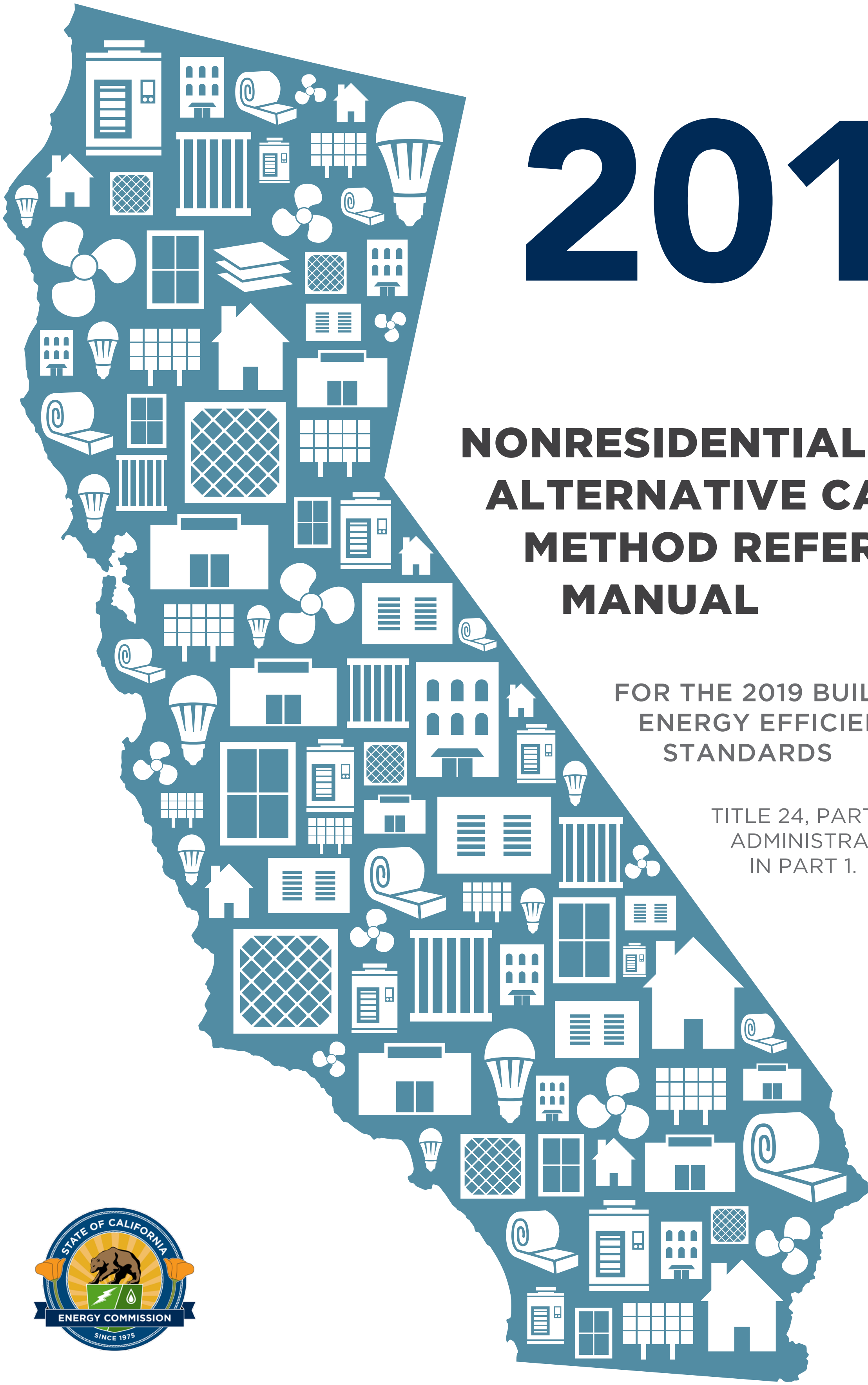

2019

NONRESIDENTIAL ALTERNATIVE CALCULATION METHOD REFERENCE MANUAL

FOR THE 2019 BUILDING ENERGY EFFICIENCY STANDARDS

TITLE 24, PART 6, AND ASSOCIATED ADMINISTRATIVE REGULATIONS IN PART 1.

MAY 2019
CEC-400-2019-006-CMF

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Acknowledgments

The *Building Energy Efficiency Standards* (Energy Standards) were first adopted and put into effect in 1978 and have been updated periodically in the intervening years. The Energy Standards are a unique California asset that have 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 2019 Energy Standards 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 *2019 Energy Standards* revision and the supporting documents were conceptualized, evaluated and justified through the excellent work of Energy Commission staff and consultants working under contract to the Energy Commission, supported by the utility-organized Codes and Standards Enhancement (CASE) Initiative, and shaped by the participation of over 150 stakeholders and the contribution of over 1,300 formal public comments.

We would like to acknowledge Commissioner Andrew McAllister and his adviser, Martha Brooks, P.E. for their unwavering leadership throughout the standards development. Larry Froess, P.E., who served as project manager and senior engineer of the nonresidential and residential alternative calculation methods; Payam Bozorgchami, P.E., who served as project manager and senior engineer for the 2019 Energy Standards; Bill Pennington, Special Advisor to the Efficiency Division, who provided overall guidance and contributed to the technical content of the Standards documents; Mazi Shirakh, P.E., who served as the senior engineer and senior technical lead for solar photovoltaic standards; Christopher Meyer, who served as the Manager for the Buildings Standards Office; Peter Strait, who served as the supervisor for the Standards Development Unit; Todd Ferris, who served as the supervisor for the Standards Tools Unit; Rebecca Westmore, Matt Chalmers, Jacqueline Moore and Galen Lemei, who provided legal counsel; and technical staff contributors of the Building Standards office including Mark Alatorre, P.E.; Courtney Jones; Simon Lee, P.E; Jeff Miller, P.E; Ronald Balneg; Adrian Ownby; Dee Anne Ross; Michael Shewmaker; Alexis Smith; Danny Tam; Gabriel Taylor, P.E.; RJ Wichert; Thao Chau; and Ingrid Neumann. Kristen Driskell, while serving as Appliances and Outreach and Education Office Manager, provided legal counsel to the staff. Additional staff input and assistance came from the Energy Hotline staff and the Energy Commission's web team.

Critical support for the staff in conceptualizing, evaluating, and reviewing this document came from NORESCO, L'Monte Information Services, Gard Analytics, National Renewable Energy Laboratory, Hitchcock Consulting, 360 Analytics, Wrightsoft Corporation, Taylor Engineering, McHugh Energy, Gabel Associates, Energy Solutions, E3, PECI, Heschong Mahone Group, and the Codes and Standards Enhancement (CASE) initiative which is supported by a consortium of California utility providers which includes the Pacific Gas and Electric Company, Southern California Edison Company, San Diego Gas and Electric Company, Southern California Gas Company, the Sacramento Metropolitan Utility District, and the Los Angeles Department of Water and Power.

ABSTRACT

The California Energy Commission's *2019 Building Energy Efficiency Standards for Nonresidential Buildings* allow compliance by either a prescriptive or performance method. The performance compliance approach uses computer modeling software to trade off efficiency measures. Performance compliance is typically the most popular compliance method because of the flexibility it provides in building design.

Compliance software must be certified by the Energy Commission, following rules established for modeling software. This document establishes the rules for the process of creating a building model, describing how the proposed design (energy use) is defined, how the standard design (energy budget) is established, and ends with what is reported on the Performance Compliance Certificate (PRF-01). This *Nonresidential Alternative Calculation Method Reference Manual* explains how the proposed and standard designs are determined. This document also establishes the procedure for performance calculation, necessary rule sets, reference method for testing compliance software accuracy, and the minimum reporting requirements.

The 2019 compliance software is the simulation and compliance rule implementation software specified by the Energy Commission. The compliance manager, called California Building Energy Code Compliance (CBECC), models all energy performance features affecting compliance of a building. To describe CBECC, this manual is divided into sections which describe how components, such as a wall or window, are modeled for the proposed design and standard design. This manual also describes how these components are reported on the Performance Compliance Certificate (PRF-01) for verification by the building enforcement agency.

Keywords: ACM, Alternative Calculation Method, Building Energy Efficiency Standards, California Energy Commission, California Building Energy Code Compliance, CBECC, Performance Compliance Certificate (PRF-01), compliance manager, compliance software, computer compliance, energy budget, Time Dependent Valuation (TDV), energy standards, energy use, prescriptive compliance, performance compliance, design, proposed design, standard design, VRF

Please use the following citation for this report:

Payam Bozorgchami, P.E., Todd Ferris, Larry Froess, P.E., Simon Lee, Jeff Miller, P.E., Michael Shewmaker, Maziar Shirakh, P.E., Danny Tam, RJ Wichert. *2019 Nonresidential Alternative Calculation Method Reference Manual*. California Energy Commission, Building Standards Office. CEC-400-2019-.

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1. Overview

1.1 Purpose

The *Nonresidential Alternative Calculation Method (ACM) Reference Manual* explains the requirements for approval of nonresidential Title 24 compliance software in California. Approved software is used to demonstrate minimum compliance with the Energy Standards, CALGreen, or any metric approved by the Commission. The procedures and processes described in this manual are designed to provide consistency and accuracy while preserving the integrity of the process of compliance. This manual addresses software for nonresidential buildings, hotels and motels, and high-rise residential buildings as outlined in Title 24, Part 6, Subchapter 5, §140.1. A separate ACM reference manual applies to low-rise residential buildings. The approval process for nonresidential software programs is specified in Title 24, Part 1, §10-101 through §10-110 of the California Code of Regulations.

1.2 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 HVAC systems, lighting systems, and other systems. Sometimes these data are known with some certainty, and other times (for instance, for speculative buildings), it is necessary to make estimates. Some of these inputs are prescribed (they are fixed for both the proposed and standard design buildings and can't be changed), while others are defaults.

1.3 Scope

This manual is intended to be used as a both a reference for the modeling methods of the CBECC-Com software and as a guide to software programs seeking certification as Title 24 compliance software for nonresidential buildings.

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

1.4 Organization

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

Chapter	Description
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 both the standard design and the proposed design, and procedures for determining system types and equipment sizes.
3. Software Requirements	Requirements for the simulation engines and software shells used to make calculations, and special reporting requirements for non-standard building features.
4. Content and Format of Standard Reports	The content and organization of the standard reports produced by qualifying software.
5. Building Descriptors Reference	The acceptable range of inputs for the proposed design and a specification for the standard design.

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 section numbers in the main manual that reference the appendices.

1.5 Reference Method

The reference procedures and method described in this manual establish the basis of comparison for all software. The approval process ensures that a minimum level of energy efficiency is achieved regardless of the software used. This is accomplished by:

- Specifying a series of reference method comparison tests that candidate software passed.
- Specifying input that may vary for credit, and input that are fixed or restricted.
- Defining standard report output requirements.
- Certifying the software vendor requirements in this manual.

The *Nonresidential ACM Reference Manual* is an approved document, separate from the formally adopted ACM regulations. This approval gives the Energy Commission flexibility to incorporate new modeling procedures or features, or fix errata, within the code cycle. The document is said to be in continuous maintenance. Software may be certified with the capability of modeling specific building systems or features.

The Energy Commission's purpose in approving additional capabilities is to accommodate new technologies which have only begun to penetrate the market and new modeling algorithms. Newly added capabilities that evaluate measures already in relatively common use shall have their standard design for the measure based on the common construction practice (or the typical base situation) for that measure since common practice is the inherent basis of the standards for all measures not explicitly regulated. For example, the Commission has no interest in an optional capability that evaluates the energy effects of dirt on windows unless a new technology produces substantial changes in this aspect of a building relative to buildings without this technology. The burden of proof that an additional capability should be approved lies with the applicant.

Companion documents that are helpful in preparing software for certification include the latest editions of the following Energy Commission publications:

- Energy Efficiency Standards
- Appliance Efficiency Regulations
- Nonresidential Compliance Manual
- ACM Approval Manual
- Reference Nonresidential Appendices
- Reference Joint Appendices

In this manual the term "standards" means the *Building Energy Efficiency Standards,* Title 24, Part 6 of the California Code of Regulations. The term "compliance" means that a building design in an application for a building permit complies with the "standards" and meets the requirements described for building designs therein.

There are a few special terms that are used in this manual. The Energy Commission approves software for use in demonstrating compliance. Energy Commission approval means that the Commission accepts the applicant's certification that software meets the requirements of this manual. The proponent of candidate software is referred to as a *vendor*. The vendor shall follow the procedure described in this document to publicly certify to the Energy Commission that the software meets the criteria in this document for:

- Accuracy and reliability when compared to the reference method.
- 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 explicit technical criteria, Energy Commission approval will also depend upon the Commission'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 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 software. The Energy Commission will evaluate the probability of the measure actually being installed and remaining functional. The Commission shall also determine that the energy impacts of the features that the software is capable of modeling will be reasonably and accurately reflected in real building applications of those features. In particular, it is important that the software does not encourage the replacement of actual energy savings with theoretical energy savings due to tradeoffs allowed by the software.

For the vendor, the process of receiving approval of software includes preparing an application, working with the Energy Commission staff to answer questions from either Commission staff or the public, and providing any necessary additional information regarding the application. The application includes the four basic elements outlined below. Commission staff evaluates the software based on the completeness of the application and overall responsiveness to staff and public comment.

The four basic requirements for approval include:

1. Required capabilities.
   a) Software shall have all the required input capabilities explained in Chapter 2.
   b) Software shall meet software requirements and documentation requirements for applicable features supported by the software, as described in Chapter 3.
2. Accuracy of simulation.
   a) The software shall demonstrate acceptable levels of accuracy by performing and passing the required certification tests discussed in Appendix 3B.
   b) The software vendor conducts the specified certification tests in Appendix 3B, evaluates the results, and certifies in writing that the software passes the tests. The Energy Commission will perform spot checks and may require additional tests to verify that the proposed software is appropriate for compliance.
   c) When energy analysis techniques are compared, two potential sources of discrepancies are the differences in user interpretation when entering the building specifications, and the differences in the 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 software algorithms, the Energy Commission allows algorithms that yield equivalent results.
3. User's Manual.

   The vendor shall include a user's manual and/or help system that provides appropriate guidance for specifying inputs and running a simulation for compliance.
4. Program support.

   The vendor shall provide ongoing user and enforcement agency support as described in the *Nonresidential ACM Approval Manual*.

The Energy Commission may hold one or more public workshops with vendor participation to allow for public review of the vendor's application. Such workshops may identify problems or discrepancies that may necessitate revisions to the application.

Commission approval of software programs is intended to provide flexibility in complying with the standards. In achieving this flexibility, however, the software shall not degrade the standards or evade the intent of the standards to achieve a particular level of energy efficiency. The vendor has the burden of proof to demonstrate the accuracy and reliability of the software relative to the reference method and to demonstrate the conformance of the software to the requirements of this manual.

1.6 Compliance

1.6.1 Type of Project Submittal

Software shall require the user to identify the type of compliance for the project. The software shall require the user to choose one of the following options:

- New Building or Addition Alone. Software may do this by treating an addition alone as a new building, 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 software is approved for this optional capability).
- Alteration of Existing Building (if software is approved for this optional capability).

1.6.2 Scope of Compliance Calculations

For each building or separately permitted space, software shall also 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 Chapter 5. Reporting requirements are documented in Chapter 4. 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 that the proposed design is compared to. 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 chapter 5 of this manual.

1.6.3 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 Appendix JA2.

1.6.4 Time Dependent Valuation

The candidate software shall calculate the hourly energy use for both the standard design and the proposed design by applying a time dependent valuation (TDV) factor for each hour of the reference year. TDV factors have been established by the Energy Commission for residential and nonresidential occupancies, for each of the climate zones, and for each fuel (electricity, natural gas, and propane). The procedures for TDV energy are documented in Reference Appendix JA3.

1.6.5 Reporting Requirements for Unsupported Features

The compliance software shall meet required capabilities and pass applicable certification tests as defined in Appendix 3A, Appendix 3B, and Appendix 3C. While the vendor's software does not need to implement every modeling rule in the *ACM Reference Manual,* all software features, systems, components, and controls that are modeled must follow the modeling guidelines in the *ACM Reference Manual*. Vendors seeking certification for software programs to be used for Title 24 compliance should clearly state the extent of the capabilities of their 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.

1.7 Approval Process

1.7.1 Application Checklist

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

- Compliance Software Vendor Certification Statement. A copy of the statement contained in Appendix A, signed by the software vendor, certifying that the software meets all Energy Commission requirements, including accuracy and reliability when used to demonstrate compliance with the energy standards.
- Computer Runs. Copies of the computer runs specified in Chapter 3 of this manual on machine-readable form as specified in Chapter 3 to enable verification of the runs.
- Help System and/or User's Manual. The vendor shall submit a complete copy of the help system and/or software user's manual, including material on the use of the software for compliance.
- Copy of the Compliance Software and Weather Data. A machine-readable copy of the software for random verification of compliance analyses. The vendor shall provide weather data for all 16 climate zones.
- TDV Factor Documentation. The software shall be able to apply the TDV multipliers described in Reference Appendix JA3.
- Application Fee. The vendor shall provide an application fee of $1,000.00 as authorized by § 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 sent to:

Executive Director
California Energy Commission
1516 Ninth Street, MS-39
Sacramento, CA 95814-5512

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

Compliance Software Nonresidential Certification
California Energy Commission
1516 Ninth Street, MS-26
Sacramento, CA 95814-5512

Following submittal of the application package, the Energy Commission may request additional information under Title 24, Part 1, § 10-110. This additional information is often necessary due to 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

This manual addresses two types of software approval: full program approval (including amendments to programs that require approval) and approval of new program features and updates.

If software vendors make a change to their programs as described below, the change must be approved by the Energy Commission. Furthermore, any software change that affects the energy use calculations for compliance, the modeling capabilities for compliance, the format and/or content of compliance forms, or any other change that would affect compliance requires approval.

Changes that do not affect compliance, such as changes to the user interface, may follow a simplified or streamlined procedure for approval. To comply with this simpler process, the software vendor shall certify to the Energy Commission that the new program features do not affect the results of any calculations performed by the program; shall notify the Commission of all changes; and shall provide the Commission with one updated copy of the program and help system/user's manual. Examples of such changes include fixing logical errors in computer program code that do not affect the numerical results (bug fixes) and new interfaces.

1.7.2.1 Full Approval and Reapproval of Compliance Software

The Energy Commission requires program approval when candidate software has never been approved by the Commission, when the software vendor changes the program algorithms, or when any other change occurs that in any way affects the compliance results. The Commission may also require that all approved software be approved again whenever substantial revisions are made to the standards or to the Commission's approval process.

The Energy Commission may change the approval process and require that all software be approved again for several reasons, including:

- If the standards undergo a major revision that alters the basic compliance process, then software would have to be updated and reapproved for the new process.

- If new analytic capabilities come into widespread use, then the Energy Commission may declare them to be required software capabilities, and may require all software vendors to update their programs and submit them for reapproval.

When reapproval is necessary, the Energy Commission will notify all software vendors of the timetable for renewal, a new version of this manual will be published, and the Commission will provide instructions for reapproval.

Reapproval shall be accompanied by a cover letter explaining the type of amendment(s) requested and copies of other documents, as necessary. The timetable for reapproval of amendments is the same as for full program approval.

1.7.2.2 Approval of New Features and Updates

Certain types of changes may be made to previously approved nonresidential software through a streamlined procedure, including implementing a computer program on a new machine and changing executable program code that does not affect the results.

Modifications to previously approved software, including new features and program updates, are subject to the following procedure:

- The software vendor shall prepare an addendum to the compliance supplement or software user's manual when new features or updates affect the outcome or energy efficiency measure choices, describing the change to the software. If the change is a new modeling capability, the addendum shall include instructions for using the new modeling capability for compliance.
- The software vendor shall notify the Energy Commission by letter of the change that has been made to the software. The letter shall describe in detail the nature of the change and the reason it is being made. The notification letter shall be included in the revised compliance supplement or software user's manual.
- The software vendor shall provide the Energy Commission with an updated copy of the software and include any new forms created by the software (or modifications in the standard reports).

The Energy Commission will respond within 45 days. The Energy Commission may approve the change, request additional information, refuse to approve the change, or require that the software vendor make specific changes to either the compliance supplement addendum or the software program itself.

With Energy Commission approval, the vendor may issue new copies of the software with the compliance supplement addendum, and notify software users and building officials.

1.7.3 Challenges

Building officials, program users, program vendors, Energy Commission staff, or other interested parties may challenge any nonresidential software approval. If any interested party believes that a compliance program, an algorithm or method of calculation used in a compliance program, a particular capability, or other aspect of a program provides inaccurate results or results that do not conform to the criteria described in his manual, the party may challenge the program.

1.7.4 Decertification of Compliance Software Programs

The Energy Commission may decertify (rescind approval of) an alternative calculation method through the following means:

- All software programs are decertified when the Standards undergo substantial changes, which occur about every three years.
- Any software can be decertified by a letter from the software vendor requesting that a particular version (or versions) of the software 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 software according to the steps outlined below. The intent is to include a means whereby unfavorable software tests, serious program errors, flawed numeric results, improper forms, and/or incorrect program documentation not discovered in the certification process can be verified and use of the particular software version discontinued. In this process, there is ample opportunity for the Energy Commission, the software vendor, and all interested parties to evaluate any alleged problems with the software program.

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

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

Following is a description of the process for challenging software or initiating a decertification procedure:

1. Any party may initiate a review of 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 software and the program version number(s) that contain the alleged errors.
   - Identify concisely the nature of the alleged errors in the 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.
2. The Executive Director shall make a copy or copies of the initial written communication available to the software vendor and interested parties within 30 days.
3. Within 75 days of receipt of the written communication, the Executive Director may request any additional information needed to evaluate the alleged 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.

4. 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 software vendor, and interested parties. All parties will have 15 days after the workshop to submit additional information regarding the alleged program errors.
5. 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 software need not be decertified.
   - Submit to the Energy Commission a written recommendation that the software be decertified.
6. 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.
7. If the Commission approves the 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 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 software vendor may use the 180- to 210-day period outlined here to update the software program, get it reapproved by the Commission, and release a revised version that does not have the problems initially brought to the attention of the Energy Commission. The software vendor may wish to be the initiating party to ensure that a faulty program version is taken off the market.

1.8 Vendor Requirements

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

1.8.1 Availability to Energy Commission

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

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

1.8.2 Enforcement Agency Support

Software vendors shall provide a copy of the software user’s manual/help system to all enforcement agencies who request one in writing.

1.8.3 User Support

Software vendors shall offer support to their users with regard to the use of the software for compliance purposes. Vendors may charge a fee for user support.

1.8.4 Compliance Software Vendor Demonstration

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

2. General Modeling Procedures

2.1 General Requirements for User-Entered Data

2.1.1 General

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.

2.1.2 Building Envelope Descriptions

The user shall provide accurate descriptions for all building envelope assemblies including exterior walls, windows, doors, roofs, exterior floors, slab-on-grade floors, below-grade walls, and below-grade floors. The user shall provide data for all of the required descriptors listed in Section 5.5 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 as using multipliers. This specification would permit a circular form to be described as an octagon.

2.1.3 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 setpoints, 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 which sets the outdoor ventilation 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 building 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 Section 5.4 of this manual.

2.1.4 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 via the exceptional calculation method to the Energy Commission. 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 software vendor to pass the necessary acceptance tests and apply for approval for the new building feature(s).

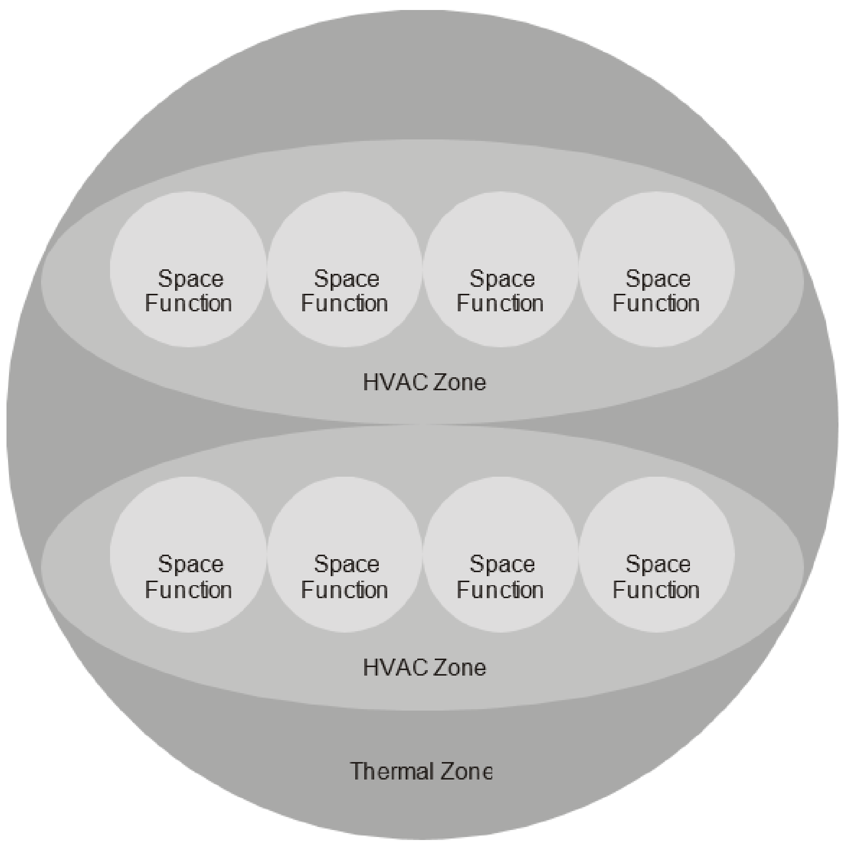
2.2 Thermal Zones, HVAC Zones, and Space Functions

2.2.1 Definitions

An *HVAC zone* is a physical space within the building that has a thermostat and zonal system for maintaining thermal comfort. 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 subcomponent of a thermal zone 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 which set outdoor air ventilation requirements documented in the ACM appendices. An HVAC zone may contain more than one space function. Appendix 5.4A lists the space functions that may be used with the software. Daylighted 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: NORESCO for California Energy Commission

2.3 Software Modeling Requirements for Zones

2.3.1 Required Zone Modeling Capabilities

For California compliance, software shall accept input for and be capable of modeling a minimum of 50 thermal zones, each with a control. Compliance software may use zone multipliers for identical zones.

2.3.2 Modeling Requirements for Unconditioned Spaces

Unconditioned space is enclosed space that is neither directly nor indirectly conditioned. Examples include stairways, warehouses, unoccupied adjacent tenant spaces, attached sunspaces, 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.

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.

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.

Indirectly conditioned spaces can either be 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.

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 or in separate zones. When located in the same thermal zone, the indirectly and directly conditioned spaces assumed to have the space temperature schedule. When indirectly conditioned space is assigned to its own thermal zone, the zone cannot have heating/cooling system, but can have a ventilation or exhaust system.

2.3.3 Space Use Classification Considerations

Thermal zones shall be combined only if the spaces have similar space conditioning requirements and operating schedules. Space function inputs, as how they translate to thermal zone and HVAC system analysis assumptions, are defined by the following rules:

Schedule Group: There are many different schedule groups defined in Appendix 5.4B for California compliance. Each schedule group defines building specific hourly profiles for thermostat setpoints, HVAC system availability, occupancy, lighting, and so forth.

Space Functions: Each building space is assigned one space function. Design internal loads and other space function input assumptions, including the assigned schedule group described above, are defined in Appendix 5.4A. The schedule group and the schedule values for each space function are prescribed for compliance analysis.

These space functions are common to many different building types and, therefore, the user can assign any of the available schedule groups defined in Appendix 5.4B. 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, default assumptions are defined in the Appendix 5.4B.

Thermal Zones: Spaces can be combined into thermal zones. In this situation, peak internal loads and other design inputs for the thermal zone are determined by weight-averaging the space function design inputs by floor area. When spaces are combined into thermal zones, the thermal zone schedules (occupancy, HVAC schedule, lighting schedule, space setpoint schedule), are based on the schedule group of the predominant space function on the building floor (by floor area) included in the thermal zone.

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. For systems that serve more than one thermal zone, the HVAC schedule group and availability schedule are determined by the most predominant schedule group (by floor area) represented in the thermal zones served.

The schedule group in the standard design is defined for each building story according to the predominant space function type and the schedule group assignment in Appendix 5.4A. Residential spaces and covered process spaces shall be served by dedicated systems, separate from nonresidential spaces.

2.4 Unmet Load Hours

This manual uses the term “unmet load hours” (UMLH) as a criterion for sizing standard design equipment and for other purposes. The concept of unmet load hours applies to thermal zones but is summed for hours whenever any conditioned thermal zone in the building has unmet loads. For a thermal zone, it represents the number of hours during a year when the HVAC system serving the thermal zone is unable to maintain the setpoint temperatures for heating and/or cooling. During periods of unmet loads, the space temperature drifts above the cooling setpoint or below the heating setpoint. A thermal zone is considered to have UMLH if the space is outside the throttling range for heating or cooling. The throttling range is defined in Chapter 5 as the space temperature difference between no cooling and full cooling, or between no heating and full heating. It is assumed that the cooling and heating setpoints are “centered” on the throttling range so that a cooling setpoint of 75°F results in an acceptable temperature band of 74°F to 76°F. The throttling range is fixed at 2°F for simulating both the standard design and proposed design.

An UMLH can occur only during periods when the HVAC system is scheduled to operate. UMLH are accounted for in each zone of the building. No zone in the building should exceed the maximum allowed UMLH.

UMLH can occur because fans, air flows, coils, furnaces, air conditioners, or other equipment are undersized. UMLH can also occur due to user errors, including mismatches between the thermostat setpoint schedules and HVAC operating schedules or from other input errors, for instance, high internal gains or occupant loads. The term, as used in this manual, addresses only equipment that is undersized. It is the responsibility of the user to address other causes of UMLH in the proposed design.

