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11. Multifamily Building Requirements

11.1 Overview

This chapter covers the requirements for all dwelling units and common use areas in multifamily buildings for both newly constructed buildings and additions or alterations to existing buildings. Multifamily buildings include the following:

- A building of occupancy groups R-2, other than a hotel/motel building or timeshare property,
- A building of occupancy group R-3 that is a non-transient congregate residence, other than boarding houses of more than 6 guests and alcohol or drug abuse recovery homes of more than 6 guests, and
- A building of occupancy group R-4.

Single-family homes, duplexes, triplexes, and all townhouses (regardless of number of habitable stories) are subject to the single-family requirements and covered in the Residential Compliance Manual.

Spaces in multifamily buildings include both dwelling units and common use areas. Dwelling unit requirements apply to living, sleeping, eating, cooking, and sanitation spaces within a single unit. A single dwelling unit may include shared living spaces with multiple sleeping rooms, such as in a dormitory. Dwelling unit requirements covered in this chapter share few requirements with nonresidential buildings. Common use area requirements apply to spaces outside the dwelling unit that are shared by building owners, residents, and their guests. Spaces used by building managers and maintenance staff qualify as common use areas.

Due to the similarity of requirements for common use areas and nonresidential spaces, this chapter frequently references other chapters of the Nonresidential Compliance Manual for common use areas. All other occupancies in a mixed-use building are subject to the nonresidential requirements in Chapters 3 through 10.

The following building types are outside the scope of the Energy Code:

- Historical buildings, as defined by the in the California Historical Building Code (Title 24, Part 8). In alterations to historical buildings, replacement lighting fixtures that are not historic or replicas of historic fixtures must comply with applicable indoor and outdoor lighting requirements.
- At the discretion of the enforcement agency, temporary buildings, temporary outdoor lighting or temporary lighting in an unconditioned building, or structures erected in response to a natural disaster (Exception 2 to §100.0(a)). These buildings may also be exempt from mandatory requirements of the Energy Code.

Buildings being converted to a multifamily occupancy from another occupancy must comply with applicable requirements for additions or alterations to multifamily buildings.

Example 11-1

Question

Three stories of residential dwelling units are planned over a first story that includes retail and restaurant occupancies. Which occupancies need to comply with the multifamily standards?

Answer

The "R" occupancy (dwelling units and common use areas) will be subject to the MF requirements, the retail (occupancy "M") and restaurant (occupancy "A") are subject to the nonresidential standards. If using the performance approach, the combined energy budget is used to determine compliance.

Example 11-2

Question

Does a four-story townhouse need to comply with the single-family standards or multifamily standards?

Answer

Townhouses, regardless of number of habitable stories, are covered under the single-family standards.

Example 11-3

Question

An apartment building has three stories of apartments, and a garage on the first floor. What are the applicable compliance requirements?

Answer

Dwelling unit and common use area spaces must comply with the multifamily standards. The parking garage must meet applicable nonresidential lighting and covered process requirements.

11.1.1 Navigating This Chapter

Multifamily building dwelling unit requirements align closely with single-family requirements, while common use area requirements align closely with nonresidential requirements. All dwelling unit requirements are covered in the multifamily chapter. In some cases, headings for common use spaces reference other nonresidential chapters. Table 11-1 shows which chapter of this manual covers dwelling units vs. common areas.

Table 11-1: Compliance Manual and Standards Navigation by Dwelling Unit and Common Use Area

	Dwelling Unit	Common Use Area
Indoor Air Quality	Section11.4	Section 4.3
Space Heating and Cooling	Section 11.6.3	Chapter 4
Water Heating	Section 11.7.3	Section 11.7.3
Indoor Lighting	Section 11.8.2	Section 11.8.4
Outdoor Lighting	Section 11.8.2	Section 11.8.5
Electrical Power Distribution	N/A	Section 11.9
Covered Processes	N/A	Chapter 10
Electric-Ready	Section 11.12	N/A
PV and Battery Storage	Section 11.9	Section 11.9

Source: California Energy Commission

Each subchapter contains the following elements:

- A summary of what is new for the 2022 code cycle.
- Presentation of a specific topic in each subsection for newly constructed buildings
- A discussion of additions and alterations for existing buildings
- Compliance and enforcement
- Code in practice

Mandatory requirements, prescriptive requirements, and performance options are described within each subsection.

