low

- a — 0.065860

- b — 57.5
- c — 0.039864
- d — 67.5

Medium

- a — 0.045503
- b — 57.5
- c — 0.039864
- d — 67.5

High

- a — 0.029794
- b — 57.5
- c — 0.039864
- d — 67.5

For instantaneous electric water heaters manufactured after June 1, 2017, with a Uniform Energy Factor, the EF shall not be input by the user, but shall be equal to the calculated recovery efficiency.

For instantaneous gas-fired water heaters manufactured after June 1, 2017, with a Uniform Energy Factor, the EF shall not be input by the user, but shall be calculated by:

$$F = N \times 0.9734 + 0.01835$$

Where:

$\boldsymbol{F}$ = Energy Factor
$\boldsymbol{N}$ = Recovery Efficiency

Standard Design: For nonresidential buildings and nonresidential spaces, the energy factor for the standard design system shall be determined from the *Appliance Efficiency Regulations*.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

UNIFORM ENERGY FACTOR

Applicability: Equipment covered by NAECA that is rated after June 1, 2017, with a Uniform Energy Factor (UEF) that includes small storage and instantaneous water heaters.

Definition: The UEF defines an efficiency level for a specific targeted use pattern.

Units: Unitless ratio.

Input Restrictions: Must meet mandatory minimum requirements defined by federal or state appliance efficiency standards.

Standard Design: For school buildings less than 25,000 square feet and less than 4 floors in climate zones 2 through 15, the standard design shall a heat pump water heater with a UEF of 2.15.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

FIRST HOUR RATING

Applicability: Water heating storage tanks with a UEF rating.

Definition: The first hour rating is a measure of the overall capacity of the water heater that incorporates both the heat input rate and the tank storage capacity and is used to determine the draw pattern.

Units: gal/hr.

Input Restrictions: As designed.

Standard Design: For school buildings less than 25,000 square feet and less than 4 floors in climate zones 2 through 15, the standard design shall be based on a heat pump water heater with a First Hour Rating of 75

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

DESIGN FLOW RATE

*Applicability: Instantaneous w*ater heater.

Definition: Water flow rate of an instantaneous water heater and is used to determine the draw pattern.

Units: gal/hr.

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

DRAW PATTERN

Applicability: Storage water heating tanks with a UEF rating.

Definition: The draw pattern is determined as: very small, low, medium, or high from the user entry of first hour rating (FHR) or flow rate depending on the type of the water heater.

Table 21: Draw Pattern

Draw Pattern	Storage	Instantaneous
Very small	< 18 gal/hr	< 1.7 gpm
Low	≥ 18 gal/hr and < 51 gal/hr	≥ 1.7 gpm and < 2.8 gpm
Medium	≥ 51gal/hr and < 75 gal/hr	≥ 2.8 gpm and < 4 gpm
High	≥ 75 gal/hr	≥ 4 gpm

Source: California Energy Commission

Units: List:

- Very small
- Low
- Medium
- High

Input Restrictions: Not user editable. Draw pattern is determined from FHR or flow rate user input.

Standard Design: For school buildings less than 25,000 square feet and less than 4 floors in climate zones 2 through 15, the standard design shall be based on a heat pump water heater with a draw pattern of "High".

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

THERMAL EFFICIENCY

Applicability: Oil and gas-fired water heaters or gas-service water heater systems not covered by NAECA.

Definition: The full load efficiency of a water heater at rated conditions expressed as a dimensionless ratio of output over input. It is also referred to as recovery efficiency.

Units: Unitless ratio.

Input Restrictions: Building descriptors for the proposed design should be consistent with equipment specified on the construction documents or observed in the candidate building.

Standard Design: For nonresidential buildings and nonresidential spaces, the thermal efficiency is determined from Table F-2 in the *Appliance Efficiency Regulations*.

Standard Design: Existing Buildings:

Baseline efficiency is set from the Appliance Efficiency Regulations

TANK STANDBY LOSS

Applicability: Water heaters not covered by NAECA.

Definition: The tank standby loss for storage tanks, which includes the effect of recovery efficiency.

Units: Btu/h for the entire tank.

Input Restrictions: Standby loss is calculated as:

$$STBY = 577.5 \times S \times VOL$$

Where:

- $\boldsymbol{S}$ = The standby loss fraction listed in the CEC's Appliance Database of Certified Water Heaters
- $\boldsymbol{VO}$ = The actual storage capacity of the water heater as listed in the CEC's Appliance Database of Certified Water Heaters (gallons)

Standard Design: Table F-2 of the Appliance Efficiency Standards.

TANK OFF-CYCLE LOSS COEFFICIENT

Applicability: Water heaters.

Definition: The tank standby loss coefficient (UA) for the water heater.

For small water heaters covered by NAECA, the loss coefficient is a derived parameter, a function of the EF and recovery efficiency.

Units: Btu/h - °F.

Input Restrictions: For NAECA covered water heaters, the loss coefficient is calculated by:

$$UA = \frac{\frac{1}{EF} - \frac{1}{RE}}{67.5\left(\frac{24}{41094} - \frac{1}{RE(P_{on})}\right)}$$

Where:

- $\boldsymbol{EF}$ — The energy factor of the rated water heater (unitless)

- $\boldsymbol{RE}$ — The recovery efficiency of the rated water heater. If this data is not available, the default shall be 0.78 for gas water heaters and 0.93 for electric water heaters.
- $\boldsymbol{P_{on}}$ — The input power to the water heater, in Btu/h

Standard Design: For nonresidential spaces, 10 Btu/h-F.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

The baseline loss coefficient for NAECA water heaters shall be10 Btu/h-F for gas-fired water heaters

OFF-CYCLE PARASITIC LOSSES

Applicability: Water heaters.

Definition: The rate of parasitic losses, such as a pilot light or controls, when the water heater is not heating.

Units: Watts.

Input Restrictions: As designed.

Standard Design: 0.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

OFF-CYCLE FUEL TYPE

Applicability: Water heaters.

Definition: The type of fuel that serves energy using parasitic equipment, such as a pilot light or controls, when the water heater is not heating.

Units: List electricity, gas, oil, or propane.

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

ON-CYCLE PARASITIC LOSSES

Applicability: Water heaters.

Definition: The rate of parasitic losses, such as a pilot light or controls, when the water heater is not heating. It may be different than off-cycle losses if the flue energy is considered.

Units: Watts.

Input Restrictions: As designed.

Standard Design: Not applicable.

Existing Buildings: Same as proposed if water heater is existing.

On-Cycle Fuel Type

Applicability: Water heaters

Definition: The type of fuel that serves energy using parasitic equipment, such as a pilot light or controls, when the water heater is not heating

Units: List electricity, gas, oil, or propane

Input Restrictions: As designed

Standard Design: Not applicable

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

Water Heater Ambient Location

Applicability: Water heaters.

Definition: The location of the water heater for determining losses and energy interaction with the surroundings.

Units: List schedule, zone, outdoors.

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

Water Heater Compressor Location

Applicability: Heat pump water heaters.

Definition: The location of the heat pump compressor for determining losses and energy interaction with the surroundings.

The air temperature at the compressor location also controls the compressor’s crankcase heater operation.

Units: List zone, outdoors.

Input Restrictions: As designed

Standard Design: Not applicable

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

Tank Standby Loss Fraction

Applicability: Storage tank water heaters.

Definition: The tank standby loss fraction for storage tanks.

Units: Unitless.

Input Restrictions: Prescribed to the value listed in the Appliance Database of Certified Water Heaters.

Standard Design: Not applicable.

The part-load curve procedure in Title 24 can be an alternate method of specifying the effects of standby and parasitic losses on performance. The primary method is to specify a loss coefficient for the storage tank.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

FUEL WATER HEATER PART-LOAD EFFICIENCY CURVE

Applicability: Water heating equipment for which a loss coefficient is not specified (alternate method).

Definition: A set of factors that adjust the full-load thermal efficiency for part load conditions; set as a curve.

Units: Percent (%).

Input Restrictions: The following prescribed curve shall be used based on user inputs. The curve shall take the form of a quadratic equation as follows:

$$Fuel_{partload} = Fuel_{design} \times FHeatPLC$$

$$FHeatPLC = \left(a + b\left(\frac{Q_{partload}}{Q_{rated}}\right)\right)$$

For Title 24, the coefficients shall be determined by:

$$a = \frac{STBY}{INPUT}$$

$$b = \frac{(INPUT \times RE) - STBY}{SRL}$$

$$PLR_n = \frac{SRL \times F_{whpl(n)}}{INPUT \times RE}$$

Recovery efficiency substituted with thermal efficiency when applicable.

For boilers, instantaneous gas, or other storage type water heaters, not in the scope of covered consumer products as defined in the Title 10 or the Code of Federal Regulations, Part 430:

$$STBY = 577.5 \times S \times VOL$$

Required inputs and standard and proposed design assumptions depend on the type of water heater and whether or not it is a DOE covered consumer product.

Where:

$\boldsymbol{FHeatPLC}$ — The fuel heating part load efficiency curve
$\boldsymbol{Fuel_{partload}}$ — The fuel consumption at part-load conditions (Btu/h)
$\boldsymbol{Fuel_{design}}$ — The fuel consumption at design conditions (Btu/h)
$\boldsymbol{Q_{partload}}$ — The water heater capacity at part-load conditions (Btu/h)
$\boldsymbol{Q_{rated}}$ — The water heater capacity at design conditions (Btu/h)
$\boldsymbol{PLR_n}$ — Part-load ratio for the n^{th} hour and shall always be less than 1
$\boldsymbol{INPUT}$ — The input capacity of the water heater expressed in Btu/hr
$\boldsymbol{STBY}$ — Hourly standby loss expressed in Btu/hr. For large storage gas water heaters, STBY is listed in the CEC's appliance database. The value includes pilot energy and standby losses. For all systems, refer to equation N2-62.
$\boldsymbol{SRL}$ — The standard recovery load, taken from Appendix 5.4A, in Btu/hr, adjusted for the number of occupants according to the occupancy schedules.
$\boldsymbol{S}$ — The standby loss fraction listed in the CEC's Appliance Database of Certified Water Heaters
$\boldsymbol{VOL}$ — The actual storage capacity of the water heater as listed in the Appliance Database of Certified Water Heaters

Standard Design: Not applicable.

Standard Design: *Existing Buildings:* Same as proposed if water heater is existing.

5.9.3 @Recirculation Systems

This chapter describes the building descriptors for hot water recirculation systems. For nonresidential application, recirculation systems are not modeled. For multifamily, the standard design has a recirculation system when the proposed design does.

Recirculating systems shall follow the rules set forth in Appendix B: Water Heating Calculation Method.

5.9.4 Water Heating Auxiliaries

EXTERNAL STORAGE TANK INSULATION

Applicability: All water heating systems that have an external storage tank.

Definition: Some water heating systems have a storage tank that is separate from the water heater(s) that provides additional storage capacity. This building descriptor addresses the heat loss related to the external tank, which is an additional load that must be satisfied by the water heater(s).

Units: R-value (h-ft^2-F/Btu).

Input Restrictions: As specified in manufacturer data and documented on the construction documents.

Standard Design: Heat loss associated with the storage tank in the standard design shall meet the requirements for an unfired storage tank in the baseline standards which is an insulation R-value of 12.5. The surface area and location of the storage tank shall be the same as the proposed design.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

EXTERNAL STORAGE TANK AREA

Applicability: All water heating systems that have an external storage tank.

Definition: Some water heating systems have a storage tank that is separate from the water heater(s) that provides additional storage capacity. This documents the entire exterior surface area of the tank.

Units: ft^2.

Input Restrictions: As specified in manufacturer specifications.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

EXTERNAL STORAGE TANK LOCATION

Applicability: All water heating systems that have an external storage tank.

Definition: Location of the storage tank, used to determine the heat loss rate and energy exchange with the surroundings.

Units: List schedule, zone, outdoors.

Input Restrictions: As designed.

Standard Design: Not applicable.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

SOLAR THERMAL

Applicability: Water heating systems with a solar thermal system.

Definition: A solar thermal water heating system consists of one or more collectors. Water is passed through these collectors and is heated under the right conditions. There are two general types of solar water heaters: integrated collector storage (ICS) systems and active systems. Active systems include pumps to circulate the water, storage tanks, piping, and controls. ICS systems generally have no pumps and piping is minimal.

Solar systems may be tested and rated as a complete system or the collectors may be separately tested and rated. Solar Rating & Certification Corporation (SRCC) OG-300 is the test procedure for whole systems and SRCC OG-100 is the test procedure for collectors. The building descriptors used to define the solar thermal system may vary with each compliance software application and with the details of system design.

The solar fraction shall be estimated by the f-chart procedure for solar water heating systems.

Units: Unitless fraction.

Input Restrictions: For multifamily buildings, the solar fraction provided by the solar DHW system shall be between 0 and 1. For all other buildings, the value is 0 (solar thermal may not be modeled for compliance.).

Standard Design: The standard design has no solar auxiliary system.

COMBINED SPACE HEATING AND WATER HEATING

Applicability: Projects that use a domestic hot water water heater to provide both space heat and water heating.

Definition: A system that provides both space heating and water heating from the same equipment, generally a domestic hot water heater. Such systems are restricted by the baseline standards but may be modeled in the candidate building. The restrictions are due to the misalignment of the space heating load and the water heating load. The first is highly intermittent and weather dependent, and the latter is more constant and not generally weather-related.

Units: Data structure.

Input Restrictions: The proposed design may have a combined space and water heating system.

Standard Design: The standard design shall be modeled with separate space heating and water heating systems.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

5.9.5 Exterior Lighting

Outdoor lighting requirements are specified in Section 140.7 of the Energy Code. Outdoor lighting shall not be modeled in the proposed design or standard design, and no tradeoffs are available with other building end uses or systems. Outdoor lighting shall meet all prescriptive requirements in the Energy Code.

5.9.6 Other Electricity Use

This set of building descriptors should be used to include any miscellaneous electricity use that would add to the electric load of the building and would be on the building meter. These energy uses are assumed to be outside the building envelope and do not contribute heat gain to any thermal zone.

MISCELLANEOUS ELECTRIC POWER

Applicability: All buildings with miscellaneous electric equipment located on the building site.

Definition: The power for miscellaneous equipment.

Units: Watts (W).

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

MISCELLANEOUS ELECTRIC SCHEDULE

Applicability: All buildings with miscellaneous electric equipment located on the building site.

Definition: The schedule of operation for miscellaneous electric equipment that is used to convert electric power to energy use.

Units: Data structure — schedule, fractional.

Input Restrictions: The schedule specified for the building should match the operation patterns of the system.

Standard Design: Same as the proposed design.

5.9.7 Other Gas Use

This set of building descriptors should be used to include any miscellaneous gas use that would add to the load of the building and would be on the building meter. These energy uses are assumed to be outside the building envelope and do not contribute heat gain to any thermal zone.

OTHER GAS POWER

Applicability: All buildings that have commercial gas equipment.

Definition: Gas power is the peak power which is modified by the schedule (see below).

Units: Btu/h-ft².

Input Restrictions: As designed.

Standard Design: Same as the proposed design.

OTHER GAS SCHEDULE

Applicability: All buildings that have commercial gas equipment.

Definition: The schedule of operation for commercial gas equipment that is used to convert gas power to energy use.

Units: Data structure — schedule, fractional.

Input Restrictions: Continuous operation is prescribed.

Standard Design: Same as the proposed design.

5.10 Onsite Energy Generation and Storage

5.10.1 Onsite Photovoltaic Energy Generation

PHOTOVOLTAIC (PV) RATED CAPACITY

Applicability: All buildings with onsite photovoltaic generation.

Definition: The rated capacity of the PV system in kilowatts_{dc}.

Units: kW_{dc}.

Input Restrictions: Non-negative value.

Standard Design: The standard design PV system is based on requirements in 2025 Title 24 Part 6, Section 140.10(a). The PV capacity of the building is based on the PV capacity for each space where mapping of the space function to PV capacity building type is documented in Appendix C. When the PV system meets one of the prescriptive exceptions, the standard design is modeled with a PV system consistent with that prescriptive exception. The minimum capacity is the smaller of the minimum rated PV system capacity system size determined by Equation 140.10-A shown below, or the total of all available Solar Access Roof Areas (SARA) (Solar Access Roof Area) multiplied by 18 for steep-sloped roofs or SARA multiplied by 14 for low-sloped roofs.

$$kW_{PVdc} = \frac{\sum_{1}^{n} CFA_i \times A_i}{1000}$$

Where:

kW_{PVdc} = Capacity of the building's PV system in kW_{dc}

CFA_i = Conditioned floor area in square feet of the i^{th} space

A_i = PV capacity factor for the i^{th} space's space function given the mapping of space function to building type from Appendix 5.4A and the PV requirement by building type from Table 140.10-A in the Energy Code as described in Appendix C

PV MODULE TYPE

Applicability: All buildings with onsite photovoltaic generation.

Definition: The type of photovoltaic module that makes up the system.

Compliance software offers two module options:

- Standard is a typical poly- or mono-crystalline silicon module, with efficiencies of 14-17 percent.
- Premium is appropriate for modeling high efficiency (approximately 18-20 percent) monocrystalline silicon modules that have anti-reflective coatings and lower temperature coefficients.

Units: List: Standard, Premium.

Standard Design: Standard module type.

ANNUAL SOLAR ACCESS

Applicability: All buildings with onsite photovoltaic generation.

Definition: The annual solar insolation (accounting for shading obstructions) divided by the total annual solar insolation if the same areas were unshaded by those obstructions.

Units: Percent.

Input Restrictions: 0-100 percent.

Standard Design: 98 percent.

MODULE LEVEL POWER ELECTRONICS

Applicability: All buildings with onsite photovoltaic generation.

Definition: The type of power electronics present in each photovoltaic module.

Units: List: None, Microinverters, DC Power Optimizers.

Standard Design: None.

PV TRACKING (ARRAY TYPE)

Applicability: All buildings with onsite photovoltaic generation.

Definition: The tracking mechanism used to improve efficiency of electricity generation. Options are fixed, one-axis or two-axis.

Units: None.

Input Restrictions: List: None, 1-axis, 2-axis.

Standard Design: Fixed

CALIFORNIA FLEXIBLE INSTALLATION (CFI)

Applicability: All buildings with onsite photovoltaic generations that choose to not model actual installation.

Definition: Whether or not PV system installation adheres to CFI limits, in which case azimuth and tilt specification is not required. All panels must have no shading except for horizon shading of no more than 2% of annual solar access.

CFI1 allows the PV installation at any orientation with an azimuth from 150 to 270 degrees on a roof with a pitch from 0:12 to 7:12.

CFI2 allows the PV installation at any orientation with an azimuth from 105 to 300 degrees on a roof with a pitch from 0:12 to 7:12. CF2 reduces PV production by 10% compared to CF1. To meet the Total LSC, the difference can be made up by increasing PV size by 10% or increasing energy efficiency features or through battery storage.

Units: None.

Input Restrictions: List: n/a, CFI1, CFI2.

Standard Design: CFI1.

Standard Design: Existing Buildings: Same as the proposed.

PV AZIMUTH

Applicability: All buildings with onsite photovoltaic generations and that no do not choose to use CFI1 or CFI2 selection limits.

Definition: The azimuth in degrees from true North (180F for South, for example). Not applicable for building-integrated panels or panels installed with no tilt.

Units: Degrees.

Input Restrictions: 0 to 360 degrees.

Standard Design: 170 degrees (face South).

PV TILT

Applicability: All buildings with onsite photovoltaic generation and that choose to use CFI1 or CFI2 selection limits.

Definition: The tilt of the PV panels from horizontal, in degrees.

Units: Degrees.

Input Restrictions: 0 to 90 degrees.

Standard Design: 22.61 degrees (equivalent to 5:12 roof pitch).

PV INVERTER EFFICIENCY

Applicability: All buildings that have onsite photovoltaic generation and detailed inputs is selected.

Definition: The rated efficiency of the inverter in converting DC to AC power.

Units: Percent.

Input Restrictions: 0-100 percent.

Standard Design: 96 percent.

5.10.2 Battery Energy Storage System (BESS)

BATTERY ENERGY STORAGE SYSTEM MINIMUM RATED USABLE ENERGY CAPACITY

Applicability: All buildings with an onsite battery energy storage system.

Definition: The minimum rated usable energy storage capacity of all onsite battery energy storage systems, in kWh_{batt}.

Units: kWh_{batt}.

Input Restrictions: Positive number.

Standard Design: The mapping of space function to battery storage capacity factor by building type is documented in Appendix C.

If SARA is not used to determine the PV system capacity, the minimum rated useable energy capacity is based on the battery energy storage system capacity, Equation 140.10-B:

$$kWh_{batt,min} = \frac{\sum_1^n CFA_i \times B_i}{1000 \times \sqrt{C}}$$

Where:

$kWh_{batt,\ min}$ = Minimum rated useable energy capacity of the battery energy storage system in kWh

CFA_i = Conditioned floor area in square feet of the i^{th} space that is subject to the PV system requirements

B_i = Battery energy storage system capacity factor for the i^{th} space's space function given the mapping of space function to building type from Appendix 5.4A and the battery requirement by building type from Table 140.10-B in the Energy Code as described in Appendix C Appendix 5.4A battery energy storage system capacity factor in kWh per square feet for the i^{th} space's space function given the mapping of space function to building type from Appendix 5.4A and the building type battery requirement from Table 140.10-B in the Building Energy Efficiency Standards Energy Code

C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the battery energy storage system

If SARA is used to determine the PV system capacity, then the minimum rated useable energy capacity is based on Equation 140.10-C:

$$kWh_{batt,min} = \frac{\sum_1^n CFA_i \times B_i}{1000 \times \sqrt{C}} \times \frac{kW_{PVdc,SARA}}{kW_{PVdc}}$$

Where:

$kWh_{batt,\ min}$ = Minimum rated useable energy capacity of the battery energy storage system in kWh

CFA_i = Conditioned floor area in square feet of the i^{th} space that is subject to the PV system requirements

B_i = Battery energy storage system capacity factor for the i^{th} space's space function given the mapping of space function to building type from Appendix 5.4A and the battery requirement by building type from Table 140.10-B in the Energy Code

C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the battery energy storage system

kW_{PVdc} = Minimum rated PV system capacity of the building's PV system in kW as calculated in Section 140.10(a) per Equation 140.10-A

$kW_{PVdc,\ SARA}$ = Minimum rated PV system capacity in kW from the SARA calculation, as described in Section 140.10(a)

BESS Charging/Discharging Rate or Roundtrip Efficiencies

Applicability: All buildings with an onsite battery energy storage system.

Definition: The efficiency of charging and discharging electricity to and from the battery.

Units: Fraction.

Input Restrictions: Positive number.

Standard Design: The standard design charge and discharge efficiencies are 95%.

Standard Design: Existing Buildings: Same as the proposed.

BESS Minimum Rated Power Capacity

Applicability: All buildings with an onsite battery energy storage system.

Definition: The rated minimum power capacity a battery can store. This capacity is determined based on the battery energy storage system minimum rated usable energy capacity.

Units: kW.

Input Restrictions: Positive number.

Standard Design: The rated power capacity of a battery energy storage system is based on the minimum rated useable energy capacity of the battery energy storage system determined by Equation 140.10-B or if SARA is limited, by Equation 140.10-C. The mapping of space function to battery storage capacity factor by building type is documented in Appendix C.

If SARA is not used to determine the PV system capacity, then the minimum rated useable energy capacity is based on the battery energy storage system capacity, Equation 140.10-B:

$$kWh_{batt,min} = \frac{\sum_1^n CFA_i \times B_i}{1000 \times \sqrt{C}}$$

Where:

$kWh_{batt, min}$ = Minimum rated useable energy capacity of the battery energy storage system in kWh

CFA_i = Conditioned floor area in square feet of the i[th] space that is subject to the PV system requirements

B_i = Battery energy storage system capacity factor for the i[th] space's space function given the mapping of space function to building type from Appendix 5.4A and the battery requirement by building type from Table 140.10-B in the Energy Code

C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the battery energy storage system

If SARA is used to determine the PV system capacity, then the minimum rated useable energy capacity, SARA-adjusted, is based on the SARA-adjusted battery energy storage system minimum rated usable energy capacity, SARA-adjusted, Equation 140.10-C:

$$kWh_{batt,min} = \frac{\sum_1^n CFA_i \times B_i}{1000 \times \sqrt{C}} \times \frac{kW_{PVdc,SARA}}{kW_{PVdc}}$$

Where:

$kWh_{batt, min}$ = Minimum rated useable energy capacity of the battery energy storage system in kWh

CFA_i = Conditioned floor area in square feet of the i[th] space that is subject to the PV system requirements

B_i = Battery energy storage system capacity factor for the i[th] space's space function given the mapping of space function to building type from Appendix 5.4A and the battery requirement by building type from Table 140.10-B in the Energy Code

C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the battery energy storage system

kW_{PVdc} = Minimum rated PV system capacity of the building's PV system in kW as calculated in Section 140.10(a)per Equation 140.10-A

$kW_{PVdc, SARA}$ = Minimum rated PV system capacity in kW from the SARA calculation, as described in Section 140.10(a)

The battery storage rated power capacity is calculated as:

$$kW_{batt} = \frac{kWh_{batt,min}}{4}$$

Where:

kW_{batt} = Minimum rated power capacity of the battery energy storage system in kW_{dc}

kWh_{batt} = Minimum rated useable energy capacity of the battery energy storage system in kWh

BESS Discharge Control

Applicability: All buildings with an onsite battery energy storage system.

Definition: Battery energy storage systems can be controlled using the basic control strategy or the Time of Use strategy (TOU) described in JA12.

Units: None.

Input Restrictions: List: The basic control strategy or TOU control strategy described in JA12.

Standard Design: TOU Control.

TOU Start/End Months

Applicability: All buildings with an onsite battery energy storage system with Time of Use control.

Definition: The start and end months where the Time of Use control scheme is active.

Units: None.

Input Restrictions: Not a user input.

Standard Design: TOU battery control operates all year, months 1-12.

Simulate Standalone Battery

Applicability: All buildings with an onsite battery energy storage system with no photovoltaic system or lowrise multifamily buildings served by community solar.

Definition: Standalone batteries are charged from the grid during low system load or LSC hours and discharged to support the building load and/or grid during peak time or high LSC hours.

Units: None.

Standard Design: Standalone batteries are not modeled in the standard design.

5.11 Common Data Structures

This chapter describes common data structures. The data structures presented here define objects and example parameters needed to define them. The parameters described are the most common for energy simulation engines. However, other parameters or data constructs are acceptable. The fields used by the simulation program must be mapped to the fields used by the building descriptor.

5.11.1 Schedule

This data structure provides information on how equipment, people, lights, or other items are operated on an hourly basis. The ultimate construct of a schedule is an hourly time series for the simulation period, typically 8,760 hours (365 days, 24 hours per day). Compliance software has often built up the hourly schedule from 24-hour schedules for different day types such as weekdays, Saturdays, Sundays, holidays, etc.

There are several types of schedules:

- Temperature schedules specify a temperature to be maintained in a space, a temperature to be delivered from an air handler, or the leaving temperature from a chiller or other equipment.
- Fraction schedules specify the fraction of lights that are on, the fraction of people that are in the space, the fraction of maximum infiltration, or other factors.
- On/off schedules specify when equipment is operating or when infiltration is occurring.
- Time period schedules define periods of time for equipment sequencing, utility tariffs, etc. A time period schedule typically breaks the year in to two or more seasons. For each season, day types are identified such as weekday, Saturday, Sunday, and holidays. Each day type in each season is then divided into time periods.

5.11.2 Holidays

A series of dates defining holidays for the simulation period. Dates identified are operated for the schedule specified for holidays.

5.11.3 Surface Geometry

This data structure represents the location, size, and position of a surface. Surfaces include roofs, walls, floors, and partitions. Surfaces are typically planar and can be represented in various manners, including:

- Rectangular surfaces, which may be represented by a height and width along with the X, Y, and Z of surface origin, and the tilt and azimuth.
- By a series of vertices (X, Y, and Z coordinates defining the perimeter of a surface). More complex polygons may be represented in this manner.