UMLH apply to thermal zones that contain any space type that is normally occupied. Thermal zones that contain only the space types listed below will not have UMLH applied to them:

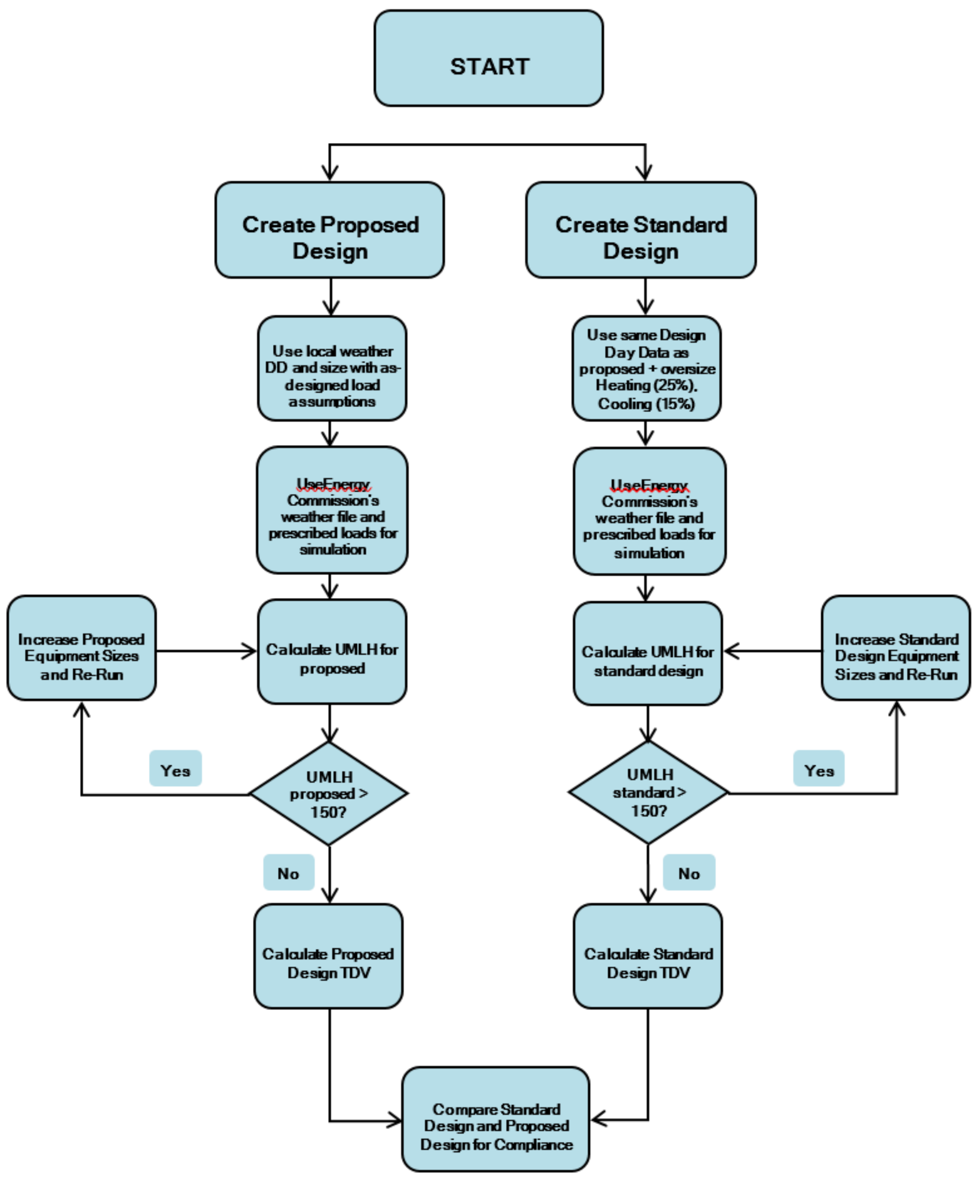
- Commercial and industrial storage areas

- Corridors, restrooms, stairs, and support areas
- Electrical, mechanical, telephone rooms
- Laundry rooms
- Locker/dressing rooms
- Parking garage areas
- Unoccupied gross floor areas
- Spaces that are not subject to any UMLH checks or restrictions are listed in Appendix 5.4A.

Calculation Procedures

The general calculation procedure is illustrated below in Figure 2. The proposed design *TDV* energy use is compared to the standard design.

Figure 2: Calculation Process for Title 24 Compliance



Source: NORESCO for 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. This information 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.
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 occupant density, equipment power density, ventilation rates, and water heating loads.
3. The next step is to make a simulation of the proposed design to determine how well the heating and cooling loads are being satisfied. The indicator is UMLH, 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 hours indicate that the equipment is undersized.
4. Test the number of UMLH in the proposed design and proceed only if the hours for each zone in the building are less than or equal to 150 for the year.
5. If the UMLH 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, other than the irregularly occupied space types listed above, may exceed 150 UMLH. If the problem is heating, then the size of the boiler or furnace may need to be increased. If the problem is cooling, then the size of the coils or chillers may need to be increased, or users can add a phantom cooling system by checking a box in the thermal zone “Add Cooling System to Meet Load”. In some cases, adjusting the zone airflows may also solve the UMLH issue. It is up to the designer to adjust equipment sizes as necessary.
6. If the UMLH are fewer than or equal to 150, then the final simulation is performed. If no changes are made in the model, this may be the same simulation in step 3. These calculations produce the results that are compared to the standard design, which is calculated in steps 7 through 16.
7. Create the standard design following the rules in this manual. The standard design has the same floor area, number of floors, and spatial configuration as the proposed design; however, systems and components are modified to be in minimum compliance with the standard design. The HVAC systems for the standard design are established according to rules in this manual and depend on the primary building activity (residential or nonresidential), the floor area, and the number of stories. See Section 5.1.
8. Sizing calculations are performed for the standard design and heating equipment is oversized by 25 percent and cooling equipment by 15 percent.
9. The number of unmet UMLH for the standard design is then tested to see if they are greater than 150 for any zone(s). This is not likely since the heating and cooling equipment is oversized by 15 percent for cooling, and 25 percent for heating in step 8.
10. If the UMLH in the standard design are greater than 150, then equipment capacity in the standard design is increased so that the unmet hours are fewer than or equal to 150. See the discussion below on how equipment sizes are increased.

11. Once the tests on UMLH are satisfied, then the energy consumption of the standard design is calculated. If the tests on unmet hours are satisfied the first time through, this step is the same as step 9.
12. Finally, the proposed design TDV energy use and standard design TDV energy use are compared for compliance.

2.5 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-air flow 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 inputs for space conditioning and report unmet load hours. Adequate capacities are required in the simulations of both the proposed design and standard design. The subsections below describe the procedures that shall be followed to ensure that both versions of the design are simulated with adequate space-conditioning capacities.

The UMLH requirement may be updated to prevent HVAC systems that show as undersized according to compliance software modeling constraints from receiving a compliance credit. This does not mandate that a specific cooling or heating capacity be specified; that is the role of the engineer of record for the building. With this change, if the proposed design appears as undersized, the user will be prompted to adjust plant, system, and/or zonal capacities as needed to meet the UMLH 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.

2.5.1 Specifying HVAC Capacities for the Proposed Design

As shown in Figure 2, the proposed design shall have no more than 150 UMLH for any thermal zone. If this limit is exceeded, the software allows the user to make changes to the proposed design building description to bring the UMLH equal to or below 150. This process is not automated by the software. There are two tests that must be met to avoid excess UMLH:

- Space loads must be satisfied. Space temperatures in all thermal zones must be maintained within one-half of the throttling range (1°F with a 2°F throttling range) of the scheduled heating or cooling thermostat setpoints. This criterion may be exceeded for no more than 150 hours for a typical year.
- System loads must be satisfied. Plant equipment must have adequate capacity to satisfy the HVAC system loads. This criterion may be exceeded for no more than 150 hours for a typical year.

If either the space or system loads do not meet the above 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. This occurs when the UMLH 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.

2.5.2 Sizing Equipment in the Standard Design

For sizing heating and cooling equipment capacities, the compliance software shall use design day schedules as specified in Section 5.3. For cooling capacity sizing, compliance software shall use the OnDay schedule from Appendix 5.4B for occupant, lighting, and equipment schedules, respectively. For heating capacity sizing, compliance software shall use the OffDay schedule from Appendix 5.4B for occupant, lighting, and equipment schedules, respectively.

Equipment in the standard design is automatically oversized by the program (25 percent for heating and 15 percent for cooling). If the automatic oversizing percentage is not sufficient to meet demands, then UMLH are evaluated at the building level by looking at the UMLH for each of the thermal zones being modeled. The zone with the greatest number of UMLH shall not exceed 150.

If the total number of UMLH for cooling and/or heating exceeds 150, then equipment capacities of cooling and/or heating equipment must be increased by the software incrementally.

1. The first step is to determine whether heating or cooling UMLH are the bigger problem. If heating UMLH are the bigger problem, upsize the heating equipment capacity. If cooling UMLH is the problem, upsize the cooling equipment capacity.
2. If the cooling is undersized, the equipment is resized by first increasing the design airflow of all zones with significant UMLH (greater than 150 for a zone) by 10 percent, then the equipment capacity for the system(s) serving the affected zones is increased to handle the increased zone loads. For a central plant, the chiller(s) and towers are resized proportionally to handle the increased system loads.

If heating is undersized, the same procedure is followed with zone terminal units resized first, heating equipment second, and finally boilers as necessary.

The capacity of the boiler or furnace shall be increased in 5 percent increments and the simulation rerun until the loads are met. For heat pumps, the capacity of the coil is increased so that the additional load is not met by auxiliary heat.

2.5.3 Handling Proposed Design with No HVAC Equipment

If a compliance model does not contain an HVAC system, and if the number of UMLH exceeds 150 hours for any zone, then the compliance software shall prompt the user to enter a cooling capacity for an HVAC cooling system. The system type and efficiency characteristics shall match that of the standard design system. 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.

2.6 Ventilation Requirements

Design decisions regarding outside air ventilation shall be based on Section 120.1 of the Energy Standards. If local codes do not apply, minimum values from Appendix 5.4A shall be used. Chapter 5.6 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. Compliance software must also follow all modeling rules specified in Chapter 5. The tests used to verify software functionality and accuracy of simulation results are referred to as the reference method. The tests fall into the following categories:

- Tests to verify that the software is evaluating thermal loads and the response of the HVAC systems to these loads in an acceptable manner. These tests reference *ASHRAE Standard 140-2007, Standard Method of Test for Evaluation of Building Energy Analysis Computer Programs*.
- Tests 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.
- Tests 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 is designed to cover representative 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 Chapter 5. The Energy Commission reserves the right to add ruleset implementation tests or software sensitivity tests to verify existing or future compliance software requirements. Moreover, the Energy Commission reserves the right to adjust the passing criteria for the software sensitivity tests to reflect the capabilities of commonly available energy simulation programs.

3.1 General Requirements

3.1.1 Scope

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

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 software shall be capable of performing design load calculations for determining required HVAC equipment capacities and air and water flow rates using accepted industry calculation methods for the standard design.

3.1.2.2 Checking Simulation Output for Unmet Loads

The software shall be capable of checking the output of the energy analysis module for the proposed design to ensure that space conditions are maintained within the tolerances specified (maximum of 150 thermal zone UMLH per year).

3.1.2.3 Adjusting Capacities

For the standard design building, the software shall be capable of modifying capacities, temperatures, or flow rates for standard design building HVAC system components causing excessive UMLH according to the procedures in Chapter 2.

3.1.2.4 Error Handling

The software shall send a warning to the user when unmet loads exceed 150 hours and provide information to the user describing the error that has occurred.

3.1.3 Climate Data

The compliance software shall perform simulations using the official Energy Commission weather files and design conditions documented in Joint Appendix 2.

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.

3.1.5 Time Dependent Valued (TDV) Energy

The compliance software shall be capable of applying the Energy Commission TDV multipliers for each hour of the simulation. See Energy Commission Joint Appendix 3.

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.

- Deadband 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, air flow 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 in adjacent thermal zones.

3.1.9 Control and Operating Schedules

The compliance software shall be capable of modeling control and operating schedules that can 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.

3.1.10 Loads Calculation

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

3.1.10.1 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.

3.1.10.2 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 defined in the Building Descriptors in Chapter 5.

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 or side fins.

3.1.10.3 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.

3.1.11 Systems Simulation

3.1.11.1 General

The compliance software shall be capable of modeling:

- The standard design building systems defined in Chapter 5.
- The lighting, water heating, HVAC, and miscellaneous equipment detailed in Chapter 5.
- All compulsory and required features, as detailed in Chapter 5.

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.

3.1.11.2 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 air flow to thermal zones.

3.1.11.3 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 air flow in variable air volume systems.

3.1.11.4 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.

3.1.11.5 Equipment Performance Curves

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

- Furnaces as a function of part load
- Boilers as a function of part load, supply hot water temperature, and return hot water temperature
- Water-cooled compressors including heat pumps and chillers 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 as a function of part load, ambient dry-bulb temperature, and wet-bulb temperature returning to the cooling coil
- Evaporative cooling systems as a function of ambient wet-bulb temperature
- Cooling towers as a function of range and ambient wet-bulb temperature

3.1.11.6 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 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

Complete lighting plans and space plans are required for the tailored method. Prescriptive compliance forms for the tailored method shall be developed and the plans examiner shall verify them.

Whenever any of the special allowance exceptions (footnotes in Standards Table 140.6-C) 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)

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 high-rise residential buildings and hotel/motel guest rooms.

If the modeled lighting power density (LPD) is different than the actual LPD calculated from the fixture schedule for the building, the compliance software shall model the larger of the two values for sizing the mechanical systems and for the compliance run. Compliance software shall report the larger value on PRF-01. Lighting levels schedules shall be adjusted by any lighting control credit watts, if input by the user.

Lighting power is not modeled in unconditioned spaces that are modeled 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 Setpoint

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 value 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 spaces, the software shall report an exceptional condition that the conditions in Section 120.1(c) of the energy standards must be met. Natural ventilation cannot be used to satisfy the requirements of 120.1(b) for high-rise residential buildings.

3.3 ASHRAE Standard 140-2007 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 pass ASHRAE 140-2014 tests, but these tests are not part of the reference method.

3.4 Ruleset Implementation Tests

3.4.1 Introduction

The tests in this section are intended to verify that the software correctly constructs the standard design model, and applies rules of the Nonresidential ACM appropriately to the proposed and standard design models. The ruleset implementation tests cover representative portions of the rules for building envelope, lighting, daylighting, space use data, and HVAC. For each test, a set of three models is defined:

- User Model – The user model contains the user inputs for the as-designed building. In most cases, the values for the proposed design will be taken from user inputs with no modification. However, there are some cases where the building input is prescribed for the proposed design, or constrained by mandatory minimums or other rules.
- Proposed Design Model – The proposed model is defined by the rules in the *ACM Reference Manual*, created by the vendor software, and is the building modeled for compliance. This model takes user inputs for building geometry, building envelope, lighting, and HVAC, and is used in the compliance simulation.
- Standard Design Model – This is the baseline model defined by the *ACM Reference Manual* modeling rules and is the basis for comparison that determines whether a building passes compliance using the performance method.

These tests do not require that simulation outputs be verified, but they do require that simulation input files for the proposed design and standard design are properly constructed according to the rules in the *ACM Reference Manual*. Some tests require that sizing runs be performed for HVAC inputs with values that are dependent on autosized standard design systems.

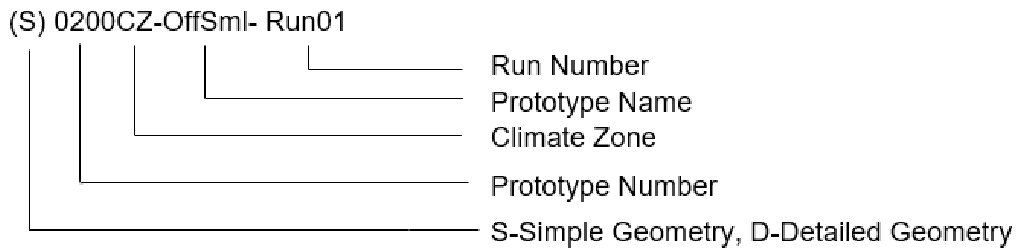
3.4.2 Overview

The test runs described in this section represent the Title 24 Nonresidential ACM code compliance calculation and use the following prototype models: small office building, medium office building, large office building, warehouse building, and small hotel. For further details on the prototype models, refer to Appendix 3C. Each standard design test case shall be created by modifying the prototype model as described in Section IV of this document. The modified prototype model shall form the proposed case for each test run. The standard design model shall be generated by compliance software as per the rules in the *Nonresidential ACM Manual*. The standard design and proposed model files for each test case shall then be evaluated to verify that:

- The standard design building envelope constructions are correctly substituted for exterior opaque surfaces and fenestrations.
- The fenestration area in the standard design building is reduced in accordance with the *Nonresidential ACM Manual*, when the proposed design fenestration area is greater than 40 percent of the exterior wall.
- The skylight area in the standard design building is adjusted in accordance with the *Nonresidential ACM Manual*, when applicable.
- Default schedules of operation are applied for both the standard design building and the proposed design building.
- The proposed and standard design cases use the same defaults, or tailored inputs, for internal loads as required by the *Nonresidential ACM Manual.*
- The standard design building lighting system is correctly specified.
- Receptacle loads and process loads are modeled according to the rules in the *Nonresidential ACM Manual.*
- The standard design building uses the correct system types as prescribed in Table 5 of the *Nonresidential ACM Manual*.
- An economizer (of the right type) is included in the standard design building, if required.
- The primary and secondary standard design building systems are properly specified and sized.
- Fan inputs are correctly specified for the standard design building.
- Prescribed modeling assumptions are applied for both the standard design building and the proposed design building.
- Conditioned, indirectly conditioned, and unconditioned spaces are modeled.
- Other standard design building specifications and/or modeling assumptions are correctly applied.

As the software developer verifies the various test conditions, the input and output files should be annotated with comments or other methods to demonstrate that the modeling rules specified in the *Nonresidential ACM Manual* are correctly applied. Software developers should use the spreadsheets included in Appendix 3C to report the results of these tests. These annotated files shall then be submitted to the Energy Commission for further evaluation. Any errors discovered shall be corrected by making modifications to the software, the runs shall be repeated, and the new results shall be annotated for submittal to the Commission.

The standard design tests are labeled using the format:



3.4.3 Ruleset Implementation Tests

The tests listed in Appendix 3C shall be performed to verify that the compliance software correctly creates the standard design model and applies modeling rules as per the requirements of the *Nonresidential ACM Reference Manual*.

The characteristics of the user model and inputs to be verified in the proposed and standard design models are described in Appendix 3C.

3.4.3.1 Results Comparison

The applicant shall perform all tests specified in Section IV and report the outputs in the forms provided in Appendix 3C. The standard design for some inputs, such as cooling efficiency and pump power, depend upon the autosizing of the HVAC equipment. The ruleset implementation tests do not check that the autosized capacity matches the reference method but that the standard design input is properly defined in relation to the autosized capacity.

3.5 Software Sensitivity Tests

This section details the eligibility requirements for an applicant simulation program for use as compliance software. A series of quantitative tests called software sensitivity tests shall be performed to measure the change in energy consumption when changing specified input parameters. Applicant software results will be compared against predetermined reference results to demonstrate that the applicant software is acceptable for use in code compliance. All the test cases described in Appendix 3A shall be performed and results summarized in the forms contained in Appendix 3B.

3.5.1 Overview

The applicant software shall perform a suite of software sensitivity tests to demonstrate that the performance is acceptable for code compliance. The applicant software test results shall be compared against a base case called the reference test case. The reference test case is the corresponding match of a particular test case simulated already on EnergyPlus engine. The reference test case results, as determined by the Energy Commission, are tabulated in Appendix 3B.

Test cases specific for simplified geometry are only for software with 2D inputs for building geometry. Software with a 2D geometry approach shall seek certification by submitting the simplified geometry test cases. In addition, they are also required to produce results for HVAC tests that will be compared against the HVAC reference test results that are common for both simplified and detailed geometry.

The test cases will assess the sensitivity of the applicant software to various inputs ranging from envelope thermal conductance to HVAC system performance. Each case tests the effect of the input component on building end-use energy and annual TDV. The following six building components will be tested through a series of tests:

- Opaque envelope
- Glazing
- Lighting
- Daylighting
- Receptacle loads
- HVAC system parameters

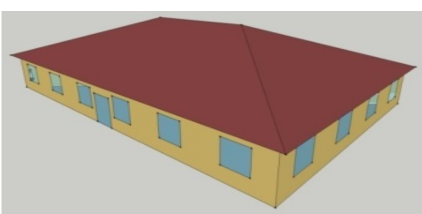
3.5.2 Prototype Models

The software sensitivity tests are performed on four prototype models that are a subset of the U.S. Department of Energy (DOE) prototype building models developed by PNNL for analysis of ASHRAE Standard 90.1. The prototype models are EnergyPlus model input files of the DOE prototype building models, modified to comply with the requirements of Title 24. The prototype models will be the reference baseline runs for the test cases. The applicant software shall replicate the building models below using the same inputs as the prototype models. The models so replicated will be the applicant baseline models for the test cases.

A summary of the prototype models is provided in Appendix 3A. Detailed input files of the reference baseline models are available from the Energy Commission's Building Energy Efficiency Software Consortium web page at http://bees.archenergy.com/.

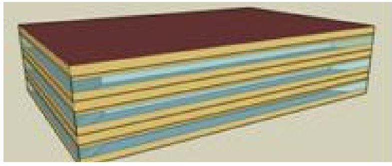
Prototype models used for software sensitivity test cases are:

- Small Office (02000CZ-OffSml):



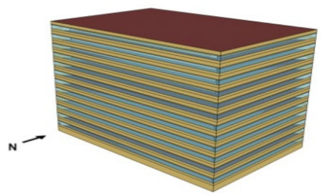
The small office building model is a single-story rectangular building of 5,500 square feet. It has punched windows and a hipped roof with an attic. There are five zones, each served by packaged single-zone air conditioner units. For more details refer Appendix 3A. This proptotype is used for simple geometry test cases only.

- Medium Office Building (0300CZ-OffMed):



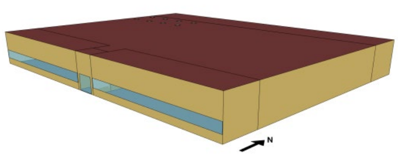
The medium office building model is a three-story rectangular building with an overall area of 53,600 square feet. It has a window-to-wall ratio of 33 percent with fenestration distributed evenly across all four façades. The zones are served by DX cooling and gas furnace heating with hot water reheat. For more details refer Appendix 3A. This prototype is used for both detailed geometry and simple geometry test cases.

- Large Office Building (0400CZ-OffLrg):



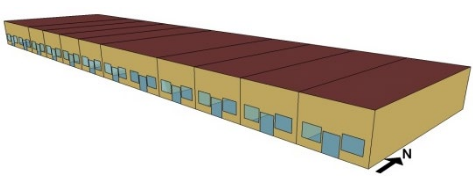
The large office building has 12 floors and a basement floor with glass windows with a window-to-wall ratio of 40 percent on the above-grade walls. The total area of the building is 498,600 square feet. The HVAC system type used is a variable air volume (VAV) system. For more details refer Appendix 3A.

- Stand-Alone Retail (0500CZ-RetlMed):



The stand-alone retail building is a single-story rectangular building measuring 178 feet by 139 feet. The total area is 24,695 square feet. Windows are located only on the street-facing façade and occupy 25.4 percent of that façade. The building is divided into five thermal zones that are served by packaged single-zone systems as described in Appendix 3A. This prototype is used for both detailed geometry and simple geometry test cases.

- Strip Mall Building (1000CZ-RetlStrp):



The strip mall building area is 22,500 square feet. It has 10 zones each with rooftop units. The building has windows in the street-facing façade and has an overall window-to-wall ratio of 10.5 percent. For more details refer to Appendix 3A.

3.5.3 Climate Zones

The software sensitivity test cases use building models for 5 of the 16 California climate zones. Most tests are performed with two or three climate zones to capture the sensitivity of the input characteristics to extremes in weather conditions. The test cases are performed in climate zones that represent mild, hot, and cold climates respectively.

Table 1: Climate Zones Tested

Climate Zone	Example City/Weather File
1	Arcata/ARCATA_725945
6	Torrance/TORRANCE_722955
7	San Diego Lindbergh/ SAN-DIEGO-LINDBERGH_722900
15	Palm Springs/PALM-SPRINGS-INTL_722868
16	Blue Canyon/BLUE-CANYON_725845

3.5.4 Labeling Test Runs

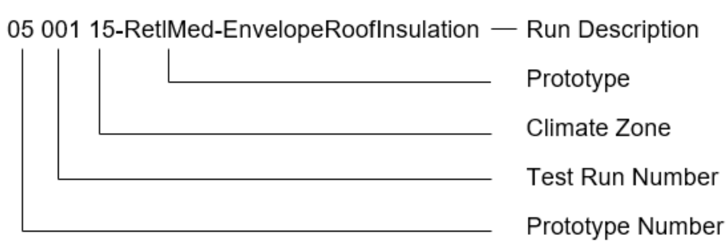
Each test case in the software sensitivity test is labeled uniquely to make it easier to keep track of the runs and to facilitate analysis. The following scheme is used:

XXYYYZZ-Prototype-RunDescription

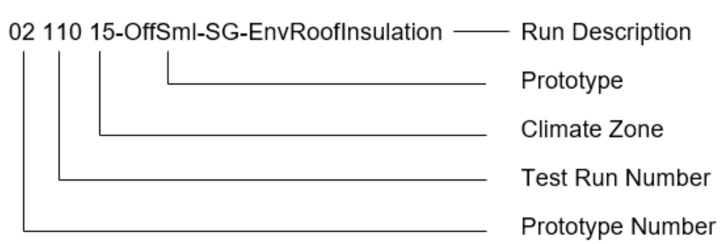
Where:

- XX denotes the Prototype Number
- YY denotes Test Run Number
- ZZ denote Climate zone

Detailed Geometry Example:



Simplified Geometry Example:



3.5.5 Test Criteria

Applicant software vendors shall perform a series of computer runs. Each of these runs shall be a systematic variation of the applicant base case model as described in Section 3.5.1.7. The applicant test case results will be compared to the reference results to verify that applicant software meets the requirements of the ACM. Simulation results for each test case will be compiled in forms provided in Appendix 3B. Compiled results will include annual site energy consumption for each end use, overall site energy consumption, total unmet load hours and annual TDV and percent variation of annual TDV and total end use site energy.

The annual TDV percent variation shall be calculated using the formula:

$TDV_{\%} = (TDV_b - TDV_n)/TDV_b$

Where, $TDV_{\%}$ is the TDV percent variation,

TDV_n is the annual TDV for test case number n and

TDV_b is the annual TDV for the base case run.

To be accepted, the applicant software should fulfill the passing criteria as determined by the Energy Commission:

> For each test case the change in energy for the test case must be in the same direction as the Reference Method test case result, and must be equal to the Reference Method test case percentage change in TDV energy, plus or minus 0.5 percent of baseline TDV energy.

If any of the tests required for the Title 24 compliance feature set fails to meet these criteria, the applicant software will not be accepted for compliance use.

3.5.6 Reporting Test Results

For each test case, the TDV energy use of the modeled building is reported (kBtu/ft^2), along with the TDV energy use attributed to the major fuel types (electricity, gas), site energy use, and energy end-use intensity for the regulated end uses (cooling, heating, lighting, and so forth). The following energy totals are reported:

1. Annual TDV EUI (kBtu/ft^2)
2. Annual Site EUI – Electricity (kWh/ft^2)
3. Annual SiteEUI – Natural Gas (therm/ft^2)
4. Annual Total End Use Site Energy EUI – kBtu/ft^2
   Site Energy End Uses
5. Site Energy: Heating (kBtu/ft^2)
6. Site Energy: Cooling (kBtu/ft^2)
7. Site Energy: Interior Lighting (kBtu/ft^2)
8. Site Energy: Interior Equipment (kBtu/ft^2)
9. Site Energy: Fans (kBtu/ft^2) (Airside Fans, does not include tower fans)
10. Site Energy: Pumps (kBtu/ft^2)
11. Site Energy: Towers (kBtu/ft^2)Water heating (kBtu/ft^2)
12. TDV percent Variation – this field is used for the compliance test
13. Total End Use Site Energy percent - percentage change in site energy use
14. Pass/Fail – test fails if it does not meet passing criteria
15. Unmet load hours (UMLH) – defined as the zone with the most UMLH
    a. Reference Model Occupied UMLH

b. Applicant Model Occupied UMLH
c. Reference Model Number of Zones with excess UMLH (>150)
d. Applicant Model Number of Zones with excess UMLH (>150)

Figure 3: Results Spreadsheet Excerpt from Appendix 3B

TEST RESULTS			11		12		13		14
					Variation from Baseline				
	Test Case	Btu/sqft)	Water Heating (kBtu/sqft)		TDV % variation		Total End Use Site Energy % Variation		Pass/Fail
		Applicant Model	Reference Model	Applicant Model	Reference Model	Applicant Model	Reference Model	Applicant Model	
	CZ15StandAloneRetailBaseline		**7.58**						
1	01CZ15StandAloneRetail Envelope RoofInsulation		7.57		2.52%		2.37%		Fail
2	02CZ15StandAloneRetail Envelope WallInsulation		7.58		0.74%		0.64%		Fail
3	03CZ15StandAloneRetail Envelope Heavy		7.57		-5.16%		-3.69%		Fail
	CZ16StandAloneRetailBaseline		**9.73**						
4	04CZ16StandAloneRetail Envelope RoofInsulation		9.73		2.01%		2.04%		Fail
5	05CZ16StandAloneRetail Envelope WallInsulation		9.73		0.55%		0.79%		Fail
6	06CZ16StandAloneRetail Envelope Heavy		9.72		-2.84%		-0.32%		Fail
	CZ06StandAloneRetailBaseline		**8.65**						
7	07CZ06StandAloneRetail Envelope RoofInsulation		8.65		0.81%		0.57%		Fail
8	08CZ06StandAloneRetail Envelope WallInsulation		8.65		0.49%		0.48%		Fail
9	09CZ06StandAloneRetail Envelope Heavy		8.64		-1.25%		0.72%		Fail
	CZ15MediumOfficeBaseline		**2.03**						
10	10CZ15MediumOffice Envelope FloorslabInsulation		2.03		-0.77%		-0.53%		Fail
11	11CZ15MediumOffice Envelope Infiltration		2.03		-0.26%		-0.29%		Fail

Source: NORESCO for California Energy Commission

The results spreadsheet provides the results of the reference method for each test and provides a column (in orange) for the vendor to report the results from the candidate compliance software.