11.1.2 Code in Practice

Each technical chapter or subsection has a Code in Practice section with example projects that demonstrate compliance. The example projects are a two-story multifamily garden complex and a five-story mixed use building.

11.1.2.1 Two-Story Garden Complex

The two-story garden complex example has multiple eight-unit buildings with dwelling unit access from the building exterior and no interior common use areas. Building features and mechanical components include:

- Slab-on-grade ground floor
- Wood framed walls
- Vented attic
- Split heat pump with ducts in the attic and dropped soffit
- Individual water heaters
- Carport parking

11.1.2.2 Five-Story Mixed Use Building

The five-story mixed-use building example has ground floor retail and common use areas, with four residential floors and 88 dwelling units with above. Building features and mechanical components include:

- Concrete podium ground floor
- Below ground parking garage
- Wood frame construction on the second through fourth floors
- Metal frame construction on the fifth floor
- Flat roof with mechanical equipment and outdoor living space
- Split heat pump
- DOAS serving common use areas
- Central water heating serving the whole building

11.1.3 What's New for the 2022 Energy Code

The most significant change in the 2022 Energy Code affecting multifamily buildings is the consolidation of dwelling unit and common use area requirements into three standalone subchapters. These changes result in consistent requirements across multifamily buildings, while the 2019 Energy Code had separate requirements for multifamily buildings up to three habitable stories and buildings with four or more habitable stories. There are also changes in requirements related to indoor air quality, space conditioning, and domestic hot water. These are further described in the *What's New for the 2022 Energy Code* section and in each technical Section 11.3 through 11.9.

11.2 Compliance and Enforcement

This section covers the compliance forms and enforcement process applicable to multifamily buildings. Refer to Chapter 2 of the Nonresidential Compliance Manual for a more complete description of the compliance and enforcement process.

11.2.1 Compliance Documentation

Compliance documentation is required at the design phase (see Table 11-2), the construction phase (see Table 11-3), and the diagnostic testing and verification phase (see Table 11-4). All compliance documentation must be completed prior to the final inspection by the enforcement agency.

For multifamily buildings with three or fewer habitable stories, when a project includes a HERS verification requirement, all Certificates of Compliance, Certificates of Installation, and Certificates of Verification must be registered copies from an approved HERS registry. For multifamily buildings with four or more habitable stories, only the Certificates of Verification must be registered copies from an approved HERS registry. More details on field verification and diagnostic testing and the HERS provider data registry are in the *2022 Reference Residential Appendices and 2022 Reference Joint Appendices*, described below:

- Reference Joint Appendix JA7 – Data Registry Requirements
- Reference Residential Appendix RA2 – Residential HERS Verification, Testing, and Documentation Procedures
- Reference Residential Appendix RA3 – Residential Field Verification and Diagnostic Test Protocols

11.2.1.1 Design Phase

At the design phase, the Certificates of Compliance must be incorporated into the building plans submitted to the enforcement agency. Depending on the compliance approach, compliance documentation can also include the following worksheets:

- Area weighted average calculation worksheet (for roofs, walls, floors, and fenestration)
- Solar heat gain coefficient worksheet
- Cool roof and SRI worksheet

When the performance approach is used for compliance, additional worksheets are not required, since the Energy Commission-approved software performs the calculations and provides the documentation contained in all other worksheets.

When the prescriptive approach is used for additions and alterations, a shorthand version of the Certificates of Compliance must be submitted with the building plans, or with the permit application when no plans are required. Additions, alterations, and HVAC changeouts each have unique Certificates of Compliance.

For multifamily buildings up to three habitable stories for which compliance requires HERS verification, the Certificates of Compliance submitted to the enforcement agency must be a registered copy from an approved HERS registry. For a more detailed explanation of the HERS program and document registration, see Chapter 2 of the Nonresidential Compliance Manual.

Table 11-2 shows the Certificates of Compliance documents required, based on the permit application and number of stories.