5.11.4 Opening Geometry

This data structure represents the location and size of an opening within a surface. The most common method of specifying the geometry of an opening is to identify the parent surface, the height and width of the opening, and the horizontal and vertical offset (X and Y coordinates relative to the origin of the parent surface). An opening can also include a recess into the parent surface, which provides shading. However, other geometric constructs are acceptable.

5.11.5 Opening Shade

This data structure describes the dimensions and position of external shading devices such as overhangs, side fins, or louvers that shade the opening. Overhangs are specified in terms of the projection distance, height above the opening, and extension distance on each side of the opening.

5.11.6 Construction Assembly

This data structure describes the layers that make up the construction of a wall, roof, floor, or partition. Typically, a construction consists of a sequence of materials, described from the outside surface to the inside surface.

5.11.7 Fenestration Construction

This data structure describes the frame, glass, and other features of a window or skylight. Information may be defined in multiple ways, but the criterion is published as a combination of U-factor, solar heat gain coefficient (SHGC), and visible light transmission (VT). Some simulation programs use more detailed methods of describing the performance of fenestration that consider the angle of incidence of sun striking the fenestration and other factors, such as the properties of each pane and the fill. The compliance software only uses whole window performance properties (U-factor, SHGC, VT).

5.11.8 Material

This data structure describes a material that is used to build up a construction assembly. Typical material properties include specific heat, density, conductivity, and thickness. Materials can also be described in terms of their thermal resistance. The latter approach is sometimes used to approximate construction layers that are not homogeneous, such as framing members in combination with cavity insulation.

5.11.9 Slab Construction

This data structure describes the composition of a slab-on-grade. The compliance model has building descriptors for the perimeter length and the F-factor, which represents the heat loss per lineal foot.

5.12 Exterior Surface Properties

This data structure describes the characteristics of exterior surfaces. Exterior surface properties may include emissivity, reflectivity, and roughness. The first two govern radiation exchange from the surface, while the latter governs the magnitude of the exterior air film resistance.

5.12.1 Occupant Heat Rate

This data structure represents the rate of heat and moisture generated by building occupants. This is typically specified in terms of a sensible heat rate and a latent heat rate. Both are specified in Btu/h.

5.12.2 Furniture and Contents

This data structure represents the thermal mass effect of furniture and other building contents. This is expressed in terms of lb/ft² for the space in question.

5.12.3 Reference Position in a Space

This data structure locates a reference point in a space, typically for the purposes of daylighting control. The typical construct for the reference point is a set of coordinates (X, Y, and Z) relative to the space coordinate system.

5.13 Two-Dimensional Curve

This data structure explains one parameter in terms of another. An example is a curve that modifies the efficiency of an air conditioner relative to the fraction of time that the equipment operates within the period of an hour. The relationship can be expressed in terms of the X and Y coordinates of points on the curve, or it can be expressed as an equation.

5.13.1 Three-Dimensional Curve

This data structure explains one parameter in terms of two others. An example is a curve that modifies the efficiency of an air conditioner relative to the outside air dry-bulb temperature and the wet-bulb temperature of air returning to the coil. The relationship is a three-dimensional surface and can be expressed in terms of the X, Y, and Z coordinates of points on the curve, or it can be expressed as an equation.

5.13.2 Temperature Reset Schedule

This data structure describes the relationship between one temperature and another. For example, the independent variable might be outside air temperature and the dependent variable is supply air temperature. In this case, a common schedule would be to set the supply air temperature at 55°F when the outside air temperature is 80°F or warmer and at 62°F when the outside air temperature is 58°F or cooler with the supply air temperature scaling between 55°F and 62°F when the outside air temperature is between 80°F and 58°F.

6. Multifamily Building Descriptors Reference

6.1 Standard Design

For multifamily buildings, the standard design building, from which the energy budget is established, is in the same location and has the same floor area, volume, configuration, wall areas and orientations as the proposed design. The details are described below.

The *energy budget* for the multifamily standard design is the energy that would be used by a building similar to the proposed design if the proposed building met the requirements of the prescriptive standards. The compliance software generates the standard design automatically, based on fixed and restricted inputs and assumptions. Custom energy budget generation shall not be accessible to program users for modification when the program is used for compliance or when the program generates compliance forms.

The basis of the standard design is prescriptive requirements from Section 170.2 of the Energy Code. Prescriptive requirements vary by climate zone. Reference Appendices, Joint Appendix JA2, Table 2-1, contains the 16 California climate zones and representative cities. The climate zone is based on the zip code for the proposed building, as documented in Reference Appendices, Joint Appendix JA2.1.1.

The following chapters present the details of how the proposed design and standard design are determined. For many modeling assumptions, the standard design is the same as the proposed design. When a building has special features, for which the CEC has established alternate modeling assumptions, the standard design features will differ from the proposed design so the building receives appropriate credit for its efficiency. When measures require verification by a Energy Code Compliance (ECC) rater, installer test and report, or are designated as a *special feature,* the specific requirement is listed on the Certificate of Compliance

6.2 Proposed Design

The multifamily building configuration is defined by the user through entries that include floor areas, wall areas, roof and ceiling areas, fenestration (which includes skylights), and door areas, the performance characteristics such as U-factors, R-values, solar heat gain coefficient (SHGC), visible transmittance (VT), solar reflectance, and information about the orientation and tilt is required for roofs, and other elements, and end use energy use such as HVAC, lighting, and DHW. Details about any solar generation systems and battery storage are also defined. The user entries for all these building elements are consistent with the actual building design and configuration. If the compliance software models the specific geometry of the building by using a coordinate system or graphic entry technique, the data generated are consistent with the actual building design and configuration.

6.2.1 6.3 Heat Pump Water Heater Load Shifting

Any HPWH installed in multifamily buildings three habitable stores or less, which is compliant with Reference Appendices, Joint Appendix JA13 will receive LSC credit in each climate zone according as shown in Table 22: JA13 HPWH Basic Control Credit. The LSC percentage reduction is applied upon the completion of the compliant simulation run. Note that this percentage reduction only applies to the LSC values for water heating.

Table 22: JA13 HPWH Basic Control Credit

Climate Zone	Credit
1	6.7
2	3.7
3	7.6
4	4.0
5	8.5
6	6.8
7	8.8
8	4.4
9	4.4
10	4.4
11	4.2
12	4.7
13	8.0
14	3.1

15	8.2
16	22.7

Source: California Energy Commission

6.3 Self-Utilization Credit

When a PV system is coupled with a battery storage system, the compliance software allows a portion of the Photovoltaic and BESS LSC to be traded against the efficiency LSC. This modest credit can be used for tradeoffs against building envelope and efficiencies of the equipment installed in the building. More detail is provided in 6.4.1 Photovoltaic and Battery Energy Storage System Requirements for Three Habitable Floors or Less. The self-utilization credit is only applicable to multifamily buildings three habitable stories or less.

6.4 Photovoltaic and Battery Energy Storage System Requirements

Requirements for PV systems and battery energy storage systems are dependent on the number of floors of the building. Multifamily buildings with three or fewer habitable floors have different requirements than multifamily buildings with four or more habitable floors. Modeling software will calculate PV system and battery energy storage system requirements to account for the number of habitable floors of the buildings.

6.4.1 Photovoltaic and Battery Energy Storage System Requirements for Three Habitable Floors or Less

The PV requirements are applicable to newly constructed multifamily buildings three habitable floors or less. PV system details are based on the publicly available System Advisor Model algorithms developed by the National Renewable Energy Laboratory, or similar calculation methods approved by the Energy Commission. See Appendix F. for more information.

PHOTOVOLTAIC STANDARD DESIGN THREE HABITABLE FLOORS OR LESS

The standard design PV system is based on requirements in Section 170.2(f) for multifamily buildings – three habitable floors or fewer. The PV capacity of the building is based on the PV capacity for each space where mapping of the space function to PV capacity building type is documented in Appendix C. When the PV system meets one of the prescriptive exceptions, the standard design is modeled with a PV system consistent with that prescriptive exception.

PHOTOVOLTAIC PROPOSED DESIGN THREE HABITABLE FLOORS OR LESS

For PV sizing calculations, the compliance software includes user-defined values for:

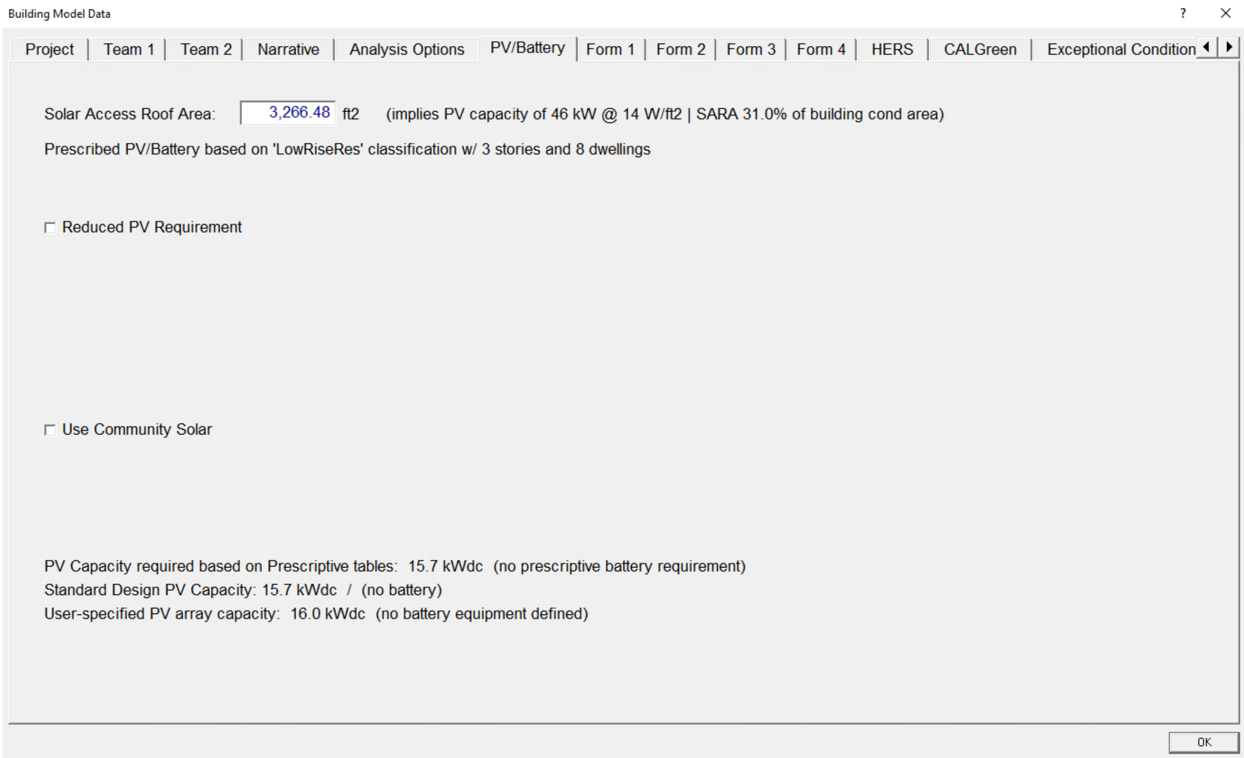
- Array azimuth, either the actual orientation or a range of azimuths included under CFI1 (installation of 150–270 degrees) or CFI2 (installation of 105–300 degrees).
- Module type, including standard (for example, poly- or mono-crystalline silicon modules with efficiencies of 14–17 percent), and premium (for example, high-efficiency monocrystalline silicon modules with anti-reflective coatings with efficiencies of 18–20 percent).
- Inverter efficiency.
- Array tilt in degrees or roof pitch, or CFI1 or CFI2 (installation up to 7:12).
- CF2 reduces PV production by 10% compared to CF1. To meet the Total LSC, the difference can be made up by increasing PV size by 10% or increasing energy efficiency features or through battery storage.
- Array tracking type including fixed, single-axis tracking, and two-axis tracking.
- Annual solar access percentage, excluding horizon shading, of the modules.
- SARA.

When the PV standard design system size is determined by one of the prescriptive exceptions, the proposed design system size shall not exceed the PV standard design size specified by the exception limits. When the PV standard design system is determined based on a limited SARA, the proposed design system size shall not exceed the SARA-determined size. The PV size is reported in kW_{dc} on the Certificate of Compliance.

Community Solar Three Habitable Floors or Less

For projects that use an approved community solar program to provide the required PV, approved compliance software must determine and report the amount (PV kW_{dc}) needed to offset the standard design PV system LSC.

Figure 8: Community Solar



Source: California Energy Commission

Battery Energy Storage System Three Habitable Floors or Less

Detailed calculations for PV and battery energy storage systems are included in Appendices C and D.

The compliance software provides credit for a battery energy storage system coupled with a PV array or simulated as standalone. If specified, the battery storage size must be 5 kWh or larger. For Energy Code compliance, PV has no impact on energy efficiency requirements or the efficiency LSC unless a battery storage system is included, and the self-utilization credit is modeled.

Battery Energy Storage System Controls Three Habitable Floors or Less

The time-of-use control strategy, as described in Reference Appendices, Joint Appendix JA12, is used to simulate the BESS for the standard design. The proposed design control strategy can use either the basic control strategy or TOU control strategy.

The controls for separate battery energy storage systems uses the basic control strategy, described in Reference Appendices, Joint Appendix JA12, for the standard design of energy storage systems that are installed separate from an on-site solar photovoltaic system.

Verification and Reporting Three Habitable Floors or Less

The following PV capacity and battery energy storage system requirements are reported as special features on the Certificate of Compliance:

- PV system
    - Minimum rated PV system capacity, kW_{dc}
- Battery energy storage system
    - Minimum rated usable energy capacity, kWh
    - Compliance cycling capacity, kWh
    - Roundtrip efficiency, %
    - Field-assembled or integrated

Self-Utilization Credit Three Habitable Floors or Less

The 2025 Energy Code does not allow a tradeoff between the Efficiency LSC and Source Energy and the effect of PV on the Total LSC/Source Energy unless battery storage is provided. When the PV system is coupled with at least a 5 kWh battery storage system, the compliance software allows a portion of the photovoltaic and BESSLSC and Source Energy to be traded against the Efficiency LSC. A modest self-utilization credit can be used for tradeoffs against building envelope and efficiencies of the equipment installed in the building. A checkbox is provided in the compliance software to enable this credit.

Table 23: Self-Utilization Credits

Climate Zone	Multifamily
01	10%
02	7%
03	10%
04	9%
05	11%
06	4%
07	4%
08	10%
09	10%
10	10%
11	10%
12	10%
13	10%
14	10%

Climate Zone	Multifamily
15	9%
16	12%

Source: California Energy Commission

6.4.2 Photovoltaic and Battery Energy Storage System Requirements Four or More Habitable Floors

Requirements for PV systems and battery energy storage systems in this chapter are applicable to newly constructed multifamily buildings with four or more habitable floors. PV system details are based on the publicly available system calculation from PVWatts®, which is a web application developed by the National Renewable Energy Laboratory, or similar calculation method approved by the Energy Commission. See Appendix F. for more information.

Photovoltaic Standard Design More than Three Habitable Floors

For multifamily buildings with more than three habitable floors and mixed occupancy buildings with more than three habitable floors with at least 80 percent of the floor area used for residential occupancy, a newly installed PV system meeting the minimum qualification requirements of Reference Appendices, Joint Appendix JA11 is required. The PV size in kWdc is the smaller of the PV system size determined by Equation 170.2-D, or the total of all available SARA multiplied by 14 W/ft^2 for low sloped roofs and 18W/ft^2 for steep sloped roofs, where the PV capacity factor of Equation 170.2-D is determined by building type.

When the solar electric generation system meets one of the prescriptive exceptions, the standard design is modeled with a PV system consistent with that prescriptive exception.

Photovoltaic Proposed Design More than Three Habitable Floors

For PV calculations, the compliance software includes user-defined values for:

- Array orientation, including CFI1 (installation of 150–270 degrees, CFI2 (installation of 105–300), or the actual orientation. Module type, including standard (for example, poly- or monocrystalline silicon modules), premium (for example, high-efficiency monocrystalline silicon modules with anti-reflective coatings).
- Inverter efficiency.
- Array tilt in degrees or roof pitch, or CFI1 or CFI2 (installation up to 7:12).
- Array tracking type including fixed, single-axis tracking, and two-axis tracking.

- CF2 reduces PV production by 10% compared to CF1. To meet the Total LSC, the difference can be made up by increasing PV size by 10% or increasing energy efficiency features or through battery.
- Annual solar access percentage, excluding horizon shading, of the modules.
- Solar Access Roof Area (SARA).

When the PV standard design system size is determined by one of the prescriptive exceptions, the proposed system size shall not exceed the PV standard design size specified by the exception limits.

The PV size is reported in kW_{dc} on the Certificate of Compliance.

Battery Energy Storage System Standard Design More Than Three Habitable Floors

For multifamily buildings more than three habitable floors that are required to have a PV System to meet Section 170.2(g), a battery energy storage system meeting qualification requirements of Reference Appendices, Joint Appendix JA12 is also required. The battery energy storage system minimum rated usable energy capacity and minimum rated power capacity is determined by Equation 170.2-E and Equation 170.2-G respectively, where the storage capacity and power factors of these equations is determined by individual space function. The mapping of space function to PV or battery used to determine capacity factors by building type is documented in Appendix C.

When the battery energy storage system meets one of the prescriptive exceptions in Section 170.2(h), the standard design is modeled with a battery energy storage system consistent with that prescriptive exception.

Battery Energy Storage System Proposed Design More Than Three Habitable Floors

Detailed calculations for PV and battery storage are included in Appendices C and D.

When the PV standard design system size is determined by one of the prescriptive exceptions, the proposed design is modeled with a system size that does not exceed the battery system capacity and rated power required by the standard design.

Battery Energy Storage System Controls More Than Three Habitable Floors

The control strategy used to simulate the BESS is the time-of-use control strategy as described in Reference Appendices, Joint Appendix JA12, for the standard design. The proposed design control strategy can use either the basic control strategy or TOU control strategy.

The controls for separate battery energy storage systems strategy uses the TOU control strategy as described in Reference Appendices, Joint Appendix JA12 for energy storage systems installed separate from an on-site solar photovoltaic system.

6.5 The Building

Proposed Design

The building is defined through entries for zones, surfaces, and equipment. Zone types are first defined as either dwelling unit spaces or common use spaces, then further defined by conditioning status and space function. Dwelling unit zones are always conditioned whereas the user defines type of conditioning and space function for common use spaces within the project. The compliance software models surfaces separating conditioned space from exterior or unconditioned spaces (such as a garage or storage), which have no solar gains, as interior surfaces with insulation meeting standards requirements. Exterior surfaces of an attached garage or storage space are modeled as part of the unconditioned zone.

The input file will include entries for floor areas, wall, door, roof and ceiling areas, and fenestration and skylight areas, as well as the water-heating, space-conditioning, ventilation, and distribution systems.

Each surface area is entered along with performance characteristics, including building materials, U-factor, SHGC , and VT. The orientation and tilt (Figure 9: Surface Definitions) are required for envelope elements.

Building elements are to be consistent with the actual building design and configuration.

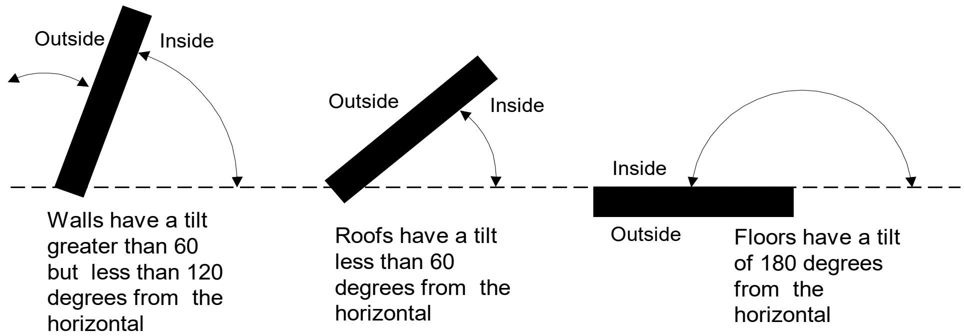
Standard Design

To determine the standard design, the compliance software creates a building with the same general characteristics (number of floors, orientation, climate zone). Energy features are set to be equal to Section 170.2, Table 170.2-A and Table 170.2-K for multifamily buildings. See Section 6.13 for details regarding additions and alterations. The details are below.

Verification and Reporting

All inputs that are used to establish compliance requirements are reported on the Certificate of Compliance.

Figure 9: Surface Definitions



Source: California Energy Commission

6.5.1 Dwelling Unit Types

Internal gains and IAQ ventilation calculations depend on the conditioned floor area and number of bedrooms. For multifamily buildings with individual IAQ ventilation systems, each combination of bedrooms and conditioned floor area has a different minimum ventilation CFM that must be verified. In buildings with multiple dwelling units, a dwelling unit type has the same floor area, number of bedrooms, IAQ ventilation system, space conditioning systems, and appliances (washer/dryer in the dwelling unit).

Proposed Design

For each dwelling unit type the user inputs the following information:

- Unit type name
- Conditioned floor area (CFA) in square feet per dwelling unit
- Number of bedrooms
- Appliance data
- Space conditioning systems
- DHW system
- IAQ ventilation system

Standard Design

The standard design shall have the same conditioned floor area and number of bedrooms and type of dwelling units as the proposed design.

Verification and Reporting

The number of units of each type and minimum IAQ ventilation for each unit type is reported on the Certificate of Compliance for field verification.

6.5.2 Dwelling Units per Space

Multifamily projects have multiple dwelling units within the project. The dwelling units per space represents the number of residential living units within a single compliance model space and is shown as a positive integer.

PROPOSED DESIGN

The proposed design represents the building as designed.

STANDARD DESIGN

The standard design assumes the same number of dwelling units as identified in the proposed design. This applies for both newly constructed buildings projects and existing building projects.

6.5.3 Number of Bedrooms

Multifamily projects can have multiple bedrooms within a dwelling unit. The user will provide the number of bedrooms per dwelling unit as an integer with a minimum of 0 and a maximum of 5.

PROPOSED DESIGN

The proposed design represents the number of bedrooms per dwelling unit as designed.

STANDARD DESIGN

The standard design assumes the same number of bedrooms per dwelling unit as identified in the proposed design. This applies for both newly constructed buildings projects and existing building projects.

6.5.4 Number of Occupants

Applicability: Multifamily projects will need to specify the number of people in a space. The number of people is modified by an hourly schedule, which approaches but does not exceed 1.0. Therefore, the number of people specified by the building descriptor is similar to design conditions as opposed to average occupancy.

The number of people may be specified in ft^2/person, or people/1000 ft^2.

PROPOSED DESIGN

For multifamily common use areas, the rules established in5.4.3 Occupants. For multifamily dwelling units, the number of occupants is defined as: Max (number of bedrooms +1, 2).

STANDARD DESIGN:

The number of occupants must be identical for both the proposed and standard design cases. This applies for both newly constructed buildings and existing building projects.

6.5.5 Lighting Classification Method

For multifamily common areas in the building, the indoor lighting power is specified using the area category method. For multifamily dwelling units, not applicable.

PROPOSED DESIGN

Area category method can be used for all areas of the building with space types listed in Appendix 5.4A, and can be used to specify both general lighting power and additional lighting power for these multifamily common use spaces.

STANDARD DESIGN

The standard design lighting power shall be modeled as described for nonresidential spaces except as noted below.

Area category method lighting power allowances, as well as additional lighting power qualified systems and allowances are defined by Table 170.2-M

6.5.6 Multifamily General Lighting Power

All common area spaces in multifamily buildings may have multifamily general lighting power. General lighting power is the power used by installed electric lighting that provides a uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect, and also known as ambient lighting.

PROPOSED DESIGN

For spaces without additional lighting power allowances or similar requirements, this input will be the same as the regulated lighting power.

Trade-offs in general lighting power are allowed between spaces all using the area category method.

STANDARD DESIGN

General lighting power is the product of the lighting power densities for the space type from Appendix 5.4A and the floor areas for the corresponding conditioned spaces.

When the lighting status is "existing" (and unaltered) for the space, the standard design is the same as the existing, proposed design.

When the lighting status is "altered" for the space, and at least 10 percent of existing luminaires have been altered:

- If the lighting status is "existing," then the standard design LPD is the same as the proposed design.
- If the lighting status is "new," then the standard design LPD is same as newly constructed buildings.

- If the lighting status is "altered," then the standard design LPD is the same as newly constructed buildings.

6.5.7 Multifamily Additional Lighting Power Task Area

Common areas spaces in multifamily buildings that use area category method can identify multifamily additional lighting power task area.

PROPOSED DESIGN

The area associated with each of the additional lighting allowances in the ALP building descriptor. This area is based on the proposed designed but cannot exceed the floor area of the space.

STANDARD DESIGN

The standard design multifamily additional lighting power task area is the same as the proposed. This applies for both newly constructed buildings and existing building projects.

6.6 Air Leakage and Infiltration

The compliance software distributes the leakage over the envelope surfaces in accordance with the building configuration and constructs a pressure flow network to simulate the airflows between the conditioned zones, unconditioned zones, and outside.

6.6.1 Building Air Leakage and Infiltration

The airflow through a blower door at 50 pascals (Pa) of pressure measured in cubic feet per minute is called CFM50. CFM50 multiplied by 60 minutes, divided by the volume of conditioned space, is the air changes per hour at 50 Pa, called ACH50.

PROPOSED DESIGN

The proposed design for primarily dwelling unit zones in multifamily buildings shall be 2.3 ACH50. The proposed design for zones in multifamily buildings that are primarily common use and nonresidential areas shall be modeled as 7 ACH50.

STANDARD DESIGN

The standard design multifamily dwelling and common area air leakage and infiltration is the same as the proposed.

VERIFICATION AND REPORTING

For dwelling units in multifamily buildings, diagnostic testing to confirm the mandatory maximum compartmentalization value of 0.3 CFM50/ft^2 of dwelling surface area in the proposed design is required and must be reported in the ECC required verification listing on the Certificate of Compliance.

6.6.2 Dwelling Unit Zones and Surfaces

Multifamily buildings that have floors between dwelling units must define dwelling zones by floor and exterior exposure (orientation), or each dwelling unit as a separate zone. Users should define a sufficient number of exterior and interior surfaces so that the compliance software can simulate the airflows between the conditioned zones, unconditioned zones, and outside.

6.7 Residential Building Materials and Construction

6.7.1 Materials

Only materials approved by the CEC may be used in defining constructions. Additional materials may be added to the compliance software at the CEC's discretion.

Table 24: Materials List shows a partial list of the materials available for construction assemblies. Additional material information can be found in Reference Appendices Joint Appendix JA4.

Material Name

The material name is used to select the material for a construction.

Thickness

Some materials, such as three-coat stucco, are defined with a specific thickness (not editable by the compliance user). The thickness of other materials, such as softwood used for framing, is selected by the compliance user based on the construction of the building.

Conductivity

The conductivity of the material is the steady-state heat flow per square foot, per foot of thickness, or per degree Fahrenheit temperature difference. It is used in simulating the heat flow in the construction.