The variation from baseline section of the spreadsheet shows the percentage change in TDV energy use (kBtu/ft^2) from the base case for testing. The percentage must be within the passing criteria for the candidate software to pass this test.

Also reported is the number of UMLH during occupied hours for the building. An UMLH for a specific zone in Title 24 compliance is defined as any hour when the zone has an unmet cooling or heating load. This is typically reported by the software for each zone in the building. For the test case results, two unmet load hour metrics must be reported: the number of UMLH for the zone with the greatest number of UMLH, and the number of zones that fail the *ACM Reference Manual* criteria for acceptable UMLH. (Any zones with greater than 150 hours fail the criteria.)

The spreadsheet where the results are documented indicates whether the candidate software passes or fails a test. The result in column AL of the spreadsheet indicates whether the candidate software passes the test.

3.5.7 Software Sensitivity Test Cases

Test cases assess the energy impact of one or more of the building or system input characteristics on the baseline model. Each test suite consists of a series of unique test cases aimed to test the effect of a specific characteristic on building energy performance. Simulations are grouped according to test criteria and sub grouped based on the reference model type to allow for direct comparison of results. For each test case, the applicant software will modify the applicant baseline model with specific inputs as described in the test case description section.

The test cases are simulated on multiple California weather files to evaluate the sensitivity of the building or system input to extremes in climate. Results of the test case runs and the TDV percentage variation over the baseline run shall be compiled and compared against the reference results.

Detailed descriptions of the standard design models are provided in Appendix 3A. CBECC input files for all baseline and test case models are available from the Energy Commission's, Building Energy Efficiency Software Consortium web page http://bees.archenergy.com. Details on each test description can be found in Appendix 3A under the test criteria tab.

3.5.8 Results Documentation

The applicant shall perform simulations for all tests specified above. A detailed description of each test case is provided in Appendix 3A and report results in the forms is provided in Appendix 3B. Some of the prototype models have variants of the baseline model. These include 1) stand-alone duct loss baseline, a variant of the stand-alone retail model; 2) StripMall-PTAC model, a variant of StripMall-PSZ model; and 3) StripMall-Fan Coil model, a variant of StripMall-PSZ model. For details refer to Appendix 3A.

Three test cases are presented here as an example: one for building envelope, one for lighting and daylighting, and one for HVAC. The development of the other required test cases follows the same process.

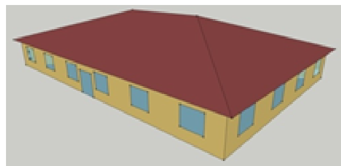
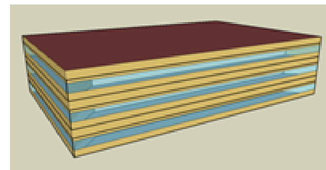
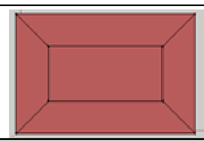
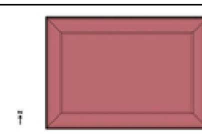
Example Test Case: 0301315-OffMed-GlazingWindowSHGC

For this test case, the U-factor and solar heat gain coefficient (SHGC) of all vertical fenestration is decreased by 20 percent. The prototype used for this test case is a medium office building.

Before the test cases are run, the first step is to generate the prototype models for the four reference buildings, which are required for all of the tests. The four prototype models are defined in the prototype model spreadsheet of Appendix 3A. (Note: While many of the prototype model inputs are based on Title 24 prescriptive requirements, the prototype models do not exactly conform to minimum Title 24 requirements but are intended to test the sensitivity of the candidate software simulation results to common variations in building inputs.)

Step 1. Generate prototype models. The first step is to generate the prototype building for the medium office building. The detailed specification of the medium office building is listed in Appendix 3A. A portion of the inputs are shown in Figure 4. The prototypes are defined for the reference models on the prototype model tab of Appendix 3A.

Figure 4: Prototype Model Definition from Appendix 3A

Prototype Description	**Small Office Building**	**Medium Office Building**
Vintage	New Construction	New Construction
Location	CZ-6/15/16	CZ-3/6/15/16
Fuel Type	gas, electricity	gas, electricity
Total Floor Area (sq feet)	5500 (90.8 ft x 60.5ft)	53600 (163.8 ft x 109.2 ft)
Building shape		
Aspect Ratio	1.5	1.5
Number of Floors	1	3
Window Fraction (Window-to-Wall Ratio)	24.4% for South and 19.8% for the other three orientations (Window Dimensions: 6.0 ft x 5.0 ft punch windows for all façades)	33% (Window Dimensions: 163.8 ft x 4.29 ft on the long side of facade 109.2 ft x 4.29 ft on the short side of the façade)
Window Locations	evenly distributed along four façades	evenly distributed along four façades
Shading Geometry	none	none
Azimuth	non-directional	non-directional
Thermal Zoning	Perimeter zone depth: 16.4 ft. Four perimeter zones, one core zone and an attic zone. Percentages of floor area: Perimeter 70%, Core 30%	Perimeter zone depth: 15 ft. Each floor has four perimeter zones and one core zone. Percentages of floor area: Perimeter 40%, Core 60%
		

Source: NORESCO for California Energy Commission

The prototype model definition in the spreadsheet contains links to other input definitions:

Rows 19, 26, 45: Links to layer-by-layer exterior construction assembly definitions in the *Construction Assembly* tab

Row 52: links to layer-by-layer interior construction assembly definitions in the *Construction Assembly* tab

Step 2. Define base case and variation for test run.

The base case is defined as the starting point for each test. In many tests, the base case will be one of the prototype models. However, in some cases a variation of the prototype may serve as the base case for the test.

For this test, the base case is found by looking at the test criteria tab of Appendix 3A.

Figure 5: Base Case Definition from Appendix 3A

Y4 | fx | Decrease U value & SHGC of windows by 20% compared to baseline case

	A	U	V	W	X
2	**Test Run Name**	**20CZ06MediumOffice Envelope FloorslabInsulation**	**21CZ06MediumOffice Envelope Infiltration**	**22CZ06MediumOffice Glazing WindowU**	**23CZ06MediumOffice Glazing WindowSHGC**
3	**Baseline**	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice
4	**Test Description**	Change Floor slab F factor to 0.45	Increase Exterior Wall Infiltration by 10% compared to baseline case	Decrease U value of windows by 20% compared to baseline case	Decrease SHGC of windows by 20% compared to baseline case
5	Location	CZ06	CZ06	CZ06	CZ06

Source: NORESCO for California Energy Commission

For this test, the baseline field in row 3 of the *Test Criteria* tab shows that the baseline is *CZ06MediumOffice*, the medium office prototype in Climate Zone 6.

This same *Test Criteria* tab shows the input(s) to be verified, which are highlighted in purple. For this test, the SHGC of all vertical fenestration is reduced by 20 percent, from 0.25 to 0.20.

Figure 6: Input Parameter Variation for Medium Office from Appendix 3A

A	U	V	W	X
Test Run Name	**20CZ06MediumOffice Envelope FloorslabInsulation**	**21CZ06MediumOffice Envelope Infiltration**	**22CZ06MediumOffice Glazing WindowU**	**23CZ06MediumOffice Glazing WindowSHGC**
Baseline	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice
Test Description	Change Floor slab F factor to 0.45	Increase Exterior Wall Infiltration by 10% compared to baseline case	Decrease U value of windows by 20% compared to baseline case	Decrease SHGC of windows by 20% compared to baseline case
Location	CZ06	CZ06	CZ06	CZ06
Dimensions		Refer MediumOffice		
Tilts and orientations				
Window				
Dimensions				
Glass-Type and frame				
U-factor (Btu / h * ft^2 * °F)			0.29	
SHGC				0.2
Visible transmittance				
Operable area				

Source: NORESCO for California Energy Commission

Step 3. Run the base case model and generate test results.

Once the base case model is developed, the simulation is run and the results are recorded onto the spreadsheet of test cases. See Appendix 3B.

The candidate software shall report electricity use by end use, gas use by end use, TDV energy, and UMLH. For compliance, UMLH are defined at the zone level, and the zone with the greatest number of UMLH must pass the criteria specified in the sizing procedure.

For the reference tests, the capacities and flow rates of the HVAC system can be found in Appendix 3A under the *Sizing Values* tab.

Step 4. Run the test case model (with the reduced SHGC) and report the results.

The model is rerun and the energy results and outputs are reported. The percentage change in energy use is reported.

Step 5. Report the change in regulated TDV energy use from the base case as a percentage change.

The reported percentage change in energy use from the candidate compliance software must fall within the passing criteria for the reference method.

4. Content and Format of Standard Reports

Consult the *Nonresidential Compliance Manual* for the reports required to be manually generated for any project. For nonresidential compliance, the PRF-01 report is generated by the software.

5. Building Descriptors Reference

5.1 Overview

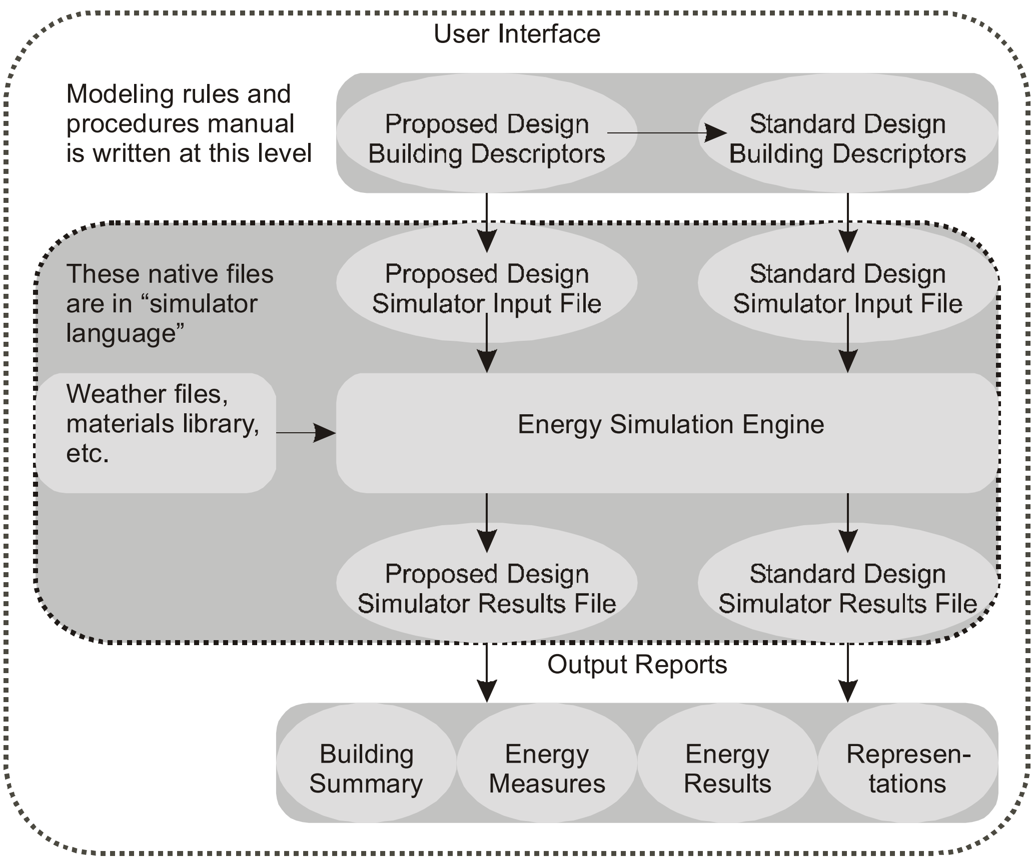
This chapter specifies, for each building descriptor, the rules that apply to the proposed design and to the standard design.

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 particular 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 IDF file. 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 7 illustrates the flow of information.

Figure 7: Information Flow



Source: NORESCO for California Energy Commission

5.1.2 HVAC System Map

The HVAC system in the standard design depends on the primary building activity, the size of the building, and the number of floors. Details about these systems are provided in subsequent sections.

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 HVAC system serving the proposed design and the standard design may be completely different, each with different components.

The HVAC system in the standard design shall be selected from Table 2: HVAC System Map, and be based on building type, number of floors, conditioned floor area, and heating source. Moreover, the selected system shall conform to the descriptions in Table 5: System Descriptions.

For systems 1, 2, 3, 7, 10, and 11, each thermal zone shall be modeled with a respective HVAC system. For systems 5, 6, and 9, each floor shall be modeled with a separate HVAC system. Floors with identical thermal zones and occupancies can be grouped for modeling. The standard design heating source is natural gas.

Table 2: HVAC System Map

Building Type	**Standard Design**
Residential or hotel/motel guestrooms in a building with seven or fewer floors above grade	System 1 - SZAC
Residential or hotel/motel guestrooms in a building with eight or more floors above grade	System 2 - FPFC
Retail building 2 floors or fewer	System 7 - SZVAV*
Warehouse and light manufacturing space types (per the Appendix 5.4A Schedule column) that do not include cooling in the proposed design	System 9 - HEATVENT
Covered process	See Table 4: System Map for Covered Processes
Healthcare Facilities	Same as the Proposed Design
All other space types	See Table 3: Nonresidential Spaces (Not Including Covered Processes)

Table 3: Nonresidential Spaces (Not Including Covered Processes)

Building Area	Floors	Standard Design	Description
< 25,000 ft^2	≤ 3 floors	System 7 - SZVAV*	Single Zone VAV
	4 or 5 floors	System 5 - PVAV	Packaged VAV Unit
	> 5 floors	System 6 - VAVS	Built-up VAV Unit
25,000 ft^2–150,000 ft^2	≤ 5 floors	System 5 - PVAV	Packaged VAV Unit
	> 5 floors	System 6 - VAVS	Built-up VAV Unit
>150,000 ft^2	Any	System 6 - VAVS	Built-up VAV Unit

* Single zone VAV (SZVAV) systems serving all space types except laboratories shall have a minimum fan speed ratio of 0.5 if the standard design total cooling capacity ≥ 65 kBtu/h, and a minimum fan speed ratio of 1 (constant volume) for a standard design total cooling capacity less than 65 kBtu/hr. SZVAV systems serving laboratory spaces shall have a minimum fan speed ratio of 0.2 for all standard design cooling capacities. SZVAV systems shall have an integrated economizer if the standard design cooling capacity exceeds 54 kBtu/h.

Retail building Standard Design rules shall apply to zones on floors (building stories) whose predominant space type is retail.

Table 4: System Map for Covered Processes

Building Type or Space Type	Floors	Standard Design System
Total computer room design cooling load is over 3,000,000 Btu/h Note: if the user chooses computer room for the space type and enters a receptacle load less than 20 W/ft^2, then the proposed and standard design shall use a receptacle load of 20 W/ft^2.	Any	System 10 – CRAH Unit
Computer rooms that do not meet the conditions for System 10, CRAH	Any	System 11 – CRAC Unit
Laboratory Space	Any	System 12 – LAB
Restaurant Kitchen	Any	System 13 – KITCH

Table 5: System Descriptions

System Type	**Description**	**Detail**
System 1 – SZAC	Residential Air Conditioner	Single zone system with constant volume fan, no economizer, DX cooling and furnace
System 2 – FPFC	Four-Pipe Fan Coil	Central plant with terminal units with hot water and chilled water coils, with separate ventilation source
System 3 – SZAC	Packaged Single Zone	Single-zone constant volume DX unit with gas heating
System 4 – RESERVED		
System 5 – PVAV	Packaged VAV Unit	VAV reheat system; packaged variable volume DX unit with gas heating and with hot water reheat terminal units
System 6 – VAVS	Built-up VAV Unit	Variable volume system with chilled water and hot water coils, water-cooled chiller, tower and central boiler
System 7 – SZVAV	Packaged Single-Zone VAV Unit	Single-zone variable volume DX unit with variable-speed drive and gas heating
System 8 – RESERVED		
System 9 – HEATVENT	Heating and Ventilation Only	Gas heating and ventilation
System 10 – CRAH	Computer Room Air Handler	Built-up variable volume unit with chilled water, no heating
System 11 – CRAC	Computer Room Air Conditioner	Packaged variable volume DX unit with no heating
System 12 – LAB	Laboratory HVAC System	Laboratory spaces in a building having a total laboratory design maximum exhaust rate of 15,000 cfm or less use Table 3, Nonresidential System Map. Laboratory spaces in a building with building floor area < 150,000 ft^2: System 5 – PVAV Laboratory spaces in a building with building floor Area ≥ 150,000 ft^2: System 6 – VAVS
System 13 – KITCH	Kitchen HVAC System	Dedicated single-zone makeup air unit (MAU) with dedicated exhaust fan. If the building is VAVS per Table 3, the cooling source is chilled water and the heating

		source is hot water. Otherwise, cooling source is DX and heating source is a gas furnace.

Residential (24-hour) occupancies in mixed-use buildings are served by separate standard design systems than 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 residential 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 20-ton computer room on each office floor, and residential on floors 5, 6, and 7 would have the following systems in the standard design:

- A KITCH serving the restaurant
- Retail spaces follow the system map, since the building has more than 2 stories
- A VAVS serving all office spaces
- Separate CRAC systems serving each computer room
- Separate FPFC systems serving each residential space

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

5.1.2.1 Additions and Alterations System Modification

For additions and alterations projects, the standard design building shall follow the same rules as the HVAC system map above, except that the building that will follow the logic of the system map rules may be the modeled building (the addition or alteration alone, or the addition or alteration and a portion of the existing building), or the entire building (the entire existing building, plus an addition, if present).

The decision on the existing building basis for applying the system map rules is:

The following rules apply to any building that has both heating and cooling systems.

1. Plant: If the change in plant cooling capacity exceeds 50 percent of the existing total cooling capacity of all cooling systems, the system map is based on the entire building characteristics. (See Section 5.2.2.)

2. Airside System: If the change in cooling capacity of the airside system (for example, air handling units, DX packaged units) of all cooling sources other than chilled water exceeds 50 percent of the existing rated cooling capacity for the building, then the HVAC system map is based on the entire building characteristics. Also, if the combined net cooling capacity of all altered airside systems exceeds 90 percent of the building cooling capacity, then the HVAC system map is based on the entire building characteristics.

3. Zone Level: If the change in the cooling capacity of the zonal systems (for example, SZAC units, FPFC units) exceeds 50 percent of the rated total cooling capacity of all zonal systems in the existing building, then the HVAC system map is based on the entire existing building characteristics. Also, if the combined net cooling capacity of all altered zonal systems exceeds 90 percent of the building cooling capacity, then the HVAC system map is based on the entire building characteristics.

4. If none of these three conditions apply, then the HVAC system map is based on the building characteristics of the modeled building for additions and alterations compliance, which may be just a portion of the entire building.

Since some additions and alterations projects will trigger the HVAC system map for the standard design, the user must enter a minimum set of building characteristics for the entire building (existing plus any addition); existing building floor area and number of stories must be entered.

Heating-Only System Modification

The following rules apply to any building that has only heating-only systems.

1. Plant: If the change in plant heating capacity exceeds 50 percent of the existing total space heating capacity of all heating systems, the system map is based on the entire building characteristics.

2. Airside System: If the change in heating capacity of the airside system (unitary DX equipment, heat pumps, for example) of all heating sources other than heating hot water exceeds 50 percent of the existing rated cooling capacity for the building, then the HVAC system map is based on the entire building characteristics. Also, if the combined net heating capacity of all altered airside systems exceeds 90 percent of the building heating capacity, then the HVAC system map is based on the entire building characteristics.

3. Zone Level: If the change in the heating capacity of the zonal systems (SZAC units, for example), exceeds 50 percent of the rated total heating capacity of all zonal systems in the existing building, then the HVAC system map is based on the entire existing building characteristics. Also, if the combined net cooling capacity of all altered zonal systems exceeds 90 percent of the building cooling capacity, then the HVAC system map is based on the entire building characteristics.

4. If none of these three conditions above apply, then the HVAC system map is based on the building characteristics of the modeled building for additions and alterations compliance, which may be just a portion of the entire building.

Since some additions and alterations projects will trigger the HVAC system map for the standard design, the user must enter a minimum set of building characteristics for the entire building (existing plus any addition): existing building floor area and number of stories must be entered.

5.1.3 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, i.e., 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. For example, heat recovery effectiveness is not applicable because the standard design (baseline building) does not have heat recovery.
Standard Design: *Existing Buildings*	Standard design for existing buildings if different than new buildings.

5.1.4 Special Requirements for Additions and Alterations Projects

Compliance projects containing additions and/or alterations 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 Chapter 5 of this manual do not have explicit definitions for the standard design when the project is an addition and/or alterations project. For these terms, the standard design rules for existing, altered components follow the same rule as the standard design rule for new construction.

For example, the receptacle loads are prescribed for both the proposed design building and standard design building for a new construction compliance project. For additions or alterations to an existing building, since the rules are not explicitly defined in the building descriptor in Section 5.3.3, 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 new construction 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:

1. 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 and/or alteration and the preexisting building is modeled as an adiabatic partition (an adiabatic wall, ceiling, roof or floor).
2. 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.
3. 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

5.2.1 General Information

Project Name	
Applicability	All projects
Definition	Name used for the project, if one is applicable
Units	Up to 50 alphanumeric characters
Input Restrictions	Input is optional for the proposed design
Standard Design	Not applicable

Building Location	
Applicability	All projects
Definition	Street address, city, state, and zip code
Units	Up to 50 alphanumeric characters on each of two lines
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	Up to 50 alphanumeric characters
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
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
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
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
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 (new construction, partial compliance or additions and alterations)
Units	List: **NewComplete:** new construction project **NewEnvelope:** new construction, partial compliance with envelope **NewEnvelopeAndLighting:** new construction, partial compliance with envelope and lighting **NewEnvelopeAndPartialLighting:** new construction, partial compliance with envelope and lighting compliance for some spaces **NewEnvelopeAndMechanical:** new construction, partial compliance with mechanical and envelope only **NewMechanical:** new construction, partial compliance with mechanical. This is the complement of a partial compliance with envelope and lighting, which should have already been performed. **NewMechanicalAndLighting:** new construction, partial compliance with mechanical and lighting only. The building should have already passed an Envelope Only partial compliance.

	NewMechanicalAndPartialLighting: new construction, partial compliance with mechanical and lighting compliance for some spaces. The building should have already passed an Envelope Only partial compliance. **ExistingAlteration:** alteration project **ExistingAdditionAndAlteration:** project with both additions and alterations **AdditionComplete:** an addition modeled alone **AdditionEnvelope:** an existing building with partial envelope compliance for a new addition **AdditionEnvelopeAndLighting:** an existing building with partial envelope and lighting compliance for a new addition **AdditionEnvelopeAndPartialLighting:** an addition to an existing building that includes the building envelope and lighting for some of the spaces. For the spaces with lighting defined in the proposed design, the space function type must be defined as well. For undefined spaces, the lighting status is “future” and both the proposed design and standard design are set to match the prescriptive lighting power limits. **AdditionEnvelopeAndMechanical:** an addition modeled with as-designed envelope and mechanical components, but the interior lighting design has not yet been defined. For this option, interior lighting must comply prescriptively. **AdditionMechanical:** an addition modeled with the as-designed mechanical system, including any plant, system or zone level equipment, as well as ventilation. For this option, all envelope and lighting components are modeled as defined by the user in both the proposed design and standard designs. **AdditionMechanicalAndLighting:** an addition modeled with as designed mechanical and lighting equipment. In this design, all building envelope components in the standard design are set to match those in the proposed design, since the envelope is assumed to have complied via a separate permit. **AdditionMechanicalAndPartialLighting:** an addition modeled with as designed mechanical equipment and with lighting systems defined for part of the building. This model is the complement to the AdditionEnvelopeAndParitalLighting compliance option, since Envelope and lighting compliance for the spaces not included in this compliance permit are assumed to have already been modeled (and permitted).
Input Restrictions	As designed
Standard Design	Same as proposed

5.2.2 Existing Building Classification

Existing Building Number of Stories	
Applicability	Additions and alterations
Definition	Total number of stories of the building (For information and reporting purposes only)
Units	Integer
Input Restrictions	As designed
Standard Design	Not applicable
Existing Buildings	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
Existing Buildings	Not applicable

5.2.3 Partial Compliance Model Input Classification

Earlier sections of this reference manual have described the available partial compliance scenarios. 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.

1) Envelope Only: The user specifies the building envelope and all spaces, space types, and thermal zones in the building. The standard design rules are applied to the envelope components. 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 new construction HVAC system map in Section 5.1.2.
2) Envelope and Lighting Only: The user specifies the building envelope, spaces, space types, thermal zones and all lighting, and any daylighting, where present. 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 new construction HVAC system map in Section 5.1.2.
3) Envelope and Mechanical Only: This compliance option assumes that the building will use separately permitted prescriptive lighting compliance. The user specifies the building envelope, spaces, space types, thermal zones, and mechanical systems in the building. For all lighting inputs, the proposed design values are prescribed and follow the rules for the standard design.
4) Envelope and Partial Lighting Only: This compliance option is used for projects where the building envelope is defined, and where the lighting in some of the spaces is defined. The user specifies the building envelope, all spaces, space types, thermal zones, and lighting for spaces with lighting systems defined, and any daylighting, where present. 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 new construction HVAC system map in Section 5.1.2.
5) Mechanical Only: 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. (For example, if the building vertical fenestration area exceeds prescriptive WWR limits, the limits are NOT applied to the standard design. Instead, the actual vertical fenestration area is used.) The mechanical systems of the proposed model are described as-designed, and the new construction rules and system map are applied to the HVAC system of the standard design.
6) Mechanical and Lighting Only: This compliance option assumes that the building has already been permitted for envelope compliance. All spaces and space types must be defined by the user, and all envelope components for the proposed design are "as designed" (must be defined by the user). The standard design lighting and HVAC components are set to match the standard design.
7) Mechanical and Partial Lighting Compliance: This compliance option assumes that the building has already been permitted for Envelope and Partial Lighting compliance (option 3 above). The envelope components, spaces and space types, and permitted lighting spaces are entered as designed for the proposed design and, for these components, the standard design is set to be the same as the proposed. For the other components as part of the permit application, the mechanical systems and new lighting systems are entered by the user for the proposed design as designed, and the standard design

components for the mechanical (HVAC) system and new lighting systems are defined by the new construction standard design rules.

8) Envelope and Partial Mechanical: For projects where mechanical systems are not defined for all thermal zones. When the "HVAC is Unknown" checkbox is enabled at the thermal zone, the proposed mechanical system for that zone will be defaulted to match the standard design. Possible uses for this compliance option include "core and shell" projects and existing/addition/alteration projects with unknown existing mechanical equipment.

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

Space Classification Type	
Applicability	All projects
Definition	One of two available classification methods for identifying the function of the building or the functions of spaces within the building, which in turn determine energy-related requirements for the standard design. Appendix 5.4A lists the building classifications that are available under the area category method. The Area Category method uses a separate space classification for each space in the building according to its function. The Tailored Lighting method allows specification of function-specific illuminance level categories and space geometry to assign allowed lighting power, following section 140.6 of the Standards.
Units	List (See Appendix 5.4)
Input Restrictions	As designed
Standard Design	Same as proposed

5.2.5 Geographic and Climate Data

The following data needs to be specified or derived in some manner. 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 Appendix JA2.

Zip Code	
Applicability	All projects
Definition	California postal designation
Units	List (see Appendix 5.4)

Input Restrictions	None
Standard Design	Not applicable

Latitude	
Applicability	All projects
Definition	The latitude of the project site
Units	Degrees (°)
Input Restrictions	Not a User Input
Standard Design	Latitude of representative city from Reference Appendix JA2

Longitude	
Applicability	All projects
Definition	The longitude of the project site
Units	Degrees (°)
Input Restrictions	Not a User Input
Standard Design	Longitude of representative city from Reference Appendix JA2

Elevation	
Applicability	All projects
Definition	The height of the building site above sea level
Units	Feet (ft)
Input Restrictions	None
Standard Design	Elevation of representative city from Reference Appendix JA2

California Climate Zone	
Applicability	All projects
Definition	One of the 16 California climate zones
Units	List (see Reference Appendices JA2)
Input Restrictions	None
Standard Design	Same as proposed

City	
Applicability	All projects
Definition	The city where the project is located
Units	Alphanumeric string
Input Restrictions	None
Standard Design	Representative city from Reference Appendix JA2

Design Day Data	
Applicability	All projects
Definition	A data structure indicating design day information used for the sizing of the proposed system. Note: this information may not necessarily match the information used in the annual compliance simulation.
Units	Data structure: contains the following: Design DB (0.5%), mean coincident wet-bulb, daily range, day of year
Input Restrictions	The design day information is taken from one of the 86 pre-defined California weather files, for the location within the same climate zone that is closest to the proposed building’s location. (This is not input by the user.)
Standard Design	Not applicable

Weather File	
Applicability	All projects
Definition	The hourly (i.e., 8,760 hour 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. If multiple weather files exist for one climate zone then

	the weather file closest in distance to the proposed design and in the same climate zone shall be used.
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

<table>
<tr><th colspan="2">Local Terrain</th></tr>
<tr><td>Applicability</td><td>All projects</td></tr>
<tr><td>Definition</td><td>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.</td></tr>
<tr><td>Units</td><td>List: the list shall contain only the following choices:
<table>
<tr><td>Description</td><td>Exponent (α)</td><td>Boundary layer thickness, δ (m)</td></tr>
<tr><td>Flat, open country</td><td>0.14</td><td>270</td></tr>
<tr><td>Rough, wooded country, Suburbs</td><td>0.22</td><td>370</td></tr>
<tr><td>Towns and cities</td><td>0.33</td><td>460</td></tr>
<tr><td>Ocean</td><td>0.10</td><td>210</td></tr>
</table>
</td></tr>
</table>

	<table><tr><td>Urban, industrial, forest</td><td>0.22</td><td>370</td></tr></table> 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: Z = altitude, height above ground (m) V_z = wind speed at altitude Z (m/s) α = wind speed profile exponent at the site δ = wind speed profile boundary layer thickness at the site (m) Z_{met} = height above ground of the wind speed sensor at the meteorological station (m) V_{met} = wind speed measured at the meteorological station (m/s) α_{met} = wind speed profile exponent at the meteorological station δ_{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	Weather data should be representative of the long term conditions at the site
Standard Design	The standard design terrain should be equal to the proposed design

5.2.6 Site Characteristics

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 is 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 fuel source that is available at the site for water heating, space heating or other fuel purposes. For most buildings connected to a utility service, this will be natural gas.
Units	List
Input Restrictions	The following choices are available: Natural Gas Propane
Standard Design	Natural gas

5.2.7 Calendar

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 ten 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, the same heating and cooling setpoint, 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. High-rise residential and nonresidential buildings with identical floors served by like systems may be modeled with floor multipliers.