Table 11-2: Certificates of Compliance by Application and Number of Stories

Application	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Performance Approach	LMCC-PRF-01-E	NRCC-PRF-01-E
Electrical Power Distribution	LMCC-ELC-E	NRCC-ELC-E

Application	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Envelope	LMCC-ENV-E	NRCC-ENV-E
Lighting – Indoor	LMCC-LTI-E	NRCC-LTI-E
Lighting - Outdoor	LMCC-LTO-E	NRCC-LTO-E
Lighting - Sign	LMCC-LTS-E	NRCC-LTS-E
Mechanical Systems	LMCC-MCH-E	NRCC-MCH-E
Water Heating Systems/Plumbing	LMCC-PLB-E	NRCC-PLB-E
Covered Processes	LMCC-PRC-E	NRCC-PRC-E
Solar	LMCC-SRA-E	NRCC-SRA-E

Source: California Energy Commission

11.2.1.2 Construction Phase Documentation

§10-103(a)3

The Certificates of Installation are separated into envelope, lighting, mechanical, plumbing, and solar categories. Most compliance features have a separate Certificate of Installation form that is specific to a particular trade (electrical, plumbing, HVAC, etc.). The Certificate of Installation forms are completed during the construction or installation phase by the contractors responsible for installing regulated energy features such as windows (fenestration), air distribution ducts and other requirements that affect building energy performance. The Certificates of Installation must be posted at the job site, kept with the building permit, or otherwise submitted to the enforcement agency.

When HERS verification of a feature is required, the builder or subcontractor performs the diagnostic test (Reference Residential Appendix RA3) of the installation to confirm compliance with the approved design requirements and the Energy Code. The Certificates of Installation for multifamily buildings with three or fewer habitable stories are registered with a HERS Registry and made available to the enforcement agency. Table 11-3 shows Certificates of Installation based on the application and number of stories.

Table 11-3: Certificates of Installation by Application and Number of Stories

Application	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Electrical Power Distribution	LMCI-ELC-E (Common use area only)	NRCI-ELC-E
Envelope NonHERS HERS	 LMCI-ENV-E LMCI-ENV-(20 through 22)-HERS	NRCI-ENV-E
Indoor Lighting	LMCI-LTI-E (common use area only)	NRCI-LTI-E
Outdoor Lighting	LMCI-LTO-E (common use area only)	NRCI-LTO-E
Sign Lighting	LMCI-LTS-E (common use area only)	NRCI-LTS-E
Mechanical NonHERS HERS	 LMCI-MCH-E LMCI-MCH-(20 through 34)-HERS	NRCI-MCH-E
Domestic Hot Water/Plumbing NonHERS HERS	 LMCI-PLB-E LMCI-PLB-(21 through 22)-HERS	NRCI-PLB-E
Covered Process	LMCI-PRC-E	NRCI-PRC-E
Renewables Battery Storage Solar Photovoltaics Solar Thermal Solar Ready	LMCI-SRA-E	NRCI-SRA-E

Source: California Energy Commission

11.2.1.3 HERS Verification Documentation

§10-103(a)5

Within the Energy Code, some mandatory, prescriptive, and performance approach requirements may have HERS verification. HERS verifications involve HERS Raters and field technicians, and can involve Acceptance Test Technicians (ATTs).

Registration of Certificates of Compliance, Installation, and Verification is required for all multifamily buildings up to three habitable stories for which compliance requires HERS field verification. There are some exceptions for additions and alterations. When registration is required, compliance documents are electronically submitted to an approved HERS registry for registration and retention. Certificates of acceptance are not required to be registered with a HERS registry. Certificates of acceptance must be made available to the enforcement agency for all applicable inspections. Certificates of acceptance for lighting controls and mechanical systems acceptance testing must be completed through an Acceptance Test Technician Certification Provider (ATTCP).

Compliance documents submitted to a HERS registry must be certified by the appropriate responsible person (§10-103). The registry will assign a unique registration number to each document when completed, and certification (by electronic signature) is provided by the responsible person. The HERS registry will retain the registered documents, which are available via secure internet access to authorized users. This allows authorized users to provide copies of registered documents for enforcement agencies or other purposes as needed.

HERS Raters provide a separate registered certificate of verification for each dwelling unit that the rater determines has met the verification and/or diagnostic requirements for compliance. For multifamily buildings with three or fewer habitable stories, the HERS Rater must not sign a certificate of verification for a dwelling unit that does not have a registered certificate of installation that has been signed/certified by the installer. If the dwelling unit was approved as part of a sample group, the certificate of verification will include additional information that identifies whether the dwelling was tested or not tested within the sample group. The certificate of verification for the tested dwelling unit of a sample group will include the HERS verification results, while the certificate of verification for the non-tested dwelling units will not include the HERS verification results. Refer to Reference Residential Appendix RA2 for more details on the HERS verification and certificate of verification documentation procedures.