Table 24: Materials List

Material Name	Thickness (in.)	Conductivity (Btu/h-°F-ft)	Coefficient for Temperature Adjustment of Conductivity (°F(-1))	Specific Heat (Btu/lb-°F)	Density (lb/ft^3)	R-Value per Inch (°F-ft^2-h/ Btu-in)
Gypsum Board	0.5	0.09167	0.00122	0.27	40	0.9091
Wood Layer	Varies	0.06127	0.0012	0.45	41	1.36

Material Name	**Thickness (in.)**	**Conductivity (Btu/h-°F-ft)**	**Coefficient for Temperature Adjustment of Conductivity (°F(-1))**	**Specific Heat (Btu/lb-°F)**	**Density (lb/ft³)**	**R-Value per Inch (°F-ft²-h/ Btu-in)**
Synthetic Stucco	0.375	0.2		0.2	58	0.2
3 Coat Stucco	0.875	0.4167		0.2	116	0.2
All other siding						0.21
Carpet	0.5	0.02		0.34	12.3	4.1667
Light Roof	0.2	1		0.2	120	0.0833
5 PSF Roof	0.5	1		0.2	120	0.0833
10 PSF Roof	1	1		0.2	120	0.0833
15 PSF Roof	1.5	1		0.2	120	0.0833
25 PSF Roof	2.5	1		0.2	120	0.0833
TileGap	0.75	0.07353		0.24	0.075	1.1333
SlabOnGrade	3.5	1		0.2	144	0.0833
Earth		1		0.2	115	0.0833
SoftWood		0.08167	0.0012	0.39	35	1.0204
Concrete		1		0.2	144	0.0833
Foam Sheathing	Varies	varies	0.00175	0.35	1.5	Varies
Ceiling Insulation	Varies	varies	0.00418	0.2	1.5	Varies
Cavity Insulation	varies	varies	0.00325	0.2	1.5	Varies
Vertical Wall Cavity	3.5	0.314	0.00397	0.24	0.075	
GHR Tile	1.21	0.026	0.00175	0.2	38	
ENSOPRO	0.66	0.03	0.00175	0.35	2	
ENSOPRO Plus	1.36	0.025	0.00175	0.35	2	
Door						5

Source: California Energy Commission

COEFFICIENT FOR TEMPERATURE ADJUSTMENT OF CONDUCTIVITY

The conductivity of insulation materials varies with temperature according to the coefficient listed. Other materials have a coefficient of zero (0), and the conductivity does not vary with temperature.

SPECIFIC HEAT

The specific heat is the amount of heat in British thermal units (Btu) it takes to raise the temperature of 1 pound of the material 1 degree Fahrenheit (Btu/lb-°F).

DENSITY

The density of the material is the weight of the material in pounds per cubic foot (lb/ft^3).

R-VALUE PER INCH

The R-value is the resistance to heat flow for a 1-inch-thick layer.

6.7.2 Residential Construction Assemblies

"Constructions" are defined by the compliance user for use in defining the building. The user assembles a construction from one or more layers of materials. For framed constructions, there is a framing layer that has parallel paths for the framing and the cavity between the framing members. The layers that are allowed depend on the surface type. The compliance software calculates a winter design U-factor that is compared to construction that meets the prescriptive standard. The U-factor is displayed as an aid to the user. The calculations used in the energy simulation are based on each layer and framing rather than the U-factor.

ASSEMBLY TYPES

The types of surfaces that the construction assemblies can be assigned to are:

- Exterior wall.
- Interior wall.
- Underground wall.
- Attic roof.
- Cathedral roof.
- Ceiling below attic.
- Interior ceiling.
- Interior floor.
- Exterior floor (over unconditioned space or exterior).
- Floor over crawl space.

Note: Exterior walls and floors, and Cathedral Ceilings can be described by either Residential Construction Assemblies (described in this section) or Nonresidential Construction Assemblies described in Chapters 5.5.3, 5.5.4, and 5.5.5 above.

CONSTRUCTION TYPE

For residential construction assemblies, a Construction Type must be defined. The available construction types depend on the Assembly Type described above.

For ceiling below attic the available construction is:

> Wood framed ceiling: In a residence with a truss roof, the ceiling is where the insulation is located, while the structure above the ceiling is encompassed by the term "attic" or "roof." The attic or roof consists of (moving from inside to outside) the radiant barrier, below-deck insulation, framing, above-deck insulation, and the roofing product, such as asphalt or tile roofing. See more in 6.10.2 Ceiling Below Attic.

For cathedral ceiling (with the roof defined as part of the assembly), the available construction types are:

- Wood-framed ceiling: Since there is no attic, the roof structure is connected to the insulated assembly at this point.
- Built-up roof.
- Structurally insulated panels (SIPs) ceiling.

For attic roof, the available construction types are:

- Wood-framed ceiling.
- Built-up roof.
- SIPs ceiling.

For interior ceiling, the available construction type is:

- Wood-framed ceiling.

For interior and exterior walls, the only available construction types are:

- Wood-framed wall.
- Metal-framed wall.

- Concrete/ICF/ brick.
- Hollow unit masonry.
- Adobe / strawbale / log
- Sips wall
- Dual panel hollow (DPH) wall

For underground walls, the only available construction type is:

- Concrete / ICF / brick

For floors (over exterior, over crawl space, or interior), the construction types are:

- Wood-framed floor
- SIPs floor
- Concrete / ICF / brick

For slab floors and underground floors, the construction type is:

- No frame (concrete/CMU)

Party surfaces separate conditioned space included in the analysis from conditioned space that may or may not be included in the analysis. Party surfaces for spaces that are modeled include surfaces between multifamily dwelling units. Party surfaces for spaces not included in the analysis include spaces joining an addition alone to the existing dwelling. Interior walls, ceilings, or floors can be party surfaces.

CONSTRUCTION LAYERS

All assemblies have a cavity path and a frame path.

As assemblies are completed, the screen displays whether the construction meets the prescriptive requirement for that component.

PROPOSED DESIGN

The user defines a construction for each surface type included in the proposed design. Any variation in insulation R-value, framing size or spacing, interior or exterior sheathing, or interior or exterior finish requires the user to define a different construction. Insulation R-values are based on manufacturer-rated properties rounded to the nearest whole R-value. Layers such as sheetrock, wood sheathing, stucco, and carpet whose properties are not compliance variables are included as generic layers with standard thickness and properties.

Walls separating conditioned spaces from unconditioned spaces are modeled as interior walls with unconditioned space as the adjacent zone, which the compliance software recognizes as a "demising wall. Floors over an unconditioned space are modeled as an interior or demising floor. The exterior surfaces of unconditioned spaces are modeled, though not subject to energy code requirements.

STANDARD DESIGN

The compliance software assembles a construction that meets the prescriptive standards for each user-defined construction or assembly. For ceiling/roof assembly, the standard design is based on Table 170.2-A Option B. For cathedral ceiling assemblies, the standard design is based on Table 170.2-A Option D. Exterior surface requirements are based on Table 170.2-A and vary based on the type of exterior surface and climate zone.

VERIFICATION AND REPORTING

All proposed constructions, including insulation, frame type, frame size, and exterior finish or exterior condition, are listed on the Certificate of Compliance. Nonstandard framing (e.g., 24" on center wall framing, advanced wall framing) is reported as a special feature.

6.7.3 Spray-Foam Insulation

The R-values for spray-applied polyurethane foam (SPF) insulation differ depending on whether the product is open cell or closed cell. Spray-foam insulation R-values are calculated based on the nominal thickness of the insulation multiplied by the default thermal resistivity per inch, or the total R-value may be calculated based on the thickness of the insulation multiplied by the tested R-value per inch as certified by the Department of Consumer Affairs, Bureau of Household Goods and Services (see details 6.7.3 Spray-Foam Insulation and Reference Appendices, Residential Appendix RA3.5).

Table 25: Required Thickness Spray Foam Insulation (in inches)

Required R-values for SPF insulation	R-11	R-13	R-15	R-19	R-21	R-22	R-25	R-30	R-38
Required thickness closed cell @ R5.8/inch	2.00	2.25	2.75	3.50	3.75	4.00	4.50	5.25	6.75
Required thickness open cell @ R3.6/inch	3.0	3.5	4.2	5.3	5.8	6.1	6.9	8.3	10.6

Source: California Energy Commission

Additional documentation and verification requirements for a value other than the default values shown in Table 25: Required Thickness Spray Foam Insulation (in inches) are required. (See Reference Appendices, Residential Appendix RA3.5.6.) For continuous insulation refer to 5.5.4 Exterior Walls.

6.7.3.1 Medium Density Closed-Cell SPF Insulation

The default R-value for spray-foam insulation with a closed cellular structure is R-5.8 per inch, based on the installed nominal thickness of insulation. Closed-cell insulation has an installed nominal density of 1.5 to 2.5 pounds per cubic foot (pcf).

6.7.3.2 Low-Density Open-Cell SPF Insulation

The default R-value for spray-foam insulation with an open cellular structure is calculated as R-3.6 per inch, based on the nominal required thickness of insulation. Open-cell insulation has an installed nominal density of 0.4 to 1.5 pcf.

Proposed Design

The user will select either typical values for open-cell or closed-cell spray-foam insulation or higher-than-typical values and enter the total R-value (rounded to the nearest whole value).

Standard Design

The compliance software assembles a construction that meets the prescriptive standards for each assembly type (ceiling/roof, wall, and floor).

Verification and Reporting for Buildings with up to Three Habitable Floors

When the user elects to use higher-than-typical R-values for open-cell or closed-cell spray-foam insulation, a special features note is included on the Certificate of Compliance requiring documentation requirements specified in Reference Appendices, Joint Appendix JA4.1.7. Furthermore, a ECC verification requirement for the installation of spray-foam insulation using higher-than-default values is included on the Certificate of Compliance.

6.7.4 Quality Insulation Installation For Building Up To Three Habitable Floors

The compliance software user may specify quality insulation installation (QII) for the proposed design as "yes" or "no." The effective R-value of cavity insulation is reduced, as shown in Table 25: Modeling Rules for Unverified Insulation Installation Quality in buildings with no QII. When set to "no," framed walls, ceilings, and floors are modeled with added winter heat flow between the conditioned zone and attic to represent construction cavities open to the attic. QII does not affect the performance of continuous sheathing in any construction.

Proposed Design

The compliance software user may specify compliance with QII. The default is "no" for QII. This results in a 30% derating applied to the cavity insulation.

STANDARD DESIGN

The standard design is modeled with "yes" for verified QII for newly constructed multifamily buildings and additions greater than 700 square feet in Climate Zones 1-6 and 8-16 (Climate Zone 7 has no QII for multifamily buildings). This results in the removal of the 30% derating to the cavity insulation.

VERIFICATION AND REPORTING

The presence of QII is reported in the ECC required verification listings on the Certificate of Compliance. Verified QII is certified by the installer and field verified to comply with Reference Appendices, Residential Appendix RA3.5. Credit for verified QII applies to ceilings/attics, knee walls, exterior walls, and exterior floors.

For alterations to existing pre-1978 construction, if the existing wall construction is assumed to have no insulation, no wall degradation is assumed for the existing wall.

Table 26: Modeling Rules for Unverified Insulation Installation Quality

Component	Modification
Walls, Floors, Attic Roofs, Cathedral Ceilings	Multiply the cavity insulation R-value/inch by 0.7.
Ceilings Below Attic	Multiply the blown and batt insulation R-value/inch by 0.96-0.00347*R.
Ceilings Below Attic	Add a heat flow from the conditioned zone to the attic of 0.015 times the area of the ceiling below attic times (the conditioned zone temperature — attic temperature) whenever the attic is colder than the conditioned space.

Source: California Energy Commission

6.8 Building Mechanical Systems

A space-conditioning system (also referred to as an HVAC system) is made up of the heating subsystem (also referred to as "heating unit," "heating equipment," or "heating system"); cooling subsystem (also referred to as "cooling unit," "cooling equipment," or "cooling system"); the distribution subsystem details (if any); and fan subsystem (if any). Ventilation cooling systems and indoor air-quality-ventilation systems are defined as part of the dwelling unit information for multifamily buildings.

Mechanical Systems Serving Multifamily buildings

The standard design HVAC systems for dwelling units and common areas in multifamily buildings is described in Table 27: Residential Standard Design HVAC System below:

Table 27: Residential Standard Design HVAC System

Space Type	Above-Grade Floors	Climate Zone	Standard Design
Dwelling Unit	Habitable floors ≤ 3	1-15	Single zone system with constant volume fan, no economizer, DX heat pump with electric resistance supplemental heat
Dwelling Unit	Habitable floors ≤ 3	16	Single zone system with constant volume fan, no economizer, DX cooling and furnace
Dwelling Unit	Habitable floors > 3	2-15	Single zone system with constant volume fan, no economizer, DX heat pump with electric resistance supplemental heat
Dwelling Unit	Habitable floors > 3	1, 16	Single zone system with constant volume fan, no economizer, DX heat pump with gas furnace supplemental heat
Directly Conditioned Common Area	Habitable floors ≤ 3	1-15	Single zone system with constant volume fan, DX heat pump with electric resistance supplemental heat
Directly Conditioned Common Area	Habitable floors ≤ 3	16	Single zone system with constant volume fan, DX cooling and furnace
Directly Conditioned Common Area	Four or more habitable floors	2-15	Single zone system with constant volume fan, DX heat pump with electric resistance supplemental heat

Directly Conditioned Common Area	Four or more habitable floors	1, 16	Single zone system with constant volume fan, DX heat pump with gas furnace supplemental heat
Indirectly Conditioned Common Area	No limit	All	Same as proposed design_with code minimum ventilation

Source: California Energy Commission

Requirements for the standard design mechanical systems in dwelling units are described in 6.8.1 Heating Subsystems_through 6.8.6 Indoor Air Quality (IAQ) Ventilation. These requirements are not applicable to common areas.

Multifamily common areas may be directly or indirectly conditioned. When the proposed design is indirectly conditioned, the standard design HVAC system matches the proposed design with code minimum ventilation. In cases where a central balanced ventilation system serves both dwelling units and an indirectly conditioned space, the requirements for heat recovery performance are based on the requirements for the dwelling units.

The standard design common area system fan shall run continuously to provide ventilation when the space is occupied. The heating and cooling efficiencies, fan power and economizer requirements, heat recovery performance and other requirements shall match those described in 5 Nonresidential Building Descriptors Reference for non-residential systems with the following exceptions:

- All heating and cooling system efficiencies shall follow the requirements for equipment using single-phase power.
- Relief fans, if included, shall not be modeled or be modeled the same in the proposed and standard designs
- Only fan power credits from Section 170.2(c)4Ai for higher levels of filtration shall be accounted for in the standard design.
- Distribution systems shall not be modeled

Multifamily Parking Garages

Parking garages shall be modeled with exhaust systems. Follow rules in 5 Nonresidential Building Descriptors Reference.

6.8.1 Heating Subsystems

The heating subsystem section describes the equipment that supplies heat to a space-conditioning system. Heating subsystems are categorized according to the types shown in Table 28: HVAC Heating Equipment Types and Table 29: Heat Pump Equipment Types.

Furnace capacity is determined by the compliance software as 200 percent of the heating load at the heating design temperature. Heat pump compressor size is determined by the compliance software as the larger of the compressor size calculated to meet 110 percent of the cooling load at the cooling design temperature, or the compressor size calculated to meet 110 percent of the heating load at the heating design temperature.

If the heat pump heating capacity is insufficient to meet load during any hour, and supplemental heating is provided by electric resistance, the unmet portion of the load is met by supplemental heating.

If the heat pump heating capacity is insufficient to meet load during any hour, and supplemental heating is provided by gas, the entire heating load for the hour would be met by supplemental heating. In applications where heating load is greater than or equal to cooling load, the heat pump is disabled whenever the outdoor air temperature is below the heat pump lockout temperature. The heat pump lockout temperature is 40 °F. In applications where cooling load is greater than heating load, the heat pump is disabled whenever the heating load is greater than the heating capacity.

PROPOSED DESIGN

The user selects the heating subsystem equipment type, and supplies required inputs from those listed in Table 28: HVAC Heating Equipment Types and Table 29: Heat Pump Equipment Types for the heating subsystem, including the rated heating efficiency. The rated heating capacity is not used as a compliance variable by the compliance software.

STANDARD DESIGN

When the standard design is a heat pump, the equipment used in the standard design building is an electric split-system heat pump with a heating seasonal performance factor (HSPF/HSPF2) meeting the current *Appliance Efficiency Regulations* minimum efficiency for heat pumps.

When the standard design is a gas heating system, the equipment used in the standard design building is a gas furnace (or propane if natural gas is not available), and an annual fuel utilization efficiency (AFUE) meeting the *Appliance Efficiency Regulations* minimum efficiency for central systems.

See Table 28: HVAC Heating Equipment Types and Table 29: Heat Pump Equipment Types for complete details on heating subsystems noted above.

Verification and Reporting

The proposed heating system type and rated efficiency are reported on the Certificate of Compliance. For heat pumps, with electric resistance supplemental heat, the ECC-verified rated heating capacity of each proposed heat pump is reported on the Certificate of Compliance. Installed capacities must be equal to or larger than the capacities modeled at 47 °F and 17 °F (Reference Appendix 3.4.4.2).

Table 28: HVAC Heating Equipment Types

Name	Heating Equipment Description
CntrlFurnace	Gas- or oil-fired central furnaces, propane furnaces, or heating equipment considered equivalent to a gas-fired central furnace, such as wood stoves that qualify for the wood heat exceptional method. Gas fan-type central furnaces have a minimum AFUE=80% before December 18, 2028 and 95% on or after December 18, 2028. Distribution can be gravity flow or use any of the ducted systems.
PkgGasFurnace	The furnace side of a packaged air-conditioning system. Packaged gas or propane furnaces have a minimum AFUE=81%. Distribution can be any of the ducted systems.
WallFurnace Gravity	Noncentral gas- or oil-fired wall furnace, gravity flow. Equipment has varying efficiency requirements by capacity. Distribution is ductless.
WallFurnace Fan	Noncentral gas- or oil-fired wall furnace, fan-forced. Equipment has varying efficiency requirements by capacity. Distribution is ductless.
FloorFurnace	Noncentral gas- or oil-fired floor furnace. Equipment has varying efficiency requirements by capacity. Distribution is ductless.
RoomHeater	Noncentral gas- or oil-fired room heaters. Noncentral gas- or oil-fired wall furnace, gravity flow. Equipment has varying efficiency requirements by capacity. Distribution is ductless.
WoodHeat	Wood-fired stove. In areas with no natural gas available, a wood-heating system with any supplemental heating system is allowed to be installed if exceptional method criteria described in the *Residential Compliance Manual* are met.
Boiler	Gas or oil boilers. Distribution systems can be radiant, baseboard, or any of the ducted systems. Boiler may be specified for dedicated hydronic systems. Systems in which the boiler provides space

Name	Heating Equipment Description
	heating and fires an indirect gas water heater (IndGas) may be listed as Boiler/CombHydro Boiler and is listed under "Equipment Type" in the HVAC Systems listing.
Electric	All electric heating systems other than space-conditioning heat pumps. Included are electric resistance heaters, electric boilers, and storage water heat pumps (air-water) (StoHP). Distribution system can be radiant, baseboard, or any of the ducted systems.
CombHydro	Water-heating system can be any gas water heater. Distribution systems can be radiant, baseboard, or any of the ducted systems and can be used with any of the terminal units (FanCoil, RadiantFlr, Baseboard, and FanConv).
FPFC	Four-pipe fan coil (FPFC)

Source: California Energy Commission

Table 29: Heat Pump Equipment Types

Name	Heat Pump Equipment Description
SplitHeatPump	Central split heat pump system. Distribution system is one of the ducted systems. Efficiency Metric: HSPF2
SDHVSplitHeatPump	Small duct, high velocity, central split-system that produces at least 1.2 inches of external static pressure when operated at the certified air volume rate of 220–350 CFM per rated ton of cooling capacity and uses high-velocity room outlets generally greater than 1,000 feet per minute that have less than 6.0 square inches of free area. Efficiency Metric: HSPF2
Ductless MiniSplit HeatPump	A heat pump system that has an outdoor section and one or more ductless indoor sections. The indoor section(s) cycle on and off in unison in response to an indoor thermostat. Efficiency Metric: HSPF2
DuctlessMultiSplitHeatPump	A heat pump system that has an outdoor section and two or more ductless indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats. Efficiency Metric: HSPF2

Name	**Heat Pump Equipment Description**
DuctlessVRFHeatPump	A variable-refrigerant-flow (VRF) heat pump system that has one or more outdoor sections and two or more ductless indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats. Efficiency Metric: HSPF2
PkgHeatPump	Central packaged heat pump systems. Central packaged heat pumps are heat pumps in which the blower, coils, and compressor are contained in a single package, powered by single-phase electric current, air-cooled, and rated below 65,000 Btu/h. The distribution system is one of the ducted systems. Efficiency Metric: HSPF2
DuctlessPkgHeatPump	Ductless packaged heat pump systems. A ductless packaged heat pump is a heat pump in which the blower, coils, and compressor are contained in a single package, powered by single-phase electric current, air-cooled, and rated below 65,000 Btu/h. Efficiency Metric: HSPF2
LrgPkgHeatPump	Large central packaged heat pump systems, rated above 65,000 Btu/h.
RoomHeatPump	Noncentral room air-conditioning systems. These include packaged terminal (commonly called "through-the-wall") units and any other ductless heat pump systems. Efficiency Metric: CEER
SglPkgVertHeatPump	Single-package vertical heat pump. This is a package air conditioner that uses reverse cycle refrigeration as the prime heat source and may include secondary supplemental heating by means of electrical resistance. Efficiency Metric: COP47
PkgTermHeatPump	Packaged terminal heat pump. This is a package terminal air conditioner that uses reverse cycle refrigeration as the prime heat source; has a supplementary heating source

Name	Heat Pump Equipment Description
	available, with the choice of electric resistant heat; and is industrial equipment. Efficiency Metric: COP47
DuctedMiniSplitHeatPump	Ducted mini-split heat pump is a system that has an outdoor section and one or more ducted indoor sections. The indoor section(s) cycle on and off in unison in response to an indoor thermostat. Efficiency Metric: HSPF2
DuctedMultiSplitHeatPump	Ducted multi-split heat pump is a system that has a single outdoor section, and two or more ducted indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats. Efficiency Metric: HSPF2
Ducted+DuctlessMultiSplitHeatPump	Multi-split heat pump system with a combination of ducted and ductless indoor units. Efficiency Metric: HSPF2
AirToWaterHeatPump	An indoor conditioning coil, a compressor, and a refrigerant-to-water heat exchanger that provides heating and cooling functions. Also, able to heat domestic hot water.
GroundSourceHeatPump	An indoor conditioning coil with air-moving means, a compressor, and a refrigerant-to-ground heat exchanger that provides heating, cooling, or heating and cooling functions. May also have the ability to heat domestic hot water.
SZDFHP	Single-zone dual fuel heat pump system with constant volume fan, direct expansion heat pump cooling and heating, and gas supplemental heating.
CHPWH	Central heat pump water heater systems including primary heating equipment, primary heating storage volume, location, secondary heating equipment, secondary heating storage

Name	Heat Pump Equipment Description
	volume, set point controls, and the way in which the components are plumbed.

Source: California Energy Commission

6.8.1.1 Heating Seasonal Performance Factor (HSPF/HSPF2)

PROPOSED DESIGN

The compliance software allows the user to specify the HSPF/HSPF2 value for heat pump equipment. A conversion factor is used to convert HSPF2 to HSPF ratings for modeling. For split-system, small-duct high-velocity, and space-constrained equipment, the conversion factor is 1/0.85. For single-package equipment, the conversion factor is 1/0.84.

STANDARD DESIGN

The standard design is the minimum allowable HSPF for the type of heat pump equipment modeled in the proposed design, based on the applicable *Appliance Efficiency Regulations*.

VERIFICATION AND REPORTING

If an HSPF/HSPF2 for the proposed design is higher than the default minimum efficiency modeled in compliance software, the HSPF/HSPF2 requires field verification. The HSPF/HSPF2 rating is verified using rating data from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Directory of Certified Product Performance website or another directory of certified product performance ratings approved by the CEC for determining compliance. Verified HSPF/HSPF2 is reported in the ECC-required verification listings on the Certificate of Compliance.

6.8.1.2 Combined Hydronic Space/Water Heating

Combined hydronic space/water heating is a system whereby a water heater is used to provide space heating and water heating. Space-heating terminals may include fan coils, baseboards, and radiant floors.

For combined hydronic systems, the water-heating portion is modeled as a domestic hot water system as described in 6.11 Domestic Hot Water (DHW). For space heating, an effective AFUE is calculated for gas water heaters. For electric water heaters, an effective HSPF/HSPF2 is calculated. The procedures for calculating the effective AFUE or HSPF/HSPF2 are described below.

Combined hydronic space-conditioning cannot be combined with heat pump water heating or with zonal control credit.

PROPOSED DESIGN

When a fan coil is used to distribute heat, the fan energy and the heat contribution of the fan motor must be considered. The algorithms for fans used in combined hydronic systems are the same as those used for gas furnaces and are described in Appendix G.

If a large fan coil is used and air-distribution ducts are in the attic, crawl space, or other unconditioned space, the efficiency of the air-distribution system must be determined using methods consistent with those described in 6.8.3 Distribution Subsystems. Duct efficiency is accounted for when the distribution type is ducted.

6.8.1.3 Commercial or Consumer Storage Gas Water Heater

When storage gas water heaters are used in combined hydronic applications, the effective AFUE is given by the following equation:

$$AFUE_{eff} = RE - \left[\frac{PL}{RI} \right]$$ **Equation 7**

Where:

$AFUE_{eff}$ – The effective AFUE of the gas water heater in satisfying the space heating load.

RE – The recovery efficiency (or thermal efficiency) of the gas storage water heater. A default value of 0.70 may be assumed if the recovery efficiency is unknown. This value is generally available from the CEC's Modernized Appliance Efficiency Database System (MAEDbS).

PL – Pipe losses (kBtu/h). This can be assumed to be zero when there is less than 10 feet of piping between the water heater storage tank and the fan coil, or when other heating elements are in unconditioned space.

RI – The rated input of the gas water heater (kBtu/h) available from the CEC's appliance directory, MAEDbS.

6.8.1.4 Instantaneous Gas Water Heater

When instantaneous gas water heaters are used in combined hydronic applications, the effective AFUE is given by the following equation:

$$AFUE_{eff} = UEF$$ **Equation 8**

Where:

$AFUE_{eff}$ – The effective AFUE of the gas water heater in satisfying the space heating load.

UEF – The rated uniform energy factor of the instantaneous gas water heater.

6.8.1.5 Storage Electric Water Heater

The HSPF of storage water heaters used for space heating in a combined hydronic system is given by the following equations.

$$HSPF_{eff} = 3.413\left[1 - \frac{PL}{3.413kWi}\right]$$ **Equation 9**

Where:

$HSPF_{eff}$ – The effective HSPF of the electric water heater in satisfying the space-heating load.
PL – Pipe losses (kBtu/h). Assumed zero when less than 10 feet of piping between the water heater storage tank and the fan coil or other heating elements are in unconditioned space.
kW_i – The kilowatts of input to the water heater available from the CEC's appliance directory.

STANDARD DESIGN

When a hydronic system is proposed to use electricity for heating, the heating equipment for the standard design is an electric split-system heat pump with an HSPF/HSPF2 meeting the *Appliance Efficiency Regulations* requirements for split-systems. The standard design heat pump compressor size is determined by the compliance software based on the compressor size calculated for the air-conditioning system.

When electricity is not used for heating, the equipment used in the standard design building is a gas furnace (or propane if natural gas is not available) with default ducts in the attic and an AFUE meeting the *Appliance Efficiency Regulations* minimum efficiency for central systems. When a proposed design uses electric and non-electric heat, the standard design is a gas furnace.

6.8.1.6 Special Systems — Hydronic Distribution Systems and Terminals

Hydronic distribution systems in unconditioned spaces are included in the building model to account for heat loss to these unconditioned spaces. Heat loss is affected by the length of piping in unconditioned spaces, pipe size, pipe insulation thickness, and pipe insulation R-value.

PROPOSED DESIGN

This listing is completed for hydronic systems that have more than 10 feet of piping (plan view) in unconditioned space. As many rows as necessary may be used to describe the piping system.

STANDARD DESIGN

The standard design is established for a hydronic system in the same way as for a central system, as described in 6.8.1 Heating Subsystems.

VERIFICATION AND REPORTING

A hydronic or combined hydronic system is reported on the Certificate of Compliance.

Other information reported includes:

Piping Run Length (ft). The length (plan view) of distribution pipe in unconditioned space, in feet, between the primary heating/cooling source and the point of distribution.

Nominal Pipe Size (in.). The nominal (as opposed to true) pipe diameter in inches.

Insulation Thickness (in.). The thickness of the insulation in inches. Enter "none" if the pipe is uninsulated.

Insulation R-value (hr-ft^2 °F/Btu). The installed R-value of the pipe insulation. Minimum pipe insulation for hydronic systems is as specified in Section 160.4(f).