5.3.1 General Information

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	Not applicable

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	Not applicable

Thermal Zone Type	
Applicability	All projects
Definition	Designation of the thermal zone as a directly conditioned, unconditioned, or plenum (i.e., unoccupied but partially conditioned as a consequence of its role as a path for returning air) space.
Units	List: directly conditioned, unconditioned or plenum
Input Restrictions	The default thermal zone type is “directly conditioned.”
Standard Design	The descriptor is identical for the proposed design and standard design.

System Name	
Applicability	All projects
Definition	The name of the HVAC system that serves this thermal zone. The purpose of this building descriptor is to link the thermal zone to a system (child points to parent). Software can make this link in other ways.
Units	Text, unique
Input Restrictions	None
Standard Design	The standard design may have a different system mapping if the standard design has a different HVAC type than the proposed design.

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 are not assigned to other thermal zones.
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 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 it must 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 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 it must 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 software shall either model the occupant loads separate for each space and the heat gain for each time step of the analysis or it must 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.

5.4 Space Uses

Each thermal zone discussed above may be subdivided into spaces. This section 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 section. Daylit spaces should generally be separately defined by space type and/or orientation.

5.4.1 General Information

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. If lighting compliance is not performed, use either approach but actual LPDs cannot be entered for the spaces; the LPDs of the building match the standard design. 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. For unconditioned spaces, the user must enter “unconditioned” as the occupancy and ventilation; internal loads and uses are set to zero. Compliance software shall require the user to identify if lighting compliance is performed (lighting plans are included or have already been submitted).
Standard Design	Same as proposed
Existing Buildings	Same as proposed

Ventilation Space Function	
Applicability	All projects

Definition	A unique identifier for ventilation requirements. A given space type may have different ventilation functions available, which define the design ventilation rate and minimum ventilation rates for the space, and any exhaust air requirements.
Units	List (from Reference Manual Appendix 5.4A)
Input Restrictions	As designed (selection from list)
Standard Design	Same as the proposed
Existing Buildings	Same as proposed

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
Existing Buildings	Same as proposed

5.4.2 Infiltration

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 area (ft^2). Other methods require the specification of a maximum rate, which is modified by a schedule.
Units	List effective leakage area, component leakage, or air changes per hour
Input Restrictions	The component leakage area is prescribed; a fixed infiltration rate shall be specified and calculated as a leakage per 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. The required information will depend on the infiltration method selected above. For the effective leakage area method, typical inputs are leakage per exterior wall area in ft² or other suitable units and information to indicate the height of the building and how shielded the site is from wind pressures. Only zones with exterior wall area are assumed to be subject to infiltration.
Units	A data structure is required to define the effective leakage area model. Infiltration shall be calculated each hour using the following equation: $$Infiltration = I_{design} \cdot F_{schedule} \cdot (A + B \cdot \lvert t_{zone} - t_{odb} \rvert + C \cdot ws + D \cdot ws^2)$$ Where: $Infiltration$ = zone infiltration airflow (m³/s-m²) I_{design} = design zone infiltration airflow (m³/s-m²) $F_{schedule}$ = fractional adjustment from a prescribed schedule, based on HVAC availability schedules in Appendix 5.4B(unitless) t_{zone} = zone air temperature (°C) t_{odb} = outdoor dry bulb temperature (°C) ws = the wind speed (m/s) *A* = overall coefficient (unitless) *B* = temperature coefficient (1/°C) *C* = wind speed coefficient (s/m) *D* = wind speed squared coefficient (s²/m²)
Input Restrictions	For the proposed design, I_{design} shall have a fixed value of 0.0448 cfm/ft² (0.000228 m³/s-m²) times the gross wall area exposed to ambient outdoor air. A, B and D shall be fixed at zero. C shall be fixed at 0.10016 hr/mile (0.224 s/m). For nonresidential spaces with operable windows that do not have mechanical system interlocks, the CBECC software shall automatically increase infiltration to the space by 0.15 cfm/ft² whenever the outside air temperature is between 50°F and 90°F and when the HVAC system is operating. High-rise dwelling units are exempt from mechanical system interlocks.
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 0.0448 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	The infiltration schedule shall be prescribed based on the HVAC system operating schedules from Appendix 5.4B. 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 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. The implementation of the prescriptive requirement for interlocks for operable windows will model mixed mode ventilation as an increased infiltration rate when outside air conditions allow for nonresidential buildings only, excluding healthcare and high-rise residential buildings and spaces.
Standard Design	The infiltration schedule for the standard design shall be set equal to 1 when the HVAC system is scheduled off and 0.25 when the HVAC system is scheduled on.

5.4.3 Occupants

For space level information on occupancy, lighting, and plug load schedules, as well as occupant density, allowed lighting power density. Appendix 5.4A provides a table of allowed space types.

Fixed Seating in Space	
Applicability	All projects that have a space with fixed seating (such as a theater or auditorium)
Definition	This is a flag that indicates that the space has fixed seating. 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 high-rise residential, hotel/motel, unoccupied, and unleased tenant area spaces. The default is false.
Standard Design	Same as proposed

Existing Buildings	The number of occupants must be identical for both the proposed and standard design cases.

Dwelling Units per Space	
Applicability	High-rise residential projects
Definition	The number of residential living units within a single compliance model space
Units	positive integer
Input Restrictions	As designed
Standard Design	1
Existing Buildings	1

Number of Bedrooms	
Applicability	High-rise residential projects
Definition	The number of bedrooms per dwelling unit
Units	Integer
Input Restrictions	As designed but constrained to a minimum of 0 (studio) and a maximum of 5
Standard Design	Same as proposed
Existing Buildings	Same as proposed

Number of Occupants	
Applicability	High-rise residential projects
Definition	The number of people in a space. The number of people is modified by an hourly schedule (see below), 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.
Units	The number of people may be specified in an absolute number, ft²/person, or people/1000 ft².
Input Restrictions	The number of occupants is prescribed, and the values are given by Space Type in Appendix 5.4A, For high-rise residential spaces, 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.

Standard Design: Existing Buildings	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 impact on energy consumption.
Units	Btu/h specified separately for sensible and latent gains
Input Restrictions	The occupant heat rate is prescribed.
Standard Design	The occupant heat rate for the standard design shall be the same as the proposed design.
Standard Design: Existing Buildings	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	The occupant schedule is prescribed for California compliance. For California compliance, an appropriate schedule from Appendix 5.4B shall be used.
Standard Design	Occupancy schedules are identical for proposed and standard design buildings.
Standard Design: Existing Buildings	Same as proposed

5.4.4 Interior Lighting

The building descriptors in this section 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 multi-purpose 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	Indoor lighting power can be specified using the area category method or the tailored method. Area category method can be used for all areas of the building with space types listed in Appendix 5.4A. This method can be used by itself or with the tailored lighting method. Tailored lighting method can be used for spaces with primary function listed in Table 140.6-D of the standards. The tailored lighting method is intended to accommodate special lighting applications. The tailored lighting method can be used by itself for all areas of the building or with the area category method. For a given area only one classification type can be used.
Units	List
Input Restrictions	Only area category or tailored lighting are allowed
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

Table 6: Lighting Specification

Options: Lighting Classification Method	Area category method	Tailored lighting Method
Allowed combinations with other lighting classification methods	May be combined with tailored method in same building, but not in same space.	May be combined with area category method, in same building, but not in same space.
Allowed Regulated lighting power types	General lighting power Additional lighting power	General lighting power Wall display lighting power Floor display and task lighting power Ornamental/special effect lighting power Very valuable display case lighting power
Allowed Trade-offs	General lighting between conditioned spaces using area category method	General lighting between conditioned spaces using tailored method

	General lighting between conditioned spaces using area category and tailored method	General lighting between conditioned spaces using tailored and area category method
Exception: With the area category method, additional lighting power can be used only if the tailored lighting method is not used in any area of the building.		

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 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: a) For the area category method: 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. b) For the tailored lighting method: the sum of the proposed general lighting power and the proposed custom lighting 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. With the area category and tailored method regulated interior lighting power for each space will be the sum of general lighting power and allowed custom lighting power.

Standard Design: Existing Buildings	For alterations where less 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 new construction 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 also 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 spaces all using the area category method, between spaces all using the tailored lighting method and between spaces that use area category and tailored methods. See Table 6: Lighting Specification for details.
Standard Design	With the area category method, 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. With the tailored lighting method, general lighting power is the product of the lighting power density for the primary function type in Table 140.6-D of the standards and the floor area of the space. The lighting power density is given as a function of room cavity ratio (RCR) and interior illumination level in Table 140.6-G. No interpolation is allowed for this table. The general lighting power in the tailored method is calculated by the following steps: Step 1. Determine illumination level from Table 140.6-D by matching the primary function area in Table 140.6-D with the space type in Appendix 5.4A. Step 2. Calculate the room cavity ratio (RCR) by using the applicable equation in Table 140.6-F. Rectangular Rooms: RCR = 5 x H x (L+W) / (L x W) Irregular Rooms: RCR = 2.5 x H x P / A Where: L = length of room; W = width of room; H = vertical distance from the work plane to the centerline of the lighting fixture; P = perimeter of room, and A = area of room

	Step 3. Determine the general lighting in the space(s) using the tailored method by a look-up in Table 140.6-G, where the general lighting LPD is a function of illuminance level and RCR. No interpolation is allowed for this table. A space between two illuminance levels (for example, 150 lux) uses the applicable LPD from the next lower illuminance level (100 lux). The standard design uses the irregular room RCR equation for both simplified and detailed geometry models. 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 standards.
Standard Design: *Existing Buildings*	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: a) If the lighting status is "existing", then the standard design LPD is the same as the proposed design. b) If the lighting status is "new", then the standard design LPD is same as new construction. c) If the lighting status is "altered", then the standard design LPD is the same as new construction.

General Lighting Exceptional Power	
Applicability	Spaces that use the area category method; note that some exceptional allowances are only applicable to certain space types. See Table 140.6-C of the standards.
Definition	The standards provide an additional lighting power allowance for special cases. Each of these lighting system cases 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). There are eight lighting power allowances, as defined in the standards Table 140.6-C footnotes.
Units	Data structure. This input has eight data elements: 1. Specialized task work, laboratory (W/ft^2) 2. Specialized task work, other approved areas (W/ft^2) 3. Ornamental lighting (W/ft^2) 4. Precision commercial and industrial work (W/ft^2) 5. White board or chalk board lighting (W/linear foot) 6. Accent, display and feature lighting (W/ft^2) 7. Decorative Lighting (W/ft^2) 8. Videoconferencing studio lighting (W/ft^2)
Input Restrictions	As designed

Standard Design	The standard design general lighting exceptional power (GLEP) is given by the following equation: $$GLEP_{std} = \sum_{i-1}^{8} \min\left(GLEP_{prop,i} \times GLETA, GLEA_i \times GLETA_i\right)$$ Where: <table><tr><td>$GLEP_{std}$</td><td>The GLEP of the standard design</td></tr><tr><td>$GLEP_{prop,i}$</td><td>The proposed GLEP of the footnote allowance i in the data structure above, or in the footnotes to Table 140.6-C of the standards</td></tr><tr><td>$GLEA_i$</td><td>The general lighting exceptional allowance (GLEA) , which is the maximum allowed added lighting power in the rightmost column in Table 140.6-C of the standards; these allowances are, for GLEA1 through GLEA8, 0.2 W/ft^2, 0.5 W/ft^2, 0.5 W/ft^2, 1.0 W/ft^2, 5.5 W/linear foot, 0.3 W/ft^2, 0.2 W/ft^2 and 1.5 W/ft^2, respectively</td></tr><tr><td>$GLETA_i$</td><td>The general lighting exceptional task area (GLETA) for the ith exception, where the exception number corresponds to the area category exception number in the footnotes to Table 140.6-C of the standards</td></tr></table>
Standard Design: Existing Buildings	Not applicable

General Lighting Exceptional Task Area	
Applicability	Spaces that use area category method
Definition	The area associated with each of the exceptional lighting allowances in the GLEP building descriptor
Units	ft^2
Input Restrictions	As designed but cannot exceed the floor area of the space
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

White Board Length	
Applicability	Spaces that use area category method and take GLEP allowance #5
Definition	The linear length of the white board or chalk board in feet
Units	Ft
Input Restrictions	As designed
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

Custom Lighting Power	
Applicability	All spaces or projects that use the tailored lighting method
Definition	Custom lighting power covers lighting sources that are not included as general lighting, including task lighting, display lighting, and other specialized lighting designated in the footnotes to Table 140.6-C and lighting systems in Table 140.6-D of the standards. This lighting must be entered separately from the general lighting because it is not subject to tradeoffs. Software shall allow the user to input a custom lighting input for the allowed lighting system. If area category method is used, custom lighting power cannot be used if the tailored method is used for any area of the building. See Table 6: Lighting Specification for details.
Units	Watts
Input Restrictions	As designed
Standard Design	Same as proposed but subject to the maximum limits specified in the footnotes to Table 140.6-C and Table 140.6-D of the standards. For spaces using the tailored method, the maximum allowed custom power is defined by the following procedure: The standard design custom lighting power is calculated by the sum of the following four terms: 1) The product of the standard design wall display power and the standard design wall display length; 2) The product of the standard design floor and task lighting power and the standard design floor and task lighting area; 3) The product of the standard design ornamental and special effect lighting power, and the standard design ornamental and special effect lighting area; and 4) The product of the standard design very valuable display case power and the standard design very valuable display case area.

Standard Design: Existing Buildings	For alterations where less than 10 percent of existing luminaires have been modified, the standard design is the existing lighting condition before the alteration. If 10 percent or more luminaires have been altered, the custom lighting power for the standard design is the same as proposed, but subject to the limits specified in the footnotes to Table 140.6-C of the standards.

Wall Display Power	
Applicability	All spaces that use the tailored method
Definition	The lighting power allowed for wall display, as specified in standards Table 140.6-D, column 3
Units	W/ft
Input Restrictions	As designed
Standard Design	The standard design lighting power is the lesser of the proposed design wall display power or the limit specified in Table 140.6-D for the applicable space type.
Standard Design: Existing Buildings	Same as proposed

Wall Display Length	
Applicability	All spaces that use the tailored method
Definition	The horizontal length of the wall display lighting area using the tailored method for the space
Units	ft
Input Restrictions	As designed but this value cannot exceed the floor area of the space
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

Floor and Task Lighting Power	
Applicability	All spaces that use the tailored method
Definition	The lighting power allowed for floor display and task lighting, as specified in Table 140.6-D, column 4, of the standards
Units	W/ft^2
Input Restrictions	As designed

Standard Design	The standard design floor and task lighting power is the lesser of the proposed design floor and task lighting power or the limit specified in Table 140.6-D, column 4, for the applicable space type.
Standard Design: Existing Buildings	Same as proposed

Floor and Task Lighting Area	
Applicability	All spaces that use the tailored method
Definition	The lighting area that is served by the floor and task lighting defined using the tailored method for the space
Units	ft^2
Input Restrictions	As designed but this value cannot exceed the floor area of the space
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

Ornamental and Special Effect Lighting Power	
Applicability	All spaces that use the tailored method
Definition	The lighting power allowed for ornamental and special effect lighting, as specified in Table 140.6-D, column 5, of the standards
Units	W/ft^2
Input Restrictions	As designed
Standard Design	The standard design ornamental and special effect lighting power is the lesser of the proposed design ornamental and special effect lighting power or the limit specified in Table 140.6-D, column 5, for the applicable space type.
Standard Design: Existing Buildings	Same as proposed

Ornamental and Special Effect Lighting Area	
Applicability	All spaces that use the tailored method
Definition	The lighting area that is served by the ornamental and special effect lighting defined using the tailored method for the space
Units	ft^2

Input Restrictions	As designed but this value cannot exceed the floor area of the space
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

Very Valuable Display Case Lighting Power	
Applicability	All spaces that use the tailored method
Definition	The lighting power allowed for very valuable display case lighting, as specified in standards section 140.6(c)3L
Units	W/ft^2
Input Restrictions	As designed
Standard Design	The standard design very valuable display case lighting power is the lesser of: a) The product of the area of the primary function and 0.8 W/ft^2; b) The product of the area of the display case and 12 W/ft^2; or c) The proposed very valuable display lighting power.
Standard Design: Existing Buildings	Same as proposed

Very Valuable Display Case Lighting Area	
Applicability	All spaces that use the tailored method
Definition	The area of the very valuable display case(s) in plan view
Units	ft^2
Input Restrictions	As designed but this value cannot exceed the floor area of the space
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

Non-Regulated Interior Lighting Power	
Applicability	All projects
Definition	For California, §140.6(a)3 of the energy efficiency standards identifies non-regulated (exempted) lighting.
Units	W/ft^2 or Watts

Input Restrictions	As designed The non-regulated lighting power should be cross-referenced to the type of exception and to the construction documents. The default for non-regulated lighting power is zero.
Standard Design	The non-regulated 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	The lighting schedule is prescribed for California compliance. An appropriate schedule from Appendix 5.4B shall be used.
Standard Design	The non-regulated interior lighting in the standard design shall be the same as the proposed design.
Standard Design: *Existing Buildings*	Same as proposed

Tailored Lighting General Illumination Height	
Applicability	Spaces that have special tailored lighting power allowances
Definition	The illumination height is the vertical distance from the work plane to the centerline of the luminaire. This distance is used in the room cavity ratio (RCR) calculation which determines the allowed general lighting power density for a tailored lighting space.
Units	Ft
Input Restrictions	As designed
Standard Design	Same as proposed The illumination height, H, is used to calculate the RCR and therefore the standard design general lighting power. See general lighting power for details.
Standard Design: *Existing Buildings*	Same as proposed

Floor/Wall Display Mounting Height Above Floor	
Applicability	Spaces that have wall display or floor display lighting and tailored lighting power allowances
Definition	The mounting height of wall display or floor display lighting above the floor
Units	List one of four choices: 1) <10’-7” 2) 10’-7” – 14’-0” 3) >14’-0” – 18’-0” 4) > 18’-0”
Input Restrictions	As designed
Standard Design	As designed The entered value maps to Table 140.6-E of the standards, that provides an adjustment multiplier for the tailored lighting wall power allowance in Table 140.6-D. The multiplier is 1.15 if the mounting height is 12 ft to 16 ft, and 1.30 if greater than 16 ft. The compliance software uses this adjustment multiplier to set the standard design lighting power.
Standard Design: Existing Buildings	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: 1) Recessed with lens 2) Recessed/downlight 3) Not in ceiling
Input Restrictions	As designed
Standard Design	Recessed/downlight
Standard Design: Existing Buildings	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 one of three choices: a) Linear fluorescent b) Compact fluorescent lamp c) Incandescent d) Light emitting diode e) Metal halide f) Mercury vapor g) High pressure sodium
Input Restrictions	As designed
Standard Design	Linear fluorescent
Standard Design: *Existing Buildings*	Linear fluorescent

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 and location. Luminaires recessed into a return air plenum contribute more of their 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 of their heat to the space. Common luminaire type/space configurations are listed in Table 3, Chapter 18, 2009 ASHRAE Handbook of Fundamentals, summarized in Table 7. Typically the data will be linked to list of common luminaire configurations similar to Table 7 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 7 values based on the luminaire, fixture, and distribution type. Where lighting fixtures having 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 7 for recessed fluorescent luminaires without lens.
Standard Design: Existing Buildings	Same as new construction

Table 7: Light Heat Gain Parameters for Typical Operating Conditions
Based on Table 3, Chapter 18, 2009 ASHRAE Handbook – Fundamentals

Fixture Type	Luminaire Type	Return Type	Space Fraction	Radiative Fraction
Recessed with Lens	Linear Fluorescent	Ducted/Direct	1.00	0.67
		Plenum	0.45	0.67
Recessed/Downlight	Linear Fluorescent	Ducted/Direct	1.00	0.58
		Plenum	0.69	0.58
	CFL	Ducted/Direct	1.00	0.97
		Plenum	0.20	0.97
	Incandescent	Ducted/Direct	1.00	0.97
		Plenum	0.75	0.97
	LED	Ducted/Direct	1.00	0.97
		Plenum	0.20	0.97
	Metal Halide	Ducted/Direct	1.00	0.97
		Plenum	0.75	0.97
Non In Ceiling	Linear Fluorescent	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	CFL	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	Incandescent	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	LED	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	Metal Halide	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	Mercury Vapor	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	High Pressure Sodium	Ducted/Direct	1.00	0.54

		Plenum	1.00	0.54

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 Standards and which reduce lighting power more or less uniformly over the day can be modeled as power adjustment factors. Power adjustment factors represent the percent 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 standards. Controls for which PAFs are eligible are listed in Table 140.6-A of the standards and include: a) Occupancy Sensing Controls for qualifying enclosed spaces and open offices. b) Demand Response Controls – Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal for qualifying building types. c) Institutional tuning – lighting tuned to not use more than 85 percent of rated power, per Section 140.6 of the standards. d) Daylight 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,. e) Horizontal slats – interior or exterior horizontal slats on fenestration adjacent to daylit areas f) Light shelves – interior or exterior light shelves adjacent to daylit areas Clerestories are modeled as Power Adjustment Factors, and are 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 Buildings	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 top-lighted 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, taking into account 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 (mandatory) and secondary daylit zone (prescriptive) 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 as a penalty. See 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	When the installed general lighting power in the primary daylit zone exceeds 120W, daylighting controls are required, per the Title 24 mandatory requirements.
Standard Design	For nonresidential spaces, when the installed general lighting power in the skylit or primary sidelit daylit zone exceeds 120W, daylighting controls are required in the primary daylit zone, per the Title 24 mandatory requirements. For parking garages, when the installed general lighting power in the primary sidelit or secondary sidelit daylit zone exceeds 120W, daylighting controls are required, per the Title 24 mandatory requirements. Luminaires located in daylit transition zones or dedicated ramps are exempt from this requirement. For nonresidential spaces, daylighting controls are specified when the installed general lighting power in the skylit, primary sidelit, or secondary sidelit daylit zone(s) exceeds 120W.

	For parking garages, when the installed general lighting power in the primary sidelit or secondary sidelit daylit zone exceeds 120W, daylighting controls are required. Luminaires located in daylit transition zones or dedicated ramps are exempt from this requirement.
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 new construction.

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	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 Section 5.5.7 of this manual are applied.
Standard Design: Existing Buildings	Same as new construction when skylights are added/replaced and general lighting altered

Installed General Lighting Power in the Primary and Skylit Daylit Zone	
Applicability	All spaces
Definition	The installed lighting power of general lighting in the primary and skylit daylit zone. The primary and skylit daylit zone shall be defined on the plans, and be consistent with the definition of the primary and skylit daylit zone in the standards. 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 new construction when skylights 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 standards. 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	W
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 new construction when skylights 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. **RDP:** 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.

	Skylit Daylit Zones	Primary Sidelit Daylit Zones	Secondary Sidelit Daylit Zones

Illuminance Setpoint	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
≤ 200 lux	3927	0	3051	1805	-0.40	3506	7044	-3.32	1167
≤ 1000 lux	12046	0	-421	6897	-7.22	475	1512	-2.88	-22
> 1000 lux	5900	0	-516	884	-5.85	823	212	-0.93	57

Illuminance Setpoint: This is defined by the user, and is entered 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:

EA_{dz} Is the combined effective aperture of all daylight sources illuminating a specific daylit zone.

VT_{fdz} Is the user specified visible transmittance of the fenestration object directly associated with the daylit zone.

A_{fdz} Is the area of the fenestration object directly associated with the daylit zone.

VT_i Is the user specified visible transmittance of the fenestration object associated with each intersecting daylit zone.

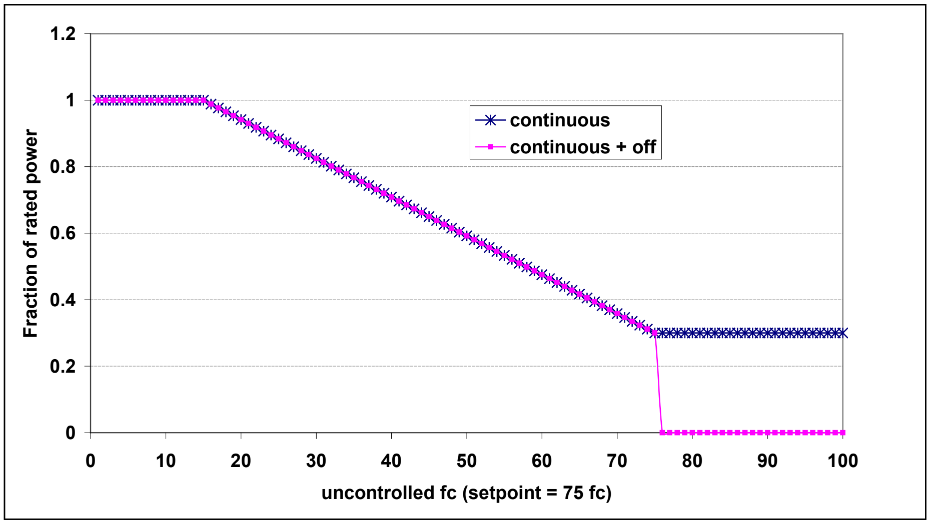
	A_i Is the area of the fenestration object directly associated with each intersecting daylit zone. F_i Is the fraction of intersecting area between the daylit zone in question and each intersecting daylit zone: $$F_i = A_{intersection}/A_{dzi}$$ A_{dzi} Is the area of each intersecting daylit zone (including area that might fall outside a space or exterior boundary). 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 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*	Additions or alternations of lighting in spaces trigger the daylighting control requirements whenever the total installed lighting in the daylit zone is 120 W or greater, and the reference positions shall be determined in the same manner as with new construction. This only applies when alterations or additions to the lighting in an existing building trigger daylighting control requirements.

Illumination Adjustment Factor	
Applicability	All Daylighted 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 new construction when skylights are added/replaced and general light is altered.

Fraction of Controlled Lighting	
Applicability	Daylighted 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 for primary and skylit daylit zone, and fraction for secondary zone
Input Restrictions	As designed for secondary daylit areas. If the proposed design has no daylight controls in the secondary daylit area the value is set to 0 for the general lights in the secondary daylit area. Primary and skylit daylit area fraction of controlled general lighting shall be as designed when the daylight control requirements building descriptor indicates that they are not required, and shall be 1 when controls are required.
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.
Standard Design: Existing Buildings	Same as for new construction when skylights are added/replaced, and general light is altered.

Daylighting Control Type	
Applicability	Daylighted 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 vary the electric input power and lighting output power in discrete equally spaced steps. At each step, the fraction of light output is equal to the fraction of rated power. • Continuous dimming controls have a fraction to rated power to fraction of rated output that is a linear interpolation of the minimum power fraction at the minimum diming light fraction to rated power (power fraction = 1.0) at full light output. See Figure 8: Example Continuous Dimming Control

	Continuous dimming + off controls are the same as continuous dimming controls except that these controls can turn all the way off when none of the controlled light output is needed. See the example control chart below. Figure 8: Example Continuous Dimming Control  Source: NORESCO for California Energy Commission
Units	List (see above)
Input Restrictions	As designed
Standard Design	Standard design uses continuous daylighting control.
Standard Design: Existing Buildings	Same as for new construction when skylights are added/replaced, and general light 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	As designed, specified from luminaire type (not a user input)
Standard Design	Standard design uses continuous dimming control with a minimum dimming power fraction from Table 8: Standard Design Power/Light Output Fraction. Where the controlled luminaire type, input by the user, determines the minimum dimming power fraction.
Standard Design: Existing Buildings	Same as for new construction when skylights are added/replaced, and general light 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	As designed
Standard Design	Standard design uses continuous dimming control with a minimum dimming light fraction from Table 8: Standard Design Power/Light Output Fraction. Where the controlled luminaire type, input by the user, determines the minimum dimming power fraction.
Standard Design: Existing Buildings	Same as for new construction when skylights are added/replaced, and general light is altered.

Table 8: Standard Design Power/Light Output Fraction

Light Source	**Power Fraction**	**Light Output Fraction**
LED	0.1	0.1
Linear Fluorescent	0.2	0.2
Mercury Vapor	0.3	0.2
Metal Halide	0.45	0.2
High Pressure Sodium	0.4	0.2
CFL	0.4	0.2
Incandescent	0.5	0.2

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/ft²) Compliance software shall also use the following prescribed values to specify the latent heat gain fraction and the radiative/convective heat gain split. For software that specifies the fraction of the heat gain that is lost from the space, this fraction shall be prescribed at 0. Heat Gain Fractions:
Input Restrictions	Prescribed to values from Appendix 5.4A
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as for new construction

Heat Gain Fractions:

	Radiative	Latent	Convective
Receptacle Power	0.20	0.00	0.80
Gas Equipment Power	0.15	0.00	0.00

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	Prescribed to schedule in Appendix 5.4A
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as for new construction

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 standard design power matching the proposed design.