Table 11-4 shows certificates of verification and acceptance by the application and number of stories.

Table 11-4: Certificates of Verification and Acceptance by Application and Number of Stories

Application	Verifier	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Envelope: Site-Built Fenestration	Contractor	LMCA-ENV-(02,03)-F	NRCA-ENV-(02,03)-F
Envelope: QII	HERS	LMCV-ENV-H	N/A

Application	Verifier	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Common Use Area Indoor Lighting	ATT	LMCA-LTI-(02,03,04,05)-A	NRCA-LTI-(02,03,04,05)-A
Outdoor Lighting	ATT	LMCA-LTO-02-A	NRCA-LTO-02-A
Dwelling Unit Mechanical	HERS	LMCV-MCH-(04,24,27,32)-H	NRCV-MCH-(04,27)-H
Dwelling Unit Mechanical	ATT	N/A	NRCV-MCH-(04,27)-A
Common Use Area Mechanical	ATT	LMCA-MCH-(04,24,27,32)-A	NRCA-MCH-02 through 21-A
Hot Water Distribution	HERS Rater	LMCV-PLB-(21,22)-H	NRCV-PLB-(21,22)-H
Covered Processes	Contractor	LMCA-PRC-(02,03,12)-F	NRCA-PRC-(02,03,12)-F
Renewables Battery Storage Solar Photovoltaics Solar Thermal Solar Ready		TBD	TBD

Source: California Energy Commission

11.2.1.4 Compliance, Operating, Maintenance, and Ventilation Information to be Provided by Builder

§10-103(b)

At the completion of construction and before occupancy, the builder is required to leave the completed (signed and dated) compliance documentation in the building. This includes the certificates of compliance, installation, verification (if HERS verification was required) and acceptance. For multifamily buildings with three or fewer habitable stories, when HERS verification is required, the certificates of compliance, installation, and verification must be copies from the HERS Registry. For multifamily buildings with four or more habitable stories, only the certificates of verification must be registered with a HERS provider.

In addition to the compliance documentation, the builder must leave in the building operating and maintenance information for all applicable features, materials, components, and manufactured devices. The operation and maintenance information must contain the details needed to provide the building owner/operator/occupant with instructions on how to operate the building and systems in an energy-efficient manner that ensures satisfactory indoor air quality and to maintain it so that it will continue to operate efficiently. For individually owned units in a multifamily building, the documentation must be provided to the owner of the dwelling unit or to the individual(s) responsible for operating the feature, equipment, or device. Information must be for the appropriate dwelling unit or building. Paper or electronic copies of these documents are acceptable.

For mixed-use buildings with 10,000 square feet of total nonresidential space or greater, building commissioning will also be required for the nonresidential spaces only. See Chapter 13 for information about building commissioning requirements.

Example 11-4

The following questions relate to the requirement to provide documentation to the building owner/occupant at occupancy (as required by §10-103(b)):

Question

If the building is a condominium, can I photocopy the same certificate of compliance information for all units?

When the building is an apartment complex (not individually owned units), who gets the documentation?

If an apartment is converted to condominiums, does each owner/occupant receive copies of the documentation?

Answer

Photocopied information is acceptable. Electronic copies available through HERS providers and ATTCPs are another option for providing documentation to building owners/occupants. It must be obvious that the certificate of compliance applies to that dwelling unit. The features installed must match the features shown on the certificates of installation. If the compliance documentation is for a whole building, a photocopy of the certificate of compliance for that building must be provided. If individual compliance is shown for each unique dwelling unit, a photocopy of the documentation that applies to that dwelling unit must be provided. The copies may be in paper or electronic format.

The documentation and operating information are provided to the individual responsible for operating the feature, equipment, or device (typically the occupant). Maintenance information is provided to the person responsible for maintaining the feature, equipment, or device. This is either the owner or a building manager (§10-103(b)).

If, during construction, the building changes from an apartment to condominiums, each owner at occupancy would receive the documentation. If an existing apartment building changes to condominiums at a later date, the documentation requirements are triggered only by a building permit application requiring compliance with the Energy Code. Changing occupancy does not trigger compliance with the standards.

Example 11-5

Question

Can a certified HERS Rater who does the field verification and completes and signs the certificate of verification for a dwelling also perform the testing required of the builder or installer to certify compliance with the Title 24, Part 6 installation requirements on the certificate of installation?