6.8.1.7 Ground-Source Heat Pump

A ground-source heat pump system, which uses the earth as a source of energy for heating and as a sink for energy when cooling, is simulated as a minimum efficiency split-system equivalent to the standard design with default duct conditions in place of the proposed system. The mandatory efficiencies for ground-source heat pumps are a minimum coefficient of performance (COP) for heating and EER/EER2 for cooling.

6.8.1.8 Air-to-Water Heat Pumps

Air-to-water heat pumps (AWHPs) must be listed in the CEC's appliance directory, MAEDbS. For the proposed design, fixed compressor speed AWHPs would be modeled equivalent to the prescriptive air source heat pump in heating and cooling operation. Variable compressor speed AWHPs are modeled with a 2% reduction in hourly heating energy use and an 8% reduction in hourly cooling energy use, relative to the prescriptive air source heat pump.

6.8.1.9 Air Source Heat Pumps

The compliance software shall represent air source heat pump performance at different outdoor dry bulb temperatures, compressor speeds, and entering air conditions, such that the modeled performance is consistent with the rated capacities and efficiencies input by the user. For performance at outdoor dry bulb temperatures and compressor speeds where user input is not provided, the compliance software shall use statistically representative normalized relationships of capacity and efficiency based on performance data of relevant products. For variable capacity heat pumps, these relationships shall enable the calculation of performance at both minimum and maximum capacity compressor operation. Air source heat pump equipment is simulated based on the RESNET Guidelines for Simulating Unitary Air-conditioning and Air-source Heat Pump

Equipment, March 28, 2025. This document can be found at https://www.resnet.us/about/standards/publications/.

If VCHP maximum heating capacity is insufficient to meet the load, it is assumed that the unmet portion of the load will be met by electric resistance heat. Defrost occurs between 35 °F and 17 °F outdoor temperature with electric resistance auxiliary heat assumed to compensate for heat lost during the defrost cycle.

6.8.2 Cooling Subsystems

The cooling subsystem describes the equipment that supplies cooling to a space-conditioning system.

Air conditioner compressor size is determined by the compliance software as 110 percent of the cooling load at the cooling design temperature. For heat pumps the compressor size is the larger of 110 percent of the heating load or 110 percent of the cooling load.

The compliance software shall represent unitary air conditioner performance at different outdoor dry bulb temperatures, compressor speeds, and entering air conditions, such that the modeled performance is consistent with the rated capacities and efficiencies input by the user. For performance at outdoor dry bulb temperatures and compressor speeds where user input is not provided, the compliance software shall use statistically representative normalized relationships of capacity and efficiency based on performance data of relevant products. Unitary air conditioning equipment is simulated based on the Resnet Guidelines for Simulating Unitary Air-conditioning and Air-source Heat Pump Equipment, March 28, 2025.

Proposed Design

Cooling subsystems are categorized according to the types shown in Table 30: HVAC Cooling Equipment Types (Air Conditioners) or Table 29: Heat Pump Equipment Types The user selects the type of cooling equipment and enters basic information to model the energy use of the equipment, such as equipment efficiency ratings. For some types of equipment, the user may also specify through checkboxes if the equipment has a multispeed compressor and if the system is zoned or not. For ducted cooling systems, the cooling airflow from the conditioned zone through the cooling coil is input as CFM per ton. The rated cooling capacity is not a compliance variable by the compliance software.

See below for more details on specific inputs.

Standard Design

The cooling system for the standard design building is a single-zone, ducted air-conditioning system or split heat pump system that meets the default minimum requirements of the applicable *Appliance Efficiency Regulations*. Fan efficacy meeting the 2025 Energy Code's mandatory is assumed in all climate zones.

For heat pumps less than 45,000 BTU the EER2 in the standard design is based on the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is below 11.7, then the EER2 in the standard design is equal to the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is 11.7 or greater, then the EER2 of the standard design is 11.7. Consequently, the maximum EER2 of heat pump equipment for cooling in the standard design is 11.7.

For heat pumps 45,000 BTU or larger, the EER2 in the standard design is based on the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is below 11.2, then the EER2 in the standard design is equal to the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is 11.2 or greater, then the EER2 of the standard design is 11.2. Consequently, the maximum EER2 of heat pump equipment for cooling in the standard design is 11.2.

Table 30: HVAC Cooling Equipment Types (Air Conditioners)

Name	Cooling Equipment Description
NoCooling	Entered when the proposed building is not cooled or when cooling is optional (to be installed at some future date). Both the standard design and the proposed design use the same default system (refer to 6.8.5.3 No Cooling).
SplitAirCond	Split air-conditioning systems. Distribution system is one of the ducted systems. (Efficiency metric: SEER/SEER2 and EER/EER2)
PkgAirCond	Central packaged air-conditioning systems less than 65,000 Btu/h cooling capacity. Distribution system is one of the ducted systems. (Efficiency metric: SEER/SEER2 and EER/EER2)
LrgPkgAirCond	Large packaged air-conditioning systems rated at or above 65,000 Btu/h cooling capacity. Distribution system is one of the ducted systems.
SDHVSplitAirCond	Small-duct, high-velocity, split air-conditioning system.
DuctlessMiniSplitAirCond	Ductless mini-split air-conditioning system having an outdoor section and one or more indoor sections. The indoor sections cycle on and off in unison in response to an indoor thermostat.
DuctlessMultiSplitAirCond	Ductless multi-split air-conditioning system having an outdoor section and two or more indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats.

Name	Cooling Equipment Description
DuctlessVRFAirCond	Ductless variable refrigerant flow (VRF) air-conditioning system.
SglPkgVertAirCond	Single-packaged vertical air-conditioning is a self-contained cooling system that is factory-assembled, is arranged vertically, can be mounted on the exterior or interior of a space and, can be installed through the wall. These units can be ducted or ductless.
PkgTermAirCond	Packaged terminal air-conditioning (PTAC) is a self-contained cooling system that is installed through the wall. These systems do not use ducts.
DuctedMiniSplitAirCond	Ducted mini-split air-conditioning system having an outdoor section and one or more indoor sections. The indoor sections cycle on and off in unison in response to an indoor thermostat.
DuctedMultiSplitAirCond	Ducted multi-split air-conditioning system having an outdoor section and two or more indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats.
Ducted+DuctlessMulti SplitAirCond	Combination of ducted and ductless multi-split air-conditioning system have an outdoor section and two or more indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats.
RoomAirCond	Room air conditioner is a self-contained cooling system that is installed through the wall. These systems do not use ducts. Same as DuctlessSplitAirCond except that cooling is not supplied to each habitable space in the dwelling unit.
EvapCondenser	Evaporatively cooled condensers. A split mechanical system, with a water-cooled condenser coil.
FPFC	Four-pipe fan coil (FPFC)

Source: California Energy Commission

VERIFICATION AND REPORTING

Information shown on the Certificate of Compliance includes cooling equipment type and cooling efficiency (SEER/SEER2 or EER/EER2 or IEER. Measures requiring verification (Table 31: Summary of Space Conditioning Measures Requiring Verification) are listed in the ECC verification section of the Certificate of Compliance.

6.8.2.1 Verified Refrigerant Charge

Proper refrigerant charge is necessary for electrically driven compressor air-conditioning and heating systems to operate at full capacity and efficiency. For cooling, software calculations set the cooling compressor efficiency multiplier to 0.90 to account for the effect of improper refrigerant charge or 0.96 for proper charge. For heating, software calculations set the heating compressor efficiency multiplier to 0.92 to account for the effect of improper refrigerant charge or 0.96 for proper charge.

PROPOSED DESIGN

The compliance software allows the user to indicate if systems will have diagnostically tested refrigerant charge. This allowance applies only to ducted split-systems and packaged air-conditioners and heat pumps.

STANDARD DESIGN

The standard design building is modeled with either diagnostically tested refrigerant charge or a field-verified FID if the building is in Climate Zone 2 or 8–15, and refrigerant charge verification is required by Section 170.2(c)3B and Table 170.2-K for the proposed cooling system type.

VERIFICATION AND REPORTING

Refrigerant charge requires field verification or diagnostic testing and is reported in the ECC required verification listings on the Certificate of Compliance. Details on refrigerant charge measurement are discussed in *Reference Appendices, Residential Appendix RA3.2*.

Table 31: Summary of Space Conditioning Measures Requiring Verification

Measure	Description	Procedures
Verified Refrigerant Charge	Air-cooled air-conditioners and air-source heat pumps must be tested diagnostically to verify that the system has the correct refrigerant charge. The system must also meet the system airflow requirement.	RA1.2, RA3.2
Verified System Airflow	When compliance requires verified system airflow greater than or equal to a specified criterion.	RA3.3
Verified Air-Handling Unit Fan Efficacy	To verify that fan efficacy (watt/CFM) is less than or equal to a specified criterion.	RA3.3
Verified HSPF/HSPF2,	Credit for increased efficiency by installation of specific air-conditioner or heat pump models.	RA3.4.4.1

Measure	Description	Procedures
SEER/SEER2 or EER/EER2		
Verified Heat Pump Capacity	Optional verification of heat-pump system capacity.	RA3.4.4.2

Source: California Energy Commission

6.8.2.2 Verified System Airflow

Adequate airflow to the conditioned space is required to allow ducted air-conditioning systems to operate at full efficiency and capacity. Efficiency is achieved by the air distribution system design by improving the efficiency of motors or by designing and installing air distribution systems that have less resistance to airflow. Compliance software calculations account for the effect of airflow on sensible heat ratio and compressor efficiency.

For systems other than small-duct, high-velocity types, a value less than 350 CFM/ton (minimum 150 CFM/ton) is a valid input only if zonally controlled equipment is selected and multispeed compressor is not selected. Inputs less than 350 CFM/ton for zonally controlled systems require verification using procedures in *Reference Appendices, Residential Appendix* RA3.3.

Section 160.3(b)5L requires verification that the central air-handling unit airflow rate is greater than or equal to 350 CFM/ton for systems other than small-duct, high-velocity types or 250 CFM/ton for small-duct, high-velocity systems. Values greater than the required CFM/ton may be input for compliance credit, which requires diagnostic testing using procedures in *Reference Appendices, Residential Appendix RA3.3*.

For single-zone systems:

- As an alternative to verification of 350 CFM/ton for systems other than small-duct, high-velocity types or 250 CFM/ton for small-duct, high-velocity systems, ECC verification of a return duct design that conforms to the specification given in Table 160.3-A or B may be used to demonstrate compliance.
- The return duct design alternative is not an input to the compliance software but must be documented on the certificate of installation.
- If a value greater than 350 CFM/ton for systems other than small-duct, high-velocity types or greater than 250 CFM/ton for small-duct, high-velocity systems is modeled for compliance credit, the alternative return duct design method using Table 160.3-A or B is not allowed for demonstrating compliance.
- Variable capacity systems including multispeed and variable-speed compressor systems must verify airflow rate (CFM/ton) for system operation at the maximum compressor speed and the maximum air handler fan speed.

For zonally controlled systems:

- The Table 160.3-A or B return duct design alternative is not allowed for zonally controlled systems.
- Variable capacity systems including multispeed, variable-speed, and single-speed compressor systems must all verify airflow rate (CFM/ton) by operating the system at maximum compressor capacity and maximum system fan speed in every zonal control mode with all zones calling for conditioning.
- Single-speed compressor systems must also verify airflow rate (CFM/ton) in every zonal control mode.
- For systems that input less than 350 CFM/ton, ECC verification compliance cannot use group sampling.

PROPOSED DESIGN

The default cooling airflow is 150 CFM/ton for a system with "zonally controlled" selected and "multispeed compressor" not selected (single-speed). Users may model airflow for these systems greater than or equal to 150 CFM/ton, which must be verified using the procedures in *Reference Appendices, Residential Appendix RA3.3.* Inputs less than the rates required by Section 160.3(b)5L will be penalized in the compliance calculation.

The default cooling airflow is 350 CFM/ton for systems other than small-duct, high-velocity types or 250 CFM/ton for small-duct, high-velocity systems. Users may model a higher-than-default airflow for these systems and receive credit in the compliance calculation if greater-than-default system airflow is diagnostically tested using the procedures of *Reference Appendices, Residential Appendix RA3.3*.

STANDARD DESIGN

The standard design shall assume a system that complies with mandatory (Section 160.3) and prescriptive (Section 170.2) requirements for the applicable climate zone.

VERIFICATION AND REPORTING

The airflow rate verification compliance target (CFM or CFM/ton) is reported in the ECC required verification listings of the Certificate of Compliance. When there is no cooling system, it is reported on the Certificate of Compliance as a special feature.

6.8.2.3 Verified Air-Handling Unit Fan Efficacy

The mandatory requirement in Section 160.3(b)5L is for an air-handling unit fan efficacy equal to or less than 0.45 watts/CFM for gas furnace air-handling units, 0.58 watts/CFM for air-handling units that are not gas furnaces, and 0.62 W/CFM for small-duct, high-velocity systems as verified by a ECC rater. Users may model a lower fan efficacy (W/CFM) and receive credit in the compliance calculation if the proposed fan efficacy value is diagnostically tested using the procedures in *Reference Appendices, Residential Appendix RA3.3*.

For single-zone systems:

- Installers may elect to use an alternative to ECC verification of the watts/CFM required by Section_160.3(b)5L: ECC verification of a return duct design that conforms to the specification given in Table 160.3-A or B.
- The return duct design alternative is not an input to the compliance software but must be documented on the certificate of installation.
- If a value less than the watts/CFM required by Section 160.3(b)5L is modeled by the compliance software user for compliance credit, the alternative return duct design method using Table 160.3-A or B is not allowed for use in demonstrating compliance.
- Multispeed or variable-speed compressor systems must verify fan efficacy (watt/CFM) for system operation at the maximum compressor speed and the maximum air handler fan speed.

For zonally controlled systems:

- The Table 160.3-A or B return duct design alternative is not allowed for zonally controlled systems.
- Variable capacity systems including multispeed, variable-speed, and single-speed compressor systems must all verify fan efficacy (watt/CFM) by operating the system at maximum compressor capacity and maximum system fan speed with all zones calling for conditioning.
- Single-speed compressor systems must verify fan efficacy in every zonal control mode.

PROPOSED DESIGN

The compliance software shall allow the user to enter the fan efficacy. The default mandatory value is 0.45, 0.58, or 0.62 W/CFM, depending on the applicable system type. However, users may specify a lower value and receive credit in the compliance calculation if verified and diagnostically tested using the procedures of *Reference Appendices, Residential Appendix RA3.3*.

If no cooling system is installed, a default value of 0.45 W/CFM is assumed.

STANDARD DESIGN

The standard design shall assume a verified fan efficacy complying with the mandatory requirement of equal to or less than the following:

- 0.45 W/CFM for gas furnace air-handling units, as well as air-handling unit that are not gas furnaces and have a capacity less than 54,000 BTU/h
- 0.58 W/CFM for air-handling units that are not gas furnaces and have a capacity greater than or equal to 54,000 BTU/h
- 0.62 W/CFM for small duct high velocity forced air systems.

VERIFICATION AND REPORTING

For user inputs lower than the default mandatory requirement, fan efficacy is reported in the ECC-required verification listings of the Certificate of Compliance.

For default mandatory 0.45 or 0.58 watts/cfm, the choice of either fan efficacy or alternative return duct design according to Table 160.3-A or B is reported in the ECC-required verification listings of the Certificate of Compliance.

No cooling system is reported as a special feature on the Certificate of Compliance.

6.8.2.4 Verified Energy Efficiency Ratio (EER/EER2) For Buildings Up To Three Habitable Floors

PROPOSED DESIGN

Compliance software shall allow the user the option to enter an EER/EER2 rating for central cooling equipment. For equipment that is rated only with an EER/EER2, the user will enter the EER/EER2. The *Appliance Efficiency Regulations* require a minimum SEER/SEER2 and EER/EER2 for central cooling equipment. Only if a value higher than a default minimum EER/EER2 is used is it reported as a ECC-verified measure. A conversion factor is used to convert EER2 to EER ratings for modeling. For all air conditioners the conversion factor is 1/0.96.

STANDARD DESIGN

The standard design is based on the default minimum efficiency EER/EER2 for the type of cooling equipment modeled in the proposed design, based on the applicable *Appliance Efficiency Regulations*. For heat pumps less than 45,000 BTU the EER2 in the standard design is based on the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is below 11.7, then the EER2 in the standard design is equal to the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is 11.7 or greater, then the EER2 of the standard design is 11.7. Consequently, the maximum EER2 of heat pump equipment for cooling in the standard design is 11.7.

For heat pumps 45,000 BTU or larger, the EER2 in the standard design is based on the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is below 11.2, then the EER2 in the standard design is equal to the EER2 of the equipment in the proposed design. When the EER2 of the equipment in the proposed design is 11.2 or greater, then the EER2 of the standard design is 11.2. Consequently, the maximum EER2 of heat pump equipment for cooling in the standard design is 11.2.

VERIFICATION AND REPORTING

If an EER/EER2 is modeled in compliance software for credit, the EER/EER2 requires field verification. The EER/EER2 rating is verified using rating data from http://www.ahridirectory.org/website or another directory of certified product performance ratings approved by the CEC for determining compliance. Verified EER is reported in the ECC-required verification listings on the Certificate of Compliance.

6.8.2.5 Verified Seasonal Energy Efficiency Ratio (SEER/SEER2) For Buildings Up To Three Habitable Floors

PROPOSED DESIGN

The compliance software allows the user to specify the SEER/SEER2 value. A conversion factor is used to convert SEER2 to SEER ratings for modeling. For split-system equipment the conversion factor is 1/0.95; for single-package equipment the conversion factor is 1/0.96; for small-duct high-velocity the conversion factor is 1.00; and for space-constrained equipment the conversion factor is 1/0.99.

STANDARD DESIGN

The standard design is based on the default minimum efficiency SEER/SEER2 for the type of cooling equipment modeled in the proposed design, based on the applicable *Appliance Efficiency Regulations*. For central-cooling equipment, the minimum efficiency is 14.3 SEER2 for split systems.

VERIFICATION AND REPORTING

If a SEER/SEER2 higher than the default minimum efficiency is modeled in compliance software, the SEER/SEER2 requires field verification. The higher-than-minimum SEER/SEER2 rating is verified using rating data from AHRI Directory of Certified Product Performance website or another directory of certified product performance ratings approved by the CEC for determining compliance. Verified SEER/SEER2 is reported in the ECC-required verification listings on the Certificate of Compliance.

6.8.2.6 Verified Evaporatively Cooled Condensers For Buildings Up To Three Habitable Floors

PROPOSED DESIGN

Compliance software shall allow users to specify an evaporatively cooled condensing unit. The installation must comply with the requirements of Reference Appendices, Residential Appendix RA4.3.2 to ensure the predicted energy savings are achieved. This credit must be combined with verified refrigerant charge testing, EER/EER2, and duct leakage testing.

STANDARD DESIGN

The standard design is based on a split-system air-conditioner meeting the requirements of Section 170.2(c) and Table 170.2-K.

VERIFICATION AND REPORTING

An evaporatively-cooled condensing unit, verified EER/EER2, and duct leakage testing are reported in the ECC required verification listings on the Certificate of Compliance.

6.8.2.7 Evaporative Cooling

Evaporative cooling technology is best suited for dry climates where indirect, or indirect-direct cooling of the supply air stream can occur without compromising indoor comfort.

PROPOSED DESIGN

Compliance software shall allow users to specify one of three types of evaporative cooling: (1) indirect; or (2) indirect-direct. Product specifications and other modeling details for evaporative cooling are found in the CEC's appliance directory, MAEDbS. For indirect or indirect-direct, select the appropriate type from the CEC's appliance directory MAEDbS and input a 13 EER as well as the airflow and media saturation effectiveness or cooling effectiveness from the CEC's appliance directory, MAEDbS.

STANDARD DESIGN

The standard design is based on a split-system air-conditioner meeting the requirements of Section 170.2(c) and Table 170.2-K.

VERIFICATION AND REPORTING

When indirect or indirect-direct evaporative cooling is modeled, the EER/EER2 verification is shown in the ECC verification section of the Certificate of Compliance along with the system type, airflow, and system effectiveness.

6.8.3 Distribution Subsystems

If multiple HVAC distribution systems serve a building, each system, and the conditioned space it serves may be modeled in detail separately or the systems may be aggregated and modeled as one large system. If the systems are aggregated, they must be the same type, and all meet the same minimum specifications.

For duct efficiency calculations, the supply duct begins at the exit from the furnace or air-handler cabinet.

6.8.3.1 Distribution Type

Fan-powered, ducted distribution systems can be used with most heating or cooling systems. When ducted systems are used with furnaces, boilers, or combined hydronic/water heating systems, the electricity used by the fan is calculated. R-value and duct location are specified when a ducted system is specified.

PROPOSED DESIGN

The compliance software shall allow the user to select from the basic types of HVAC distribution systems and locations listed in Table 32: HVAC Distribution Type and Location Descriptors. For ducted systems, the default location of the HVAC ducts and the air handler are in conditioned space for multifamily buildings and in the attic for all other buildings.

Table 32: HVAC Distribution Type and Location Descriptors

Name	HVAC Distribution Type and Location Description
Ducts located in attic (ventilated and unventilated)	Ducts located overhead in the attic space.
Ducts located in a crawl space	Ducts located under floor in the crawl space.
Ducts located in a garage	Ducts located in an unconditioned garage space.
Ducts located within the conditioned space (except < 12 linear ft)	Ducts located within the conditioned floor space except for less than 12 linear feet of duct, furnace cabinet, and plenums — typically an HVAC unit in the garage mounted on return box with all other ducts in conditioned space.
Ducts located entirely in conditioned space	HVAC unit or systems with all HVAC ducts (supply and return) within the conditioned floor space. Location of ducts in conditioned space eliminates conduction losses but does not change losses due to leakage. Leakage either from ducts that are not tested for leakage or from sealed ducts is modeled as leakage to outside the conditioned space.
Distribution system without ducts (none)	Air-distribution systems without ducts such as ductless split-system air-conditioners and heat pumps, window air-conditioners, through-the-wall heat pumps, wall furnaces, floor furnaces, radiant electric panels, combined hydronic heating equipment, electric baseboards, or hydronic baseboard finned-tube natural convection systems, etc.
Ducts located in outdoor locations	Ducts in exposed locations outdoors.
Verified low-leakage ducts located entirely in conditioned space	Duct systems for which air leakage to outside is equal to or less than 25 CFM when measured in accordance with Reference Residential Appendix RA3.1.4.3.8.
Ducts located in multiple places	Ducts with different supply and return duct locations.

Source: California Energy Commission

Table 33: Summary of Verified Distribution Systems

Measure	Description	Procedures
Multifamily Buildings Verified Duct Sealing	Mandatory measures require that space-conditioning ducts be sealed. Field verification and diagnostic testing are required to verify that approved duct system materials are used and that duct leakage meets the specified criteria.	RA3.1.4.3
Multifamily Buildings Verified Duct Location, Reduced Surface Area and R-value	Compliance credit can be taken for improved supply duct location, reduced surface area, and R-value. Field verification is required to verify that the duct system was installed according to the duct design, including location, size and length of ducts, duct insulation R-value, and installation of buried ducts.[1] For buried duct measures, verified QII is required, as well as duct sealing.	RA3.1.4.1, 3.1.4.1.1
Multifamily Buildings Low-Leakage Ducts in Conditioned Space	When the Energy Code specify use of the procedures in Reference Appendices, Residential Appendix RA3.1.4.3.8 to determine if the space-conditioning system ducts are entirely in directly conditioned space, the duct system location is verified by diagnostic testing. Compliance credit can be taken for verified duct systems with low air leakage to the outside when measured in accordance with Reference Appendices, Residential Appendix RA3.1.4.3.8. Field verification for ducts in conditioned space is required. Duct sealing is required.	RA3.1.4.3.8
Multifamily Buildings Hydronic Delivery in Conditioned Space	Compliance credit can be taken for hydronic delivery systems with no ducting or piping in unconditioned space. For radiant ceiling panels, the verifications in Reference Appendices, Residential Appendix RA3.4.5 must be completed to qualify.	RA3.4.5
Multifamily Buildings Low-Leakage Air-Handling Units	Compliance credit can be taken for installing a factory-sealed air-handling unit tested by the manufacturer and certified to the CEC to have met the requirements for a low-leakage air-handling unit. Field verification of the air handler model number is required. Duct sealing is required.	RA3.1.4.3.9

Measure	Description	Procedures
Multifamily Buildings Verified Return Duct Design	Verification to confirm that the return duct design conforms to the criteria given in Table 160.3-A or Table 160.3-B. as an alternative to meeting 0.45 or 0.58 W/CFM fan efficacy of Section 160.3(b)5L.	RA3.1.4.4
Multifamily Buildings Verified Bypass Duct Condition	Verification to determine if system is zonally controlled and confirm that bypass ducts condition modeled matches installation.	RA3.1.4.6

1. Compliance credit for increased duct insulation R-value (not buried ducts) may be taken without field verification if the R-value is the same throughout the building, and for supply ducts located in crawl spaces and garages where all supply registers are either in the floor or within 2 feet of the floor. If these conditions are met, ECC rater verification is not required.

Source: California Energy Commission

The compliance software will allow users to select default assumptions or specify any of the verified or diagnostically tested HVAC distribution system conditions in the proposed design (Table 33: Summary of Verified Distribution Systems), including duct leakage target, R-value, supply and return duct area, diameter, and location.

Standard Design

The standard heating and cooling system for central systems is modeled with air distribution ducts located as described in Table 34: Summary of Standard Design Duct Location for Buildings Up to Three Habitable , with duct leakage as specified in Table 42: Duct/Air Handler Leakage. The standard design duct insulation is determined by Table 170.2-K as R-6 in Climate Zones 3 and 5–7, and R-8 in Climate Zones 1, 2, 4, and 8–16. The standard design building is assumed to have the same number of floors as the proposed design for determining the duct efficiency.

Table 34: Summary of Standard Design Duct Location for Buildings Up to Three Habitable Floors

Configuration of the Proposed Design	Standard Design Duct Location	Detailed Specifications
Attic over the dwelling unit	Ducts and air handler located in the attic	Ducts sealed (mandatory requirement) No credit for verified R-value, location, or duct design
No attic but crawl space or basement	Ducts and air handler located in the crawl space or basement	Ducts sealed (mandatory requirement) No credit for verified R-value, location, or duct design
Multifamily buildings with no attic, crawl space or basement	Ducts and air handler located indoors	Ducts sealed (mandatory requirement) No credit for verified R-value, location, or duct design

This table is applicable only when the standard design system has air-distribution ducts

Source: California Energy Commission

Verification and Reporting

Distribution type, location, R-value, and the determination of whether tested and sealed will be shown on the Certificate of Compliance. If there are no ducts, the absence of ducts is shown as a special feature on the Certificate of Compliance. Any duct location other than attic (for example, crawl space) is shown as a special feature on the Certificate of Compliance. Ducts in crawl space or the basement shall include a special feature note if supply registers are within 2 feet of the floor. Measures that require ECC verification will be shown in the ECC required verification section of the Certificate of Compliance.

6.8.3.2 Duct Location For Buildings Up to Three Habitable Floors

Duct location determines the external temperature for duct conduction losses, the temperature for return leaks, and the thermal regain of duct losses.

Proposed Design

If any part of the supply or return duct system is in an unconditioned attic, that entire duct system is modeled with an attic location. If no part of the supply or return duct system is located in the attic, but the duct system is not entirely in conditioned space, it is modeled in the unconditioned zone, which contains the largest fraction of the surface area. If the supply or return duct system is entirely in conditioned space, the duct system is modeled in conditioned space.

For ducted HVAC systems with some or all ducts in unconditioned space, the user specifies the R-value and surface area of supply and return ducts and the duct location.

Duct location and areas other than the defaults shown in Table 34: Summary of Standard Design Duct Location for Buildings Up to Three Habitable may be used following the verification procedures in *Reference Appendices, Residential Appendix RA3.1.4.1*.

STANDARD DESIGN

The standard design duct location is determined from the building conditions.