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. Two methods are included in this manual: • Title 24 defaults. With this method, the power density values provided in Appendix 5.4A[1] 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 new construction

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	W/ft^2

[1] See Table C-43, p. 146 of NREL/TP-550-41956, Methodology for Modeling Building Energy Performance across the Commercial Sector, Technical Report, Appendix C, March 2008. The values in this report were taken from Table 8-3 of the California Commercial End-Use Survey, Consultants Report, March 2006, CEC-400-2006-005

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 defaults are used.
Standard Design: Existing Buildings	Same as for new construction

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.[2] Buildings up to about five to seven stories typically use hydraulic elevators because of their lower initial cost. Mid-rise buildings commonly use traction elevators with geared motors, while high-rise 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	W/unit
Input Restrictions	The power values are prescribed 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
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

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

Input Restrictions	The operating schedule is prescribed and indicated in Appendix 5.4B.
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	Not applicable

5.4.9 Process, Gas

Commercial gas equipment includes the following:

- Ovens
- Fryers
- Grills
- Other equipment

The majority of gas equipment is located in the space and may contribute both sensible and latent heat. Gas equipment is modeled by specifying the rate of peak gas consumption and a fractional schedule that is prescribed in Appendix 5.4B. 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.

The prescribed values are provided in Appendix 5.4A. Schedules are defaulted to be continuous operation.

Gas Equipment Power	
Applicability	All buildings that have commercial gas equipment
Definition	Commercial gas power is the average power for all commercial gas equipment, assuming constant year-round operation.
Units	Btu/h-ft² Compliance software shall also use the following prescribed values to specify the latent heat gain fraction and the radiative/convective heat gain split. For 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	Not applicable

Gas Equipment Schedule	
Applicability	All buildings that have commercial gas equipment
Definition	The schedule of operation for commercial gas equipment. This 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
Standard Design: Existing Buildings	Not applicable

Gas Equipment Location	
Applicability	All buildings that have commercial gas equipment
Definition	The assumed location of the gas equipment for modeling purposes.
Units	List (in the space or external)
Input Restrictions	As designed.
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	Not applicable

Radiation Factor	
Applicability	Gas appliances located in the space
Definition	The fraction of heat gain to appliance energy use
Units	Fraction
Input Restrictions	Default value is 0.15. Other values can be used when a detailed inventory of equipment is known. The override value shall be based on data in Table 5C, Chapter 18, ASHRAE HOF, 2009, or similar tested information from the manufacturer.
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	Not applicable

Usage Factor	
Applicability	Gas appliances located in the space
Definition	A duty cycle or usage factor to appliance energy use. The radiation factor and usage factor are used together to determine the sensible heat gain to the space: $Q_{sens} = Q_{input} \times F_U \times F_R$ Where Q_{input} is the heat input of the equipment in Btu/h or Btu/h-ft2, F_U is the usage factor and F_R is the radiation factor
Units	Fraction
Input Restrictions	Default value is 0.70. Other values can be used when a detailed inventory of equipment is known. The override value shall be based on data in Table 5C, Chapter 18, ASHRAE HOF, 2009, or similar tested information from the manufacturer.
Standard Design	Same as the proposed design
Standard Design: *Existing Buildings*	Not applicable

Gas Process Loads	
Applicability	Spaces with 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: sensible (Btu/h), latent (Btu/h)

Input Restrictions	Compliance software shall receive input for sensible and/or latent process load for each zone in the proposed design. The process load input shall include the amount 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 new construction

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 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 fraction shall be defaulted to 0.2 and the convective fraction shall be defaulted to 0.8 by the compliance software. 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 zone in the proposed design. The process load input shall include the amount of the process load (Btu/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 new construction

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 Process Load Schedule	
Applicability	All buildings that have commercial gas equipment
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 section 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
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 5.5A 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 5.5A are non-homogeneous, for instance, framing members with insulation in the cavity. The properties of each material layer can be found in ACM Appendix 5.5A.

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 5.5A. 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 5.5A
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 5.5A
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 5.5A
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 5.5A
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 5.5A. 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.

Geometry

The geometry of roofs, walls, floors, doors and fenestration should match the construction documents or as-built drawings as accurately as possible. Unusual curved surfaces such as a dome or semi-circular wall may be approximated by a series of constructions.

Mass Walls

For mass walls, the user first chooses the mass layer from Appendix 5.5A. After that, the user may select an insulating layer from Appendix 5.5A 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/ft^2. 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 Joint Appendix IV 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 new construction

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 new construction

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 standards. This descriptor can be derived from other building descriptors and it may not be necessary for the software user to specify it directly.
Units	List: attic and other roofs; metal building roofs; and roofs with insulation entirely above deck metal building, wood framed or other
Input Restrictions	Not applicable for new construction; 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 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 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 (office, retail, etc.)
Standard Design: Existing Buildings	Same as new construction

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	
Input Restrictions	For roofs that are part of new construction, 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: $\rho_{aged} = 0.2 + \beta \cdot (\rho_{init} - 0.2)$ Where, ρ_{aged} = the calculated aged reflectance β = 0.65 for field-applied coatings, 0.7 for all other roof surfaces ρ_{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: 1. Conforms to material standard ASTM D1863. 2. Conforms to ASTM D448, size number equal between No.6 and No.7. 3. 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 Building Energy Efficiency Standards.

	4. Has a label on bags or containers of aggregate stating that the materials conform to ASTM D1863 and ASTM D448.
Standard Design	For new construction, the standard design reflectance is defined in Table 140.3-B for nonresidential buildings, Table 140.3-C for high-rise residential buildings and hotel-motel buildings containing guestrooms, and Table 140.3-D for relocatable classroom buildings. For alterations to more than 50 percent of the roof area or roof areas above 2,000 ft², 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 of the standards.
Standard Design: *Existing Buildings*	Same as new construction

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	
Input Restrictions	For roofs, new construction: 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: 1. Conforms to material standard ASTM D1863. 2. Conforms to ASTM D448, size number equal between No.6 and No.7. 3. 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 Building Energy Efficiency Standards. 4. Has a label on bags or containers of aggregate stating that the materials conform to ASTM D1863 and ASTM D448.
Standard Design	For roofs, new construction, 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 ft², 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.

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 of the standards for new construction, and Section 141.0 of the standards 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 5.5A. **New Construction** Metal Building: U – 0.098 Wood Framed and Others: U – 0.075 **Additions and Alterations** Roof / Ceiling Insulation: See 141.0(b)2Biii of the standards 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 5.5B for details. For new construction, 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, C or D of the standards. Programs that model a U-factor shall include an exterior and interior air film resistance.

<table>
<tr>
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<td>
The standard design construction is based on JA4-10 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:
<table>
<tr><td>Layer 1</td><td>Metal Standing Seam 1/16 in.</td><td>R - 0.00</td></tr>
<tr><td>Layer 2</td><td>Continuous Insulation</td><td>R - Based on Climate Zone</td></tr>
<tr><td>Layer 3</td><td>Open Framing + No Insulation</td><td>R - 0.00</td></tr>
</table>
The value of the continuous insulation layer entirely above framing shall be set to achieve the following R-values:
Nonresidential Buildings: Continuous Insulation
<table>
<tr><td>Climate Zones 2, 3, 4, 9-16</td><td>R - 28.63 (U-0.034)</td></tr>
<tr><td>Climate Zones 1, 5</td><td>R - 28.63 (U-0.034)</td></tr>
<tr><td>Climate Zones 7, 8</td><td>R - 19.62 (U-0.049)</td></tr>
<tr><td>Climate Zones 6</td><td>R - 19.62 (U-0.049)</td></tr>
</table>
High-Rise Residential Buildings and Hotel/Motel Guestrooms: Continuous Insulation
<table>
<tr><td>Climate Zones 1, 2,4,8-16</td><td>R - 34.93 (U-0.028)</td></tr>
<tr><td>Climate Zone 7</td><td>R - 24.86 (U-0.039)</td></tr>
<tr><td>Climate Zones 3, 5, 6</td><td>R - 28.63 (U-0.034)</td></tr>
</table>
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 of the standards. 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.
</td>
</tr>
<tr>
<td>Standard Design:
Existing Buildings</td>
<td>
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 new construction 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:
</td>
</tr>
</table>

	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 of the standards. 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: 1. Mass Light 2. Mass Heavy 3. Metal building 4. Metal framing 5. 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 new construction.
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 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 standards for new construction. 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 (R-13 cavity + R-2 continuous insulation, or equivalent)
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.

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

<table>
<tr><td></td><td>

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

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).</td></tr>
<tr><td>Standard Design</td><td>

The U-factor required for wall construction of the standard design building is defined in Table 140.3-B, C or D of the standards. Programs that model a U-factor shall use an exterior and interior air film resistance. The standard design construction is based on JA4-10 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:

<table>
<tr><td>Layer 1</td><td>Stucco – 7/8 in.</td><td>R - 0.18</td></tr>
<tr><td>Layer 2</td><td>Building Paper</td><td>R – 0.06</td></tr>
<tr><td>Layer 3</td><td>Continuous Insulation</td><td>R - Based on Climate Zone</td></tr>
<tr><td>Layer 4</td><td>Closed Framing and No Ins.</td><td>R – 0.65</td></tr>
<tr><td>Layer 5</td><td>Gypsum Board – 1/2 in.</td><td>R – 0.45</td></tr>
</table>
</td></tr>
<tr><td>Standard Design:
Existing Buildings</td><td>

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

Nonresidential Buildings: Continuous Insulation

<table>
<tr><td>Climate Zones 1, 6, and 7</td><td>R – 12.30</td></tr>
<tr><td>Climate Zones 2, 4, 5, and 8 – 16</td><td>R – 13.94</td></tr>
<tr><td>Climate Zones 3</td><td>R – 10.01</td></tr>
</table>

High-Rise Residential Buildings and Hotel/Motel Guestrooms: Continuous Insulation

<table>
<tr><td>Climate Zones 1 - 6, and 8-16</td><td>R – 12.30</td></tr>
<tr><td>Climate Zone 7</td><td>R – 7.33</td></tr>
</table>

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 high-rise residential spaces shall use the high-rise residential 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.</td></tr>
</table>

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 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 of the standards for new construction, and Section 141.0 of the standards 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. New Construction Raised Mass Floors: U – 0.269 Other Floors: U – 0.071 Heated Slab Floors: Climate Zone (see Section 120.7) 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, C or D of the standards. Programs that model a U-factor shall use an

	exterior and interior air film resistance. The standard design construction is based on JA4-10 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 High-Rise Residential Buildings and 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

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 new construction

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 new construction

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 standards for new construction. There are no restrictions for alterations.
Standard Design	For new construction, the U-factor required for door construction is defined in Table 140.3-B, C or D of the standards. 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 High-Rise Residential Buildings and 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
Standard Design: *Existing Buildings*	For alterations, the U-factor in the standard design is either the same standard design as the new construction 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.

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

High-Rise Residential Buildings and 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

Operable Door Opening Type	
Applicability	All exterior doors
Definition	The opening type that determines whether interlocks with mechanical cooling and heating are required, per Section 140.4(n). If manual, then interlocks are required when operable windows are present in any nonresidential space, excluding high-rise residential 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

Standard Design: Existing Buildings	

5.5.7 Fenestration

Note that fenestration includes windows, doors that have 50 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, or Glazed Doors
Input Restrictions	As designed
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	Same as new construction

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, or Tubular Daylighting Devices (TDD)

Input Restrictions	As designed
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	Same as new construction

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 standards 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
Standard Design	Not applicable
Standard Design: Existing Buildings	

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 standards 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 Glass block is only allowed if the default fenestration type is operable or fixed.
Standard Design	Not applicable
Standard Design: Existing Buildings	

Default Framing Type	
Applicability	All fenestration that uses default thermal performance factors and window films for altered fenestration

Definition	This is a classification of fenestration that determines the thermal performance for fenestration using defaults from standards 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: metal, metal with thermal break, or nonmetal
Input Restrictions	As designed
Standard Design	Not applicable
Standard Design: *Existing Buildings*	

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 is 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 story 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 story 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 (§140.3 of the standards). 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 (story) 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 exempt from skylight requirements §140.3 of the standards.
Input Restrictions	As designed Specification of the fenestration position within its parent surface is required for the following conditions: 1) Exterior shading is modeled from buildings, vegetation, or other objects; or 2) 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 (a server process load of 20W/ft^2 or higher) 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 ($0.40/WWR_o$) 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 $0.40/WWR_o$. 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 ($0.40/WWR_o$), 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: 1) Adjust the west window area multiplying the west window area by the ratio $0.4/WWR_w$. 2) Calculate the WWR of the north, east and south facades: WWR_{nes} = Window $Area_{nes}$ / Gross Wall $Area_{nes}$ 3) Adjust the window area of the windows on the north, east and south facades by the following ratio: $WindowArea_{N,std} = WindowArea_{N,prop} \times 0.4 / WWR_{nes}$ $WindowArea_{E,std} = WindowArea_{E,prop} \times 0.4 / WWR_{nes}$ $WindowArea_{S,std} = WindowArea_{S,prop} \times 0.4 / WWR_{nes}$ 4) 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. 5) 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: 1) 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. 2) 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. 3) 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 condition, adjustments to the SRR as described shall be made. i. 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 for detail description on primary daylit area and skylit daylit area. ii. If the above condition is met and SRR ≤ 0.05, no adjustments are needed. iii. If the condition is met and SRR > 0.05, skylight dimensions = Existing Dimension x [1- √ (0.05/SRR of Proposed Building)] iv. 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/SRR of proposed building)]. Note that the adjustments to SRR are done after adjustments to WWR, if any are completed.
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 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 exempt from the minimum skylight area requirement for spaces with high ceilings. Identifying areas subject to §140.3 of the standards: 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 stories above grade, the user shall enter the fraction of the modeled space that is exempt from requirements of §140.3 of the standards. 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 exempt to §140.3 of the standards, the compliance software shall require that the user indicate at least one of the following exceptions: 1. The building is not located in climate zone 1 or climate zone 16 2. Designed general lighting is less than 0.5 W/ft^2 3. Existing walls on plans result in enclosed spaces less than 5,000 ft^2 4. Future walls or ceilings on plans result in enclosed spaces less than 5,000 ft^2 or ceiling heights less than 15 ft 5. Plans or documents show that space is an auditorium, religious building of worship, movie theater, museum, or refrigerated warehouses
Units	List five exceptions listed above (specified if fraction > 0)
Input Restrictions	No restrictions, other than that the vertical fenestration type must agree with the type specified on the construction documents or 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 SHGC: whole window solar heat gain coefficient VT: visible transmittance
Input Restrictions	For new construction, performance information for fenestration shall be obtained from NFRC test results or shall be developed from procedures outlined in section 110.6 of the standards, 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 Energy Commission 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 fenestration (total of new and altered) 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: $U_T = C_1 + (C_2 \cdot U_c)$ $SHGC_T = 0.08 + (0.86 \cdot SHGC_c)$ $VT_T = VT_F \cdot VT_C$ Where, U_T = U-factor is the total performance of the fenestration including glass and frame C_1 = Coefficient selected from Table NA6-5 in Reference Appendix NA6 C_2 = Coefficient selected from Table NA6-5 in Reference Appendix NA6 U_C = Center of glass U-factor calculated in accordance with NFRC 100 Section 4.5.3.1 $SHGC_T$ = Total SHGC performance including glass and frame $SHGC_C$ = Center of glass SHGC calculated in accordance with NFRC 200 Section 4.5.1.1

	VT_T = Is the total performance of the fenestration including glass and frame VT_F = 0.53 for projecting windows, such as casement and awning windows VT_F = 0.67 for operable or sliding windows VT_F = 0.77 for fixed or non-operable windows VT_F = 0.88 for curtain wall/storefront, site-built and manufactured non-curb mounted skylights VT_F = 1.0 for curb mounted manufactured skylights VT_C = 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 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 standards.
Standard Design	For new construction, 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 standards. 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 standards when the existing window area is unchanged (different than the new construction performance requirement), or Table 140.3-B, C, or D of the standards 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 and overhangs. Recessed windows may also be modeled with side fins 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 standards for new construction, and Section 141.0 of the standards for alterations. Note that these requirements only apply when the slab floor connected to the below-grade wall is heated.

	For new construction, the inputs shall be in agreement 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 Appendix JA4. For alterations there are no restrictions.
Standard Design	For new construction, see Table 13. 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 new construction 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 9: 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 CMU, solid grout	8	0.45	115	0.20	0.87	
	R-10 continuous insulation	3.0	0.02	1.8	0.29	12.50	
	Total assembly					13.37	0.075

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: 1) Heated slab-on-grade floors, 2) Unheated slab-on-grade floors 3) Heated below-grade floors 4) 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 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 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 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 software shall also provide the following slab insulation options: 1) Horizontal+Vertical, R-5 vertical down to the horizontal insulation and R-5 horizontal insulation extending 4 feet inwards from the perimeter 2) 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 standards for new construction, and Section 141.0 of the standards for alterations. For new construction, F-factors shall be taken from Table 4.4.8 of Reference 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 standards. That information is used in Table 4.4.8 of Reference 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 new construction 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 5/8-inch gypsum board, 4 inches of heavyweight concrete, and 5/8-inch gypsum board.
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 Standards. 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 Standards. 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. 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 section 5.5.3. Demising floor partitions shall be insulated to the same levels as exterior floors in section 5.5.5.
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 section 5.5.3. Demising floor partitions shall be insulated to the same levels as exterior floors in section 5.5.5.

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 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 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 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 Story Count – the total number of stories
- Total Above Grade Stories – the total number of stories above grade, used in determination of high-rise residential 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, size, and heating source. The applicability of each building descriptor for each of the 11 standard design systems is indicated in tables under the building descriptor standard design rules. Additions and alterations should follow the same requirements stated for new construction proposed designs and new construction standard designs; unless otherwise noted in the descriptor.

5.6.1 Space Temperature Control

Space Thermostat Throttling Range	
Applicability	All thermal zones
Definition	The number of degrees that the room temperature must change to cause the HVAC system to go from no heating or cooling (i.e., space temperatures floating) to full heating or cooling
Units	Degrees Fahrenheit (°F)
Input Restrictions	The prescribed value is 2°F. (This is equivalent to a +/- 1°F temperature tolerance around the heating and cooling setpoint.) No input is needed and the prescribed value may not be overridden.
Standard Design	Same as the proposed design

Standard Design: Existing Buildings	

Space Temperature Schedule	
Applicability	All thermal zones
Definition	An hourly space thermostat schedule
Units	Data structure: temperature schedule
Input Restrictions	Prescribed The schedule group is specified for the given space type in Appendix 5.4A, and the schedule values are specified in Appendix 5.4B.
Standard Design	Schedules in the standard design shall be identical to the proposed design, unless operable windows are present in the thermal zone. For nonresidential spaces, if operable windows are present in the proposed design, the heating schedule shall be overridden to 50°F and the cooling schedule shall be overridden to 90°F whenever the operable window schedule for that hour indicates that the window(s) are open.
Standard Design: Existing Buildings	

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 has the ability to re-heat or re-cool in response to the zone thermostat. This includes: • None (the case for single zone units) • VAV box • Series fan-powered VAV box • Parallel fan-powered VAV box • Dual-duct mixing box (constant volume and VAV)
Units	List (see above)
Input Restrictions	As designed
Standard Design	Only applicable for multiple zone systems 5 (packaged VAV) and 6 (built-up VAV). See Section 5.1.2 for a summary of the HVAC mapping. For healthcare facilities, same as the Proposed Design.

Standard Design: Existing Buildings	Same as proposed design for unaltered components; same as new construction 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 reheat coils at the zone level
Definition	The heating source for the terminal unit. This includes: • Electric resistance • Gas furnace • Oil furnace • Hot water • Steam
Units	List (see above)
Input Restrictions	As designed
Standard Design	Hot water for terminal units with reheat coils For healthcare facilities, same as the Proposed Design.
Standard Design: Existing Buildings	

Terminal Heat Capacity	
Applicability	Systems that have reheat coils at the zone level
Definition	The heating capacity of the terminal heating source
Units	Btu/h
Input Restrictions	As designed If the unmet load hours exceed 150, the energy analyst and design team may have to increase the size of the equipment so that the unmet load hours are less than 150.
Standard Design	The software shall automatically size the terminal heating capacity to be 25 percent greater than the design loads.
Standard Design: Existing Buildings	

Reheat Delta T (ΔT_{reheat})	
Applicability	Systems that have reheat coils at the zone level
Definition	This is an alternate method to enter the terminal heat capacity, which can be calculated as follows: $\Delta T_{reheat} = T_{reheat} - T_{cool\_supply}$ $\Delta T_{reheat} = Q_{coil}/1.1 \times CFM$ Where: ΔT_{reheat}: Heat rise across the terminal unit heating coil F) T_{reheat}: Heating air temperature at design (F) T_{cool_supply}: Supply air temperature at the heating coil (F) Q_{coil}: Heating coil load (Btu/h) 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. The temperature difference shall be no more than 40°F. See heat capacity.
Standard Design: Existing Buildings	

5.6.4 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
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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	
Standard Design	Not applicable, except for healthcare facilities, same as the Proposed Design.
Standard Design: Existing Buildings	

5.6.5 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

VRF Zone System Type	
Applicability	VRF
Definition	Type of zone system
Units	VRF
Input Restrictions	VRF
Standard Design	Not applicable

Count	
Applicability	VRF
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	Not applicable

Indoor Unit Type	
Applicability	VRF
Definition	Ducted or Unducted
Units	List – Ducted, Unducted
Input Restrictions	None
Standard Design	Not applicable

Design Supply Air Temperature (Cooling)	
Applicability	VRF
Definition	Design SAT in cooling for the zone
Units	Deg F
Input Restrictions	As Designed
Standard Design	Not applicable

Design Supply Air Temperature (Heating)	
Applicability	VRF

Definition	Design SAT in heating for the zone
Units	Deg F
Input Restrictions	As Designed
Standard Design	Not applicable

Net Cooling Capacity	
Applicability	VRF
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	Not applicable

Net Heating Capacity	
Applicability	VRF
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	Not applicable

Supply Fan Capacity for Cooling	
Applicability	VRF
Definition	The supply fan flow rate when the zone requires cooling
Units	cfm (for each mode)
Input Restrictions	None
Standard Design	Not applicable

Supply Fan Capacity for Heating	
Applicability	VRF
Definition	The supply fan flow rate
Units	cfm (for each mode)

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	None
Standard Design	Not applicable

Supply Temp Control	
Applicability	VRF
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	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	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	Not applicable

5.6.6 Zone Level Air Flow

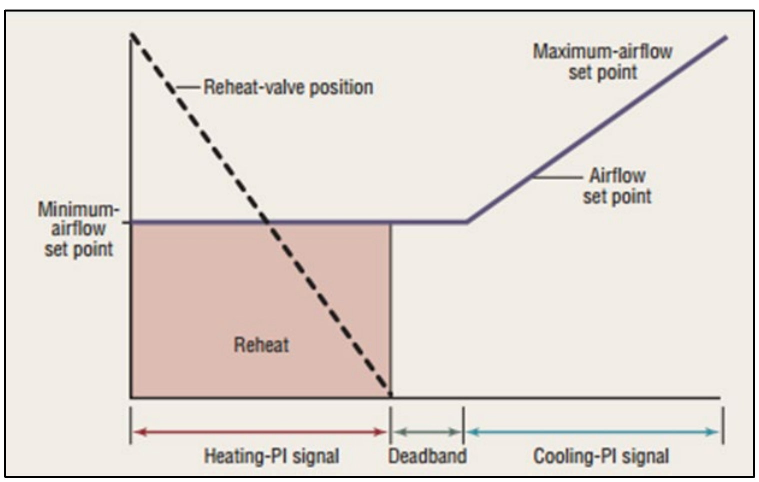
5.6.6.1 VAV Air Flow

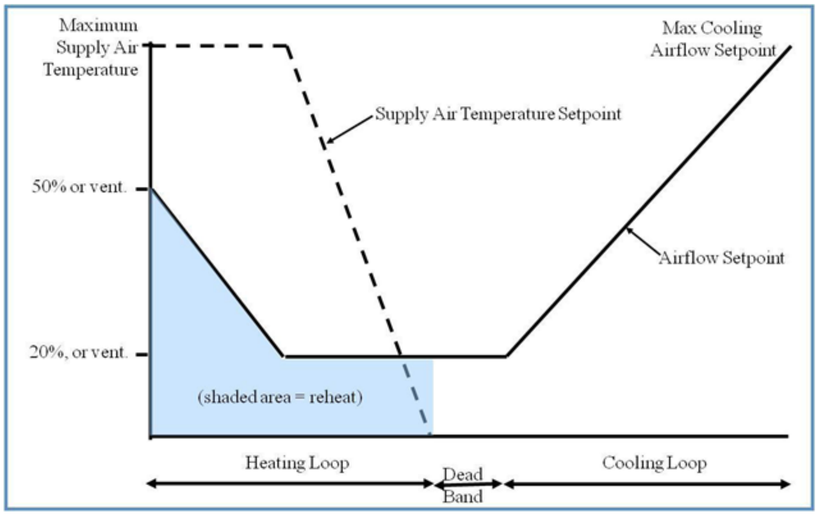
This group of building descriptors applies to proposed design systems that vary the volume of air at the zone level. The building descriptors are applicable for standard design systems 5 and 6.

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 If the unmet load hours in the proposed design are greater than 150, the user may have to modify the design airflow value manually.
Standard Design	For systems 5 and 6, the software shall automatically size the system airflow to meet both: a) 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 standards, or makeup air, whichever is greater. b) The standard design peak heating load based on 50 percent zone flow and 95°F supply air temperature. An exterior zone is defined as a type of thermal zone that has any exterior walls, and that has a non-zero amount of vertical fenestration (windows). Any zone that does not meet the definition of an exterior zone is an interior zone. For kitchen MAU systems, the design airflow is the greater of the airflow required to meet the design cooling loads and the total exhaust cfm.
Standard Design: *Existing Buildings*	

Terminal Minimum Stop	
Applicability	Systems that vary the volume of air at the zone level
Definition	The minimum airflow that will be delivered by a terminal unit before reheating occurs
Units	Unitless fraction of airflow (cfm) or specific airflow (cfm/ft²)
Input Restrictions	Input must be greater than or equal to the outside air ventilation rate

Standard Design	For systems 5 and 6, packaged VAV units and built-up VAV air handling units, set the minimum airflow to be the greater of 20 percent of the peak supply air volume to the zone or the minimum outside air ventilation rate. For laboratories, the minimum airflow fraction shall be fixed at a value equivalent to the greater of the proposed design minimum exhaust requirements or the minimum ventilation rate.
Standard Design: Existing Buildings	

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 9: Single Maximum VAV Box Control  *Source: Taylor Engineering* 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. 1. 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.

	2. 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). Figure 10: Dual Maximum Control Sequence  *Source: Taylor Engineering*
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	Dual maximum For healthcare facilities, same as the Proposed Design.
Standard Design: Existing Buildings	

5.6.6.2 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	Not applicable

	For healthcare facilities, same as the Proposed Design.
Standard Design: Existing Buildings	

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	Not applicable For healthcare facilities, same as the Proposed Design.
Standard Design: Existing Buildings	

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 (of zones)
Input Restrictions	As designed
Standard Design	Not applicable For healthcare facilities, same as the Proposed Design.
Standard Design: Existing Buildings	

Parallel 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	Not applicable For healthcare facilities, same as the Proposed Design.

Standard Design: Existing Buildings	

Parallel Fan Box Thermostat Setpoint	
Applicability	Thermal zones that have fan powered boxes
Definition	Temperature difference above the heating setpoint at which the parallel fan is turned on
Units	Degrees Fahrenheit (°F)
Input Restrictions	2°F above the heating setpoint schedule
Standard Design	Not applicable For healthcare facilities, same as the Proposed Design.
Standard Design: Existing Buildings	

5.6.6.3 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 section also contains unique inputs for kitchen exhaust systems that must meet requirements of section 140.9 of the Standards.

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
Standard Design: Existing Buildings	

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-A of the standards
Units	List:

	• Wall-mounted canopy • Single island • Double island • Eyebrow • Backshelf/Passover
Input Restrictions	As designed
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	

Kitchen Exhaust Hood Cooking Duty	
Applicability	Exhaust fans in spaces of type kitchen, commercial food preparation
Definition	The hood cooking duty as defined in Table140.9-A of the standards
Units	List: • Light-duty • Medium-duty • Heavy-duty • Extra heavy-duty
Input Restrictions	As designed
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

Exhaust Air Flow 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 air flow 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 air flow 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 of the standard design ventilation rates listed in Appendix 5.4A and required exhaust ventilation rates from Standards Table 120.1-B for spaces that do not include covered processes. Exception for buildings with over 5,000 cfm of kitchen exhaust; the standard design 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 standards, Table 140.9-A. For lab exhaust systems, the standard design is the same as the proposed. For healthcare facilities, same as the Proposed Design.
Standard Design: *Existing Buildings*	

Exhaust Minimum Air Flow 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 air flow rate is the maximum of the hood scheduled exhaust air flow rate and the minimum ventilation rate. A warning is posted if the minimum exhaust rate is 2 ACH or less.
Standard Design	For laboratory systems with minimum exhaust flow rates exceeding 10 ACH exhaust, the exhaust minimum air flow rate is equal to the proposed design minimum. For VAV laboratory systems with variable flow and variable speed drive exhaust fan control, the exhaust minimum air flow rate is the greater of the proposed design minimum exhaust air flow rate and 20% of the design exhaust air flow rate. For healthcare facilities, same as the Proposed Design.