Answer

Yes. This approach is allowed when the HERS Rater is doing field verification for every dwelling (100 percent testing), but it is not allowed when the rater performs verification using a designated sample group of dwellings. When 100 percent testing is used for HERS verification, the builder or the installer may use the information from the rater's verification or diagnostic test results when completing the certificate of installation. When doing so, builders or installers signing the certification statement on the certificate of installation are assuming responsibility for the information in the form and are certifying that the installation conforms to all applicable codes and regulations. The rater may not sign the form and cannot be assigned the responsibilities of the builder or installer, as stated on the certificate of installation and in regulations.

If the HERS Rater determines that the compliance requirements are not met, the HERS Rater will submit the data of the failed verification/testing into a HERS registry for retention. The builder or installer must make the needed corrections. Once corrections have been made and the rater determines that all compliance requirements are met, the builder or installer may certify the work by completing and signing the applicable section of the certificate of installation. The HERS Rater can complete the certificate of verification for the dwelling.

11.2.2 HERS Field Verification and Diagnostic Testing

For multifamily buildings up to three habitable stories, HERS verifications are performed by HERS Raters that are specially trained and certified by an Energy Commission-approved HERS provider to perform these services. Raters cannot be employees of the builder or contractor whose work they are verifying. Also, raters cannot have a financial interest in the builder's or contractor's business or advocate or recommend the use of any product or service that they are verifying. The training, quality assurance, and general oversight of the raters are conducted by Energy Commission-approved HERS providers.

For multifamily buildings with four or more habitable stories, dwelling unit leakage rate (compartmentalization) and kitchen exhaust airflow and sound rating must be verified by a HERS Rater. ERV/HRV and central ventilation shaft sealing must be verified by an acceptance test technician. Also, for multifamily buildings with four or more habitable stories, duct leakage testing, refrigerant charge testing, and airflow and fan watt draw measurements are only required to be completed by the person responsible for the installation. HERS-verified compliance credits available to multifamily buildings with three or fewer habitable stories are not available for multifamily buildings with four or more habitable stories.

The Energy Code's detailed reporting requirements are intended to provide design, construction, and enforcement personnel with the information to ensure that the energy features are properly installed. Each party is accountable to ensure that the features that they are responsible for are correctly installed. The HERS provider makes available via phone or internet a way for building officials, builders, HERS Raters, and other authorized users of the data registry to verify that the information displayed on copies of the submitted certificate(s) conforms to the registered document information on file in the registry for the dwelling unit.

11.2.2.1 Features Requiring HERS Verification

HERS verifications are required when certain regulated efficiency requirements or equipment features are installed. The following features require HERS verification:

- Building envelope air leakage
- Quality insulation installation (QII)
- Quality insulation installation for spray polyurethane foam
- Continuous whole-dwelling unit mechanical ventilation airflow
- Intermittent whole-building mechanical ventilation airflow
- Kitchen exhaust fan HVI or AHAM airflow, sound, and capture efficiency ratings
- Duct sealing
- Supply duct location, surface area, and R-value
- Low-leakage ducts in conditioned space
- Low-leakage air handlers
- Return duct design
- Air filter device design, MERV rating, and labeling
- Bypass duct prohibition
- Refrigerant charge in ducted split-system and ducted packaged unit air conditioners and heat pumps, and mini-split systems
- Refrigerant fault indicator display (FID)
- System airflow
- Air handler fan efficacy
- Energy efficiency ratio (EER)
- Seasonal energy efficiency ratio (SEER)
- Heat pump rated heating capacity
- Maximum rated total cooling capacity
- Evaporatively-cooled condensers
- Central fan-integrated ventilation cooling systems
- Zonal controls
- Parallel piping
- Compact hot water distribution system
- Pipe insulation credit

- Drain water heat recovery system
- Point of use
- Demand recirculation: manual control
- Demand recirculation: sensor control
- Multiple recirculation loop design for DHW systems serving multiple dwelling units

11.2.2.2 Verification, Testing, and Sampling

Field verification and diagnostic testing may be completed for each dwelling unit or for a sample of dwelling units. Sampling is permitted only when multiple dwelling units of the same type are constructed within the same multifamily development by the same subcontractor. Sampling may also be used for alterations to groups of dwelling units having the same features installed that require HERS verification, and where the same installing contractor has installed the features. More details are in RA2.6 and RA2.8, or NA1.6 and NA1.8 Sampling is also explained in the Residential Compliance Manual Chapter 2, section 2.5.2.