VERIFICATION AND REPORTING

Duct location is reported on the Certificate of Compliance. Ducts entirely in conditioned space and verified low-leakage ducts entirely in conditioned space are reported in the ECC-required verification listing on the Certificate of Compliance.

Default duct locations are shown in Table 35: Location of Default Duct Surface Area. The duct surface area for crawl space and basement applies only to buildings or zones with all ducts installed in the crawl space or basement. If the duct is installed in locations other than crawl space or basement, the default duct location is "Other." For dwelling units with two or more floors, 35 percent of the default duct area may be assumed to be in conditioned space, as shown in Table 35: Location of Default Duct Surface Area.

The surface area of ducts in conditioned space is ignored in calculating conduction losses.

Table 35: Location of Default Duct Surface Area

Supply Duct Location	One floor	Two or more floors
All in crawl space	100% crawl space	65% crawl space, 35% conditioned space
All in basement	100% basement	65% basement, 35% conditioned space
Other	100% attic	65% attic, 35% conditioned space

Source: California Energy Commission

6.8.3.3 Duct Surface Area

The supply-side and return-side duct surface areas are treated separately in distribution efficiency calculations. The duct surface area is determined using the following methods.

6.8.3.4 Default Return Duct Surface Area

Default return duct surface area is calculated using:

$$A_{r,out} = K_r \times A_{floor}$$

Equation 10

Where K_r (return duct surface area coefficient) is 0.05 for one-floor dwelling units and 0.1 for dwelling units with two or more floors and A_{floor} is the floor area. $A_{r,out}$ is the surface area of the return duct.

6.8.3.5 Default Supply Duct Surface Area

STANDARD DESIGN

The standard design and default proposed design supply duct surface area is calculated using Equation 5.

$$A_{s,out}A_{s,out} = 0.27 \times A_{floor}\, x\, K_s$$ **Equation 11**

Where:

K_s = Supply duct surface area coefficient is 1 for one-floor buildings and 0.65 for two or more floors

A_{floor} = Floor area

$A_{s,out}$ = Surface area of the return duct.

6.8.3.6 Supply Duct Surface Area for Less Than 12 feet of Duct in Unconditioned Space

PROPOSED DESIGN

For proposed design HVAC systems with air handlers outside the conditioned space but with less than 12 linear feet of duct outside the conditioned space, including air handler and plenum, the supply duct surface area outside the conditioned space is calculated using Equation 6. The return duct area remains the default for this case.

$A_{s,out} = 0.027\, x\, A_{floor}$ **Equation 12**

6.8.3.7 Diagnostic Duct Surface Area for Buildings Up to Three Habitable Floors

Proposed designs may claim credit for reduced surface area using the procedures in *Reference Appendices, Residential Appendix RA3.1.4.1*.

The surface area of each duct system segment shall be calculated based on the associated inside dimensions and length. The total supply surface area in each unconditioned location (attic, attic with radiant barrier, crawl space, basement, other) is the sum of the area of all duct segments in that location. The surface area of ducts completely inside conditioned space need not be input in the compliance software and is not included in the calculation of duct system efficiency. The area of ducts in floor cavities or vertical chases that are surrounded by conditioned space and separated from unconditioned space with draft stops are also not included. The compliance software assumes the user input duct system area is 85 percent of the total duct system area. The other 15 percent is assumed to be air handler, plenum, and connectors. Because of this, the total duct system area used in the building simulation is:

Simulated Duct System Area = 1.1765 multiplied by the total user entered duct system area

6.8.3.8 Bypass Duct

Section 170.2(c)3C prohibits use of bypass ducts unless a bypass duct is otherwise specified on the certificate of compliance. A bypass duct may be needed for some single-speed outdoor condensing unit systems. The compliance software allows users to specify a bypass duct for the system. Selection of a bypass duct does not trigger changes in the ACM modeling defaults, but verification by a ECC rater is required to use the procedure in Reference Appendices, Residential Appendix RA3.1.4.6.

Specification of a zonally controlled system with a single-speed condensing unit will trigger a default airflow rate value of 150 CFM/ton for the calculations. User input less than 350 CFM/ton reduces the compliance margin as compared to systems that model 350 CFM/ton as described in 6.8.2.2 Verified System Airflow.

PROPOSED DESIGN

Compliance software shall allow users to specify whether a bypass duct is used for a zonally controlled forced air system.

STANDARD DESIGN

The standard design is based on a split-system air-conditioner meeting the requirements of Section 170.2 and Table 170.2-K. The system is not a zonally controlled system.

VERIFICATION AND REPORTING

An HVAC system with zonal control, and the determination of whether the system is assumed to have a bypass duct or have no bypass duct, is reported in the ECC-required verification listings on the Certificate of Compliance.

6.8.3.9 Duct System Insulation

For conduction calculations in the standard and proposed designs, 85 percent of the supply and return duct surface is assumed duct material at the related specified R-value, and 15 percent is assumed air handler, plenum, connectors, and other components at the mandatory minimum R-value.

The area weighted effective R-value is calculated by the compliance software using Equation 7, including each segment of the duct system that has a different R-value.

$$R_{eff} = \frac{(A_1 + A_2 .... + A_N)}{\left[\frac{A_1}{R_1} + \frac{A_2}{R_2} .... + \frac{A_N}{R_N}\right]}$$ **Equation 13**

Where:

R_{eff} - Area weighted effective R-value of duct system for use in calculating duct efficiency,
(h-ft²-°F/Btu)
A_N - Area of duct segment n, square feet
R_N - R-value of duct segment n including film resistance (duct insulation rated R + 0.7) (h-ft²-°F/Btu)

PROPOSED DESIGN

The compliance software user inputs the R-value of the proposed duct insulation and details. The default duct thermal resistance is based on Table 170.2-K, which is R-6 in Climate Zones 3 and 5–7, R-8 in Zones 1, 2, 4, and 8–16.

Duct location and duct R-value are reported on the Certificate of Compliance. Credit for systems with mixed insulation levels, nonstandard supply and return duct surface areas, or ducts buried in the attic require the compliance and diagnostic procedures in *Reference Appendices, Residential Appendix RA3.1.4.1*.

If verified duct design is selected, the user must enter the duct design into the compliance software. For each duct segment entered, the user must specify Type (supply/return), Buried (yes/no, as specified by 6.8.3.10 Buried Attic Ducts), Diameter (inside/nominal), Length, and Duct Insulation R-value. User-entered duct design must be verified by a ECC rater according to the procedures in *Reference Appendices, Residential Appendix RA3.1.4.1.1*. User-entered duct design and duct location are reported on the Certificate of Compliance when nonstandard values are specified.

STANDARD DESIGN

The required duct insulation R-value is from Table 170.2-K for the applicable climate zone used in the standard design.

VERIFICATION AND REPORTING

Duct type (supply/return), nominal diameter, length, R-value, and location, and supply and return areas are reported on the Certificate of Compliance. Verified duct design is reported in the ECC-required verification listing on the Certificate of Compliance.

6.8.3.10 Buried Attic Ducts

Ducts partly, fully, or deeply buried in blown attic insulation in dwelling units meeting the requirements for verified QII may take credit for increased effective duct insulation. To qualify for buried duct credit, ducts must meet mandatory insulation levels (R-6) prior to burial, be directly or within 3.5 inches of ceiling gypsum board and be surrounded by at least R-30 attic insulation. Moreover, credit is available only for duct runs where the ceiling is level, there is at least 6 inches of space between the duct outer jacket and the roof sheathing, and the attic insulation has uniform depth. Existing ducts are not required to meet the mandatory minimum insulation levels, but to qualify for buried duct credit, they must have greater than R-4.2 insulation before burial.

In addition to the above requirements, deeply buried ducts must be buried by at least 3.5 inches of insulation above the top of the duct insulation jacket and located within a lowered area of the ceiling, a deeply buried containment system, or buried by at least 3.5 inches of uniformly level insulation. Mounding insulation to achieve the 3.5-inch burial level is not allowed.

Deeply buried duct containment systems must be installed such that the walls of the system are at least 7 inches wider than the duct diameter (3.5 inches on each side of duct), the walls extend at least 3.5 inches above the duct outer jacket, and the containment area surrounding the duct must be completely filled with blown insulation.

The duct design shall identify the segments of the duct that meet the requirements for being buried, and these are input into the compliance software separately from non-buried ducts. For each buried duct, the user must enter the duct size, R-value, and length, and determination of whether the duct qualifies as deeply buried. The user must also indicate if a duct uses a deeply buried containment system. The compliance software calculates the weighted average effective duct system R-value based on the user-entered duct information, blown insulation type (cellulose or fiberglass), and R-value.

Duct-effective R-values are broken into three categories: partially, fully, and deeply, with each having different burial levels and requirements. Partially buried ducts have less than 3.5 inches of exposed duct depth, fully buried ducts have insulation depth at least level with the duct jacket, and deeply buried ducts have at least 3.5 inches of insulation above the duct jacket in addition to the above requirements. Effective duct R-value used by the compliance software are listed in Table 36: Buried Duct Effective R-Values through Table 41: Buried Duct Effective R-Values.

PROPOSED DESIGN

The compliance software calculates the effective R-value of buried ducts based on user-entered duct size, R-value, and length; attic insulation level and type; and determination of whether the duct meets the requirements of a deeply buried duct by using a lowered ceiling chase or a containment system. This feature must be combined with verified QII, verified duct location, reduced surface area and R-value, and verified minimum airflow. The compliance software will allow any combination of duct runs and the associated buried condition, and the overall duct system effective R-value will be a weighted average of the combination. The default is no buried ducts.

STANDARD DESIGN

The standard design has no buried ducts.

VERIFICATION AND REPORTING

Buried duct credit is reported in the ECC required verification listing on the Certificate of Compliance.

Table 36: Buried Duct Effective R-Values

R-8 Ducts With Blown Fiberglass Attic Insulation

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
3"	R-18	R-26	R-26	R-26	R-26	R-26
4"	R-13	R-18	R-26	R-26	R-26	R-26
5"	R-13	R-18	R-18	R-26	R-26	R-26
6"	R-13	R-18	R-18	R-18	R-26	R-26
7"	R-13	R-13	R-18	R-18	R-26	R-26
8"	R-8	R-13	R-13	R-18	R-18	R-26
9"	R-8	R-13	R-13	R-13	R-18	R-26
10"	R-8	R-13	R-13	R-13	R-18	R-26
12"	R-8	R-8	R-8	R-13	R-13	R-26
14"	R-8	R-8	R-8	R-8	R-13	R-18
16"	R-8	R-8	R-8	R-8	R-8	R-13
18"	R-8	R-8	R-8	R-8	R-8	R-13
20"	R-8	R-8	R-8	R-8	R-8	R-8
22"	R-8	R-8	R-8	R-8	R-8	R-8
24"	R-8	R-8	R-8	R-8	R-8	R-8

Source: California Energy Commission

Table 37: Buried Duct Effective R-Values

R-8 Ducts with Blown Cellulose Attic Insulation

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
3"	R-14	R-20	R-20	R-20	R-32	R-32
4"	R-14	R-14	R-20	R-20	R-20	R-32
5"	R-8	R-14	R-14	R-20	R-20	R-32
6"	R-8	R-14	R-14	R-14	R-20	R-32
7"	R-8	R-14	R-14	R-14	R-20	R-20
8"	R-8	R-8	R-8	R-14	R-14	R-20
9"	R-8	R-8	R-8	R-8	R-14	R-20
10"	R-8	R-8	R-8	R-8	R-14	R-20
12"	R-8	R-8	R-8	R-8	R-8	R-14
14"	R-8	R-8	R-8	R-8	R-8	R-8
16"	R-8	R-8	R-8	R-8	R-8	R-8
18"	R-8	R-8	R-8	R-8	R-8	R-8
20"	R-8	R-8	R-8	R-8	R-8	R-8
22"	R-8	R-8	R-8	R-8	R-8	R-8
24"	R-8	R-8	R-8	R-8	R-8	R-8

Source: California Energy Commission

Table 38: Buried Duct Effective R-Values

R-6 Ducts with Blown Fiberglass Attic Insulation

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
3"	R-15	R-24	R-24	R-24	R-24	R-24
4"	R-15	R-24	R-24	R-24	R-24	R-24
5"	R-11	R-15	R-24	R-24	R-24	R-24
6"	R-11	R-15	R-15	R-24	R-24	R-24
7"	R-11	R-15	R-15	R-15	R-24	R-24
8"	R-11	R-15	R-15	R-15	R-24	R-24

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
9"	R-6	R-11	R-11	R-15	R-24	R-24
10"	R-6	R-11	R-11	R-15	R-15	R-24
12"	R-6	R-6	R-11	R-11	R-15	R-24
14"	R-6	R-6	R-6	R-6	R-11	R-15
16"	R-6	R-6	R-6	R-6	R-11	R-15
18"	R-6	R-6	R-6	R-6	R-6	R-11
20"	R-6	R-6	R-6	R-6	R-6	R-11
22"	R-6	R-6	R-6	R-6	R-6	R-6
24"	R-6	R-6	R-6	R-6	R-6	R-6

Source: California Energy Commission

Table 39: Buried Duct Effective R-Values

R-6 Ducts with Blown Cellulose Attic Insulation

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
3"	R-12	R-18	R-18	R-18	R-31	R-31
4"	R-12	R-18	R-18	R-18	R-31	R-31
5"	R-12	R-12	R-18	R-18	R-18	R-31
6"	R-6	R-12	R-12	R-18	R-18	R-31
7"	R-6	R-12	R-12	R-12	R-18	R-31
8"	R-6	R-12	R-12	R-12	R-18	R-31
9"	R-6	R-6	R-6	R-12	R-12	R-18
10"	R-6	R-6	R-6	R-6	R-12	R-18
12"	R-6	R-6	R-6	R-6	R-6	R-12
14"	R-6	R-6	R-6	R-6	R-6	R-12
16"	R-6	R-6	R-6	R-6	R-6	R-6
18"	R-6	R-6	R-6	R-6	R-6	R-6
20"	R-6	R-6	R-6	R-6	R-6	R-6
22"	R-6	R-6	R-6	R-6	R-6	R-6
24"	R-6	R-6	R-6	R-6	R-6	R-6

Source: California Energy Commission

Table 40: Buried Duct Effective R-Values

R-4.2 Ducts With Blown Fiberglass Attic Insulation

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
3"	R-13	R-22	R-22	R-22	R-22	R-22
4"	R-13	R-22	R-22	R-22	R-22	R-22
5"	R-13	R-22	R-22	R-22	R-22	R-22
6"	R-13	R-13	R-22	R-22	R-22	R-22
7"	R-9	R-13	R-13	R-22	R-22	R-22
8"	R-9	R-13	R-13	R-13	R-22	R-22
9"	R-9	R-13	R-13	R-13	R-22	R-22
10"	R-4.2	R-9	R-13	R-13	R-13	R-22
12"	R-4.2	R-9	R-9	R-9	R-9	R-22
14"	R-4.2	R-4.2	R-4.2	R-9	R-9	R-22
16"	R-4.2	R-4.2	R-4.2	R-4.2	R-9	R-13
18"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-9
20"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-9
22"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
24"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2

Source: California Energy Commission

Table 41: Buried Duct Effective R-Values

R-4.2 Ducts with Blown Cellulose Attic Insulation

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
3"	R-15	R-15	R-29	R-29	R-29	R-29
4"	R-9	R-15	R-15	R-15	R-29	R-29
5"	R-9	R-15	R-15	R-15	R-29	R-29
6"	R-9	R-9	R-15	R-15	R-15	R-29
7"	R-4.2	R-9	R-9	R-15	R-15	R-29
8"	R-4.2	R-9	R-9	R-9	R-15	R-29
9"	R-4.2	R-9	R-9	R-9	R-15	R-15

Duct Diameter	R-30 Ceiling	R-38 Ceiling	R-40 Ceiling	R-43 Ceiling	R-49 Ceiling	R-60 Ceiling
10"	R-4.2	R-4.2	R-9	R-9	R-9	R-15
12"	R-4.2	R-4.2	R-4.2	R-4.2	R-9	R-15
14"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-9
16"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-9
18"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
20"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
22"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
24"	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2

Source: California Energy Commission

6.8.3.11 Duct/Air Handler Leakage

The total duct/air handler leakage shown in Table 43: Individual IAQ System Standard Design Fan Efficacy is used in simulating the duct system. The supply duct leakage for each case is the table value multiplied by 0.585. The return leakage is the table value multiplied by 0.415.

PROPOSED DESIGN

For each ducted system, the compliance software user specifies one of the duct/air handler leakage cases shown in Table 42: Duct/Air Handler Leakage.

STANDARD DESIGN

For ducted systems, the standard design is sealed and tested duct systems in existing dwelling units or new duct systems.

VERIFICATION AND REPORTING

Sealed and tested duct systems are listed in the ECC verification section of the Certificate of Compliance. Duct leakage is measured in accordance with procedures and values specified in Reference Appendices, Residential Appendix RA3.

6.8.3.12 Low Leakage Air Handlers

A low-leakage air handler may be specified as well as a lower duct leakage value. (See 6.8.3.11 Duct/Air Handler Leakage.) Installation requires installing one of the list of approved low-leakage air handling units published by the CEC. The manufacturer certifies that the appliance complies with the requirements of Reference Appendices, Joint Appendices JA9.2.1, 9.2.2, 9.2.3, and 9.2.4.

Table 42: Duct/Air Handler Leakage

Case	Duct Leakage	Air Handler Leakage	Total Duct/Air Handler Leakage
Sealed and tested new or altered duct systems in conditioned or unconditioned space in a multifamily dwelling unit	12%	Included in duct leakage	12%
Verified low-leakage ducts in conditioned space	0%	0%	0%
Low leakage air handlers in combination with sealed and tested new duct systems	5% or as measured	0%	5% or as measured

Source: California Energy Commission

PROPOSED DESIGN

Credit can be taken for installing a factory-sealed air-handling unit tested by the manufacturer and certified to the CEC to meet the requirements for a low-leakage air-handler. Field verification of the air handler model number is required.

STANDARD DESIGN

The standard design has a normal air handler.

VERIFICATION AND REPORTING

A low-leakage air handler is reported on the compliance report and field verified in accordance with the procedures specified in Reference Appendices, Residential Appendix RA3.1.4.3.9.

6.8.3.13 Verified Low-Leakage Ducts in Conditioned Space

PROPOSED DESIGN

For ducted systems, the user may specify that all ducts are entirely in conditioned space, and the compliance software will model the duct system with no leakage and no conduction losses.

STANDARD DESIGN

The standard design has ducts in the default location.

VERIFICATION AND REPORTING

Systems that have all ducts entirely in conditioned space are reported on the compliance documents and verified by measurements showing duct leakage to outside conditions is equal to or less than 25 CFM when measured in accordance with *Reference Appendices, Residential Appendix RA3*.

6.8.4 Space-Conditioning Fan Subsystems

Fan systems move air for air-conditioning, heating, and ventilation systems. The compliance software allows the user to define the fans to be used for space-conditioning, IAQ, and ventilation cooling. IAQ and ventilation cooling are discussed in 6.8.6 Indoor Air Quality (IAQ) Ventilation.

PROPOSED DESIGN

For the space-conditioning fan system, the user selects the type of equipment and enters basic information to model the energy use of the equipment. For ducted central air-conditioning and heating systems, the fan efficacy default is the mandatory minimum verified efficacy of 0.45, 0.58, or 0.62 W/CFM, depending on applicable system type (also assumed when there is no cooling system).

STANDARD DESIGN

The standard design shall assume a verified fan efficacy complying with the mandatory requirement of equal to or less than 0.45, 0.58, or 0.62 watts/CFM, depending on the applicable system type.

VERIFICATION AND REPORTING

Minimum verified fan efficacy is mandatory for all ducted cooling systems. Fan efficacy is reported in the ECC required verification listings on the Certificate of Compliance.

6.8.5 Space-Conditioning Systems

This chapter describes the general procedures for heating and cooling systems in multifamily buildings. The system includes the cooling system, the heating system, distribution system, and mechanical fans.

If multiple systems serve a building, each system, and the conditioned space it serves may be modeled in detail separately or the systems may be aggregated and modeled as one large system. If the systems are aggregated, they must be the same type and all meet the same minimum specifications.

6.8.5.1 Multiple System Types Within Building

PROPOSED DESIGN

For proposed designs using more than one heating system type, equipment type, or fuel type, and the types do not serve the same floor area, the user shall zone the building by system type.

STANDARD DESIGN

The standard design shall have the same zoning and heating system types as the proposed design.

VERIFICATION AND REPORTING

The heating system type of each zone is shown on the Certificate of Compliance.

6.8.5.2 Multiple Systems Serving Same Area

If a space or a zone is served by more than one heating system, compliance is demonstrated with the most LSC energy-consuming system serving the space or the zone. For spaces or zones that are served by electric resistance heat in addition to other heating systems, the electric resistance heat is deemed the most LSC energy-consuming system unless the supplemental heating meets the exception to Section 170.2(c)3A. See eligibility criteria in *Nonresidential Compliance Manual* Section 11.5.3.2 for conditions under which the supplemental heat may be ignored.

For floor areas served by more than one cooling system, equipment, or fuel type, the system, equipment, and fuel type that satisfy the cooling load are modeled.

6.8.5.3 No Cooling

PROPOSED DESIGN

When the proposed design has no cooling system, the proposed design is required to model the standard design cooling system defined in Section 170.2 and Table 170.2-K. Since the proposed design system is identical to the standard design system, there is no penalty or credit.

STANDARD DESIGN

The standard design system is the specified in Section 170.2 and Table 170.2-K for the applicable climate zone.

VERIFICATION AND REPORTING

No cooling is reported as a special feature on the Certificate of Compliance.

6.8.5.4 Zonally Controlled Forced-Air Cooling Systems

Zonally controlled central forced-air cooling systems must be able to deliver, in every zonal control mode, an airflow to the dwelling of > 350 CFM per ton of nominal cooling capacity and operating at an air-handling unit fan efficacy of < 0.45 or 0.58 W/CFM depending on the applicable system type. This is a ECC-verified measure, complying with Reference Appendices, *Residential Appendix RA3.3*.

An exception allows multispeed or variable-speed compressor systems, or single-speed compressor systems to meet the mandatory airflow (CFM/ton) and fan efficacy (watt/CFM) requirements by operating the system at maximum compressor capacity, and system fan speed with all zones calling for conditioning, rather than in every zonal control mode.

PROPOSED DESIGN

The user selects zonally controlled as a cooling system input.

STANDARD DESIGN

The standard design building does not have a zonally controlled cooling system.

VERIFICATION AND REPORTING

Zonally controlled forced-air cooling systems are required to have the system bypass duct status verified by a ECC rater according to the procedures in *Reference Appendices, Residential Appendix RA3.1.4.6*, and the fan efficacy and airflow rate are required to be verified according to the procedures in *RA3.3*.

6.8.6 Indoor Air Quality (IAQ) Ventilation

For newly constructed buildings and additions greater than 1,000 ft^2 with dwelling units, the Energy Code requires that all dwelling units meet the IAQ ventilation requirements of ASHRAE Standard 62.2 with California amendments specified in Section 160.2(b)2 and 160.2(c)3. Ventilation for spaces that are not dwelling units within the building should follow the nonresidential ventilation described in Section 120.1 as calculated according to Section 5.6.8 in the ACM Reference Manual. IAQ ventilation is not required for newly constructed buildings that are not dwelling units. Providing acceptable IAQ through mechanical ventilation is one of the requirements of ASHRAE Standard 62.2.

VERIFICATION AND REPORTING

The required ventilation rate to comply with the Energy Code and the means to achieve compliance are indicated on the Certificate of Compliance. The IAQ system characteristics are reported in the ECC required verification listing on the Certificate of Compliance. The diagnostic testing procedures are in Reference Appendices, Residential Appendix RA3.7.

Special features are reported on the Certificate of Compliance when the proposed system has heat or energy recovery or when the proposed fan efficacy is less than the applicable value in Table 43.

6.8.6.1 Design Ventilation Rate

The quantity of ventilation air must be identified for each residential dwelling unit thermal zone.

PROPOSED DESIGN

The design ventilation rate may be between 95 percent and 110 percent of code-minimum required ventilation rates for multifamily common area in a residential zone group without penalty.

Total common area ventilation rates below 95 percent of the code-minimum required ventilation rate for a residential zone group are not allowed.

The design ventilation rate may be between 100 percent and 125 percent of the code-minimum required ventilation rate for multifamily dwelling units without penalty.

Ventilation rates below the code-minimum required ventilation rate for a multifamily dwelling unit are not allowed.

STANDARD DESIGN

For common spaces ventilation is provided by a SZHP where the ventilation rate is determined in the same way as for the nonresidential area, see Section 5.6.8.

For multifamily building dwelling units, the standard design ventilation rate is the greater of the code minimum ventilation rate and the proposed design minimum ventilation rate, but subject to a limit of 125% of the code-minimum required ventilation rate.

6.8.6.2 IAQ System Type

PROPOSED DESIGN

For dwelling units in multifamily buildings, the user identifies the type of IAQ system in the proposed design (supply only or balanced) and whether the supply and/or exhaust are central or individual. System type must be consistent for all dwelling units in a building.

STANDARD DESIGN

For dwelling units, the standard design mechanical ventilation system type is the same as the proposed design except in Climate Zones 1, 2, 4, 11 through 14, and 16, where the software defaults to balanced with HRV to reflect the prescriptive requirements. System type is determined by whether the supply/exhaust is central (system serving multiple zones) vs. individual (system serving one zone) and the configuration of the system; balanced (supply and exhaust with equal airflow), supply only. The standard design system type, either individual or central, is the same as the proposed design for each type of supply and exhaust stream. For example, if the proposed design has central supply and individual exhaust the standard design will have central supply and individual exhaust.

For multifamily common spaces, ventilation is provided by the standard heating and cooling system described in .

6.8.6.3 Ventilation Source

The dwelling unit and common area thermal zone ventilation source may be forced, through fans. For common areas with no space conditioning system, the ventilation source may be natural through operable openings.

PROPOSED DESIGN

The source of ventilation for a thermal zone is based on the proposed design and is natural, forced, or none.

STANDARD DESIGN

For residential units the standard design ventilation system is forced air.

6.8.6.4 IAQ System Fan Efficacy

PROPOSED DESIGN

All individual systems serving multifamily dwelling units must meet IAQ system fan efficacies based on the following conditions:

Systems with supply ducts (balanced and supply-only) are simulated with increased fan wattage to account for maintenance and installation factors affecting system efficacy. For these systems, fan wattage is increased by a factor of 1.10 (10 percent increase in wattage). For IAQ systems with fault indicator displays (FID) meeting the specifications in Reference Appendices, Joint Appendix JA17, these factors don’t apply.

Systems with heat or energy recovery serving a single dwelling unit shall have a fan efficacy of ≤1.0 W/cfm in accordance with Section 160.2(b)2.A.iv.b.1.

STANDARD DESIGN

Table 43: Individual IAQ System Standard Design Fan Efficacy

Climate Zone	Supply Only	Balanced without Heat Recover	Balanced with Heat Recovery
1, 2, 4 and 11 through 14, and 16	0.35 W/cfm	N/A	0.6 W/cfm
5 through 10, and 15 (4+ floors)	0.35 W/cfm	0.7 W/cfm	N/A

5 through 10, and 15 (<4 floors)	0.35 W/cfm	0.4 W/cfm	N/A
3	0.35 W/cfm	0.7 W/cfm	N/A

Source: California Energy Commission

Individual IAQ standard design fan efficacy equals the value in Table 43 based on the proposed system design and climate zone.

Table 44: Central IAQ System Standard Design Fan Efficacy Limits

Type	≤5,000 cfm	>5,000 and ≤10,000 cfm	>10,000 cfm
Supply-Only	0.441 W/cfm	0.476 W/cfm	0.450 W/cfm
Central Supply + Individual Exhaust	0.791 W/cfm	0.826 W/cfm	0.800 W/cfm
Individual Supply + Central Exhaust	0.652 W/cfm	0.636 W/cfm	0.631 W/cfm
Central Supply + Central Exhaust	0.743 W/cfm	0.762 W/cfm	0.731 W/cfm
Central Supply + Central Exhaust + Heat Recovery	1.098 W/cfm	1.069 W/cfm	1.005 W/cfm

Source: California Energy Commission

Central IAQ standard design fan efficacy equals proposed or the limit from Table 44 whichever is lower. Table 43: Individual IAQ System Standard Design Fan Efficacy

6.8.6.5 Heat/Energy Recovery

Heat/Energy recovery can be specified using recovery effectiveness or adjusted sensible recovery efficiency (ASRE) and sensible recovery efficiency (SRE). For larger AHRI rated equipment, inputs are covered in 5.7.7 Exhaust Air Heat Recovery.