Standard Design: Existing Buildings	

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 non-process spaces, schedule is prescribed based on occupancy type and specified in Appendix 5.4B. Exhaust fans for non-process loads shall be modeled as constant volume and always on. Exhaust schedules for kitchen exhaust hoods are prescribed and specified in Appendix 5.4B, and dependent on whether the exhaust is constant or variable volume. Exhaust schedules for laboratory spaces are prescribed and specified in Appendix 5.4B, and dependent on whether the exhaust is constant or variable volume. If the exhaust is variable flow, the compliance software shall automatically use either the no sash control or sash control laboratory variable exhaust schedule or a volume-weighted interpolated average of the two schedules if only a fraction of the exhaust hoods have sash control.
Standard Design	Same as the proposed design for non-covered process spaces Exhaust schedules for kitchen exhaust hoods are prescribed and specified in Appendix 5.4B. For laboratory spaces, the standard design is constant volume if the proposed exhaust system is constant volume and has a minimum exhaust air flow rate greater than 10 ACH. Otherwise, the standard design is variable volume. If the standard design is variable volume and the proposed laboratory space is fume hood intense (as defined in Standards Table 140.9-B) then the standard design will use the Appendix 5.4B 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 standard design is variable volume and the proposed space is not fume hood intense then the standard design shall use the VAV exhaust schedule for non-controlled sashes. For healthcare facilities, same as the proposed design.
Standard Design: Existing Buildings	

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-B of the Standards) For healthcare facilities, same as the Proposed Design.
Standard Design: *Existing Buildings*	As Designed (between 0 and 1)

5.6.6.4 Outdoor Air Ventilation

Ventilation Source	
Applicability	All thermal zones
Definition	The source of ventilation for a thermal zone. The choices are: • Natural (by operable openings) • Forced (by fan)
Units	List: None, Natural, or Forced
Input Restrictions	For hotel/motel guest rooms, as designed. For all other occupancies, Forced.
Standard Design	For residential units, Forced; ventilation shall be provided by a balanced fan system in each zone. For hotel/motel guest rooms, labs, and healthcare facilities, same as the proposed. For other occupancies, Forced.
Standard Design: *Existing Buildings*	

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 maximum occupancy. This is adjusted by the occupancy fraction to determine the design ventilation rate for the space.
Units	cfm
Input Restrictions	To accommodate transfer air requirements for makeup air for exhaust from other zones, the design ventilation rate may be between 95 percent and 120 percent of the code required ventilation rate for high-rise residential spaces and thermal zones, or between 95 percent and 110 percent of code required ventilation rates for all other buildings on a building story without penalty. As defined by the user, provided that the total outside air ventilation rate to the building story matches the standard design outside air ventilation rate for the building story within a specified tolerance (within 20%). Ventilation rates below 95% of the code required ventilation rate for a building story are not allowed. If the ventilation source is natural for residential dwelling spaces, then the proposed design ventilation rate for compliance model purposes shall be zero.
Standard Design	For labs and healthcare facilities, same as the Proposed Design. If the total exhaust airflow requirement on the building floor does not exceed the total ventilation requirement, then the standard design outside air ventilation rate shall be the same as the proposed, if the design ventilation rate is between the limits defined above (95% and 120% of code minimum for high-rise residential spaces, and 95% and

	110% for all other buildings.. If the proposed ventilation rate exceeds the limits 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 story is equal to the maximum allowed ventilation air rate: Design Ventilation $Rate_{std}$ = Design Ventilation $Rate_{prop}$ x ($BFVent_{std}$ / $BFVent_{prop}$) Where: $BFVent_{min}$ is the building floor design minimum required ventilation flow, as specified by the standards, 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 new construction.

Occupancy Fraction	
Applicability	All thermal zones
Definition	The space design requirements for ventilation at design occupancy that are compliant with space egress requirements and design ventilation requirements. The occupancy fraction also affects hot water use requirements for the space.
Units	Unitless fraction
Input Restrictions	Default of 0.5 as designed with a minimum value of 0.5 and a maximum value of 5
Standard Design	0.5
Standard Design: Existing Buildings	0.5

Building Floor Ventilation Requirement	
Applicability	Internal variable, calculated for each building story (floor)
Definition	The total outside air ventilation airflow requirement for all spaces on a building story or 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 air flow requirements.
Units	cfm (ft^3/min)

Input Restrictions	Not a user input; derived by summing the ventilation and exhaust air flows from all spaces on the building floor
Standard Design	For labs and healthcare facilities, same as the Proposed Design. For all other spaces: This is calculated by the following procedure: 1. Calculate the proposed ventilation for the building story as the sum of design ventilation flow for each space included on a building story, including all spaces except space designated as lab space. 2. Calculate the proposed exhaust for the building story as the sum of design exhaust flow for each space on the building story, including all spaces except spaces designated as lab space. 3. 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 story. 4. If the proposed exhaust is greater than the code minimum ventilation rate, then: a. Total standard design building story ventilation requirement shall be: Standard ventilation = Min (proposed ventilation, proposed exhaust x 1.2) Otherwise: Standard ventilation = Min (code minimum ventilation, proposed ventilation)
Standard Design: *Existing Buildings*	

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 larger of 15 cfm times the design occupancy times the occupancy fraction or the conditioned floor area times the applicable ventilation rate from Appendix 5.4A. 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 residential spaces where the proposed design ventilation source is natural ventilation, the minimum ventilation rate shall be zero.

Standard Design	For labs 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.
Standard Design: *Existing Buildings*	

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^2 must have an occupancy sensor for ventilation control and setback to meet the mandatory Title 24 Standards requirements of 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.

Standard Design: Existing Buildings	

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 SZAC – Single-zone Air Conditioner PTHP – Packaged Terminal Heat Pump PSZ-AC – Packaged Single Zone Air Conditioner PSZ-HP – Packaged Single Zone Heat Pump Air Conditioner 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 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 * Choice includes series and parallel fan-powered boxes as zone terminal units
Standard Design	Based on the prescribed system type in the HVAC system map (see Section 5.1.2).
Standard Design: Existing Buildings	

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	None
Input Restrictions	List one of the following inputs: Direct digital control (DDC) control 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
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, DDC control to the zone level
Standard Design: Existing Buildings	

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, same as the Proposed Design. For all others, Schedule group is prescribed in Appendix 5.4A and schedule values are prescribed in Appendix 5.4B. See Section 2.3.3 on how software shall assign schedules when the spaces served by the system are assigned to different schedule groups in Appendix 5.4A. The fan schedules and HVAC operations are defined so that the air handlers provide the necessary outside air 1 hour prior to scheduled occupancy. When a fan system serves several occupancies, the fan schedule remains ON to serve the operating hours of each occupancy.
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	

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 all others, Cycles with loads for FPFC and SZAC systems; continuous for all other standard design system types.
Standard Design: Existing Buildings	

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. This control strategy modifies the heating, cooling, and fan schedules.
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
Standard Design: Existing Buildings	

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.
Units	None
Input Restrictions	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
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Cycle on call from any zone

Standard Design: Existing Buildings	

5.7.2.3 Supply Air Temperature Control

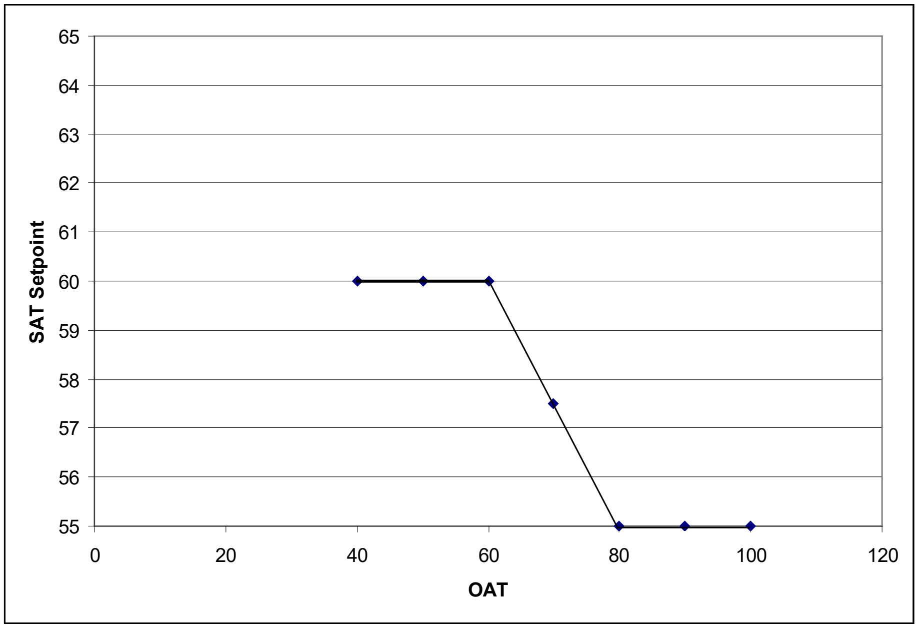
Cooling Supply Air Temperature	
Applicability	Applicable to all systems
Definition	The supply air temperature setpoint at design cooling conditions
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, 15°F below the space temperature setpoint for interior zones that are served by multiple zone systems; for all other zones, 20°F below the space temperature setpoint
Standard Design: Existing Buildings	

Heating Supply Air Temperature	
Applicability	All 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 system types 1-4; 60°F for multiple zone systems; no heating for data centers and computer rooms
Standard Design: Existing Buildings	

Supply Air Temperature Control	
Applicability	Any cooling system
Definition	The method of controlling the supply air temperature. Choices are:

	• No control – for this scheme the coils are energized whenever there is a call for heating or cooling at the zone. • Fixed (constant) • Reset by warmest zone, airflow first • Reset by warmest zone, temperature first • Reset by outside air dry-bulb temperature • Scheduled setpoint
Units	List (see above)
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, For standard design systems 1 through 4, the SAT control is No Control. For systems 5 through 8, 10, and 11, the SAT control shall be reset by warmest zone, airflow first. For system 9 (heating and ventilation), this input is not applicable.
Standard Design: Existing Buildings	

Reset Schedule by OSA	
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 the following data points (see Figure 9): • 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

	Figure 11: SAT Cooling Setpoint Reset Based On Outdoor Air Temperature (OAT)  Source: NORESCO for 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
Standard Design: *Existing Buildings*	

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 section. See Section 5.7.1, Table 27 for the HVAC standard design system mapping.

When the proposed design has exhaust fans (toilets or kitchens) or fume hood exhaust systems, the standard design has the same exhaust systems.

5.7.3.2 Supply Fans

Supply 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, same as the Proposed Design. For all others, The standard design shall use the brake horsepower method for all HVAC systems except the SZAC unit used in residential spaces, the heating and ventilation only system, and the four-pipe fan coil system, which shall use the power-per-unit-flow method.
Standard Design: Existing Buildings	

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 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	As designed, not a user input. This is the ratio of the supply fan power to total system fan power, which includes supply fans, exhaust fans, any return fans, and any series-powered fans.
Standard Design	Same as proposed
Standard Design: Existing Buildings	Same as proposed

Supply Fan Design Airflow	
Applicability	All fan systems
Definition	The air flow 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* **The airflow is typically between 250 cfm/ton and 500 cfm/ton; values well outside of this range may cause simulation engine runtime efforts that must be addressed by the user (currently there are no input restrictions on this).*
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, The program shall automatically size the air flow at each thermal zone to meet the loads. The design air flow rate calculation shall be based on a 20°F temperature differential between supply air and the room air 20°F temperature differential between the supply air and the return air for exterior zones and a 15°F temperature differential for interior zones served by multiple zone systems. The design supply air flow rate is the larger of the flow rate required to meet space conditioning requirements and the required ventilation flow rate. For equipment with DX cooling coils, the program applies the results of a sizing run, and oversizes both the cooling coil capacity and airflows by 15% to obtain the appropriate airflow. For multizone systems, the supply fan design air flow rate shall be the system airflow rate that satisfies that coincident peak of all thermal zones at the design supply air temperature.
Standard Design: Existing Buildings	

Fan Control Method	
Applicability	All fan systems
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
Standard Design	For healthcare facilities, same as the Proposed Design. Based on the prescribed system type. Refer to the HVAC System Map in 5.1.2.
Standard Design: *Existing Buildings*	

Table 10: Standard Design Fan Control Method

Standard Design building System	**Fan Control Method**
System 1 – SZAC	Constant volume, cycling
System 2 – FPFC	Constant volume, cycling
System 3 – PSZ-AC	Constant volume
System 5 – Packaged VAV with Reheat	Variable-flow, variable speed drive (VSD)
System 6 – VAV with Reheat	Variable-flow, variable speed drive (VSD)
System 7 – Single Zone VAV	Variable-flow, variable-speed drive (VSD)
System 9 – Heating and Ventilation	Constant volume
System 10 – CRAH Units	Variable-flow, variable speed drive (VSD)*
System 11 – CRAC Units	Variable-flow, variable speed drive (VSD)*

* For CRAH Units, fan volume shall be linearly reset from 100 percent air flow at 100 percent cooling load to minimum airflow at 50 percent cooling load and below.

Supply Fan Brake Horsepower	
Applicability	All fan systems, except those specified using the power-per-unit-flow method
Definition	The design shaft brake horsepower of each supply fan. This input does not need to be supplied if the supply fan kW is supplied.
Units	Horsepower (hp)
Input Restrictions	As designed If this building descriptor is specified for the proposed design, then the static pressure and fan efficiency are not. The compliance software shall apply the following rule to specify the proposed design bhp, based on user input:

	A standard motor size table (hp) is defined as: 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, and 200. The user entered brake horsepower for the proposed design is compared against the next smaller motor size from the user entered supply fan motor horsepower. The proposed design supply fan brake horsepower (bhp) is set to the maximum of the user entered bhp and 95 percent of the next smaller motor horsepower: Proposed bhp = max(user bhp, 95 percent ×MHP_{i-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 above. For example, if 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.
Standard Design	For healthcare facilities, same as the Proposed Design. For FPFC and heating and ventilation systems, not applicable. For laboratory systems where the building lab design exhaust flow is greater than 10,000 cfm, a separate exhaust fan power allowance is given, and the entire fan power budget can be allocated to the supply fan: VAV Supply Fan BHP = (0.0013 x cfmmax + A) CAV Supply Fan BHP = (0.00094 x cfmmax + A) For PVAV and built-up VAV systems: Supply Fan BHP = (0.0013 x cfmmax + A) x Supply Fan Ratio, For other systems, Supply Fan BHP = (0.00094 x cfm + A) x SupplyFanRatio, where cfm = the design supply air flow, and A = the fan power adjustment (see separate building descriptor) SupplyFanRatio is the ratio of supply fan brake horse power at design conditions to total system brake horsepower at design conditions
Standard Design: Existing Buildings	Same as proposed if existing and unaltered; otherwise, same as new construction

Supply Fan Motor Horsepower	
Applicability	All fan systems, except those specified using the power-per-unit-flow method

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
Input Restrictions	As designed. This building descriptor is required for the static pressure or the brake horsepower methods.
Standard Design	Set to the standard motor efficiency for the next larger nominal HP size, from NEMA standards
Standard Design: *Existing Buildings*	Set to the standard motor efficiency for the next larger nominal HP size, from NEMA standards

Supply Fan Static Pressure	
Applicability	All fan systems using the static pressure method
Definition	The design static pressure for the supply fan. This is important for both fan electric energy usage and duct heat gain calculations.
Units	Inches of water column (in. H_20)
Input Restrictions	As designed The design static pressure for the supply fan does not need to be specified if the supply fan brake horsepower (bhp) is specified.
Standard Design	Not applicable. Defined in the software as a function of brake horsepower or power-per-unit flow.
Standard Design: *Existing Buildings*	Not applicable

Supply 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	65%

	Not applicable for the four-pipe fan coil system.
Standard Design: Existing Buildings	Not applicable

Supply Motor Efficiency	
Applicability	All supply fans, except those specified using the power-per-unit-flow method
Definition	The full-load efficiency of the motor serving the supply fan
Units	Unitless
Input Restrictions	As designed Not applicable when the power-per-unit-flow method is used.
Standard Design	The motor efficiency is determined from ***Table 11*** for the next motor size greater than the bhp.
Standard Design: Existing Buildings	Same as proposed

Fan Power Adjustment	
Applicability	Any system with special requirements for filtration or other process requirements
Definition	Additional system brake horsepower 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. If the adjustment credit is specified in terms of static pressure, the static pressure adjustment is fixed. For the credits that depend on the design, the user enters the pressure drop for each device. The proposed design fan power adjustment (bhp) is given by the equation: $FPA = \Sigma SP_i \times CFM_i / 4131$ Where SPi = the static pressure through the device, inches w.c. CFMi = the design airflow through the device Device | Adjustment Credits

	Return of exhaust systems required by code to be fully ducted	0.5 in. of water
	Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of the proposed design
	Particulate filtration credit: MERV 16 or greater and electronically enhanced filters	Pressure drop calculated at 2 x clean filter pressure drop at fan system design condition
	Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
	Biosafety cabinet	Pressure drop of device at fan system design condition
Standard Design	Same as proposed	
Standard Design: Existing Buildings	Same as proposed for new HVAC equipment; not applicable for existing, unaltered systems.	

Table 11: Minimum Nominal Efficiency for Electric Motors (Percent)

Motor Horse Power	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

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

Standard Design: Existing Buildings	

Motor Position	
Applicability	All supply fans
Definition	The position of the supply fan motor relative to the cooling air stream. The choices are in the air stream or out of the air stream.
Units	List (see above)
Input Restrictions	As designed
Standard Design	In the air stream
Standard Design: Existing Buildings	

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 air flow. The curve is typically represented as a quadratic equation with an absolute minimum power draw specified.
Units	Unitless ratio
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. 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: PLR: Ratio of fan power at part load conditions to full load fan power $PowerMn$: Minimum fan power ratio $FanRatio$: Ratio of cfm at part-load to full-load cfm $a, b, c, and\ d$: Constants from the table below

Standard Design	For healthcare facilities, 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.
Standard Design: Existing Buildings	

Supply Fan Power Index	
Applicability	Fan systems that use the power-per-unit-flow method
Definition	The supply 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, same as the Proposed Design. For all others, For FPFC systems, 0.35 W/cfm for heating and ventilation only systems, 0.53 W/cfm ; For CRAC and CRAH systems, 0.81 W/cfm (approximate value for 27 W/kBtu-h of sensible cooling capacity assuming 400 cfm/ton). For other systems, not applicable.
Standard Design: Existing Buildings	

5.7.3.3 Return/Relief Fans

The standard design building has no return fan. The standard design system has a relief fan only if the standard design system has an economizer.

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
Standard Design: Existing Buildings	

Return Air Path	
Applicability	Any system with return ducts or return air plenum
Definition	Describes the return path for air. Can be ducted return, plenum return, or direct-to-unit.
Units	List (see above)
Input Restrictions	As designed
Standard Design	Applicable when the standard design has a relief fan. For standard design systems 1 and 2, the return air path shall be direct-to-unit. For standard design systems 3 through 11, the standard design shall be ducted return.
Standard Design: Existing Buildings	

Return/Relief Fan Modeling Method	
Applicability	All fan systems
Definition	The specification method for return fan power. The simple method is for the user to enter the electric power-per-unit of flow (W/cfm). 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	Not applicable (the standard design does not include return fans, and relief fans are not explicitly modeled)
Standard Design: Existing Buildings	Not applicable

Return/Relief Fan Design Airflow	
Applicability	All systems with a return or relief fan
Definition	The design air flow 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	For return fans, as designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, not modeled.
Standard Design: *Existing Buildings*	

Return/Relief Fan Brake Horsepower	
Applicability	Any system with return fans that uses the brake horsepower method
Definition	The design shaft brake horsepower of the return/relief fan(s)
Units	Brake horsepower (bhp)
Input Restrictions	As designed The compliance software shall apply the following pre-processing rule to specify the proposed design return/relief fan brake horsepower, based on user input: A standard motor size table (hp) is defined as: 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, and 200. The return/relief fan brake horsepower is determined from user inputs of brake horsepower and motor horsepower for the proposed design, in the same manner as the supply fan brake horsepower. Proposed bhp = min (user bhp, 95 percent x MHP_{i-1}) Where: Proposed bhp is the return/relief fan brake horsepower used in the simulation; User bhp is the actual fan bhp as entered by the user; and MHP_{i-1} is the motor horsepower of the next smaller motor size from the standard motor size table above; MHP_i is the motor size that the user enters for the return/relief fan. See the supply fan brake horsepower descriptor for further details.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, not modeled.

Standard Design: Existing Buildings	

Return/Relief Fan Motor Horsepower	
Applicability	All fan systems, except those specified using the power-per-unit-flow method
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
Input Restrictions	As designed This building descriptor is required for the static pressure or the brake horsepower methods.
Standard Design	Not modeled
Standard Design: Existing Buildings	

Return/Relief Design Static Pressure	
Applicability	Any system with return or relief fans that uses the static pressure method
Definition	The design static pressure for return fan system. This is important for both fan electric energy usage and duct heat gain calculations.
Units	Inches of water column (in. H20 gauge)
Input Restrictions	As designed. The design static pressure for the return fan does not need to be specified if the return fan brake horsepower (bhp) is specified.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, not applicable (there are no return fans, and the relief fan is not modeled.
Standard Design: Existing Buildings	

Return/Relief Fan Efficiency	
Applicability	Any system with return or relief fans that uses the static pressure method
Definition	The efficiency of the fan at design conditions. This is the static efficiency and does not include the efficiency loss of the motor.

Units	Unitless
Input Restrictions	As designed. The return/relief fan efficiency does not need to be specified if the return fan brake horsepower (bhp) is specified.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, not applicable.
Standard Design: Existing Buildings	

Return/Relief Motor Efficiency	
Applicability	All return fans, except those specified using the power-per-unit-flow method
Definition	The full-load efficiency of the motor serving the supply fan
Units	Unitless
Input Restrictions	As designed. Not applicable when the power-per-unit-flow method is used.
Standard Design	Not applicable
Standard Design: Existing Buildings	

Motor Position	
Applicability	All return fans
Definition	The position of the supply fan motor relative to the cooling air stream. The choices are in the air stream or out of the air stream.
Units	List (see above)
Input Restrictions	As designed.
Standard Design	In the air stream
Standard Design: Existing Buildings	

Fan Part-Flow Power Curve	
Applicability	All return fans for variable flow fan systems.
Definition	A part-load power curve which represents the percentage full-load power draw of the supply fan as a function of the percentage full-load air flow.

Units	Unitless ratio
Input Restrictions	As designed. The default fan curve shall be selected from Appendix 5.7 for the type of fan specified in the proposed design.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

5.7.3.4 Exhaust Fan Systems

The standard design shall track the proposed design exempt process exhaust flow rate up to the prescribed outside air ventilation rate by space type (see Appendix 5.4A for the standard design maximum exhaust rate). Covered process exhaust includes garage ventilation, lab exhaust and exhaust from kitchens with over 5,000 cfm of exhaust. Rules for the standard design covered process exhaust rate and fan power are discussed in the following sections.

Exhaust fan flow is specified and scheduled for each thermal zone. An exhaust fan system may serve multiple thermal zones. For the standard design, total outside air ventilation supply airflow may need to be adjusted so that the design supply airflow for each floor of the building matches the total design exhaust airflow for that floor.

Exhaust Fan Name	
Applicability	All exhaust systems serving multiple thermal zones
Definition	A unique descriptor for each exhaust fan. This should be keyed to the construction documents, if possible, to facilitate plan checking. Exhaust rates and schedules at the thermal zone level refer to this name.
Units	Text, unique
Input Restrictions	Where applicable, this should match the tags that are used on the plans.
Standard Design	The standard design shall have an exhaust system that corresponds to the proposed design. However, if the user has specified an exhaust system as the ventilation system an equivalent standard design system will not be modeled since the standard design has its own definition for ventilation systems. The name can be identical to that used for the proposed design or some other appropriate name may be used.
Standard Design: Existing Buildings	

Exhaust Fan System Modeling Method	
Applicability	All exhaust fan systems

Definition	Compliance software can model fans in three ways. See definition for supply system modeling method.
Units	List: power-per-unit-flow, static pressure or brake horsepower
Input Restrictions	As designed
Standard Design	The standard design shall use the static pressure method.
Standard Design: *Existing Buildings*	

Exhaust 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 fan and exhaust fans, a ratio is defined that is the ratio of non-exempt exhaust fan power to total system fan power.
Units	List power-per-unit-flow, static pressure, or brake horsepower
Input Restrictions	As designed, not a user input. This is the ratio of the exhaust fan power to total system fan power, which includes: supply fans, exhaust fans, return fans, and any series-powered fans.
Standard Design	Same as proposed
Standard Design: *Existing Buildings*	Same as proposed

Exhaust Fan Design Airflow	
Applicability	All exhaust fan systems
Definition	The rated design air flow rate of the exhaust fan system. This building descriptor defines the 100 percent flow point of the part-flow curve. Actual air flow 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. The total design exhaust flow capacity for building (conditioned space) shall not exceed the sum of building story minimum ventilation (outdoor) air flow. Exhaust makeup can be transferred from other zones in the building provided that the total building exhaust rate does not exceed the total minimum outside air flow rate.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others,

	Same as proposed design, but with the same limitations described under input restrictions. The design supply air ventilation rate for zone(s) may need to be adjusted by the 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.
Standard Design: Existing Buildings	

Exhaust Fan Control Method	
Applicability	All exhaust fan systems
Definition	A description of how the exhaust fan(s) are controlled. The options include: • Constant volume • Variable-flow, variable speed drive (VSD)
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 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, variable speed drive when the minimum exhaust flow is 10 ACH or less. If the lab exhaust flow minimum is greater than 10 ACH, the control method is the same as proposed.
Standard Design: Existing Buildings	

Exhaust Fan Brake Horsepower	
Applicability	All exhaust fan systems
Definition	The design shaft brake horsepower of the exhaust fan(s).
Units	Brake horsepower (bhp)
Input Restrictions	As designed The compliance software implements a pre-processing rule to specify the proposed design exhaust fan brake horsepower (bhp), based on user input:

	A standard motor size table (hp) is defined as: 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 The exhaust fan brake horsepower is determined from user inputs of brake horsepower and motor horsepower for the proposed design, in the same manner as the supply fan brake horsepower. Proposed bhp = max (user bhp, 95 percent x MHP_{i-1}) Where: Proposed bhp is the return/relief fan brake horsepower used in the simulation, User bhp is the actual fan bhp as entered by the user MHP_{i-1} is the motor horsepower of the next smaller motor size from the standard motor size table above; MHP_i is the motor size that the user enters for the exhaust fan See the supply fan brake horsepower descriptor for further details.
Standard Design	For healthcare 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 all others, the standard design exhaust fan brake horsepower is equal to the fan system power allowance times the exhaust fan power ratio: For constant volume systems, (0.00094 x cfm_{max} + A) x ExhaustFanPowerRatio For variable volume systems, 0.0013 x cfm_{max} + A) x ExhaustFanPowerRatio

Exhaust Fan Motor Horsepower	
Applicability	All fan systems, except those specified using the power-per-unit-flow method
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
Input Restrictions	As designed This building descriptor is required for the static pressure or the brake horsepower methods.
Standard Design	Not applicable
Standard Design: *Existing Buildings*	

Exhaust Fan Design Static Pressure	
Applicability	Any system with exhaust fans that uses the static pressure method
Definition	The design static pressure for exhaust fan system.
Units	Inches of water column (in. of water)
Input Restrictions	As designed. The design static pressure for the exhaust fan does not need to be specified if the exhaust fan brake horsepower (bhp) or power-per-unit flow is specified.
Standard Design	For healthcare facilities, same as the Proposed Design. For kitchen exhaust fans, the static pressure is fixed at 2.5 in. of water. For lab exhaust fans, fan power is specified as W/cfm, so this input is not applicable. For all other exhaust fans, the standard design fan static pressure shall be the same as the proposed design.
Standard Design: Existing Buildings	

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	For kitchen exhaust fans, the fan efficiency is prescribed at 50 percent. For all other exhaust fans, as designed. The exhaust fan efficiency does not need to be specified if the return fan brake horsepower (bhp) is specified.
Standard Design	For healthcare facilities, same as the Proposed Design. For kitchen exhaust fans, the fan efficiency is 50 percent, while for lab exhaust it is 62 percent. For all other exhaust fans, the standard design efficiency (and resulting W/cfm) is 65%
Standard Design: Existing Buildings	

Exhaust Fan Motor Efficiency	
Applicability	All exhaust fan systems
Definition	The full-load efficiency of the motor serving the exhaust fan
Units	Unitless
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For exempt process fans other than lab, kitchen, and garage exhaust fans, same as proposed. For all other fans, the value is taken from *Table 11*.
Standard Design: Existing Buildings	

Fan Part-Flow Power Curve	
Applicability	All variable flow exhaust fan systems
Definition	A part-load power curve that represents the ratio full-load power draw of the exhaust fan as a function of the ratio full-load air flow.
Units	Unitless ratio
Input Restrictions	As designed The default fan curve shall be selected from Appendix 5.7 for the type of fan specified in the proposed design.
Standard Design	For healthcare facilities, same as the proposed design. For all others, the standard design fan curve shall be selected from Appendix 5.7 for the type of fan specified in the proposed design.
Standard Design: Existing Buildings	

Exhaust Fan Power Index	
Applicability	Exhaust systems serving high-rise residential units and hotel/motel guestrooms
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
Standard Design	For healthcare facilities, same as the Proposed Design.