The HERS Rater must transmit and certify the test results to the HERS registry.

11.2.2.3 First Dwelling Unit Field Verification and Diagnostic Testing

The HERS Rater must diagnostically test and field-verify the first dwelling unit of each model of a multifamily development. To be considered the same model, dwelling units must have the same basic floor plan layout, energy design, and compliance features as shown on the certificate of compliance for each dwelling unit. Variations in the basic floor plan layout, energy design, compliance features, zone floor area, or zone volume, that do not change the HERS features to be tested or the heating or cooling capacity of the HVAC unit(s) must not cause dwelling units to be considered a different model. For multifamily buildings, variations in exterior surface areas caused by location of dwelling units within the building must not cause dwelling units to be considered a different model.

The HERS Rater will transmit the test results to the data registry. The HERS provider will make available a registered copy of each certificate of verification to the rater, the builder, the enforcement agency, and other authorized users of the data registry.

11.2.2.4 Group Sample Field Verification and Diagnostic Testing

For each unique dwelling unit model, after the first dwelling unit field verification and diagnostic testing are completed, the builder or the builder’s authorized representative determines which sampling procedure to use for the group of dwellings that require HERS field verification. There are two procedures for HERS verification compliance using group sampling: (1) sampling a closed group of up to seven dwelling units; and (2) sampling of an open group of up to five dwelling units. The group sampling requirements for each procedure are discussed in this section.

For multifamily buildings with three or fewer habitable stories, registration of all dwelling unit-level (as opposed to building-level) certificates of installation for at least one dwelling unit to the HERS registry is required to open a new group. Additional dwellings may be entered into the registry and included in an "open" group over a specific period, subject to transmittal/submittal of the certificate(s) of installation information to the registry for each additional dwelling. However, the group must not remain open to receive additional dwellings for a period longer than six months from the earliest date shown on any certificate of installation for a dwelling included in a group. A group may be closed at any time after the group has been opened at the option of the builder or builder's authorized representative. The size of a closed group may range from a minimum of two dwelling units to a maximum of seven dwellings. When a group is closed, no additional dwelling units must be added to the group. Whenever the HERS Rater for the group changes, a new group must be established.

Sampling of a closed group of up to seven dwelling units requires the following conditions to be met prior to receiving HERS compliance verification for the group:

1. All dwelling units in the sample group have been identified. Up to seven dwellings are allowed in a closed sample group.
2. Installation of all features that require HERS verification has been completed in all dwelling units in the group and registration of the certificates of installation for all dwelling units has been completed.
3. The group has been classified as a closed group in the data registry.
4. At the request of the builder or the builder's authorized representative, a rater will randomly select one dwelling unit from the closed sample group for field verification and diagnostic testing. If the dwelling unit meets the compliance requirements, this tested dwelling and each of the other non-tested dwelling units in the group will receive a registered certificate of verification.

Sampling of an open group of up to five dwelling units requires the following conditions to be met prior to receiving HERS compliance verification for the group:

1. At least one dwelling unit from the sample group has been identified. Up to five dwelling units are allowed in an open sample group.
2. Installation of all features that require HERS verification must be completed in all dwelling units. Registration of the certificates of installation for all dwelling units has been completed.
3. At the request of the builder or the builder's authorized representative, a rater will randomly select one dwelling unit from the open sample group for field verification and diagnostic testing. If the dwelling unit meets the compliance requirements, the tested dwelling and each of the other non-tested dwelling units must receive a registered certificate of verification. If there are fewer than five dwelling units, the group must be allowed to remain open and eligible to receive additional dwelling units. Dwelling units admitted to the open group after successful HERS compliance verification of the tested dwelling unit must also receive a registered certificate of verification as a non-tested dwelling unit, subject to receipt of the registered certificates of installation by the data registry for the dwelling. The group must be closed when it reaches the limit of five

dwelling units, when the six-month limit for open groups has been exceeded, or when the builder requests that the group be closed.

The rater must confirm that the certificates of installation have been completed as required and that the installer's diagnostic test results and the certificates of installation show compliance consistent with the certificate of compliance for the dwelling unit.