Proposed Design

Systems serving individual dwelling units with supply ducts (balanced and supply-only) are simulated with reduced recovery efficiency (SRE and ASRE or recovery effectiveness) to account for maintenance and installation factors affecting system efficacy. For these systems, recovery efficiency is reduced by a factor of 0.90 (10 percent decrease in recovery efficiency). For IAQ systems with an FID meeting the specifications in Reference Appendices, Joint Appendix JA17, these factors don’t apply.

STANDARD DESIGN

If the proposed design is a balanced central system, both central supply and central exhaust systems serving multiple dwelling units, in Climate Zones 1, 2, 4, 11 through 14, or 16, in a building with four or more habitable floors, the standard design is a heat recovery ventilation system with a sensible recovery effectiveness of 67% in both heating and cooling modes and includes recovery bypass to directly economize with ventilation air based on the outdoor air temperature limits specified in Table 170.2-G.

If the proposed design is a balanced system serving individual dwelling units in Climate Zones 1, 2, 4, 11 through 14, or 11-16, the standard design is a heat recovery ventilation system with a sensible recovery effectiveness of 67 percent in both heating and cooling modes.

6.8.6.6 Exhaust Air Sensible Heat Recovery Effectiveness

The effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams is defined as:

$$HREFF = \frac{EEA_{db} - ELA_{db}}{EEA_{db} - OSA_{db}}$$

Where:

$\boldsymbol{HREFF}$ - The air-to-air heat exchanger effectiveness
$\boldsymbol{EEA_{db}}$ - The exhaust air dry-bulb temperature entering the heat exchanger
$\boldsymbol{ELA_{db}}$ - The exhaust air dry-bulb temperature leaving the heat exchanger
$\boldsymbol{OSA_{db}}$ - The outside air dry-bulb temperature

This results in two unitless numbers (ratio between 0 and 1), separate for cooling and heating, and is based on the proposed design.

6.8.6.7 Exhaust Air Sensible Part-Load Effectiveness

The effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams at 75 percent of design airflow is defined as:

$$HREFF = \frac{EEA_{db} - ELA_{db}}{EEA_{db} - OSA_{db}}$$

Where:

- $\boldsymbol{HREFF}$ - The air-to-air heat exchanger effectiveness

- EEA_{db} - The exhaust air dry-bulb temperature entering the heat exchanger
- ELA_{db} - The exhaust air dry-bulb temperature leaving the heat exchanger
- OSA_{db} - The outside air dry-bulb temperature

This results in two unitless numbers (ratio between 0 and 1), separate for cooling and heating, and is based on the proposed design.

6.8.6.8 Economizer Enabled during Heat Recovery

All systems with airside heat recovery must identify if the economizer is enabled during heat recovery.

PROPOSED DESIGN

Indication of whether the economizer is enabled when heat recovery is active is based on the proposed design.

STANDARD DESIGN

The economizer is disabled if using balance system serving multiple dwelling units in Climate Zones 1, 2, 4, 11 through 14, or 16. Not applicable for Climate Zones 3, 5 through 10, and 15.

For existing buildings, the economizer is disabled if using a balanced system serving multiple dwelling units in Climate Zones 1, 2, 4, 11 through 14, or 16. Not applicable for Climate Zones 3, 5 through 10, and 15.

6.8.6.9 Recovery Type

Systems with airside heat recovery not using ASRE and SRE must identify the heat recovery system type. The type of heat recovery system is identified as sensible, latent, or total (sensible and latent).

6.8.6.10 Tempering Coils

Proposed Design

The proposed design may have tempering coils.

Standard Design

The standard design does not include tempering coils.

6.8.6.11 IAQ System Fault Indicator Display

All balanced and supply ventilation systems serviced from inside the attic or with an HRV/ERV must specify if the system includes an FID that meets the requirements in Reference Appendices, Joint Appendix JA17, Qualification Requirements for Indoor Air Quality System Fault Indicator Displays.

Proposed Design

Selection is based on the proposed design.

Standard Design

The standard design assumes an FID system meeting the requirements of Reference Appendices, Joint Appendix JA17.

6.9 Zones

The compliance software requires the user to enter the characteristics of one or more zones. Subdividing dwelling units into zones for input convenience or increased accuracy is optional.

6.9.1 Zone Type

PROPOSED DESIGN

The zone is defined as directly conditioned indirectly conditioned, or unconditioned and is further distinguished as dwelling unit, common use space, attic, or crawl space.

STANDARD DESIGN

The standard design is the same as proposed.

6.9.2 Space Function

PROPOSED DESIGN

The compliance software requires the user to select the space type that most appropriately matches one of the area category occupancy types fromTable 170.2-M.

STANDARD DESIGN

The standard design space function is the same as the proposed design and sets the baseline for various other categories such as number of occupants, ventilation rates, and lighting power allowances.

VERIFICATION AND REPORTING

No special verification or reporting.

6.9.3 Floor Area

The total floor area is the raised floor as well as the slab-on-grade floor area of the spaces measured from the exterior surface of exterior walls. Stairs are included in floor area as the area beneath the stairs and the tread of the stairs.

PROPOSED DESIGN

The compliance software requires the user to enter the total floor area of each zone.

STANDARD DESIGN
The standard design building has the same floor area and same zones as the proposed design.

VERIFICATION AND REPORTING
The floor area of each zone is reported on the Certificate of Compliance.

6.9.4 Number of Floors

6.9.4.1 Number of Floors of the Zone

PROPOSED DESIGN
The number of floors of the zone, integer value greater than 0.

STANDARD DESIGN
The standard design is the same as the proposed design.

6.9.4.2 Ceiling Height

PROPOSED DESIGN
The average ceiling height of the proposed design is the conditioned volume of the building envelope. The volume (in cubic feet) is determined from the total conditioned floor area and the average ceiling height.

STANDARD DESIGN
The volume of the standard design building is the same as the proposed design.

VERIFICATION AND REPORTING
The conditioned volume of each zone is reported on the Certificate of Compliance.

6.9.4.3 Free Ventilation Area

Free ventilation area is the window area adjusted to account for bug screens, window framing and dividers, and other factors.

PROPOSED DESIGN
Free ventilation area for the proposed design is calculated as 10 percent of the fenestration area (rough opening), assuming all windows are operable.

STANDARD DESIGN
The standard design value for free ventilation area is the same as the proposed design.

VERIFICATION AND REPORTING
Free ventilation is not reported on the Certificate of Compliance.

6.9.4.4 Ventilation Height Difference

Ventilation height difference is not a user input.

PROPOSED DESIGN

The default assumption for the proposed design is 2 feet for one-floor buildings or one-floor dwelling units and 8 feet for two or more floors (as derived from number of floors and other zone details).

STANDARD DESIGN

The standard design modeling assumption for the elevation difference between the inlet and the outlet is 2 feet for one-floor dwelling units and 8 feet for two or more floors.

6.9.4.5 Zone Elevations

The elevation of the top and bottom of each zone is required to set up the airflow network.

PROPOSED DESIGN

The user enters the height of the top surface the lowest floor of the zone relative to the ground outside as the "bottom" of the zone. The user also enters the ceiling height (the floor-to-floor height [ceiling height plus the thickness of the intermediate floor structure] is calculated by the compliance software).

Underground zones are indicated with the number of feet below grade (e.g., -8).

STANDARD DESIGN

The standard design has the same vertical zone dimensions as the proposed design.

6.9.4.6 Cooling Ventilation

Cooling ventilation (from windows) is available in dwelling units and residential common areas with windows when needed and available. Spaces shall be zoned by orientation and exposure to prevent cross ventilation through corridors and compartment walls. As shown in the example, multiple zones do not cross the corridor. In zones with windows on one or two sides only, the Natural Ventilation Wind Pressure of each window shall be multiplied by the relevant Wind Pressure Coefficient in Table 48: Wind Pressure Coefficients to reflect the lack of cross ventilation.

Figure 10: Example Floor Plan

Source: California Energy Commission

Table 45: Wind Pressure Coefficients

Exposures	Coefficient
1	0.25
2	0.5
3 or 4	1.0

Source: California Energy Commission

The amount of natural ventilation used by computer compliance software for natural cooling is the lesser of the maximum potential amount available and the amount needed to drive the interior zone temperature down to the natural cooling setpoint. When natural cooling is not needed or is unavailable, no natural ventilation is used.

Computer compliance software shall assume that natural cooling is needed when the building is in "cooling mode," when the outside temperature is below the estimated zone temperature, and when the estimated zone temperature is above the natural cooling setpoint temperature. Only the amount of ventilation required to reduce the zone temperature to the natural ventilation setpoint temperature is used, and the natural ventilation setpoint temperature is constrained by the compliance software to be greater than the heating setpoint temperature.

Table 46: Hourly Thermostat Set Points

Hour	Cooling	Venting	Heat Pump Heating	Standard Gas Heating Single-Zone	Zonal Control Gas Heating Living	Zonal Control Gas Heating Sleeping
1	78	Off	68	65	65	65
2	78	Off	68	65	65	65
3	78	Off	68	65	65	65
4	78	Off	68	65	65	65
5	78	Off	68	65	65	65
6	78	68*	68	65	65	65
7	78	68	68	65	65	65
8	78	68	68	68	68	68
9	78	68	68	68	68	68
10	78	68	68	68	68	65
11	78	68	68	68	68	65
12	78	68	68	68	68	65
13	78	68	68	68	68	65
14	78	68	68	68	68	65
15	78	68	68	68	68	65
16	78	68	68	68	68	65
17	78	68	68	68	68	68
18	78	68	68	68	68	68
19	78	68	68	68	68	68
20	78	68	68	68	68	68
21	78	68	68	68	68	68
22	78	68	68	68	68	68
23	78	68	68	68	68	68
24	78	Off	68	65	65	65

***Venting starts in the hour the sun comes up.**

Source: California Energy Commission

6.9.5 Conditioned Zone Assumptions

6.9.5.1 Internal Thermal Mass

Internal mass objects are completely inside a zone so that they do not participate directly in heat flows to other zones or outside. They are connected to the zone radiantly and convectively and participate in the zone energy balance by passively storing and releasing heat as conditions change.

Table 47: Conditioned Zone Thermal Mass Objects shows the standard interior conditioned zone thermal mass objects and the calculation of the simulation inputs that represent them.

Table 47: Conditioned Zone Thermal Mass Objects

Item	Description	Simulation Object
Interior walls	The area of one side of the walls completely inside the conditioned zone is calculated as the conditioned floor area of the zone minus ½ of the area of interior walls adjacent to other conditioned zones. The interior wall is modeled as a construction with 25 percent 2x4 wood framing and sheetrock on both sides.	Wall exposed to the zone on both sides
Interior floors	The area of floors completely inside the conditioned zone is calculated as the difference between the CFA of the zone and the sum of the areas of zone exterior floors and interior floors over other zones. Interior floors are modeled as a surface inside the zone with a construction of carpet, wood decking, 2x12 framing at 16 in. on-center with miscellaneous bridging, electrical, and plumbing, and a sheetrock ceiling below.	Floor/ceiling surface exposed to the zone on both sides
Furniture and heavy contents	Contents of the conditioned zone with significant heat storage capacity and delayed thermal response, for example heavy furniture, bottled drinks, canned goods, contents of dressers, enclosed cabinets. These are represented by a 2 in. thick slab of wood twice as large as the conditioned floor area, exposed to the room on both sides.	Horizontal wood slab exposed to the zone on both sides
Light and thin contents	Contents of the conditioned zone that have a large surface area compared to weight, for example, clothing on hangers, curtains, pots,	Air heat capacity (C_{air}) = CFA * 2

Item	Description	Simulation Object
	and pans. These are assumed to be 2 Btu per square foot of conditioned floor area.	

Source: California Energy Commission

PROPOSED DESIGN

The proposed design has standard conditioned zone thermal mass objects (such as gypsum board in walls, cabinets, sinks, and tubs) that are not user-editable and are not a compliance variable. If the proposed design includes specific interior thermal mass elements that are significantly different from what is included in typical wood-frame production housing, such as masonry partition walls, the user may include them. See also 6.9.7.4 Exterior Thermal Mass.

STANDARD DESIGN

The standard design has standard conditioned zone thermal mass objects.

6.9.5.2 Thermostats and Schedules

Thermostat settings are shown in Table 46: Hourly Thermostat Set Points. The values for cooling, venting, and standard heating apply to the standard design run and are the default for the proposed design run. See the explanation later in this chapter regarding the values for zonal control.

Heat pumps equipped with supplementary electric resistance heating are assumed to meet mandatory control requirements specified in Section 110.2(b) and (c).

Systems with no setback required by Section 110.2(c) (gravity gas wall heaters, gravity floor heaters, gravity room heaters, noncentral electric heaters, fireplaces or decorative gas appliances, wood stoves, room air-conditioners, and room air-conditioner heat pumps) are assumed to have a constant heating set point of 68 degrees Fahrenheit. The cooling set point from Table 46: Hourly Thermostat Set Points is assumed in both the proposed design and standard design.

PROPOSED DESIGN

The proposed design assumes a mandatory setback thermostat meeting the requirements of Section 110.2(c). Systems that are not required to have a setback thermostat are assumed to have no setback capabilities.

STANDARD DESIGN

The standard design has setback thermostat conditions based on the mandatory requirement for a setback thermostat. For equipment that is not required to meet the setback thermostat requirement, the standard design has no setback thermostat capabilities.

6.9.5.3 Determining Heating Mode vs. Cooling Mode

When the building is in the heating mode, the heating setpoints for each hour are set to the "heating" values in Table 46: Hourly Thermostat Set Points, the cooling setpoint is a constant 78 degrees Fahrenheit (°F), and the ventilation setpoint is set to a constant 77°F. When the building is in the cooling mode, the heating setpoint is a constant 60°F, and the cooling and venting setpoints are set to the values in Table 46: Hourly Thermostat Set Points.

The mode depends upon the outdoor temperature averaged over hours 1 through 24 of eight days prior to the current day through two days prior to the current day. (For example, if the current day is June 21, the mode is based on the average temperature for June 13 through 20.) When this running average temperature is equal to or less than 60°F, the building is in a heating mode. When the running average is greater than 60°F, the building is in a cooling mode.

6.9.6 Internal Gains

Internal gains assumptions are included in Appendix E and consistent with the CASE report on plug loads and lighting (Rubin 2016, see Appendix F). The internal gains assumptions for the standard design building is the same as the proposed design.

6.9.7 Exterior Surfaces

The user enters exterior surfaces to define the envelope of the proposed design. The areas, construction assemblies, orientations, and tilts modeled are consistent with the actual building design and shall equal the overall roof/ceiling area with conditioned space on the inside and unconditioned space on the other side.

6.9.7.1 Ceilings Below Attics

Ceilings below attics are horizontal surfaces between conditioned zones and attics. The area of the attic floor is determined by the total area of ceilings below attics defined in conditioned zones.

PROPOSED DESIGN

The compliance software allows the user to define ceilings below attic, enter the area, and select a construction assembly for each.

STANDARD DESIGN

The standard design for newly constructed buildings has the same ceiling below attic area as the proposed design. The standard design is a ceiling constructed with 2x4 framed trusses, insulated at the ceiling and below roof deck with the R-values specified in Section 170.2(a)1Bii and Table 170.2-A, Option B for the applicable climate zone. A radiant barrier and CRRC cool roof are also specified in Table 170.2-A for specific climate zones. The roof surface is a 10 lbs/ft^2 tile roof with an air space when the proposed roof is steep slope or a lightweight roof when the proposed roof is low slope.

VERIFICATION AND REPORTING

Ceiling below attic area and constructions are reported on the Certificate of Compliance. SIP assemblies are reported as a special feature on the Certificate of Compliance.

6.9.7.2 Non-Attic (Cathedral) Ceiling and Roof

Non-attic ceilings, also known as cathedral ceilings, are surfaces with roofing on the outside and finished ceiling on the inside but without an attic space.

PROPOSED DESIGN

The compliance software allows the user to define cathedral ceilings, enter the area, and select a construction assembly for each. The user also enters the roof characteristics of the surface.

STANDARD DESIGN

The standard design has the same area as the proposed design cathedral ceiling modeled with the features from Section 170.2 and Table 170.2-A or for the applicable climate zone.

The standard design roof and ceiling surfaces are modeled with the same construction assembly and characteristics, aged reflectance, and emittance as Section 170.2, Table 170.2-A for the applicable climate zone.

VERIFICATION AND REPORTING

Non-attic ceiling/roof area and constructions are reported on the Certificate of Compliance. SIP assemblies are reported as a special feature on the Certificate of Compliance.

6.9.7.3 Exterior Walls

PROPOSED DESIGN

The compliance software allows the user to define walls, enter the gross area, and select a construction assembly for each. The user also enters the plan orientation (front, left, back, or right) or plan azimuth (value relative to the front, which is represented as zero degrees) and tilt of the wall.

The wall areas modeled are consistent with the actual building design, and the total wall area is equal to the gross wall area with conditioned space on the inside and unconditioned space or exterior conditions on the other side. Underground mass walls are defined with inside and outside insulation and the number of feet below grade. Walls separating conditioned from unconditioned spaces, which have no solar gains, are entered as an interior wall with the zone on the other side specified as an unconditioned zone, and the compliance software treats that wall as a demising wall.

STANDARD DESIGN

The standard design building has high-performance walls modeled with the same area of framed walls as is in the proposed design separating conditioned space and the exterior, with a U-factor equivalent to that as specified in Section 170.2 and Table 170.2-A for the applicable climate zone, wall assembly type, and required fire rating.

The total gross exterior wall area in the standard design is equal to the total gross exterior wall area of the proposed design for each wall type and for each orientation. Window and door areas are subtracted from the gross wall area to determine the net wall area in each orientation.

VERIFICATION AND REPORTING

Exterior wall area and construction details are reported on the Certificate of Compliance. Metal-framed and SIP assemblies are reported as a special feature on the Certificate of Compliance.

6.9.7.4 Exterior Thermal Mass

Constructions for standard exterior mass are supported but not implemented beyond the assumptions for typical mass.

The performance approach assumes that both the proposed design and standard design building have a minimum mass as a function of the conditioned area of slab floor and non-slab-floor. (See 6.9.5.1 Internal Thermal Mass.)

Mass such as concrete slab floors, masonry walls, double gypsum board, and other special mass elements can be modeled. When the proposed design has more than the typical assumptions for mass in a building, then each element of heavy mass is modeled in the proposed design, otherwise; the proposed design is modeled with the same thermal mass as the standard design.

PROPOSED DESIGN

The proposed design may be modeled with the default 20 percent exposed mass/80 percent covered mass or with actual mass areas modeled as separate covered and exposed mass surfaces. Exposed mass surfaces covered with flooring material that is in direct contact with the slab can be modeled as exposed mass. Examples of such materials are tile, stone, vinyl, linoleum, and hardwood.

STANDARD DESIGN

The conditioned slab floor in the standard design is assumed to be 20 percent exposed slab and 80 percent slab covered by carpet or casework. Interior mass assumptions as described in 6.9.5.1 Internal Thermal Mass are also assumed. No other mass elements are modeled in the standard design. The standard design mass is modeled with the following characteristics:

- The conditioned slab floor area (slab area) shall have a thickness of 3.5 inches, a volumetric heat capacity of 28 Btu/ft^3-°F, and a conductivity of 0.98 Btu-in/hr-ft^2-°F. The exposed portion shall have a surface conductance of 1.3 Btu/h-ft^2-°F (no thermal resistance on the surface), and the covered portion shall have a surface conductance of 0.50 Btu/h-ft^2-°F, typical of a carpet and pad.
- The "exposed" portion of the conditioned non-slab floor area shall have a thickness of 2.0 inches, a volumetric heat capacity of 28 Btu/ft^3-°F, a conductivity of 0.98 Btu-in/hr- ft^2-ºF; and a surface conductance of 1.3 Btu/h-ft^2-°F (no added thermal resistance on the surface). These thermal mass properties apply to the "exposed" portion of non-slab floors for both the proposed design and standard design. The covered portion of non-slab floors is assumed to have no thermal mass.

VERIFICATION AND REPORTING

Exposed mass greater than 20 percent exposed slab on grade, and any other mass modeled by the user is reported as a special feature on the Certificate of Compliance.

6.9.7.5 Opaque Doors

Doors are defined as an opening in a building envelope. If the rough opening of a door includes fenestration equal to 25 percent or more of glass or fenestration, it is fenestration. (See 6.9.7.9 Exterior Shading.) Doors with less than 25 percent fenestration are considered an opaque door.

PROPOSED DESIGN

The compliance software shall allow users to enter doors specifying the U-factor, area, and orientation. Doors to the exterior or to unconditioned zones are modeled as part of the conditioned zone. For doors with less than 25 percent glass area, the U-factor shall come from Reference Appendices, Joint Appendix *JA4, Table 4.5.1* (default U-factor 0.20) or from National Fenestration Rating Council (NFRC) certification data for the entire door. For unrated doors, the glass area of the door, calculated as the sum of all glass surfaces plus 2 inches on all sides of the glass (to account for a frame), is modeled under the rules for fenestrations; the opaque area of the door is considered the total door area minus this calculated glass area. Doors with 25 percent or more glass area are modeled under the rules for fenestrations using the total area of the door.

When modeling a garage zone, large garage doors (metal roll-up or wood) are modeled with a 1.0 U-factor.

STANDARD DESIGN

The standard design has the same door area for each dwelling unit as the proposed design. The U-factor for the standard design is taken from Section 170.2 and Table 170.2-A. All swinging opaque doors are assumed to have a U-factor of 0.20. The net opaque wall area is reduced by the door area in the standard design.

VERIFICATION AND REPORTING

Door area and U-factor are reported on the Certificate of Compliance.

6.9.7.6 Fenestration

Fenestration is modeled with a U-factor, solar heat gain coefficient (SHGC), and visible transmittance (VT). Acceptable sources of these values are National Fenestration Rating Council (NFRC), default tables from Section 110.6 of the Energy Code, and *Reference Appendices, Nonresidential Appendix NA6*.

In limited cases for certain site-built fenestration that is field fabricated, the performance factors (U-factor, SHGC) may come from *Reference Appendices, Nonresidential Appendix NA6* as described in Exception 3 to Section 170.2(a)3Aii.

There is no detailed model of chromogenic fenestration available. As allowed by Exception 2 to Section 170.2(a)3Aii, the lower-rated labeled U-factor and SHGC may be used only when installed with automatic controls as noted in the exception. Chromogenic fenestration cannot be averaged with nonchromogenic fenestration.

PROPOSED DESIGN

The compliance software allows users to enter individual skylights and fenestration types, the U-factor, SHGC, VT, area, orientation, and tilt.

Performance datum (U-factors, SHGC, and VT) are from NFRC values or from the CEC default tables from Section 110.6 of the Energy Code. Solar gains from windows or skylights use the California Simulation Engine (CSE) default solar gain targeting or similar calculation method approved by the Energy Commission.

Skylights are a fenestration with a slope of 60 degrees or more. Skylights are modeled as part of a roof.

STANDARD DESIGN

If the proposed design fenestration area is less than 20 percent of the conditioned floor area, and less than 40 percent of the exterior wall area, the standard design fenestration area is set equal to the proposed design fenestration area for each orientation Otherwise, the standard design fenestration area is set equal to 20 percent of the conditioned floor area, or 40 percent of the exterior wall area, whichever is smaller, and the area is proportionally distributed for each orientation to match the proposed fenestration distribution.

The standard design has no skylights.

The net wall area on each orientation is reduced by the fenestration area and door area on each façade. The U-factor, SHGC, and VT performance factors for the standard design are taken from Section 170.2 and Table 170.2-A. In cases where the SHGC is “NR” the standard design is equal to 0.35.

VERIFICATION AND REPORTING

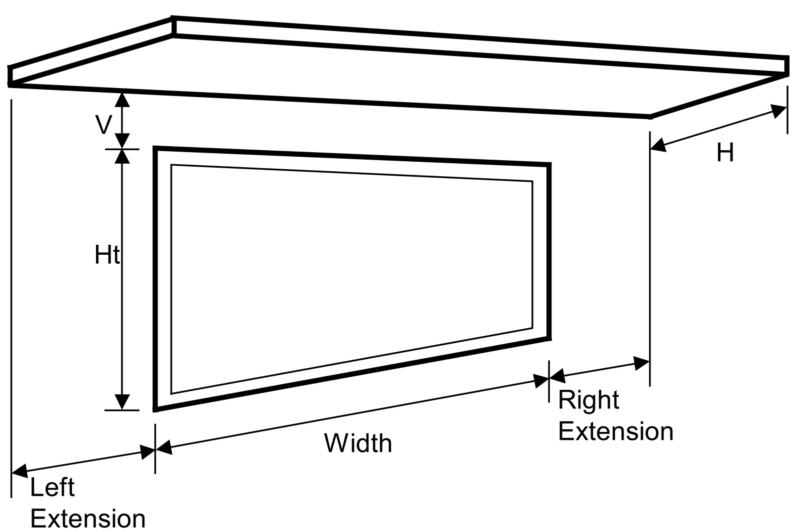
Fenestration area, U-factor, SHGC, VT, and orientation, are reported on the Certificate of Compliance. SHGC is reported on the Certificate of Compliance as an allowable maximum and minimum for each window calculated as the SHGC entered by the user plus or minus 0.01.

6.9.7.7 Overhangs and Sidefins

PROPOSED DESIGN

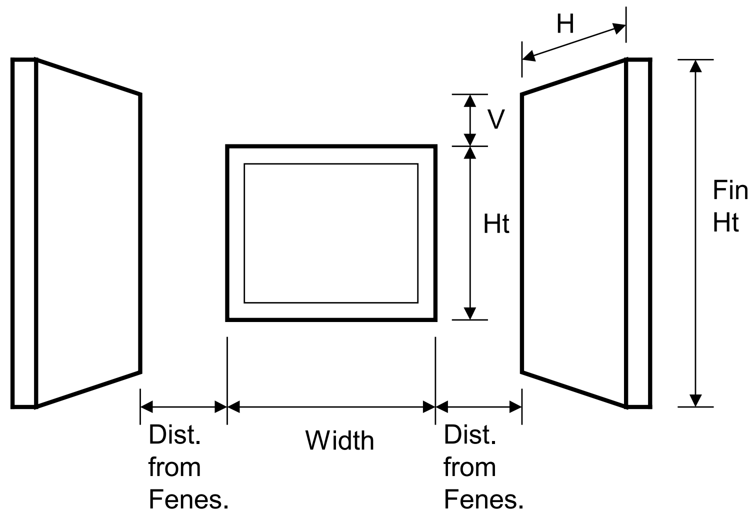
Compliance software users enter a set of basic parameters for a description of an overhang and sidefin for each individual fenestration or window area entry. The basic parameters include fenestration height, overhang/sidefin length, and overhang/sidefin height. Compliance software user entries for overhangs may also include fenestration width, overhang left extension, and overhang right extension. Compliance software user entries for sidefins may also include fin left extension and fin right extension for both left and right fins. Walls at right angles to windows may be modeled as sidefins.

Figure 11: Overhang Dimensions



Source: California Energy Commission

Figure 12: Sidefin Dimensions



Source: California Energy Commission

STANDARD DESIGN

The standard design does not have overhangs or sidefins.

VERIFICATION AND REPORTING

Overhang and fin dimensions are reported on the Certificate of Compliance.

6.9.7.8 Interior Shading Devices

For both the proposed and standard design, all windows are assumed to have draperies, and skylights are assumed to have no interior shading. Window medium drapes are closed at night and half open in the daytime hours. Interior shading is not a compliance variable and is not user-editable.