	For high-rise residential units and hotel/motel guestrooms, 0.58 W/cfm
Standard Design: Existing Buildings	

5.7.3.5 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 Name	
Applicability	All garage exhaust systems
Definition	A unique descriptor for each garage exhaust fan or fan system Fans with equivalent efficiency and motor efficiencies may be combined and modeled as one fan.
Units	Text, unique
Input Restrictions	Where applicable, this should match the tags that are used on the plans.
Standard Design	The standard design shall have an exhaust system that corresponds to the proposed design. The name can be identical to that used for the proposed design or some other appropriate name may be used.
Standard Design: Existing Buildings	

Garage Exhaust Fan System Modeling Method	
Applicability	All exhaust fan systems
Definition	Software commonly models fans in three ways, see definition for supply system modeling method.
Units	List power-per-unit-flow, static pressure, or brake horsepower
Input Restrictions	Brake horsepower method (fixed value)
Standard Design	The standard design building shall use the power-per-unit-flow method.
Standard Design: Existing Buildings	

Garage Exhaust Fan Rated Capacity	
Applicability	All exhaust systems
Definition	The rated design air flow rate of the garage exhaust fan system

Units	Cfm
Input Restrictions	As designed
Standard Design	Same as proposed design
Standard Design: Existing Buildings	

Garage Exhaust Fan Control Method	
Applicability	All 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 constant volume 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
Standard Design: Existing Buildings	

5.7.3.6 Duct Systems in Unconditioned Space

Duct Leakage Rate	
Applicability	Any single-zone systems with ducts in unconditioned space serving zones of 5,000 ft^2 or less
Definition	The leakage rate from the duct system into unconditioned space. All leakage is assumed to occur to unconditioned space (not to outdoors).
Units	Percentage of design airflow (%)
Input Restrictions	For new systems: If duct leakage testing is performed as per instructions in the Reference Appendices and certified by a Home Energy Rating System (HERS) rater or Acceptance Test Technician (ATT), as designed. If not tested, 15 percent. For existing, altered systems: 15 percent if tested and verified by the HERS procedures in Reference Appendix NA2. If untested or if failed test, 20 percent.
Standard Design	Not applicable

Standard Design: Existing Buildings	

Duct Leakage HERS Fan Power Adjustment	
Applicability	Single zone, constant volume systems with ducts in unconditioned space, serving 5000 ft^2
Definition	A fan power penalty or credit based on the testing performed when ducts are in unconditioned spaces
Units	List: Penalty, No Change Credit
Input Restrictions	Not a user input Penalty: if the HERS duct leakage testing isn't done when required, or if the testing fails the duct leakage rate criteria No Change: testing not required Credit: testing not required, but HERS testing performed and leakage rates are verified
Standard Design	All in conditioned space
Standard Design: Existing Buildings	

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 all systems above 54,000 Btu/h cooling capacity; 0.9 for other systems.
Standard Design	1.0 for all systems above 54,000 Btu/h cooling capacity; 0.9 for other systems
Standard Design: Existing Buildings	

Design Outside Air Flow	
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 air flow 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.
Standard Design: *Existing Buildings*	

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 taking into account 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	As designed
Standard Design	Average flow
Standard Design: *Existing Buildings*	

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 air flow. The control types include: • No economizer. • Fixed dry-bulb. The economizer is enabled when the temperature of the outside air is equal to or lower than temperature fixed setpoint (e.g., 75°F). • Differential dry-bulb. The economizer is enabled when the temperature of the outside air is lower than the return air 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 is less than the return air dry-bulb 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	For healthcare facilities, same as the Proposed Design. For all others, The control should be no economizer when the standard design total cooling capacity < 54,000 Btu/h and when the standard design cooling system is not a computer room air handling unit (CRAH). Otherwise, the standard design shall assume an integrated differential dry-bulb economizer. An exception is that economizers shall not be modeled for systems serving high-rise residential or hotel/motel guestroom occupancies.
Standard Design: Existing Buildings	

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 modeling software to translate this into software-specific inputs to model this feature. The input could take the following values:

	• Non-integrated - 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	I For healthcare facilities, same as the Proposed Design. For all others, integrated for systems above capacity 54,000 Btu/h at Air-Conditioning, Heating, and Refrigeration Institute (AHRI) conditions
Standard Design: Existing Buildings	

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	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

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	For healthcare facilities, same as the Proposed Design. For all others, Not applicable

Standard Design: Existing Buildings	

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	For healthcare facilities, same as the Proposed Design. For all others, not applicable
Standard Design: Existing Buildings	

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 source of cooling for the system; either chilled water, direct expansion (DX), or other
Units	List (see above)
Input Restrictions	As designed (determined automatically from system type)
Standard Design	The standard design cooling source is: For built-up VAV (system 6) and CRAH (system 10): chilled water, For heating and ventilation (system 9), none, and For all other systems, direct expansion (DX) shown in Table 33

Standard Design: Existing Buildings	Same as proposed for unaltered

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	NOT A USER INPUT For packaged equipment that has the fan motor in the air stream such that it adds heat to the cooled air, the software shall calculate the net total cooling capacity as follows: $$Q_{t,net,rated} = Q_{t,gross,rated} - Q_{fan,rated}$$ Where: $Q_{t,net,rated}$: The net total cooling capacity of a packaged unit as rated by AHRI (Btu/h) $Q_{t,gross,rated}$: The AHRI rated 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 If the gross and net total cooling capacities at AHRI conditions are known, the fan heat at rated conditions is the difference between the two values. If the either the gross or net total cooling capacity is unknown, the fan heat at rated conditions shall be accounted for by using Equation 4: $$Q_{fan,rated} = Q_{t,gross,rated} \times 0.0415$$ Equation 4 is based on an AHRI rated fan power of 0.365 W/cfm, and a cooling airflow of 400 cfm/ton. If the number of UMLH in the proposed design exceeds 150, the software shall warn the user to resize the equipment.
Standard Design	The gross total cooling capacity of the systems in the standard design is determined from the standard design net cooling capacity, and from applying the fan power rules above for adjusting for fan heat.
Standard Design: Existing Buildings	

Gross Sensible Cooling Capacity	
Applicability	All cooling systems
Definition	The gross sensible cooling capacity of the coil or packaged equipment 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 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	As designed. For packaged equipment, the compliance software adjusts the user input of gross sensible cooling capacity to account for the effect of fan motor heat as follows: $$Q_{s,net,rated} = Q_{s,gross,rated} - Q_{fan,rated}$$ Where: $Q_{s,net,rated}$ The AHRI rated (from manufacturers' literature) or net sensible cooling capacity of a packaged unit (Btu/h) $Q_{t,gross,rated}$ The AHRI rated (from manufacturers' literature) or gross sensible 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 air stream) at AHRI rated or hourly conditions (Btu/h). See gross total cooling capacity building descriptor. If the number of UMLH in the proposed design exceeds 150, the software shall warn the user to resize the equipment.
Standard Design	The gross total cooling capacity of the systems serving the standard design is autosized by the compliance software, and then oversized by 15 percent. Sizing calculations shall be based on 0.5 percent design dry-bulb and mean coincident wet-bulb.
Standard Design: Existing Buildings	

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: $Q_{t,available}$: Available cooling capacity at specified evaporator and/or condenser conditions (MBH) $Q_{t,adj}$: Adjusted capacity at AHRI conditions (Btu/h) CAP_FT: A multiplier to adjust $Q_{t,adj}$ t_{wb}: The entering coil wet-bulb temperature (°F) t_{db}: The entering coil dry-bulb temperature (°F) t_{wt}: The water supply temperature (°F) 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. Software may represent the relationship between cooling capacity and temperature in ways other than the equations given above.
Units	Data structure
Input Restrictions	As designed The equations and coefficients given above are the default.
Standard Design	Use the default curves or equivalent data for other models
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

Coil Bypass Factor	
Applicability	All DX cooling systems using the bypass factor coil latent modeling method
Definition	The ratio of air that bypasses the cooling coil at design conditions to the total system airflow
Units	Ratio
Input Restrictions	Prescribed values defined in Appendix 5.7
Standard Design	Defaults
Standard Design: Existing Buildings	

Coil Bypass Factor Adjustment Curve	
Applicability	All DX cooling systems using the bypass factor coil latent modeling method
Definition	Adjustments for the amount of coil bypass due to the following factors: • Coil airflow rate as a percentage of rated system airflow • Entering air wet-bulb temperature • Entering air dry-bulb temperature • Part load ratio
Units	Data structure
Input Restrictions	Where applicable, prescribed (fixed) simulation engine defaults based on HVAC system type. The following default values shall be used for the adjustment curves: $CBF_{adj} = CBF_{rated}(Coil_{BF,Flow})(Coil_{BF,FT})(Coil_{BF,FPLR})$ $Coil_{BF,Flow} = a + b(CFMR) + c(CFMR)^2 + d(CFMR)^3$ $Coil_{BF,FT} = a + b(T_{wb}) + c(T_{wb})^2 + d(T_{db}) + e(T_{db})^2 + f(T_{wb})(T_{db})$

	$$Coil_{BF,FPLR} = a + b(PLR)$$ Where: <table><tr><td>CBF_{rated}</td><td>The coil bypass factor at AHRI rating conditions</td></tr><tr><td>CBF_{adj}</td><td>The coil bypass factor adjusted for airflow and coil conditions</td></tr><tr><td>$CFMR$</td><td>The ratio of airflow to design airflow</td></tr><tr><td>$Coil_{BF,Flow}$</td><td>A multiplier on the rated coil bypass factor to account for variation in air flow across the coil (take coefficients from Table 34)</td></tr><tr><td>$Coil_{F,FT}$</td><td>A multiplier on the rated coil bypass factor to account for a variation in coil entering conditions (take coefficients from Table 35)</td></tr><tr><td>$Coil_{BF,FPLR}$</td><td>A multiplier on the rated coil bypass factor to account for the part load ratio (take coefficients from Table 36)</td></tr><tr><td>T_{wb}</td><td>The entering coil wet-bulb temperature (F)</td></tr><tr><td>T_{db}</td><td>The entering coil dry-bulb temperature (F)</td></tr><tr><td>PLR</td><td>Part load ratio</td></tr></table>
Standard Design	Defaults
Standard Design: Existing Buildings	

Cooling Capacity Airflow Adjustment Curve	
Applicability	All DX cooling systems using the NTU effectiveness coil latent modeling method
Definition	Normalized curve that varies cooling capacity as a function of airflow, which affects system latent capacity
Units	Data structure
Input Restrictions	Where applicable, prescribed (fixed) simulation engine defaults based on HVAC system type. The following default values shall be used for the adjustment curves: $$CoolCap_{adj} = CoolCap_{rated} \times CoolCap_{FFLOW} \times CoolCap_{FT}$$ Where: <table><tr><td>$CFMR$</td><td>The ratio of airflow to design airflow</td></tr><tr><td>$CoolCap_{FFLOW}$</td><td>A multiplier on the rated coil capacity to account for variation in air flow across the coil (take coefficients from Table 33)</td></tr></table>

	$CoolCap_{FT}$ — A multiplier on the rated coil bypass factor to account for a variation in coil entering conditions (take coefficients from Table 34) The curve takes the form: $$CoolCap_{FFLOW} = a + b(CFMR) + c(CFMR)^2 + d(CFR)^3$$ With the coefficients defined in Appendix 5.7.
Standard Design	Use defaults as described above
Standard Design: Existing Buildings	

5.7.5.2 Direct Expansion

Direct Expansion Cooling Efficiency	
Applicability	Packaged DX equipment
Definition	The cooling efficiency of a direct expansion (DX) cooling system at AHRI rated conditions as a ratio of output over input in Btu/h per W, excluding fan energy. The abbreviation used for this full-load efficiency is Energy Efficiency Ratio (EER). For all unitary and applied equipment where the fan energy is part of the equipment efficiency rating, the EER shall be adjusted as follows: $$EER_{adj} = \frac{Q_{t,net,rated} + Q_{fan,rated}}{\frac{Q_{t,net,rated}}{EER} - \frac{Q_{fan,rated}}{3.413}}$$ Where: EER_{adj} — The adjusted EER for simulation purposes EER — The rated EER $Q_{t,net,rated}$ — The AHRI rated total gross cooling capacity of a packaged unit (kBtu/h) $Q_{fan,rated}$ — The AHRI rated fan energy, specified in Equation 7 for the gross total cooling capacity building descriptor
Units	Btu/h-W
Input Restrictions	As designed, except that the user-entered value must meet mandatory minimum requirements of Table 110.2-A, Table 110.2-B, Table 110.2-C, or Table 110.2-E for the applicable equipment type. When possible,

	specify the SEER and EER for packaged equipment with cooling capacity less than 65,000 Btu/h from manufacturer's literature. For equipment with capacity above 65,000 Btu/h, specify EER. Equipment subject to minimum efficiency requirements under the Appliance Efficiency Regulations (small packaged air conditioners and heat pumps with SEER ratings) must meet the applicable mandatory minimum efficiency requirements. When EER is not available for packaged equipment with SEER 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 shall be calculated by the equation above, but constrained to be no greater than 13. Evaporative cooling systems that pass the requirements of the Western Cooling Challenge may be modeled with an EER as if the equipment were packaged unitary equipment. See Section 5.7.5.4.
Standard Design	Use the minimum cooling efficiency (EER) from tables in Tables 110.2-A, 110.2-B, and 110.2-E in Section 110.2 of the standards.
Standard Design: Existing Buildings	

Seasonal Energy Efficiency Ratio	
Applicability	Packaged DX equipment with AHRI cooling capacity of 65,000 Btu/h or smaller
Definition	The seasonal cooling efficiency of a direct expansion (DX) cooling system at AHRI rated conditions as a ratio of output over input in Btu/h per W, excluding fan energy. The software must accommodate user input in terms of either the EER or the SEER. For equipment with SEER ratings, EER shall be taken from manufacturers' data when it is available.
Units	Btu/h-W
Input Restrictions	As designed This input is required for small DX systems. The Direct Expansion Cooling Efficiency input is optional for these systems.
Standard Design	Use the minimum SEER from the 2015 Appliance Efficiency Standards.
Standard Design: Existing Buildings	

Integrated Energy Efficiency Ratio	
Applicability	Packaged DX equipment with AHRI cooling capacity of 65,000 Btu/h or greater
Definition	Integrated Energy Efficiency Ratio This is a SEER that 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 If the IEER rating is below mandatory minimum required levels specified in Section 110.2 of the standards, the compliance run shall fail.
Standard Design	Not applicable
Standard Design: *Existing Buildings*	

Direct Expansion Cooling Efficiency Temperature Adjustment Curve

Applicability: Packaged DX equipment

Definition: A curve that varies the cooling efficiency of a direct expansion (DX) coil as a function of evaporator conditions, condenser conditions, and for small packaged equipment, part-load ratio.

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:

EIR_{FPLR}	Part-load ratio based on available capacity (not rated capacity)
EIR_{FT}	A multiplier on the EIR to account for the wet-bulb temperature entering the coil and the outdoor dry-bulb temperature
t_{wb}	The entering coil wet-bulb temperature (F)
t_{wt}	The water supply temperature (F)

<table>
<tr><td></td><td><table>
<tr><td>t_{odb}</td><td>The outside-air dry-bulb temperature (F)</td></tr>
<tr><td>P_{rated}</td><td>Rated power draw at AHRI conditions (kW)</td></tr>
<tr><td>$P_{operating}$</td><td>Power draw at specified operating conditions (kW)</td></tr>
</table></td></tr>
<tr><td>Units</td><td>Data structure</td></tr>
<tr><td>Input Restrictions</td><td>User may input curves or use default curves. If defaults are overridden, the software must indicate that supporting documentation is required on the output forms.

For DX equipment with a capacity greater than 65,000 Btu/h, the user may not enter data on the temperature dependent equipment performance. However, the ACM compliance software vendor may work with manufacturers to collect such data and build this data into the ACM compliance software. The user may either select equipment for which the ACM compliance software vendor has collected or use the defaults.</td></tr>
<tr><td>Standard Design</td><td>For all systems except packaged DX units with cooling capacity <= 65,000 Btu/h, use default curves from Appendix 5.7. For packaged DX units with cooling capacity less than or equal to 65,000 Btu/h that have SEER ratings, the user inputs EER and SEER. The software generates the equipment performance curve based on the pre-defined performance curves specified in Appendix 5.7.</td></tr>
<tr><td>Standard Design:
Existing Buildings</td><td></td></tr>
</table>

Direct Expansion Part-Load Efficiency Adjustment Curve	
Applicability	Packaged systems with DX cooling
Definition	A normalized performance adjustment curve to the rated efficiency (energy input ratio) that describes how the efficiency varies at part-load conditions. At a value of 1 (full load), the normalized efficiency is 1 (same as part-load conditions). The default curves are given as follows as adjustments to the energy input ratio (EIR): $PLR = \frac{Q_{operating}}{Q_{available}(t_{wb}, t_{odb/wt})}$ $EIR_{FPLR} = a + b(PLR) + c(PLR)^2 + d(PLR)^3$ $PLF_{FPLR} = a + b(PLR) + c(PLR)^2 + d(PLR)^3$ This curve may take the form of a part-load factor (PLF) or EIR-FLPR, which is the fraction of time that the unit must run to meet the part-load for that hour. For example, at 40 percent of full load, the equipment might need to run 50 percent of the hour for cycling losses. Note: For small packaged equipment with SEER ratings <65,000 Btu/h, the part-load efficiency curve is set to no degradation, since the part-load degradation is built into the direct expansion cooling efficiency temperature adjustment curve. Default curves are provided for the different major classes of equipment. Where: EIR_{FPLR}: Part-load ratio based on available capacity (not rated capacity) PLF_{FPLR}: A multiplier on the EIR to account for the wet-bulb temperature entering the coil and the outdoor dry-bulb temperature t_{wb}: The entering coil wet-bulb temperature (°F) t_{wt}: The water supply temperature (°F) t_{odb}: The outside-air dry-bulb temperature (°F) $Q_{operating}$: Present load on heat pump (Btu/h) $Q_{available}$: Heat pump available capacity at present evaporator and condenser conditions (Btu/h)
Units	Coefficients (three for a quadratic, or up to four for a cubic)
Input Restrictions	The coefficients should sum to 1 (within a small tolerance). This corresponds to a curve output of 1 for an input of 1.

Standard Design	The standard design part-load efficiency adjustment curves are shown in the tables below.
Standard Design: *Existing Buildings*	

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. Systems with unequally sized compressors may have additional cooling stages.
Units	None (Integer)
Input Restrictions	As designed
Standard Design	The standard design shall be two for the single zone VAV baseline and packaged VAV baseline.
Standard Design: *Existing Buildings*	

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.
Standard Design: *Existing Buildings*	

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 section 5.7.1. Air-cooled for systems 1 (SZAC), 3, (PSZ), 5 (PVAV) and 11 (CRAC). Not applicable for other standard design systems.
Standard Design: Existing Buildings	

Supplementary DX Cooling Unit	
Applicability	Required when no cooling system is specified, or when a zone has excessive unmet load hours
Definition	The specification of a supplementary DX cooling system that must be used when the user-defined cooling system results in unmet load hours exceeding 150 for any zone.
Units	List
Input Restrictions	The compliance software shall define the following prescribed system characteristics: Cooling Capacity (Btu/h) – Autosized by software Efficiency - minimum efficiency from Table 110.2-A, based on cooling capacity and assuming 3-phase System airflow – Autosized by software Economizer - none Design supply air temperature - 55°F Supply air temperature control - None Design heating supply air temperature - 95°F
Standard Design	Not applicable

Standard Design: Existing Buildings	

5.7.5.3 Evaporative Cooler

This is equipment that pre-cools the outside air that is brought into the building. It may be used with any type of cooling system that brings in outside air. This equipment is not applicable for the standard design.

Evaporative Cooling Type	
Applicability	Systems with evaporative cooling
Definition	The type of evaporative pre-cooler, including: • None • Non-integrated direct • Non-integrated indirect • Non-integrated direct/Indirect • Integrated direct • Integrated indirect • Integrated direct/indirect An integrated cooler can operate together with compressor or CHW cooling. A non-integrated cooler will shut down the evaporative cooling whenever it is unable to provide 100 percent of the cooling required. Direct evaporative cooling can only be applied to the outside air. Indirect evaporative cooling can be applied to outside air or return air.
Units	None
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

Evaporative Cooling System Capacity	
Applicability	Systems with evaporative cooling
Definition	The total sensible cooling capacity of the evaporative cooling system at design outdoor dry-bulb conditions. This value may be derived from other inputs of supply fan design air rated capacity (Section 5.7.3), direct stage effectiveness, indirect stage effectiveness, and design outdoor conditions.

Units	None
Input Restrictions	Not applicable Derived input. If there are excessive unmet load hours in any zone served by the evaporative cooling system, a supplementary DX cooling unit must be defined by the user. See Section 5.7.5.2.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

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: $Direct_{EFF}$ — The direct stage effectiveness T_{db} — The entering air dry-bulb temperature T_{wb} — The entering air wet-bulb temperature 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
Standard Design: Existing Buildings	

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: $Indirect_{EFF}$ — The indirect stage effectiveness T_{db} — The entering air dry-bulb temperature T_{wb} — The entering air wet-bulb temperature $T_{indirect}$ — 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
Standard Design: Existing Buildings	

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: PLR — Part load ratio of airflow based on design airflow EFF_{FFLOW} — A multiplier on the evaporative cooler effectiveness to account for variations in part load $CFM_{operating}$ — Operating primary air stream airflow (cfm) 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 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

Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

5.7.5.4 Four-Pipe Fan Coil Systems

This section contains building descriptors required to model four-pipe fan coil systems. Note that this system requires an outside air ventilation source to serve the zones and that an airside economizer is not available.

Supply air flow rates are set at the zone level. Chilled water flow rates are set according to the rules in section 5.8.5 on pumps.

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 section 5.8.4 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 at the zone. The following choices are available: • Constant Fan Variable Flow • Cycling Fan • Variable Fan Constant Flow • Variable Fan Variable Flow
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	For healthcare facilities, same as the Proposed Design. For all others, Cycling Fan

Standard Design: Existing Buildings	

Rated Gross Capacity	
Applicability	Four-pipe fan coil systems and chilled beams
Definition	The gross cooling capacity of the cooling coil
Units	Btu/h
Input Restrictions	None
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

5.7.5.5 Chilled Beams

Active and passive chilled beams can be modeled, in a similar manner to four-pipe fan coil systems. Active chilled beams are modeled as a four-pipe fan coil object. The zone fan for the beam is not specified by the user, but is internally added to the compliance model 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
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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	None
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: *Existing Buildings*	

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
Standard Design: *Existing Buildings*	

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
Standard Design: *Existing Buildings*	

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 air flow rate.
Units	Cfm
Input Restrictions	None
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: *Existing Buildings*	

Active Fan Static Pressure	
Applicability	Chilled beams
Definition	The design status of the active fan
Units	in. of water
Input Restrictions	None
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: *Existing Buildings*	

Active Fan Static Efficiency	
Applicability	Chilled beams
Definition	The fan static efficiency
Units	in. of water
Input Restrictions	Between 0 and 1
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: *Existing Buildings*	

Active Fan Motor Efficiency	
Applicability	Chilled beams
Definition	The motor efficiency of the fan
Units	in. of water
Input Restrictions	None
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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 and preheat coils The choices are: • Hot water • Electric resistance • Electric heat pump • Gas furnace • Oil furnace
Units	List (see above)
Input Restrictions	As designed
Standard Design	Based on the prescribed system type. Refer to the HVAC system map in Section 5.1.2. The heat source is: For system types 5 (packaged VAV), 6 (built-up VAV): hot water; For system types 1 (SZAC), 7 (SZVAV) and 9 (Heat Vent): Gas Furnace For system type 3: (PSZ): gas or oil furnace
Standard Design: *Existing Buildings*	Same as proposed if unaltered

5.7.6.2 Hydronic/Steam Heating Coils

Systems with boilers have heating coils, including standard design systems with hot water heating.

Heating Coil Capacity	
Applicability	All systems with a heating coil
Definition	The heating capacity of a heating coil at AHRI conditions
Units	Btu/h
Input Restrictions	As designed The user may need to manually adjust the capacity if the number of unmet load hours exceeds 150.

Standard Design	Autosize with a heating oversizing factor of 25 percent. If the number of unmet load hours for the standard design exceeds 150, increase the heating coil capacity as indicated in Section 2.6.2.
Standard Design: Existing Buildings	

5.7.6.3 Furnace

Furnace Capacity	
Applicability	Systems with a furnace
Definition	The full load heating capacity of the unit
Units	Btu/h
Input Restrictions	As designed The user may need to manually adjust the capacity if the number of unmet load hours exceeds 150.
Standard Design	Autosize with an oversizing factor of 25 percent (let the software determine heating capacity based on the building loads). If the number of unmet load hours for the standard design exceeds 150, increase the furnace capacity as indicated in Section 2.4 and 2.6.2
Standard Design: Existing Buildings	

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 software must accommodate input in either thermal efficiency (Et) or annual fuel utilization efficiency (AFUE). Where AFUE is provided, Et shall be calculated as: Et = 0.0051427 * (FurnAFUE * 100)) + 0.3989 Where: $AFUE$ The annual fuel utilization efficiency (%) E_t The thermal efficiency (fraction)
Units	Fraction
Input Restrictions	As designed

Standard Design	Look up the requirement from the equipment efficiency tables in Table 6.8.1E of the Appliance Efficiency Standards. The standard design efficiency requirement is located in Table E-3 or Table E-4 of the *Appliance Efficiency Standards*. Use the heating input of the standard design system to determine the size category.
Standard Design: Existing Buildings	

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: $FHeatPLC$ — The fuel heating part load efficiency curve $Fuel_{partload}$ — The fuel consumption at part load conditions (Btu/h) $Fuel_{rated}$ — The fuel consumption at full load (Btu/h) $Q_{partload}$ — The capacity at part load conditions (Btu/h) Q_{rated} — The capacity at rated conditions (Btu/h)
Units	Data structure
Input Restrictions	Fixed
Standard Design	Fixed
Standard Design: Existing Buildings	

Furnace Fuel Heating Pilot	
Applicability	Systems that use a furnace 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)

Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

5.7.6.4 Electric Heat Pump

Electric Heat Pump Heating Capacity	
Applicability	All heat pumps
Definition	The full load heating capacity of the unit, excluding supplemental heating capacity at AHRI rated conditions
Units	Btu/h
Input Restrictions	As designed
Standard Design	Autosize and use an oversizing factor of 25 percent. The software determines heating capacity based on the building loads.
Standard Design: Existing Buildings	

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 • Oil furnace

	• Hot water • Other
Units	List (see above)
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Electric resistance
Standard Design: *Existing Buildings*	

Electric Heat Pump Heating Efficiency	
Applicability	All heat pumps
Definition	The heating efficiency of a heat pump at AHRI rated conditions as a dimensionless ratio of output over input. The software must accommodate user input of either the coefficient of performance (COP) or the heating season performance factor (HSPF). Where HSPF 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: COP_{adj} — The adjusted coefficient of performance for simulation purposes COP — The AHRI rated coefficient of performance $HCAP_{rated}$ — The AHRI rated heating capacity of a packaged unit (kBtu/h) $Q_{fan,rated}$ — ARI rated fan power, equal to the gross rated cooling capacity times 0.04.
Units	Unitless
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable

Standard Design: Existing Buildings	

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: $Q_{available}$ – Available heating capacity at present evaporator and condenser conditions (kBtu/h) t_{db} – The entering coil dry-bulb temperature (°F) t_{wt} – The water supply temperature (°F) t_{odb} – The outside-air dry-bulb temperature (°F) Q_{rated} – Rated capacity at AHRI conditions (in kBtu/h)
Units	Data structure
Input Restrictions	Fixed. Use curves in Appendix 5.7 for water-source or air-source heat pumps as appropriate.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

Electric Heat Pump Heating Efficiency Adjustment Curve(s)	
Applicability	All heat pumps
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: PLR: Part-load ratio based on available capacity (not rated capacity) EIR_{FPLR}: A multiplier on the EIR of the heat pump as a function of part-load ratio 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 $Q_{operating}$: Present load on heat pump (Btu/h) $Q_{available}$: Heat pump available capacity at present evaporator and condenser conditions (Btu/h) t_{db}: The entering coil dry-bulb temperature (°F) 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)
Units	None
Input Restrictions	Fixed from appropriate curve from Appendix 5.7
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

Electric Heat Pump Supplemental Heating Capacity	
Applicability	All heat pumps

Definition	The design heating capacity of a heat pump supplemental heating coil at AHRI conditions
Units	Btu/h
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

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 all others, Not applicable
Standard Design: Existing Buildings	

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 all others, Not applicable
Standard Design: Existing Buildings	

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 others, Not applicable
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

Crank Case Heater kW	
Applicability	All 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	As designed; defaults to 0.1 if nothing is entered
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

Crank Case Heater Shutoff Temperature	
Applicability	All 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	As designed; defaults to 50°F
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

5.7.6.5 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, Not applicable
Standard Design: Existing Buildings	

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: $$HREFF = \frac{EEA_{db} - ELA_{db}}{EEA_{db} - OSA_{db}}$$ 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, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

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, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

<table>
<tr><th colspan="2">Exhaust Air Latent Heat Recovery Effectiveness</th></tr>
<tr><td>Applicability</td><td>Any system with outside air enthalpy heat recovery</td></tr>
<tr><td>Definition</td><td>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:
<table>
<tr><td>$HREFF$</td><td>The air-to-air heat exchanger effectiveness</td></tr>
<tr><td>EEA_w</td><td>The exhaust air humidity ratio (fraction of mass of moisture in air to mass of dry air) entering the heat exchanger</td></tr>
<tr><td>ELA_w</td><td>The exhaust air humidity ratio leaving the heat exchanger</td></tr>
<tr><td>OSA_w</td><td>The outside air humidity ratio</td></tr>
</table>
Note: For sensible heat exchangers, this term is not applicable.</td></tr>
<tr><td>Units</td><td>Two unitless numbers (ratio between 0 and 1), separate for cooling and heating</td></tr>
<tr><td>Input Restrictions</td><td>As designed</td></tr>
<tr><td>Standard Design</td><td>For healthcare facilities, same as the Proposed Design. For all others, Not applicable</td></tr>
<tr><td>Standard Design:
Existing Buildings</td><td></td></tr>
</table>

<table>
<tr><th colspan="2">Exhaust Air Latent Part-Load Effectiveness</th></tr>
<tr><td>Applicability</td><td>Any system with outside air enthalpy heat recovery</td></tr>
<tr><td>Definition</td><td>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:
<table>
<tr><td>$HREFF$</td><td>The air-to-air heat exchanger effectiveness</td></tr>
<tr><td>EEA_w</td><td>The exhaust air humidity ratio (fraction of mass of moisture in air to mass of dry air) entering the heat exchanger</td></tr>
</table></td></tr>
</table>

	ELA_w — The exhaust air humidity ratio leaving the heat exchanger 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	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

Economizer Enabled during Heat Recovery	
Applicability	All systems with airside heat recovery
Definition	A flag to indicate whether or not the economizer is enabled when heat recovery is active
Units	Boolean
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

5.8 HVAC Primary Systems

5.8.1 Boilers

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.
Standard Design: Existing Buildings	

Boiler Fuel Source	
Applicability	All boilers
Definition	The fuel source for the central heating equipment The choices are: • Gas • Oil • 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: <table><tr><td></td><td>Electricity</td><td>Gas</td><td>Steam</td></tr><tr><td>Steam Boiler</td><td>n/a</td><td>n/a</td><td>Allowed</td></tr><tr><td>Hot Water Boiler</td><td>n/a</td><td>Allowed</td><td>n/a</td></tr></table>
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Gas
Standard Design: Existing Buildings	Same as proposed for existing, unaltered; same as new construction if altered

Boiler Type	
Applicability	All boilers
Definition	The fuel source for the central heating equipment The choices are: • Gas • Oil • Electricity
Units	List (see above)
Input Restrictions	As designed

Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Hot water boiler
Standard Design: Existing Buildings	Same as proposed for existing, unaltered; same as new construction if altered