The rater must diagnostically test and field verify the selected dwelling unit and enter the test results into the data registry regardless of whether the results indicate a pass or fail. If the test fails, then the failure must be entered into the data registry, even if the installer immediately corrects the problem. In addition, any applicable procedures for resampling, full testing, and corrective action must be followed.

The provider will make available to the rater, the builder, the enforcement agency, and other approved users of the data registry a registered copy of the certificate of verification for the tested dwelling unit and for all other non-tested dwelling units in the group at the time of the sample test.

11.2.2.5 Installer Requirements and HERS Procedures for Alterations to Buildings up to Three Habitable Stories

When compliance for an alteration requires field verification and diagnostic testing by a certified HERS Rater, the building owner may choose for field verification and diagnostic testing to be completed for each dwelling unit or as part of a designated sample group of dwelling units for which the same installing company has completed work that requires testing and field verification for compliance. The only alterations that require HERS testing and verification are HVAC changeouts in multifamily buildings with three or fewer habitable stories. The building owner or agent of the building owner must complete the applicable portions of a shorthand version of the certificate of compliance for the appropriate climate zone. When compliance requires verification, the building owner or agent must arrange for transmittal/submittal of the certificate of compliance to the data registry, identifying the altered HVAC system and features that require verification. The building owner must submit an approved/signed copy of the certificate of compliance to the rater.

When the installation is complete, the person responsible for performing the installation must complete the certificates of installation. All required certificates of installation must be registered with an approved data registry when field verification and diagnostic testing are required.

After verifying that the certificate of compliance and all required certificates of installation are completed, signed, and registered, the rater must verify compliance. If group sampling is used for compliance, the sampling procedures described in Reference Residential Appendix RA2.6.3.3 and RA2.8, for sampling of a closed group of up to seven dwelling units must be used. The installing company may request a sample group that has fewer than seven dwelling units. Resampling, full testing, and corrective action must be completed, if necessary, as specified by Reference Residential Appendix RA2.6.4.

The enforcement agency cannot approve the alteration until the agency has verified completed, signed, and registered certificate of compliance, certificates of installation, and certificates of verification documentation for the altered HVAC system.

Third-party quality control programs, as specified in Reference Residential Appendix RA2.7, may be used with alterations and must be limited to closed sample group sizes of 30 dwelling units (HVAC systems) or fewer. When a third-party quality control program is used, the enforcement agency may approve compliance based on the certificates of installation, where data checking has indicated that the unit complies, on the condition that if the required HERS verification procedures determine that resampling, full testing, or corrective action is necessary, such work must be completed.

11.2.3 Acceptance Testing

For common use areas and dwelling units in multifamily buildings with four or more habitable stories, as well as site-built fenestration in all multifamily buildings, acceptance testing by a field technician or ATT may be required. Refer to Chapter 14 for an explanation of acceptance testing requirements. Multifamily features requiring acceptance testing include:

- Site-built fenestration
- Common use area mechanical systems:
    - Outdoor air ventilation
    - Constant volume, single zone air conditioning and heat pump unit controls
    - Duct systems
    - Air economizers
- Whole-dwelling unit mechanical systems in buildings four or more habitable stories:
    - Dwelling unit ventilation systems
    - Dwelling unit enclosure leakage (compartmentalization)
    - Central ventilation duct leakage
    - Central ventilation heat recovery or energy recovery systems
- Common use area indoor and outdoor lighting controls
- Parking garage ventilation
- Elevator lighting and ventilation

11.3 Building Envelope Requirements

This chapter covers building envelope features and compliance strategies for newly constructed multifamily buildings and additions and alterations to multifamily buildings. It highlights the energy code requirements that affect the design of the building envelope. Multifamily envelope requirements, except for HERS requirements, apply to all dwelling units and common use areas in all multifamily buildings. HERS envelope requirements apply to multifamily buildings up to three habitable stories. Nonresidential occupancies in a mixed-use building must comply with nonresidential envelope requirements outlined in Chapter 3.

This chapter is organized by building envelope component and includes:

- A description of opaque envelope requirements related to air sealing and leakage, insulation, roofing products, radiant barriers, air barriers, vapor retarders, and attic ventilation. The opaque envelope includes roof, wall, and floor assemblies.
- A description of fenestration requirements for U-factor, solar heat gain coefficient (SHGC), visible transmittance (VT), and window area.
- Verification requirements, including those for QII.
- Additions and alterations requirements

Table 11-5 summarizes the location of mandatory, prescriptive, and performance requirements in the multifamily standards and in the compliance manual.