6.9.7.9 Exterior Shading

For both the proposed and standard design, all windows are assumed to have bug screens, and skylights are assumed to have no exterior shading. Exterior shading is modeled as an additional glazing system layer using the ASHRAE Window Attachment (ASHWAT) calculation or approved method showing minimum energy equivalency.

PROPOSED DESIGN

The compliance software shall require the user to accept the default exterior shading devices, which are bug screens for windows and none for skylights. Credit for shading devices that are allowable for prescriptive compliance are not allowable in performance compliance.

STANDARD DESIGN

The standard design shall assume bug screens. The standard design does not have skylights.

6.9.7.10 Slab on Grade Floors

PROPOSED DESIGN

The compliance software allows users to enter areas and exterior perimeter of slabs that are heated or unheated, covered, or exposed, and with or without slab-edge insulation. Perimeter is the length of wall between conditioned space and the exterior, but it does not include edges that cannot be insulated, such as between the house and the garage. The default condition for the proposed design is that 80 percent of each slab area is carpeted or covered by walls and cabinets, and 20 percent is exposed. Inputs other than the default condition require that carpet and exposed slab conditions are documented on the construction plans.

When the proposed heating distribution is radiant floor heating (heated slab), the compliance software user will identify that the slab is heated and model the proposed slab edge insulation. The mandatory minimum requirement is R-5 insulation in Climate Zones 1-15 and R-10 in Climate Zone 16 (Section 110.8(g), Table 110.8-A).

STANDARD DESIGN

The standard design perimeter lengths and slab on grade areas are the same as the proposed design. 80 percent of standard design slab area is carpeted, and 20 percent is exposed. For the standard design, an unheated slab edge has no insulation with the exception of Climate Zone 16, which assumes R-7 to a depth of 16 inches. The standard design for a heated slab is a heated slab with the mandatory slab edge insulation of R-5 in Climate Zones 1-15 and R-10 in Climate Zone 16.

VERIFICATION AND REPORTING

Slab areas, perimeter lengths, and inputs of other than the default condition are reported on the Certificate of Compliance.

6.9.7.11 Underground Floors

PROPOSED DESIGN

The compliance software allows users to enter areas and depth below grade of slab floors occurring below grade. Unlike slab-on-grade floors, there is no perimeter length associated with underground floors.

STANDARD DESIGN

The standard design underground floor areas are the same as the proposed design.

6.9.7.12 Raised Floors

Proposed Design

The compliance software allows the user to input floor areas and constructions for raised floors over a crawl space, over exterior (garage or unconditioned), and concrete raised floors. The proposed floor area and constructions are consistent with the actual building design.

Standard Design

The standard design has the same area and type of construction as the proposed design. The thermal characteristics meet Section 170.2 and Table 170.2-A. For floor areas that are framed construction, the standard design floor has R-19 in 2x6 wood framing, 16-in. on center (0.037 U-factor). For floor areas that are concrete raised floors, the standard design floor is 6 inches of normal weight concrete with R-8 continuous insulation in Climate Zones 1, 2, 11, 13, 14, 16; Climate Zones 12 and 15 have R-4; Climate Zones 3-10 have R-0.

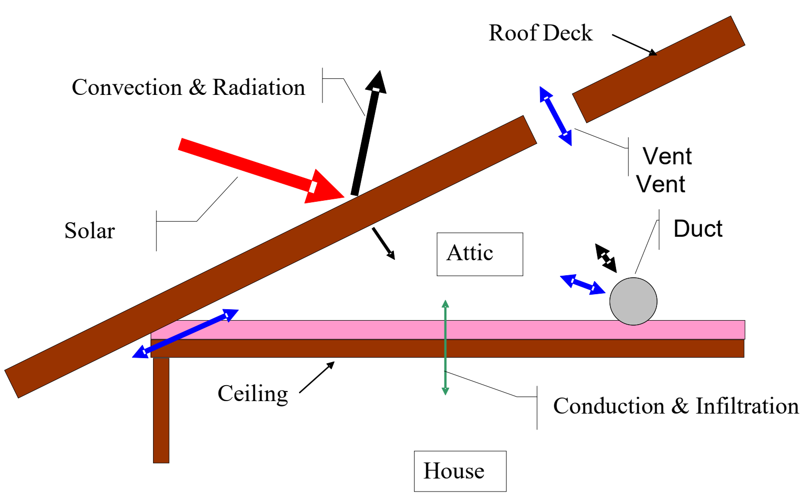
Verification and Reporting

Raised floor areas and constructions are reported on the Certificate of Compliance.

6.10 Attics

The compliance software models attics as a separate thermal zone and includes the interaction with the air distribution ducts, infiltration exchange between the attic and the house, the solar gains on the roof deck, and other factors. These interactions are illustrated in Figure 13: Attic Model Components.

Figure 13: Attic Model Components



Source: California Energy Commission

6.10.1 Attic Components

6.10.1.1 Roof Rise

The roof rise is the ratio of rise to run (or pitch) and refers to the number of feet the roof rises vertically for every 12 feet horizontally. For roofs with multiple pitches, the roof rise that makes up the largest roof area is used.

6.10.1.2 Vent Area

This value is the vent area as a fraction of attic floor area. This value is not a compliance variable and is assumed set equal to attic floor area divided by 300.

6.10.1.3 Fraction High

The fraction of the vent area that is high due to the presence of ridge, roof, or gable end-mounted vents. Soffit vents are considered low ventilation. The default value is zero for attics with standard ventilation. Attics with radiant barriers are required to have a vent high fraction of at least 0.3.

6.10.1.4 Roof Deck/Surface Construction

Typical roof construction types are concrete or clay tile, metal tile, gravel, ballast, or other steep- or low-sloped roofing types.

6.10.1.5 Solar Reflectance

This input is a fraction that specifies the certified aged reflectance of the roofing material or 0.1 default value for uncertified materials. The installed value must be equal to or higher than the value specified in the proposed model. Roof construction with a roof membrane mass of at least 25 lbs/ft^2, or a roof area that has integrated solar collectors, is assumed to meet the minimum solar reflectance.

6.10.1.6 Thermal Emittance

Thermal emittance is the certified aged thermal emittance (or emissivity) of the roofing material, or a default value. Unless a default value is modeled, the installed value must be equal to or greater than the value modeled. The default value is 0.85 if certified aged thermal emittance value is not available from the Cool Roof Rating Council (CRRC), www.coolroofs.org. Roof construction with a roof membrane mass of at least 25 lbs/ft^2 or roof area incorporated integrated solar collectors is assumed to meet the minimal, default, thermal emittance.

PROPOSED DESIGN

The conditioning is either ventilated or unventilated. Each characteristic of the roof is modeled to reflect the proposed construction. Values for solar reflectance and thermal emittance shall be default or from the CRRC.

Roofs with solar collectors or with thermal mass over the roof membrane with a weight of at least 25 lbs/ft² may model the prescriptive values for solar reflectance and thermal emittance.

STANDARD DESIGN

The standard design depends on the variables of the climate zone and roof slope. Low-sloped roofs (with a roof rise of 2 feet in 12 or less) in Climate Zones 13 and 15 will have a standard design aged solar reflectance of 0.63 and a thermal emittance of 0.85.

Steep-sloped roofs in Climate Zones 10-15 will have a standard design roof with an aged solar reflectance of 0.20 and a minimum thermal emittance of 0.85.

Roofs with solar collectors or with thermal mass over the roof membrane with a weight of at least 25 lbs/ft² are assumed to meet the standard design values for solar reflectance and thermal emittance.

VERIFICATION AND REPORTING

A reflectance of 0.20 or higher is reported as a cool roof. A value higher than the default but less than 0.20 is reported as a non-standard roof reflectance value.

6.10.2 Ceiling Below Attic

PROPOSED DESIGN

For each conditioned zone, the user enters the area and construction of each ceiling surface that is below an attic space. The compliance software shall allow a user to enter multiple ceiling constructions. Surfaces that tilt 60 degrees or more are treated as knee walls and are not included as ceilings. The sum of areas shall equal the overall ceiling area with conditioned space on the inside and unconditioned attic space on the other side.

The compliance software creates an attic zone with a floor area equal to the sum of the areas of all the user input ceilings below an attic in the building. The user specifies the framing and spacing, the materials of the frame path, and the R-value of the insulation path for each ceiling construction.

The user inputs the proposed insulation R-value rounded to the nearest whole R-value. For simulation, all ceiling below attic insulation is assumed to have nominal properties of R-2.6 per inch, a density of 0.5 lb/ft^3, and a specific heat of 0.2 Btu/lb.

STANDARD DESIGN

The standard design shall have the same area of ceiling below attic as the proposed design. The ceiling/framing construction is based on the prescriptive requirement and standard framing is assumed to be 2x4 wood trusses at 24 inches on center.

VERIFICATION AND REPORTING

The area, insulation R-value, and layer of each construction are reported on the Certificate of Compliance.

6.10.3 Attic Roof Surface and Pitch

PROPOSED DESIGN

The roof pitch is the ratio of rise to run, (for example, 4:12 or 5:12). If the proposed design has more than one roof pitch, the pitch of the largest area is used.

The compliance software creates an attic zone roof. The roof area is calculated as the ceiling below attic area divided by the cosine of the roof slope where the roof slope is an angle in degrees from the horizontal. The roof area is then divided into four equal sections with each section sloping in one of the cardinal directions (north, east, south, and west). Gable walls, dormers, or other exterior vertical surfaces that enclose the attic are ignored.

If the user specifies a roof with a pitch less than 2:12, the compliance software creates an attic with a flat roof that is 30 inches above the ceiling.

STANDARD DESIGN

The standard design shall have the same roof pitch, roof surface area, and orientations as the proposed design.

VERIFICATION AND REPORTING

The roof pitch is reported on the Certificate of Compliance.

6.10.4 Attic Conditioning

Attics may be ventilated or unventilated. Insulation in a ventilated attic must be installed at the ceiling level. Unventilated attics usually have insulation at the roof deck and sometimes on the ceiling (Section 160.1[a]).

In an unventilated attic, the roof system becomes part of the insulated building enclosure. Local building jurisdictions may impose additional requirements.

PROPOSED DESIGN

A conventional attic is modeled as ventilated. When an attic will not be vented, attic conditioning is modeled as unventilated.

STANDARD DESIGN

Attic ventilation is set to ventilated for the standard design.

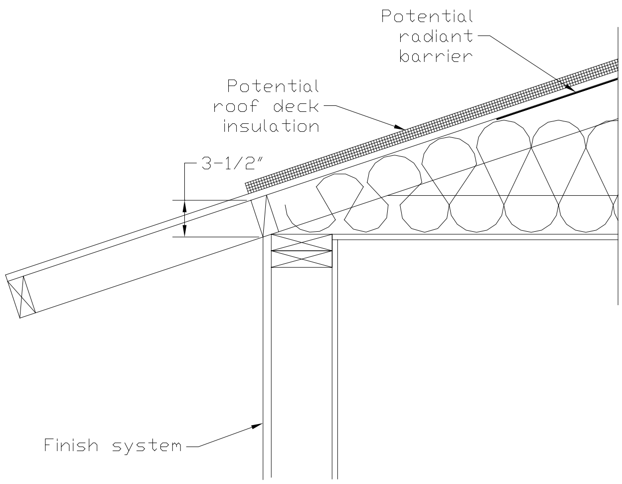
VERIFICATION AND REPORTING

The attic conditioning (ventilated or unventilated) is reported on the Certificate of Compliance.

6.10.5 Attic Edge

With a standard roof truss (Figure 14: Section at Attic Edge with Standard Truss), the depth of the ceiling insulation is restricted to the space left between the roof deck and the wall top plate for the insulation path, and the space between the bottom and top chord of the truss in the framing path. If the modeled insulation completely fills this space, there is no attic air space at the edge of the roof. Heat flow through the ceiling in this attic edge area is directly to the outside both horizontally and vertically, instead of to the attic space. Measures that depend on an attic air space, such as radiant barriers or ventilation, do not affect the heat flows in the attic edge area.

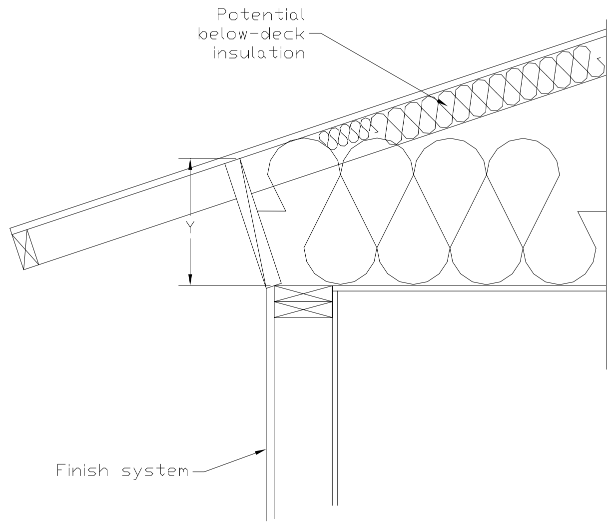
Figure 14: Section at Attic Edge with Standard Truss



Source: California Energy Commission

A raised heel truss (Figure 15: Section at Attic Edge with a Raised Heel Truss) provides additional height at the attic edge that, depending on the height Y and the ceiling insulation R, can either reduce or eliminate the attic edge area and its thermal impact.

Figure 15: Section at Attic Edge with a Raised Heel Truss



Source: California Energy Commission

For cases where the depth of insulation (including below-deck insulation depth) is greater than the available height at the attic edge, the compliance software automatically creates cathedral ceiling surfaces to represent the attic edge area and adjusts the dimensions of the attic air space using the algorithms contained in Appendix G. If above-deck insulation is modeled, it is included in the attic edge cathedral ceiling constructions, but radiant barriers below the roof deck are not.

Proposed Design

The compliance software shall allow the user to specify that a raised heel truss will be used (as supported by construction drawings), with the default being a standard truss as shown in Figure 14: Section at Attic Edge with Standard Truss. If the user selects a raised heel truss, the compliance software will require the user to specify the vertical distance between the wall top plate and the bottom of the roof deck (Y in Figure 15: Section at Attic Edge with a Raised Heel Truss).

Standard Design

The standard design shall have a standard truss with the default vertical distance of 3.5 inches between wall top plate and roof deck.

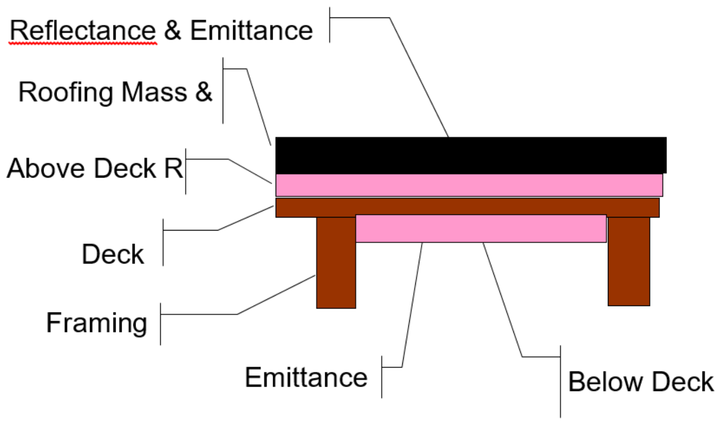
Verification and Reporting

A raised heel truss is a special feature, and the vertical height above the top plate will be included on the Certificate of Compliance.

6.10.6 The Roof Deck

The roof deck is the construction at the top of the attic and includes the solar optic properties of the exterior surface, the roofing type, the framing, insulation, air gaps, and other features. These are illustrated in Figure 16: Components of the Attic Through Roof Deck, which shows a detailed section through the roof deck.

Figure 16: Components of the Attic Through Roof Deck



Source: California Energy Commission

6.10.6.1 Radiant Barrier

Radiant barriers are used to reduce heat flow at the bottom of the roof deck in the attic. A 0.05 emittance is modeled at the bottom surface of the roof deck if radiant barriers are used. If no radiant barrier is used, the value modeled is 0.9. If radiant barrier is installed over existing skip sheathing in a reroofing application, 0.5 is modeled.

Proposed Design

The user shall specify whether the proposed design has:

- A radiant Barrier
- No Radiant Barrier

Standard Design

The standard design shall have a radiant barrier if required by the prescriptive Energy Code (Section 170.2 and Table 170.2-A) for the applicable climate zone.

Verification and Reporting

Radiant barriers are reported as a special feature on the Certificate of Compliance.

6.10.6.2 Below Deck Insulation

Below-deck insulation is insulation that will be installed below the roof deck between the roof trusses or rafters.

Proposed Design

The compliance software shall allow the user to specify the R-value of insulation that will be installed below the roof deck between the roof trusses or rafters. The default is an uninsulated roof deck.

Standard Design

The standard design has below-deck insulation as specified in 6.10.2 Ceiling Below Attic.

Verification and Reporting

The R-value of any below-deck insulation is reported as a special feature on the Certificate of Compliance.

6.10.6.3 Roof Deck and Framing

The roof deck is the structural surface that supports the roofing. The compliance software assumes a standard wood deck, and this is not a compliance variable. The size, spacing, and material of the roof deck framing are compliance variables.

Proposed Design

The roof deck is wood siding/sheathing/decking. The compliance software shall default the roof deck framing to 2x4 trusses at 24 in. on center. The compliance software shall allow the user to specify alternative framing size, material, and framing spacing.

Standard Design

The standard design is 2x4 trusses at 24 in. on center.

Verification and Reporting

Nonstandard roof deck framing or spacing is reported as a special feature on the Certificate of Compliance.

6.10.6.4 Above Deck Insulation

Above-deck insulation represents the insulation value of the air gap in "concrete or clay tile" or "metal tile or wood shakes." The R-value of any user modeled insulation layers between the roof-deck and the roofing is added to the air gap value.

Proposed Design

This input defaults to R-0.85 for "concrete or clay tile" or for "metal tile or wood shakes" to represent the benefit of the air gap but no additional insulation. The compliance software shall allow the user to specify the R-value of additional above-deck insulation in any roof-deck construction assembly.

Standard Design

The standard design accounts for the air gap based on roofing type but has no additional above-deck insulation.

VERIFICATION AND REPORTING

Above-deck insulation R-value is reported as a special feature on the Certificate of Compliance.

6.10.6.5 Roofing Type and Mass

PROPOSED DESIGN

The choice of roofing type determines the air gap characteristics between the roofing material and the deck and establishes whether other inputs are needed, as described below. The choices for roof type are shown below.

- Concrete or clay tile. Both types have significant thermal mass and an air gap between the deck and the tiles.
- Metal tile or wood shakes. These are lightweight with an air gap between the tiles or shakes and the deck. Note that tapered cedar shingles do not qualify and are treated as a conventional roof surface.
- Other steep-slope roofing types. These include asphalt and composite shingles and tapered cedar shingles. These products have no air gap between the shingles and the structural roof deck.
- Low-slope membranes. These are basically flat roofs with a slope of less than 2:12.
- Above-deck mass. The above-deck mass depends on the roofing type. The mass is 10 lbs/ft² for concrete and clay tile and 5 lbs/ft² for metal tile, wood shakes, or other steep-slope roofing types. For low-slope roofs, the additional thermal mass is assumed to be gravel or stone, and the user chooses one of the following inputs that is equal to or less than the weight of the material being installed above the roof deck:
- No mass (asphalt)
  - 5 lbs/ft²
  - 10 lbs/ft²
  - 15 lbs/ft²
  - 25 lbs/ft²

STANDARD DESIGN

The roof slope shall match the proposed design. The roof type for a steep slope roof is 10 lbs/ft^2 tile. The roof type for low-slope roof is lightweight roof.

VERIFICATION AND REPORTING

The roof type is reported on the Certificate of Compliance.

6.10.6.6 Solar Reflectance and Thermal Emittance

PROPOSED DESIGN

The compliance software shall allow the user to default the solar reflectance and thermal emittance of the roofing. The solar reflectance product default is 0.10 for all roof types. The thermal emittance default is 0.85.

The compliance software shall allow the user to input aged solar reflectance and thermal emittance of roofing material that are rated by the CRRC. The installed value must be equal to or higher than the value specified here. Roof construction with a roof membrane mass of at least 25 lbs/ft^2 or roof area incorporated integrated solar collectors are assumed to meet the minimal solar reflectance.

STANDARD DESIGN

The solar reflectance and thermal emittance of the standard design roofing are as specified in Table 170.2-A of the prescriptive standards.

VERIFICATION AND REPORTING

Thermal emittance and solar reflectance shall be reported on the Certificate of Compliance. A reflectance of 0.20 or higher is reported as a cool roof. A value higher than the default but less than 0.20 is reported as a nonstandard roof reflectance value.

6.11 Domestic Hot Water (DHW)

Water heating energy use is based on the number of dwelling units, number of bedrooms, fuel type, distribution system, water heater type, and conditioned floor area. Detailed calculation information is included in Appendix B: Water Heating Calculation Method of the Residential ACM Reference Manual.

PROPOSED DESIGN

The water heating system is defined by the heater type (gas, electric resistance, or heat pump), tank type, dwelling-unit distribution type, efficiency (either uniform energy factor (UEF) or recovery efficiency with the standby loss), tank volume, exterior insulation R-value (only for indirect), rated input, and tank location (for electric resistance and heat pump water heater only).

Unitary heat pump water heaters are defined by UEF (and optionally E_{50} and E_{95}), and volume, or, for Northwest Energy Efficiency Alliance Advanced Water Heating Specification (AWHS) qualified heat pumps, by selecting the Tier qualification level, entering the UEF (and optionally E_{50} and E_{95}) or the specific heater brand and model.

Water heater and tank types include:

- Consumer storage: ≤ 75,000 Btu/h gas/propane, ≤ 12 kW electric, or ≤ 24 amps heat pump, rated with UEF.

- Consumer instantaneous: ≤ 200,000 Btu/h gas or propane, or ≤ 12 kW electric. An instantaneous water heater is a water heater with an input rating of ≥ 4,000 Btu/h/gallon of stored water, rated with a UEF.
- Residential-duty commercial storage: > 75,000 Btu/h, ≤ 105,000 Btu/h gas/propane, ≤ 12 kW electric, ≤ 24 amps heat pump, and rated storage volume < 120 gallons, rated with a UEF.
- Residential-duty commercial instantaneous: ≤ 200,000 Btu/h gas/propane, ≤ 58.6 kW electric, rated storage volume ≤ 2 gallons, rated with a UEF.
- Commercial storage: > 75,000 Btu/h gas/propane, >105,000 Btu/h oil, or > 12 kW electric, rated with thermal efficiency and standby loss.
- Commercial instantaneous: >200,000 Btu/h gas/propane, > 12 kW electric. Instantaneous water heater is a water heater with an input rating of ≥ 4,000 Btu/h per gallon of stored water, rated with thermal efficiency.
- Unitary heat pump water heater: ≤ 24 amps AWHS rating or rated with UEF.
- Mini-tank (modeled only in conjunction with an instantaneous gas water heater): a small electric storage buffering tank that may be installed downstream of an instantaneous gas water heater to mitigate delivered water temperatures (e.g., cold water sandwich effect). If the standby loss of this aftermarket tank is not listed in the CEC appliance database, a standby loss of 35 W must be assumed.
- Indirect: a tank with no heating element or combustion device used in combination with a boiler or other device serving as the heating element.
- Boiler: a water boiler that supplies hot water, rated with thermal efficiency or AFUE.

Heater element type includes:

- Electric resistance.
- Gas.
- Heat pump.

Dwelling unit distribution system types for systems serving individual dwelling units include:

- Standard (all piping and plumbing appurtenances for domestic hot water systems shall be insulated and insulation shall be continuous).
- Point of use.
- Central parallel piping.
- Recirculation with nondemand control (continuous pumping).
- Recirculation with demand control, push button.
- Recirculation with demand control, occupancy/motion sensor.

- ECC-required pipe insulation, all lines including the first 8 ft of inlet cold water piping from storage tank. If pipe insulation is not verified per Residential Reference Appendix RA3.6.3, then an energy compliance penalty is applied based on Appendix B Table B-6 to reflect imperfect insulation.
- ECC-required central parallel piping.
- ECC-required recirculation, demand control, push button.
- ECC-required recirculation with demand control, occupancy/motion sensor.

Some distribution systems can increase the amount of credit received if the option for ECC verification is selected. See Appendix B for the amount of credit and Reference Appendices, Residential Appendix Table RA2-6 for a summary of inspection requirements.

When a multifamily building has central water heating, both a dwelling unit and a central system distribution type must be specified. Dwelling unit distribution types for this case include:

- Standard (all distribution pipes insulated).
- ECC-required pipe insulation, all lines.

Multifamily central hot water heating central system distribution types include:

- No loops or recirculation system pump.
- Recirculation with no control (continuous pumping).

Pipe Sizing

California Plumbing Code (CPC) Appendix M establishes that the standard design pipe sizing methodology be used for all distribution piping. If CPC Appendix A methodology is followed, then an energy compliance penalty is applied based on Appendix B Table B-6.

6.11.1 Distribution Compactness

Applicable to single dwelling units or multifamily with individual water heaters in each dwelling unit. Distribution compactness identifies the proximity between the water heater and use points. The distribution compactness of the water heating system must be specified. The choices include:

- None.
- Compact distribution basic credit.

- Compact distribution expanded credit (ECC).

Once basic credit or expanded credit is specified, either the plan view fixture distances (to master bathroom, kitchen, and furthest fixture) will need to be input for the DHW system or, if the distances are unknown, allow a user input compactness factor to be used.

If the fixture distances are specified, the compliance software will determine if the distances qualify for the credit.

If the fixture distances are not specified, compliance with the user input compactness factor will be verified on the Certificate of Installation where the actual fixture distances for the design will need to be specified.

6.11.2 Drain Water Heat Recovery

Drain water heat recovery (DWHR) is a system where the waste heat from shower drains is used to preheat the cold inlet water. The preheated water can serve a shower, water heater, or both.

The user specifies the DHWR device for the water heating system. The rated efficiency of the DWHR device, the number of shower(s) served, and the configuration must be specified. The configuration choices include:

- Equal flow to shower and water heater: The potable-side heat exchanger output feeds both the fixture and the water heater inlet. Potable and drain flow rates are equal, assuming no other simultaneous hot water draws.
- Unequal flow to shower: The potable-side heat exchanger output feeds the inlet(s) of the water heater(s) that are part of the parent DHW system. (The inlet temperature is adjusted to reflect recovered heat.)
- Unequal flow to water heater: The potable-side heat exchanger output feeds only the associated fixture.

Multiple DHWR devices can be used for a water heater system.

Drain water heat recovery is a ECC-verified measure.

6.11.3 Individual Water Heaters Serving Dwelling Units – - Standard Design

Multifamily buildings three habitable floors or less:

When calculating the LSC the standard design for all climate zones is a single HPWH with a 2.0 UEF. If the proposed building has an attached garage, then the standard design HPWH location is in the garage. If the proposed building does not have an attached garage, then the standard design HPWH location is in an exterior closet with louvers open to the exterior.

In climate zones 1 or 16 the standard design will include a compact distribution system meeting the requirements of RA4.4.6. In climate zone 16 the standard design will include both a compact distribution system and a drain water heat recovery system.

When calculating the standard design source energy, the domestic water heating system is a gas tankless water heater with an input of 200,000 BTU/h, a high draw pattern, and 0.81 UEF.

Multifamily buildings four habitable floors or greater:

If the proposed design uses electricity as the fuel source, the standard design is a single heat pump water heater with a 2.0 UEF with compact distribution basic credit in Climate Zones 1 and 16, and a drain water heat recovery system in Climate Zone 16.

If the proposed building has an attached garage, then the standard design HPWH location is the garage. If the proposed building does not have an attached garage, then the standard design HPWH location is in the conditioned space with the air inlet and outlet ducted to the outside.

If the proposed design is gas, then the standard design is a single gas or propane consumer instantaneous water heater for each dwelling unit. The single consumer instantaneous water heater is modeled with an input of 200,000 Btu/h, a tank volume of zero gallons, a high draw pattern, and a UEF meeting the minimum federal standards. The current minimum federal standard for a high-draw-pattern instantaneous water heater is 0.81 UEF.