Boiler Draft Type	
Applicability	All boilers
Definition	How combustion airflow is drawn through the boiler. The choices are natural (sometimes called atmospheric) or mechanical. 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. Mechanical draft boilers enhance the air flow in one of three ways: 1) induced draft, which uses ambient air, a steam jet, or a fan to induce a negative pressure which pulls flow through the exhaust stack; 2) forced draft, which uses a fan and ductwork to create a positive pressure that forces air into the furnace, or 3) balanced draft, which uses both induced draft and forced draft methods to bring air through the furnace, usually keeping the pressure slightly below atmospheric.
Units	List (see above)
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Mechanical (forced)
Standard Design: Existing Buildings	

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	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 size boilers for plants serving more than 15,000 ft^2.
Standard Design: Existing Buildings	

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	The 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.
Standard Design: Existing Buildings	

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 (E_t) is the ratio of the heat transferred to the water divided by the heat input of the fuel. • Combustion efficiency (E_c) 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	AFUE for all gas and oil-fired boilers with less than 300,000 Btu/h capacity. Thermal efficiency (E_t) for all gas and oil-fired boilers with capacities between 225,000 and 2,500,000 Btu/h. Combustion efficiency (E_c), for all gas and oil-fired boilers with capacities above 2,500,000 Btu/h.
Standard Design: Existing Buildings	

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 software must accommodate input in either thermal efficiency (E_t), combustion efficiency (E_c), or AFUE. The 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: $75\% \leq AFUE < 80\%$: $E_t = 0.1(AFUE + 72.5\%)$ $80\% \leq AFUE \leq 100\%$: $E_t = 0.875(AFUE + 10.5\%)$ 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	As designed
Standard Design	Boilers for the standard design are assumed to have the minimum efficiency as listed in Table E-4 of the *California Appliance Efficiency Regulations*.
Standard Design: Existing Buildings	

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: $FHeatPLC$: The fuel heating part-load efficiency curve $Fuel_{partload}$: The fuel consumption at part-load conditions (Btu/h)

	<table><tr><td>$Fuel_{design}$</td><td>The fuel consumption at design conditions (Btu/h)</td></tr><tr><td>$Q_{partload}$</td><td>The boiler capacity at part-load conditions (Btu/h)</td></tr><tr><td>Q_{rated}</td><td>The boiler capacity at design conditions (Btu/h)</td></tr><tr><td>a</td><td>Constant</td></tr><tr><td>b</td><td>Constant</td></tr><tr><td>c</td><td>Constant</td></tr></table>
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.
Standard Design: *Existing Buildings*	

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 software shall convert the user entry of motor horsepower to fan power in watts by the following equation: $Fan\ Power = Motor\ HP(7.46)(0.5)$
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Sized for an energy input ratio of 0.001018 (0.2984 W per kBtu/h heat input)
Standard Design: *Existing Buildings*	

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 value, the software must indicate that supporting documentation is required on the output forms. Fixed at 1 percent (this accounts for jacket losses and start/stop losses).
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, 1 percent
Standard Design: *Existing Buildings*	

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 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 healthcare facilities, same as the Proposed Design. For all others, 0 gpm
Standard Design: *Existing Buildings*	

Hot Water Supply Temperature	
Applicability	All boilers
Definition	The temperature of the water produced by the boiler and supplied to the hot water loop

Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Use 180°F for standard design boiler
Standard Design: Existing Buildings	

Hot Water Return Temperature	
Applicability	All boilers
Definition	The temperature of the water returning to the boiler from the hot water loop
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Use 140°F for standard design boiler
Standard Design: Existing Buildings	

Hot Water Supply Temperature Reset	
Applicability	All boilers
Definition	Variation of the hot water supply temperature with outdoor air temperature
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed (not allowed for non-condensing boilers)
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, The hot water supply temperature should vary according to the following: • 180°F when outside air is < 20°F • Ramp linearly between 180°F and 150°F when outdoor air is between 20°F and 50°F • 150°F when outdoor air is > 50°F
Standard Design: Existing Buildings	

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
Standard Design: *Existing Buildings*	

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 • Direct-Fired Single Effect Absorption – uses a single generator and condenser • Direct-Fired Double Effect Absorption – uses two generators/ concentrators and condensers, one at a lower temperature and the other at a higher temperature. It is more efficient than the single effect but it must use a higher temperature heat source. • Indirect-Fired Double Effect Absorption • Gas Engine-Driven *Positive displacement – includes reciprocating (piston-style), scroll and screw compressors
Units	List (see above). The software shall support all chiller types listed above.
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, The standard design chiller is based on the design capacity of the standard design as follows:

	Table 12: Type and Number of Chillers Building Peak Cooling Load — Number and type of chiller(s) ≤ 300 tons — One water-cooled screw chiller 300 < Load < 600 — Two water-cooled screw chillers, sized equally ≥ 600 tons — A minimum of two water-cooled centrifugal chillers, sized to keep the unit size below 800 tons
Standard Design: Existing Buildings	

Table 12: Type and Number of Chillers

Building Peak Cooling Load	Number and type of chiller(s)
≤ 300 tons	One water-cooled screw chiller
300 < Load < 600	Two water-cooled screw chillers, sized equally
≥ 600 tons	A minimum of two water-cooled centrifugal chillers, sized to keep the unit size below 800 tons

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
Standard Design: Existing Buildings	

Number of Identical Chiller Units	
Applicability	All chillers
Definition	The fuel source for the chiller The choices are: • Electricity (for all vapor-compression chillers) • Gas (absorption units only, designated as direct-fired units) • Hot water (absorption units only, designated as indirect-fired units) • Steam (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:

	Electricity	Gas	Hot Water	Steam
Reciprocating	Allowed	n/a	n/a	n/a
Scroll	Allowed	n/a	n/a	n/a
Screw	Allowed	n/a	n/a	n/a
Centrifugal	Allowed	n/a	n/a	n/a
Single Effect Absorption	n/a	Allowed	Allowed	Allowed
Direct-Fired Double Effect Absorption	n/a	Allowed	Allowed	Allowed
Indirect-Fired Absorption	n/a	Allowed	Allowed	Allowed

Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Electricity
Standard Design: Existing Buildings	

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	Determine loads for standard design and oversize by 15 percent
Standard Design: Existing Buildings	

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 new construction rules if altered or replacement

Integrated Part-Load Value	
Applicability	All chillers
Definition	The part-load efficiency of a chiller developed from a weighted average of four rating conditions, according to AHRI Standard 550
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	Not used When the standard design system has a chiller, the standard design will always use Path B performance curves.
Standard Design: Existing Buildings	

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 13: Default Minimum Unloading Ratios

Chiller Type	Default Unloading Ratio

	<table><tr><td>Reciprocating</td><td>25%</td></tr><tr><td>Screw</td><td>15%</td></tr><tr><td>Centrifugal</td><td>10%</td></tr><tr><td>Scroll</td><td>25%</td></tr><tr><td>Single Effect Absorption</td><td>10%</td></tr><tr><td>Double Effect Absorption</td><td>10%</td></tr></table>
Units	Percent (%)
Input Restrictions	As designed but constrained to a minimum value of 10 percent. 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
Standard Design: Existing Buildings	

Chiller Minimum Part Load 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 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. 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.
Standard Design: Existing Buildings	

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: $Q_{available}$: Available cooling capacity at present evaporator and condenser conditions (MBH) t_{chws}: The chilled water supply temperature (°F) t_{cws}: The condenser water supply temperature (°F) t_{odb}: The outside air dry-bulb temperature (°F) 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	For healthcare facilities, same as the Proposed Design (choose from available performance curves, no custom curves). For all others, Use prescribed curve for Path B chiller as applicable to the standard design chiller type.
Standard Design: Existing Buildings	

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: $$PLR = \frac{Q_{operating}}{Q_{available}(t_{chws}, t_{cws/odb})}$$ $$EIR_{FPLR} = a + b(PLR) + c(PLR)^2$$ 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: PLR — Part-load ratio based on available capacity (not rated capacity) $Q_{operating}$ — Present load on chiller (Btu/h) $Q_{available}$ — Chiller available capacity at present evaporator and condenser conditions (Btu/h) t_{chws} — The chilled water supply temperature (°F) t_{cws} — The condenser 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) 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 software inputs of full-load efficiency and integrated part-load value with the requirements of standards Table 110.2-D.

Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Use Path B curves specified in Appendix 5.7
Standard Design: Existing Buildings	

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

<table>
<tr><td></td><td>there are three sets of curves for different ranges of operation based on the engine speed.
Where:
<table>
<tr><td>PLR</td><td>Part-load ratio based on available capacity (not rated capacity)</td></tr>
<tr><td>FIR_{FPLR}</td><td>A multiplier on the fuel input ratio (FIR) to account for part-load conditions</td></tr>
<tr><td>FIR_{FT}</td><td>A multiplier on the fuel input ratio (FIR) to account for the chiller water supply temperature and the condenser water temperature</td></tr>
<tr><td>FIR_{FT1}</td><td>A multiplier on the fuel input ratio (FIR) to account for chilled water supply temperature</td></tr>
<tr><td>FIR_{FT2}</td><td>A multiplier on the fuel input ratio (FIR) to account for condenser water supply temperature</td></tr>
<tr><td>CAP_{FT}</td><td>A multiplier on the capacity of the chiller (Equation 45)</td></tr>
<tr><td>$Q_{operating}$</td><td>Present load on chiller (in Btu/h)</td></tr>
<tr><td>$Q_{available}$</td><td>Chiller available capacity at present evaporator and condenser conditions (in Btu/h)</td></tr>
<tr><td>t_{chws}</td><td>The chilled water supply temperature (in °F)</td></tr>
<tr><td>t_{cws}</td><td>The condenser water supply temperature (in °F)</td></tr>
<tr><td>t_{odb}</td><td>The outside air dry-bulb temperature (°F)</td></tr>
<tr><td>$Fuel_{rated}$</td><td>Rated fuel consumption at AHRI conditions (in Btu/h)</td></tr>
<tr><td>$Fuel_{partload}$</td><td>Fuel consumption at specified operating conditions (in Btu/h)</td></tr>
</table>
</td></tr>
<tr><td>*Units*</td><td>Data structure</td></tr>
<tr><td>*Input Restrictions*</td><td>Restricted to curves specified in Appendix 5.7</td></tr>
<tr><td>*Standard Design*</td><td>Use prescribed curves specified in Appendix 5.7</td></tr>
<tr><td>*Standard Design:*
Existing Buildings</td><td></td></tr>
</table>

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.
Standard Design: Existing Buildings	

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.
Standard Design: Existing Buildings	

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 none, outside air-based reset, or demand-based reset
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Outside air-based reset
Standard Design: Existing Buildings	

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.
Standard Design: Existing Buildings	

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 all others, the standard design chiller is always assumed to have a water-cooled condenser, although the chiller type will change depending on the design capacity.
Standard Design: Existing Buildings	

5.8.3 Cooling Towers

Standard Design Summary. Standard design system 6 has 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	Descriptive name that keys the standard design building plant
Standard Design: Existing Buildings	

Cooling Tower Type	
Applicability	All cooling towers
Definition	Type of cooling tower employed. The choices are: • Open tower, centrifugal fan • Open tower, 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, same as the Proposed Design. For all others, The standard design cooling tower is an open tower axial fan device
Standard Design: Existing Buildings	

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	The standard design building chiller is autosized and increased by 15 percent. The tower is sized to supply 85°F condenser water at design conditions for the oversized chiller.

Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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	Gpm/hp or unitless if energy input ratio (EIR) is specified (if the nominal tons but not the condenser water flow is specified, the condenser design water flow shall be 3.0 gpm per nominal cooling ton).
Input Restrictions	As designed, but the cooling towers shall meet minimum performance requirements in Standards Table 110.2-G
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, The cooling tower fan horsepower is 60 gpm/hp, with the following exceptions: 1) Cooling towers in climate zones 1 or 16 shall set the standard design to the mandatory minimum, 42.1 gpm/hp 2) Cooling towers with a design condenser water flow of 900 gpm or less shall set the standard design to the mandatory minimum, 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
Standard Design: Existing Buildings	

Cooling Tower Design Entering 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	85°F or 10°F above the design wet-bulb temperature, whichever is lower
Standard Design: Existing Buildings	

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	Set to a range of 10°F (10°F above the cooling tower design entering water temperature)
Standard Design: Existing Buildings	

Cooling Tower Capacity Adjustment Curve	
Applicability	All cooling towers
Definition	A curve or group of curves that represent the available total cooling capacity as a function of outdoor air wet-bulb, condenser water supply, and condenser water return temperatures. The default curves are given as follows: Approach = Coeff(1) + Coeff(2)•FRair + Coeff(3)•(FRair)2 +Coeff(4)•(FRair)3 + Coeff(5)•FRwater + Coeff(6)•FRair•FRwater + Coeff(7)•(FRair)2•FRwater + Coeff(8)•(FRwater)2 + Coeff(9)•FRair•(FRwater)2 + Coeff(10)•(FRwater)3 + Coeff(11)•Twb + Coeff(12)•FRair•Twb + Coeff(13)•(FRair)2•Twb + Coeff(14)•FRwater•Twb + Coeff(15)•FRair•FRwater•Twb + Coeff(16)•(FRwater)2•Twb + Coeff(17)•(Twb)2 + Coeff(18)•FRair•(Twb)2 + Coeff(19)•FRwater•(Twb)2 + Coeff(20)•(Twb)3 + Coeff(21)•Tr + Coeff(22)•FRair•Tr + Coeff(23)•FRair•FRair•Tr + Coeff(24)•FRwater•Tr + Coeff(25)•FRair•FRwater•Tr + Coeff(26)•(FRwater)2•Tr + Coeff(27)•Twb•Tr + Coeff(28)•FRair•Twb•Tr + Coeff(29)•FRwater•Twb•Tr + Coeff(30)•(Twb)2•Tr + Coeff(31)•(Tr)2 + Coeff(32)•FRair•(Tr)2 + Coeff(33)•FRwater•(Tr)2 + Coeff(34)•Twb•(Tr)2 + Coeff(35)•(Tr)3 Where: FRair – ratio of airflow to airflow at design conditions FRwater – ratio of water flow to water flow at design conditions Tr – tower range (°F) Twb – 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
Standard Design: Existing Buildings	

Cooling Tower Set Point Control	
Applicability	All cooling towers
Definition	The type of control for the condenser water supply. The choices are fixed or wet-bulb reset. A fixed control will modulate the tower fans to provide the design condenser water supply temperature at all times when possible. A wet-bulb reset control will reset the condenser water 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 95°F
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
Standard Design: *Existing Buildings*	

Cooling Tower Capacity Control	
Applicability	All cooling towers
Definition	Describes the modulation control employed in the cooling tower. Choices include: • **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** are the same from an energy perspective. 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** is a variable frequency drive is installed for the tower fan so that the speed can be modulated.
Units	List (see above)
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Variable-speed fan

Standard Design: Existing Buildings	

Cooling Tower Low-Speed Airflow Ratio	
Applicability	All cooling towers with two-speed or pony motors
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, Not applicable
Standard Design: Existing Buildings	

Cooling Tower Low-Speed kW Ratio	
Applicability	All cooling towers with two-speed or pony motors
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, Not applicable
Standard Design: Existing Buildings	

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: PLR: Part-load ratio based on available capacity (not rated capacity) $Q_{operating}$: Present load on tower (in Btu/h) $Q_{available}$: Tower available capacity at present range, approach, and outside wet-bulb conditions (in Btu/h) t_{OWB}: The outside air wet-bulb temperature (°F) t_R: The tower range (°F) t_A: The tower approach (°F) P_{rated}: Rated power draw at CTI conditions (kW) $P_{operating}$: 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
Standard Design: Existing Buildings	

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, same as the Proposed Design. For all others, 0.5
Standard Design: Existing Buildings	

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; default is no water-side economizer
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, No water economizer
Standard Design: Existing Buildings	

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 non-integrated 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
Standard Design: Existing Buildings	

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: $$Q_{econ} = (m_{CHW})(Cp_{CHW})(\varepsilon)(T_{CHW,R} - T_{CW,S})$$ Where: Q_{econ} — The maximum load that the economizer can handle m_{CHW} — The chilled water flow rate Cp_{CHW} — The chilled water specific heat $T_{CHW,R}$ — The chilled water return temperature $T_{CW,S}$ — The condenser water supply temperature WSEeff — The effectiveness of the water-side economizer coil tea — The entering coil air dry-bulb temperature (°F) tla — The leaving coil air dry-bulb temperature (°F) tea — The entering coil water temperature (°F)
Units	Ratio
Input Restrictions	As designed; default is 60 percent
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, No water economizer
Standard Design: Existing Buildings	

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	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: Existing Buildings	

Water-Side Economizer Approach	
Applicability	All water-side economizers
Definition	The design temperature difference between the chilled water temperature leaving the heat exchanger and the condenser water inlet to the 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
Standard Design: Existing Buildings	

Water-Side Economizer Maximum CWS	
Applicability	All water-side economizers
Definition	The control temperature (condenser water supply temperature) 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
Standard Design: Existing Buildings	

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	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, No water economizer
Standard Design: Existing Buildings	

Water-Side Economizer Auxiliary kW	
Applicability	Water-side economizers with an open tower
Definition	The electrical input (pumps and auxiliaries) for a dedicated pump for the chilled water side of the heat exchanger This power is in excess of the condenser water pumps and cooling tower fans for the system during water-side economizer operation.
Units	KW or kW/ton
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, No water economizer
Standard Design: *Existing Buildings*	

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 (system 6) is a primary system. Each chiller has its own primary and condenser water pumps that operate when the chiller is activated.

General Notes - The building descriptors in this section 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; were applicable, should match the tags that are used on the plans
Standard Design	Same as proposed design If there is no equivalent in the proposed design, 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).
Standard Design: *Existing Buildings*	

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 • Loop water (for hydronic heat pumps)
Units	List (see above)
Input Restrictions	As designed
Standard Design	As needed by the standard design system
Standard Design: Existing Buildings	

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.
Standard Design: Existing Buildings	

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; for chilled water loops, a primary loop design is assumed.
Standard Design: Existing Buildings	

Pump Motor Modeling Method	
Applicability	All pumps
Definition	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
Standard Design: Existing Buildings	

Pump Motor Power-Per-Unit-Flow	
Applicability	All proposed design 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	As designed
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
Standard Design: Existing Buildings	

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
Standard Design	Not applicable
Standard Design: *Existing Buildings*	

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, cooling tower design entering water temperature, and cooling tower design return water temperature shall be used to calculate the proposed brake horsepower. This shall be compared to the pump motor horsepower for the next smaller motor size (MHPi-1) than the one specified by the user (MHPi). The proposed design for the 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: $design\ bhp_{prop}$: The brake horsepower used in the simulation $design\ bhp_{prop-user-head}$: The brake horsepower resulting from the user input of design head MHP_i: The pump motor horsepower specified by the user i: The index into the standard motor size table for the user motor horsepower 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: (40 ft) + (0.03 ft/ton) x [chiller plant nominal capacity (tons)] (not to exceed 100 ft) 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	Ratio
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, Not applicable
Standard Design: *Existing Buildings*	

Motor Efficiency	
Applicability	All pumps in proposed design that use the detailed modeling method
Definition	The full load efficiency of the pump motor
Units	Ratio
Input Restrictions	For healthcare facilities, same as the Proposed Design. For all others, As designed
Standard Design	The motor efficiency is taken from ***Table 11***, using the next larger motor size than the calculated standard design brake horsepower
Standard Design: *Existing Buildings*	

Pump Minimum Speed	
Applicability	All two-speed or variable-speed pumps
Definition	The minimum pump speed for a two-speed for variable-speed pump.

	For two-speed pumps this is typically 0.67 or 0.5. Note: The pump minimum speed is not necessarily the same as the minimum flow ratio, since the system head may change.
Units	Ratio
Input Restrictions	As designed
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, 0.10
Standard Design: *Existing Buildings*	

Pump Minimum Flow Ratio	
Applicability	Primary chilled water pumps
Definition	The minimum fraction of design flow when the pump is operating at its minimum speed. The pump minimum speed is not necessarily the same as the minimum flow ratio, since the system head may change.
Units	Ratio
Input Restrictions	As designed For compliance software that cannot model intermittent pump operation, the minimum flow ratio is set to 0 and the minimum power per the part-load performance curve is fixed at 0.103.
Standard Design	For healthcare facilities, same as the Proposed Design. For all others, For compliance software that cannot model intermittent pump operation, the minimum flow ratio is set to 0 and the minimum power per the part-load performance curve is fixed at 0.103.
Standard Design: *Existing Buildings*	

Pump Design Flow (GPM)	
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	Not a user input
Standard Design	For healthcare facilities, same as the Proposed Design. 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. A VSD is required for heating pumps when the service area is greater than or equal to 120,000 ft². For hot water pumps servicing boilers, the flow rate in gpm shall correspond to a loop temperature drop of 40°F.
Standard Design: Existing Buildings	

Pump Control Type	
Applicability	All pumps
Definition	The type of control for the pump Choices are: • Fixed speed, fixed flow • Fixed speed, variable flow (the default, with flow control via a valve) • Two-speed • Variable speed, variable flow
Units	List, see above
Input Restrictions	As designed; default is “fixed speed, variable flow”, 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 pumps shall be modeled as variable-speed, variable flow, and the condenser water pumps shall be modeled as fixed speed. The hot water pumps shall be modeled as fixed-speed, variable flow, riding the curve.
Standard Design: Existing Buildings	

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.
Standard Design: Existing Buildings	

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: PLR: Part-load ratio (the ratio of operating flow rate in gpm to design flow rate in gpm) P_{pump}: Pump power draw at part-load conditions (W) 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	Default is “Default (No Reset)”. The Differential Pressure (DP) reset curve may only be selected if the DDC control type building descriptor indicates that the building has DDC controls.
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.
Standard Design: Existing Buildings	

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 section 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	Not applicable

Heat Recovery	
Applicability	VRF
Definition	Identification if heat recovery (refrigerant loop) is present.
Units	Boolean
Input Restrictions	None (default : No)
Standard Design	Not applicable

Control Priority	
Applicability	VRF
Definition	A control parameter used to determine when outdoor unit is in heating or cooling
Units	List: MasterThermostat Priority or Load Priority
Input Restrictions	None
Standard Design	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	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 to 1
Standard Design	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) per AHRI rating conditions
Units	Btu/h-W
Input Restrictions	None
Standard Design	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) per AHRI rating conditions
Units	None
Input Restrictions	None
Standard Design	Not applicable

Rated Indoor Type	
Applicability	VRF
Definition	A flag to determine when the VRF system was rated with ducted or unducted indoor units
Units	List: ducted, unducted

Input Restrictions	None
Standard Design	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	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	Not applicable

Defrost Heat Source	
Applicability	VRF
Definition	The defrost heat source type
Units	List – electric or gas
Input Restrictions	None
Standard Design	Not applicable

Defrost Control Strategy	
Applicability	VRF
Definition	The control method for enabling defrost
Units	List – TimedCycle or OnDemand
Input Restrictions	None
Standard Design	Not applicable

Max Defrost Temp	
Applicability	VRF
Definition	The maximum outdoor dry-bulb temperature at which defrost will occur
Units	Deg F
Input Restrictions	None
Standard Design	Not applicable

Crankcase Heater Capacity	
Applicability	VRF
Definition	The capacity of the resistive defrost heating element
Units	W
Input Restrictions	None
Standard Design	Not applicable

Compressor Quantity	
Applicability	VRF
Definition	The number of compressors in the condenser, which determines crankcase heater operation
Units	Deg F
Input Restrictions	None
Standard Design	Not applicable

Crankcase Heater Cutoff	
Applicability	VRF
Definition	The outdoor dry-bulb temperature below which the crankcase heater can operate
Units	None
Input Restrictions	None
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 • Electrical generation
Units	None
Input Restrictions	As designed
Standard Design	Same as the proposed design
Standard Design: Existing Buildings	

Equipment Schedule	
Applicability	All plant equipment
Definition	A schedule that identifies when the equipment is in service
Units	Data structure
Input Restrictions	As designed
Standard Design	Operation staging when multiple equipment is used
Standard Design: Existing Buildings	

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 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	As designed; default is on-demand
Standard Design	Assume on-demand operation
Standard Design: Existing Buildings	

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	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.
Standard Design: Existing Buildings	

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	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	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	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	As designed
Standard Design	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	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	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	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	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	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	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-ft²-F/Btu)
Input Restrictions	As designed
Standard Design	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 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.
Standard Design: *Existing Buildings*	

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. 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, prescribed values from Appendix 5.4A if a service hot water heating system is installed; otherwise, all values are 0. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design	Prescribed values from Appendix 5.4A if a service hot water heating system is installed; otherwise, all values are 0. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design: *Existing Buildings*	

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. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design	The schedules from Appendix 5.4A shall be used. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design: *Existing Buildings*	

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 high-rise residential buildings, the rules in the Residential ACM Reference Manual shall be followed. 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*	

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, the schedules from Appendix 5.4A shall be used. The water mains temperature schedule shall be fixed for a given climate zone. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design	For nonresidential spaces, the schedules from Appendix 5.4A shall be used. The water mains temperature schedule shall be fixed for a given climate zone. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.

Standard Design: Existing Buildings	

5.9.2 Water Heaters

This section 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.
Standard Design: Existing Buildings	

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 high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
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	

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. 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. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design: Existing Buildings	

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	

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	
Standard Design: Existing Buildings	

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 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:

$$F = \frac{(NUb) - (N^2PUa)}{d(U-N) + c(N^2P - NPU) - Ub + NPUa}$$

Where:

F	Energy Factor
N	Recovery Efficiency
P	Power Input (W)
U	UEF
N	Recovery efficiency defined as 0.80 for storage water heater UEF to EF conversion

Draw Pattern	a	b	c	d

	<table><tr><td>Very Small</td><td>0.250266</td><td>57.5</td><td>0.039864</td><td>67.5</td></tr><tr><td>Low</td><td>0.065860</td><td>57.5</td><td>0.039864</td><td>67.5</td></tr><tr><td>Medium</td><td>0.045503</td><td>57.5</td><td>0.039864</td><td>67.5</td></tr><tr><td>High</td><td>0.029794</td><td>57.5</td><td>0.039864</td><td>67.5</td></tr></table>
Standard Design	For nonresidential buildings and nonresidential spaces, the energy factor for the standard design system shall be determined from the *Appliance Efficiency Regulations*. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design: Existing Buildings	

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	Not applicable
Standard Design: Existing Buildings	

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	Not applicable

Standard Design: Existing Buildings	

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). Very small: 0-18 gal/hr Low: 18-51 gal/hr Medium: 51-75 gal/hr High: > 75 gal/hr
Units	List: • Very small • Low • Medium • High
Input Restrictions	Not user editable. Draw pattern is determined from FHR user input.
Standard Design	Not applicable
Standard Design: Existing Buildings	

Thermal Efficiency	
Applicability	Oil and gas-fired water heaters 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*.

	For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed.
Standard Design: Existing Buildings	

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: S: The standby loss fraction listed in the Energy Commission's Appliance Database of Certified Water Heaters VO: The actual storage capacity of the water heater as listed in the Energy Commission's Appliance Database of Certified Water Heaters (gallons)
Standard Design	Table F-2 of the *Appliance Efficiency Standards*
Standard Design: Existing Buildings	

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: EF — The energy factor of the rated water heater (unitless) 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. P_{on} — The input power to the water heater, in Btu/h
Standard Design	For nonresidential spaces, 10 Btu/h-F. For high-rise residential spaces and residential living spaces of hotels and motels (guestrooms), the rules in the *Residential ACM Reference Manual* are followed
Standard Design: Existing Buildings	

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	

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	

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
Standard Design: *Existing Buildings*	

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*	

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*	

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	

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	

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:

$FHeatPLC$	The fuel heating part load efficiency curve
$Fuel_{partload}$	The fuel consumption at part-load conditions (Btu/h)
$Fuel_{design}$	The fuel consumption at design conditions (Btu/h)
$Q_{partload}$	The water heater capacity at part-load conditions (Btu/h)
Q_{rated}	The water heater capacity at design conditions (Btu/h)
PLR_n	Part-load ratio for the n^{th} hour and shall always be less than 1
$INPUT$	The input capacity of the water heater expressed in Btu/hr
$STBY$	Hourly standby loss expressed in Btu/hr. For large storage gas water heaters, STBY is listed in the

	Energy Commission's appliance database. The value includes pilot energy and standby losses. For all systems, refer to equation N2-62.
SRL	The standard recovery load, taken from Appendix 5.4A, in Btu/hr, adjusted for the number of occupants according to the occupancy schedules.
S	The standby loss fraction listed in the Energy Commission's Appliance Database of Certified Water Heaters
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	

5.9.3 Recirculation Systems

This section describes the building descriptors for hot water recirculation systems. The standard design has a recirculation system when the proposed design does. This is one aspect of the water heating system configuration (see above).

Recirculating systems shall follow the rules set forth in Appendix E of the *Residential ACM Reference Manual*.

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-ft2-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	

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	

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	

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 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 high-rise residential 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.
Standard Design: Existing Buildings	

Combined Space Heating and Water Heating	
Applicability	Projects that use a boiler to provide both space heat and water heating
Definition	A system that provides both space heating and water heating from the same equipment, generally the space heating boiler. 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	

5.9.5 Exterior Lighting

Outdoor lighting requirements are specified in Section 140.7 of the standards. 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 standards.

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
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

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
Standard Design: Existing Buildings	

5.10 Common Data Structures

This section 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.

5.10.1 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). 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.

5.10.2 Holidays

A series of dates defining holidays for the simulation period. Dates identified are operated for the schedule specified for holidays.

5.10.3 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.

5.10.4 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.

5.10.5 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.

5.10.6 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.

5.10.7 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 are 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 take into account 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).

5.10.8 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.

5.10.9 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.

5.11 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.

5.11.1 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.

5.11.2 Furniture and Contents

This data structure represents the thermal mass effect of furniture and other building contents. This is expressed in terms of lb/ft^2 for the space in question.

5.11.3 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.

5.12 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.

5.12.1 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 and Y coordinates of points on the curve, or it can be expressed as an equation.

5.12.2 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.