6.11.4 Multiple Dwelling Units – Central Water Heating Standard Design

The energy performance of central water heating systems is determined by the primary heating equipment, primary heating storage volume, location, secondary heating equipment, secondary heating storage volume, set point controls, and the way in which the components are plumbed.

Water-heating device

If the proposed central water heating device uses electricity as the fuel source, the standard design is a central split heat pump water heater system that includes the following:

- Primary single-pass, split-system heat pump plumbed to a primary storage volume. The standard design heat pump water heater output capacity and the primary storage tank capacity are automatically sized so that the heat pump and primary storage volume jointly meet the peak water used on the design (coldest) day. The algorithm sizes the primary tank volume to meet the peak water draw

period and the heat pump output capacity so that the system runs for approximately sixteen hours on the design days.
- The primary single-pass heat pump is a generic heat pump, based on the R-134 refrigerant operating cycle, with minimum output capacity as determined above.
- In the standard design, the recirculation loop is decoupled from the primary system. The secondary heater and tank are connected to the primary system in series and both the primary tank outlet and hot water circulation return are connected to the bottom of the secondary tank.

The secondary tank is an electric resistance water heater with output heating capacity calculated as follows:
Output Capacity (watts) = 1.75 * 100 * Number of Dwelling Units
The secondary tank storage volume is determined by the following:
Tank Volume (gallons) = 80 if Number of Dwelling Units < 48
Tank Volume (gallons = 120 if Number of Dwelling Units > 48
Both the primary and secondary storage tanks have insulation R-values of 16 (°F ft^2 hr/BTU)
The locations for the standard design storage tanks and heat pumps are the same as the proposed design.
The temperature setpoints are:
Primary single-pass HPWH: 135 °F
Secondary water heater: 125 °F

Thermostatic mixing valve outlet: 125 °F.

If the proposed central water heating device uses gas or propane as the fuel source, the standard design uses a natural gas-fired or propane commercial packaged boiler. In Climate 1 through 9, if the total proposed design installed water heating input capacity is 1 MMBtu/hr or greater, the standard design gas water-heating equipment thermal efficiency is 90 percent. Otherwise, the appropriate efficiencies and standby losses for each standard water-heating device are assigned to match the minimum federal requirements. The standards for consumer water heaters, as defined by 42 U.S.C 6291(16), are specified in 10 CFR 430.32(d); the standards for commercial water heaters, as defined by 42 U.S.C 6291(16), are specified in 10 CFR 431.110.

Recirculating system. If the central water-heating system has recirculation loops, the standard design includes a recirculation system with demand control and one recirculation loop.

Master Mixing Valve

Thermostatic master mixing valve is the standard design used for central water heating systems. A correction factor is used to adjust the energy usage simulated based on the system characteristics. A 1.0 correction factor represents no energy credit or penalty, while correction factors greater than 1.0 result in increased energy usage penalties for the system. Table 48: Heat Pump Water Heater System Correction Factor, Table 49: Gas-Fired Water Heater System Correction Factor. This factor is dependent on the heating plant characteristics based on the heating source, heater and storage tank configuration, and heating plant hot water outlet and recirculation return temperature. The correction factor is also dependent on whether a mechanical master mixing valve, digital master mixing valve or no master mixing valve is specified. The standard design assumes a mechanical master mixing valve with a correction factor of 1.0.

Table 48: Heat Pump Water Heater System Correction Factor

Heat Pump Water Heater Systems	Digital Master Mixing Valve	Mechanical Master Mixing Valve	No Master Mixing Valve
Multi-Pass Integrate HPWH 1 °F < ∆T(Outlet Return) < 7 °F	1	1	1.15
Multi-Pass Integrated HPWH 7 °F < ∆T	1	1	1.12
Single-Pass Primary HP with Recirculation Return to Primary Tank 1 °F < ∆T < 7 °F	0.96	1	1.14
Single-Pass Primary HP with Recirculation Return to Primary Tank 7 °F < ∆T	1	1	1.09
Multi-Pass Primary HP with Recirculation Return to Primary Tank 1 °F < ∆T < 7 °F	0.96	1	1.15
Multi-Pass Primary HP with Recirculation Return to Primary Tank 7 °F < ∆T	0.98	1	1.12
Single-Pass Primary HP with Recirculation Return to Series Electric Resistance Water	0.96	1	1.08

Heater 1 °F < ∆T < 7 °F			
Single-Pass Primary HP with Recirculation Return to Series Electric Resistance Water Heater 7 °F < ∆T	0.99	1	1.05
Single-Pass Primary HP with Recirculation Return to Secondary Parallel HPWH 1 °F < ∆T < 7 °F	0.96	1	1.10
Single-Pass Primary HP with Recirculation Return to Secondary Parallel HPWH 7 °F < ∆T	0.96	1	1.10

Source: California Energy Commission

Table 49: Gas-Fired Water Heater System Correction Factor

Heat Pump Water Heater Systems	Digital Master Mixing Valve	Mechanical Master Mixing Valve	No Master Mixing Valve
Integrated Gas Atmospheric Water Heater	1	1	1.03
Integrated Gas Condensing Water Heater	1	1	1.03
Multi-Pass Primary Gas Atmospheric Water Heater with Recirculation Return to Primary Tank	1	1	1.03
Multi-Pass Primary Gas Condensing Water Heater with Recirculation Return to Primary Tank	1	1	1.03

Source: California Energy Commission

Solar thermal water-heating system. If the proposed system uses gas or propane water heater, the standard design has a solar water heating system meeting the installation criteria specified in *Reference Residential Appendix RA4* and with a minimum solar savings fraction of 0.20 in Climate Zones 1-9, or 0.35 in Climate Zones 10-16. If a drain water heat recovery system is installed, these solar savings fractions are reduced to 0.15 in Climate Zones 1-9 or 0.30 in Climate Zones 10-16.

VERIFICATION AND REPORTING

All modeled features and the number of devices modeled for the water heating system are reported on the Certificate of Compliance. Electric resistance and heat pump water heaters indicate the location of the water heater. NEEA-rated heat pumps are identified by the brand and model, which must be verified by the building inspector.

Where water heating system features or distribution systems specify or require ECC verification, those features are listed in the ECC required verification listings on the Certificate of Compliance.

6.11.5 Solar Thermal Water Heating Credit

When a water heating system has a solar thermal system to provide part of the water heating, the user enters information about the Solar Rating and Certification Corporation approved collector (manufacturer, brand, model number), including details of the installation (azimuth, tilt).

Alternatively, the solar fraction (SF) is determined using the CEC Solar Water Heating Calculator, or approved method showing minimum energy equivalency, OG-100 calculation method, or the certified OG-300 rating. The calculation method requires that the user specify the climate zone and conditioned floor area, in addition to published data for the solar thermal water heating system.

6.11.6 JA13 Basic Control Credit

The Reference Appendices, Joint Appendix JA13 HPWH Basic Control Credit provides compliance credit for systems that provide daily load shifting for the purpose of bill reductions, maximization of solar self-utilization, and grid harmonization. The Basic Control Credits are based on modeling of typical HPWHs, where the control turns the water heater on and off at optimal times for maximum LSC benefits without exceeding the user set point temperature. Variation by climate zone is dependent on LSC values and climate conditions such as ambient air and ground water temperatures in each climate zone.

Any HPWH compliant with Reference Appendices, Joint Appendix JA13 will receive an LSC percentage credit which is climate zone specific as specified in Table 50: JA13 HPWH Basic Control Credit. The LSC percentage reduction is applied to the Proposed

Design water heating annual LSC budget which is part of the efficiency LSC, upon the completion of the compliance simulation run.

Table 50: JA13 HPWH Basic Control Credit

Climate Zone	JA13 Basic Control Credit (%)
1	6.7
2	3.7
3	7.6
4	4.0
5	8.5
6	6.8
7	8.8
8	4.4
9	4.4
10	4.4
11	4.2
12	4.7
13	8.0
14	3.1
15	8.2
16	22.7

6.12 Additions/Alterations

Addition and alteration compliance is based on Energy Code, Section 180.0, Section 180.1, Section 180.2, and Section 180.3. The energy budget for additions and alterations is based on LSC energy. Alterations must model the entire dwelling unit. Additions may be modeled as addition alone, alteration alone, or as "ExistingAdditionAndAlteration".

The standard design and tradeoffs are not included for the following features:

- Cool roof when an addition is 300 ft^2 or less.
- Ventilation cooling for additions that are 1,000 ft^2 or less.
- Solar generation/PV requirements.

6.12.1 Whole Building

The entire proposed building, including all additions or alterations or both, is modeled the same as a newly constructed building. The building complies if the proposed design uses equal to or less energy than the standard design.

6.12.2 Alteration-Alone Approach

The proposed alteration alone floor area is modeled. The alteration requirements of Section 180.2 are applied to any new features.

6.12.3 Addition-Alone Approach

The proposed addition alone is modeled the same as a newly constructed building except that the internal gains are prorated based on the size of the dwelling. None of the exceptions included for prescriptive additions, which are implemented in the existing plus addition plus alteration compliance approach (6.12.4 ExistingAdditionAndAlteration Approach), are given to the addition alone approach. (See Energy Code, Section 180.1(b)2.) The addition complies if the proposed design LSC energy consumption is less than the standard design energy budget. Additions are not required to meet a source energy budget.

The addition-alone approach shall not be used when alterations to the existing building are proposed. Modifications to any surfaces between the existing building and the addition are part of the addition and are not considered alterations.

PROPOSED DESIGN

The user shall indicate that an addition alone is being modeled and enter the conditioned floor area of the addition. Any surfaces that are between the existing building and the addition are not modeled or are treated as adiabatic surfaces. All other features of the addition shall be modeled the same as a newly constructed building.

When an existing HVAC system is extended to serve the addition, the standard design shall assume the same efficiency for the HVAC equipment as the proposed design. (See 6.8.1 Heating Subsystems and 6.8.2 Cooling Subsystems.)

When a dual-glazed greenhouse or garden window is installed in an addition or alteration, the proposed design U-factor can be assumed to be 0.30.

STANDARD DESIGN

The addition alone is modeled the same as a newly constructed building, with the following exceptions:

- When roofing requirements are included in Table 170.2-A, they are included in the standard design if the added conditioned floor area is greater than 300 ft^2.
- When compliance with IAQ requirements of Section 160.2 apply to an addition with greater than 1,000 ft^2 added, the conditioned floor area of the entire dwelling unit shall be used to determine the required ventilation airflow. For additions with 1,000 ft^2 or less of added conditioned floor area, no IAQ requirements apply.
- PV requirements are not included.
- For dwelling units with water heaters serving individual dwelling units, the standard design DHW system is a heat pump water heater with a 2.0 UEF. In climate zone 3, 4, 13 and 14, if the proposed design is gas, the standard design DHW system is a natural gas tankless (or propane if natural gas is not available) water heating system. See 6.11.3Individual Water Heaters Serving Dwelling Units – - Standard Design for equipment efficiencies and operating details for each type of water heater.

6.12.4 ExistingAdditionAndAlteration Approach

Energy Code Section 180.1 contains the provisions for additions and Section 180.2 for alterations when the existing building is included in the calculations. These provisions are the "ExistingAdditionAndAlteration" performance approach. The proposed existing + addition + alteration design complies if the LSC energy consumption is less than the standard design energy budget.

PROPOSED DESIGN

The proposed design is modeled by identifying each energy feature as part of the existing building (as existing, altered, or new), or as part of the addition. The compliance software uses this information to create an ExistingAdditionAndAlteration standard design using the rules in the Energy Code that take into account whether altered components meet or exceed the threshold at which they receive a compliance credit and whether any related measures are triggered by altering a given component.

For building surfaces and systems designated below, all compliance software must provide an input field with labels for the proposed design, which define how the standard design requirements are established based on the option selected by the compliance software user:

- Existing: The surface or system remains unchanged within the proposed design. (Both standard design and proposed design have the same features and characteristics.)
- Altered: the surface or system is altered in the proposed design. New: a new surface or system is added in the proposed design (may be in the existing building or the addition).

Deleted features are not included in the proposed design.

Section 180.2, Table 180.2-B specifies the details of the standard design for altered components.

6.12.4.1 QII

STANDARD DESIGN

For multifamily building up to three habitable floors, the standard design includes QII for additions greater than 700 ft^2 in multifamily building in Climate Zones 1-6 and 8-16 (Section 180.1(a)1Bv).

The provisions of Section 180.1(a)1Aiv, as applied to converting an existing unconditioned space to conditioned space, are accommodations made by the ECC rater in the field. No adjustments to the energy budget are made.

6.12.4.2 PV

STANDARD DESIGN

The standard design does not include PV for additions and alterations.

6.12.4.3 Roof/Ceilings

STANDARD DESIGN

The standard design roof/ceiling construction assembly is based on the proposed design assembly type as shown in Table 51: Standard Design for Roofs/Ceilings**.** For additions equal to or less than 700 ft^2, radiant barrier requirements follow Option C (Section 170.2(a)1Bii). The standard design for unaltered ceilings and roofs is the existing condition.

Table 51: Standard Design for Roofs/Ceilings

Proposed Design Roof/Ceiling Types	Addition < 300 ft²	Addition > 300 ft² and < 700 ft	Addition > 700 ft²	Altered
Roof Deck Insulation (below-deck, where required) at vented attic	NR	NR	CZ 4, 8, 9, 11-15 = R-19, CZ 10, 16 = R-13	CZ 4, 8, 9, 11-15 = R-19, CZ 10, 16 = R-13
Ceilings Below Attic	CZ 1, 2, 8-16 = R-38 CZ 3, 5-7 = R-30	CZ 1, 2, 4, 8-16 = R-38 CZ 3, 5-7 = R-30	CZ 1, 2, 4, 8-16 = R-38 CZ 3, 5-7 = R-30	CZ 5-7 = R-19 CZ 1-4, 8-16 = R-49
Non-Attic (Cathedral) Ceilings and Roofs	R-22/U-0.043	R-22/U-0.043	Same as above	R-19/U-0.054
Radiant Barrier	CZ 2-15 REQ CZ 1, 16 NR	CZ 2-15 REQ CZ 1, 16 NR	CZ 2, 3, 5-7 REQ CZ 1, 4, 8-16 NR	NR
Roofing Surface (Cool Roof) Steep-Sloped	NR	CZ 10-15 =0.20 Reflectance, =0.75 Emittance	CZ 10-15 =0.20 Reflectance, =0.75 Emittance	CZ 4, 8-15 =0.20 Reflectance =0.75 Emittance
Roofing Surface (Cool Roof) Low Slope	NR	CZ 13, 15 = 0.63 Reflectance, =0.75 Emittance	CZ 13, 15 = 0.63 Reflectance, =0.75 Emittance	CZ 4, 6-15 =0.63 Reflectance =0.75 Emittance
Above Deck Insulation, Low-Sloped	NR	NR	NR	CZ 1, 2, 4, 8-16 R-14 continuous

Source: California Energy Commission

6.12.4.4 Exterior Walls and Doors

The compliance software allows the user to indicate whether a new wall in an addition is an extension of an existing wood-framed wall and, if so, the dimensions of the existing wall. The standard design exterior wall construction assembly is based on a wood-framed wall with R-15 cavity insulation for existing 2x4 walls or R-21 cavity insulation for existing 2x6 walls.

The compliance software allows the user to indicate if a wall is existing, where siding is not removed or replaced. The user also identifies if the walls have 2x4 or 2x6 framing. The standard design exterior wall construction assembly is based on a wood-framed wall with R-15 cavity insulation for existing 2x4 walls or R-21 cavity insulation for existing 2x6 walls.

PROPOSED DESIGN

Existing structures with insulated wood-framed walls that are being converted to conditioned space using an E+A+A approach are allowed to show compliance using the existing wall framing, without having to upgrade to current prescriptive continuous insulation requirements. The walls are modeled as an assembly with the existing framing and either R-15 (in 2x4 framing) or R-21 (in 2x6 framing) insulation (Exception to Section 160.1(b) and Section 180.1(a)1).

STANDARD DESIGN

The areas, orientation, and tilt of existing, new, and altered net exterior wall areas (with windows and doors subtracted) are the same in the existing and addition portions of standard design as in the proposed design.

The gross exterior wall areas (wall area without subtracting window area) and orientations of the standard design match the proposed design.

The standard design exterior wall construction assembly is based on the proposed design assembly type as shown in Table 52: Addition Standard Design for Walls and Doors are modeled as 16-in. on center wood framing. The standard design for unaltered walls is the existing condition.

The standard design for exterior opaque or swinging doors is 0.20 U-factor. Fire-rated doors (from the house to garage) use the proposed design door U-factor as the standard design U-factor.

Table 52: Addition Standard Design for Walls and Doors

Proposed Design Exterior Wall Assembly Type or Door	Addition	Altered
Framed & Non-Mass Exterior Walls (≤1hr fire rating)	CZ 1-5, 8-16 = R-21+R-4 in 2x6 (U-0.051) CZ 6-7 = R-15+R-4 in 2x4 (U-0.065)	R-13 in 2x4 R-20 in 2x6
Framed & Non-Mass Exterior Walls (>1hr fire rating)	CZ 1-5, 8-10, 12, 13 = (U-0.059) CZ 6, 7 = (U-0.065) CZ 11, 14-16 = (U-0.051)	R-13 in 2x4 R-20 in 2x6
Wood Framed Existing Walls where Siding is not Removed Extension of an Existing Wall	R-15 in 2x4 R-21 in 2x6	R-13 in 2x4 R-20 in 2x6
Framed Wall Separating Conditioned and Unconditioned Space (e.g., Demising or Garage Wall)	R-15 in 2x4 R-21 in 2x6	R-13 in 2x4 R-20 in 2x6
Above Grade Mass Interior Insulated	CZ 1-15 = R-13 (0.077) CZ 16 = R-17 (0.059)	N/R Mandatory requirements have no insulation for mass walls
Below Grade Mass Interior Insulation	CZ 1-15 = R-13 CZ 16 = R-15	N/R Mandatory requirements have no insulation for mass walls
Swinging Doors	0.20	0.20

Source: California Energy Commission

6.12.4.5 Fenestration

PROPOSED DESIGN

Fenestration areas are modeled in the addition as new. In an existing building, they may be existing, altered, or new. Altered (replacement) fenestration is defined in Section 180.2(b)1.C as "existing fenestration area in an existing wall or roof [which is] replaced with a new manufactured fenestration product. Up to the total fenestration area removed in the existing wall or roof...." Altered also includes fenestration installed in the same existing wall, even if in a different location on that wall. Added fenestration area in an existing wall or roof is fenestration that did not previously exist and is modeled as new.

STANDARD DESIGN

Standard design fenestration U-factor and SHGC are based on the values shown in Table 53: Standard Design for Fenestration (in Walls and Roofs). Vertical glazing includes all fenestration in exterior walls such as windows, clerestories, and glazed doors. Skylights include all glazed openings in roofs and ceilings.

New fenestration in an alteration is modeled with the same U-factor and SHGC as required for an addition.

West-facing limitations are combined with the maximum fenestration allowed and are not an additional allowance.

The standard design is set for fenestration areas and orientations as shown in Table 53: Standard Design for Fenestration (in Walls and Roofs):

Proposed design < allowed percentage of total fenestration area:

In the existing building, the standard design uses the same area and orientation of each existing or altered fenestration area (in the respective existing or altered wall or roof.)

In an addition, the standard design uses the same area and orientation of new fenestration up to the allowed fenestration.

Proposed design > allowed percentage of total fenestration area:

The standard design first calculates the allowed total fenestration area as the total existing and altered fenestration area in existing or altered walls and roofs. Added to this is the percent of fenestration allowed in the addition, based on the conditioned floor area of the addition.

Table 53: Standard Design for Fenestration (in Walls and Roofs)

Proposed Design Fenestration Type	Addition < 400 ft²	Addition > 400 and < 700 ft²	Addition > 700 ft²	Altered
Vertical Glazing: Area and Orientation	75 ft² or 30%	Min of 20% WWR or 40% WFR	Min of 20% WWR or 40% WFR	Min of 20% WWR or 40% WFR
West Facing Maximum Allowed	CZ 2, 4, 6 - 15=60 ft²	CZ 2, 4, 6 - 15=60 ft²	CZ 2, 4, 6 - 15=70 ft² or 5%	NR
Vertical Glazing: U-Factor	CZ 1, 3-5,11, 13-16 = 0.28 CZ 2, 6, 8-10, 12 = 0.30 CZ7 = 0.34	CZ 1, 3-5,11, 13-16 = 0.28 CZ 2, 6, 8-10, 12 = 0.30 CZ7 = 0.34	CZ 1, 3-5,11, 13-16 = 0.28 CZ 2, 6, 8-10, 12 = 0.30 CZ7 = 0.34	CZ 1, 3-5,11, 13-16 = 0.28 CZ 2, 6, 8-10, 12 = 0.30 CZ7 = 0.34
Vertical Glazing: SHGC	CZ 1, 3, 5, 16 = NR CZ 2, 4, 6-15 = 0.23	CZ 1, 3, 5, 16 = NR CZ 2, 4, 6-15 = 0.23	CZ 1, 3, 5, 16 = NR CZ 2, 4, 6-15 = 0.23	CZ 1, 3, 5, 16 = NR CZ 2, 4, 6-15 = 0.23
Skylight: Area and Orientation	5%	5%	5%	5%
Skylight: U-Factor	0.30	0.30	0.30	0.55
Skylight: SHGC	CZ 2, 4, 6 - 15=0.25 CZ 1,3 5 & 16=0.35	CZ 2, 4, 6 - 15=0.25 CZ 1,3 5 & 16=0.35	CZ 2, 4, 6 - 15=0.23 CZ 1,3 5 & 16=0.35	CZ 2, 4, 6 -15=0.25 CZ 1,3 5 & 16=0.35

Source: California Energy Commission

6.12.4.6 Overhangs, Sidefins and Other Exterior Shading

Standard Design

The standard design for a proposed building with overhangs, sidefins, and exterior shades is shown in Table 54: Standard Design for Overhangs, Sidefins, and Other

Exterior Shading Exterior shading (limited to bug screens) is treated differently than fixed overhangs and sidefins, as explained in 6.9.7.9 Exterior Shading.

Table 54: Standard Design for Overhangs, Sidefins, and Other Exterior Shading

Proposed Design Shading Type	Addition	Altered
Overhangs and Sidefins	No overhangs or sidefins	Proposed altered condition
Exterior Shading	Standard (bug screens on fenestration, none on skylights)	Proposed altered condition
Window Film	No window film	Proposed altered condition

Source: California Energy Commission

6.12.4.7 Window Film

Proposed Design

A window film must have at least a 15-year warranty and is treated as a window replacement. The values modeled are either the default values from Tables 110.6-A and 110.6-B or the NFRC Window Film Energy Performance Label.

6.12.4.8 Floors

Standard Design

The standard design for floors is shown in Table 55: Standard Design for Floors.

Table 55: Standard Design for Floors

Proposed Design Floor Type	Addition	Altered (mandatory)
Raised Floor Over Crawl Space or Over Exterior	R-19 in 2x6 16" o.c. wood framing	R-19 in 2x6 16" o.c. wood framing
Slab-on-Grade: Unheated	CZ1-15: R-0 CZ16: R-7 16" vertical	R-0

Proposed Design Floor Type	Addition	Altered (mandatory)
Slab-on-Grade: Heated	CZ1-15: R-5 16" vertical CZ 16: R-10 16" vertical	CZ1-15: R-5 16" vertical CZ 16: R-10 16" vertical
Raised Concrete Slab	CZ1,2,11,13,14,16: R-8 CZ3-10: R-0 CZ12,15: R-4	R-0

Source: California Energy Commission

6.12.4.9 Thermal Mass

STANDARD DESIGN

The standard design for thermal mass in existing plus addition plus alteration calculations is the same as for all newly constructed buildings as explained in 6.9.5.1 Internal Thermal Mass.

6.12.4.10 Air Leakage and Infiltration

STANDARD DESIGN

Standard design air leakage and infiltration is shown in Table 56: Standard Design for Air Leakage and Infiltration.

Table 56: Standard Design for Air Leakage and Infiltration

Proposed Air Leakage and Infiltration	Addition	Altered
Multifamily Buildings	7 ACH50	7 ACH50

Source: California Energy Commission

6.12.4.11 Space Conditioning System

STANDARD DESIGN

The standard design for space-conditioning systems is shown in Table 57: Standard Design for Space Conditioning Systems.

Table 57: Standard Design for Space Conditioning Systems

Proposed Design Space-Conditioning System Type	Addition	Altered
Heating System	Same as newly constructed.	For common areas, same as newly constructed. For dwelling units, proposed heating fuel type and equipment type/efficiency. If the existing equipment is electric resistance and none of the exceptions in Section 180.2(b)2Av are met, the Standard Design system shall be a heat pump meeting the same requirements as newly constructed.
Cooling System	Same as newly constructed.	Same as newly constructed.
Refrigerant Charge	CZ 2, 8-15: Yes CZ 1, 3-7, 16: No	Same as Addition

Source: California Energy Commission

6.12.4.12 Duct System

PROPOSED DESIGN

Duct insulation shall be based on the new or replacement R-value input by the user. Duct leakage shall be based on the tested duct leakage rate entered by the user or a default rate of 30 percent.

STANDARD DESIGN

Table 58: Standard Design for Duct Systems

Proposed Design Duct System Type	Standard Design
Altered or Extended Ducts serving existing space	CZ 1-2, 4, 8-16: Duct insulation R-8 and duct leakage of 15% CZ 3, 5-7: Duct insulation R-6 and duct leakage of 15%
New Ducts	CZ 1-2, 4, 8-16: Duct insulation R-8 and duct leakage of 12% CZ 3, 5-7: Duct insulation R-6 and duct leakage of 12%

Based on Table 180.2-C

Note 1: Refer to Section 180.2(b)2Aii for definition of an "Entirely New or Complete Replacement Duct System."

Source: California Energy Commission

6.12.4.13 Indoor Air Quality and Local Mechanical Ventilation

Indoor air quality (IAQ) requirements apply to an addition when either adding an entirely new dwelling unit that is not considered a junior accessory dwelling unit (JADU) or constructing an addition to an existing dwelling unit greater than 1,000 ft^2. When an addition to a dwelling unit with greater than 1,000 ft^2 of added conditioned floor area, the conditioned floor area of the entire dwelling unit is used to determine the required ventilation airflow. For additions with 1,000 ft^2 or less of added conditioned floor area, no IAQ requirements shall apply.

Alterations of IAQ systems include new or complete replacements of an existing system and component alterations only. An example of an IAQ system component is a fan serving an HRV system.

Dwelling unit air leakage test is not required for IAQ alterations or additions.

PROPOSED DESIGN

IAQ system type and specifications identified by the user or a default system based on the standard design for the system type. Identification of new or replacement kitchen ventilation system to identify compliance with local mechanical exhaust requirements.

STANDARD DESIGN

IAQ ventilation requirements for additions and alterations are the same as for newly constructed buildings for supply and balanced IAQ system types. Altered IAQ systems,

both complete replacement and altered components, can install an exhaust-only ventilation system if the existing system is exhaust-only.
Local kitchen mechanical exhaust requirements, when triggered by the user as part of the addition or alteration, are the same as newly constructed building requirements.

6.12.4.14 Water Heating System

STANDARD DESIGN

Table 59: Standard Design for Water Heater Systems

Proposed Design Water Heating System Type	Addition (adding water heater)	Altered
Multifamily Individual Water Heater for Each Dwelling Unit	Prescriptive water heating system for each dwelling unit (see 6.11 Domestic Hot Water (DHW))	Same as proposed fuel type, proposed tank type, mandatory requirements (excluding any solar)
Multifamily Central Water Heating System	Central water heating system (see 6.11 Domestic Hot Water (DHW))	Mandatory requirements of Section 110.3 only. Standard design system same as proposed design.

Source: California Energy Commission

6.13 Documentation

The compliance software shall be capable of displaying and printing an output of the energy use summary and a text file of the building features. These are the same features as shown on the Certificate of Compliance when generated using the report manager.

See public domain software user guide or vendor software guide for detailed modeling rules.