Table 11-5: Overview of Envelope Requirements in the Energy Code and Compliance Manual Organization

Envelope Component	Mandatory	Prescriptive	Performance	Compliance Manual
Ceiling and Roof Insulation	§§110.8(a) - (d), 110.8(h),160.1(a)	§170.2(a)1, Table 170.2-A	§170.1	3.2.3.1, 3.2.4.1
Radiant Barrier	§110.8(j)	§170.2(a)1C, Table 170.2-A, RA4.2.1	§170.1	11.1.9.1
Roofing Products	§§10-113, 110.8(i),	§170.2(a)1A, Table 170.2-A	§170.1	3.2.4.1,
Wall Insulation	§§110.8(a) - (c), 160.1(b)	§170.2(a)2, Table 170.2-A	§170.1	3.2.3.1, 11.1.9.3
Raised Floor Insulation	§§110.8(a) - (d), 110.8(g), 160.1(c)	§170.2(a)5, Table 170.2-A	§170.1	3.2.3.1, 3.2.8.1
Slab Insulation	§110.8(g), Table 110.8-A	§170(a)5B, Table 170.2-A	§170.1	11.1.9.5
Opaque Doors	§§10.111, 110.6(a)	§170.2(a)4, Table 170.2-A	§170.1	11.1.9.6
Vapor Retarder	§160.1(d)	N/A	N/A	11.1.9.7

Envelope Component	Mandatory	Prescriptive	Performance	Compliance Manual
Air sealing and air leakage	§§110.7, 160.1(f)	N/A	N/A	11.1.9.8
QII	N/A	§170.2(a)6, Table 170.2-A, RA3.5	§170.1	11.1.9.9
Fenestration	§§10-111, 10-112, 110.6(a), Table 110.6-A, §160.1(e)	§170.2(a)3, Table 170.2-A	§170.1	3.3.1, 3.3.2, 11.1.10,
Daylighting	N/A	§170.2(b)	§170.1	3.3.4.2E, 11.1.11
Additions	§160.1	§180.1(a)1	§180.1(b)	11.1.12.1
Alterations	§180.2(a)	§180.2(b)1	§180.2(c)	11.1.12.2

Source: California Energy Commission

11.3.1 What's New for the 2022 Energy Code

The *2022 Building Energy Efficiency Standards* for multifamily buildings consolidate requirements for all multifamily building types, with requirements based on assembly or fenestration type rather than number of stories. This reclassification allows for better alignment of energy efficiency requirements with fire safety and structural requirements. Table 170.2-A of the Energy Code captures the updated requirements for all multifamily buildings. Notable 2022 envelope changes include:

- Buildings up to three habitable stories have a new prescriptive insulation Option D for roof assemblies without attics.
- Buildings with four stories or more with attics have new prescriptive Options B or C for roof and ceiling insulation.
- Prescriptive roof reflectance and emissivity requirements depend on roof options Option B, C, or D
- Prescriptive roof reflectance requirements increased to 0.63 in climate zones 9-11 and 13-15 for buildings with low-sloped roofs and no attic.
- Mandatory and prescriptive wall U-factors are recategorized by assembly type and by fire rating for framed assemblies. This results in many climate zone-specific adjustments. The greatest changes include reduced U-factors for framed walls in multifamily buildings with four or more stories.
- Prescriptive fenestration properties, including U-factor, solar heat gain coefficient (SHGC), and visual transmittance (VT), depend on categorization into curtainwall, Class AW, or all other fenestration, and vary by climate zone. There is no distinction between fixed and operable windows. The greatest change is for fenestration in multifamily buildings with four or more stories that fall into all other fenestration category (not curtainwall or Class AW).
- Prescriptive requirements for fenestration properties in multifamily building additions and alterations depend on window classification (curtainwall, Class AW, or all other).

- Prescriptive fenestration area is limited to both 40 percent window-to-wall ratio and 20 percent window-to-floor ratio.

11.3.2 Opaque Envelope

This section of the building envelope chapter addresses the requirements for air leakage, roof products, roof and ceiling insulation, radiant barriers, and vapor retarders.

11.3.2.1 General Insulation Requirements

§110.8(a) – (c), 110.8(g)

Insulation materials must be certified by the Department of Consumer Affairs, Bureau of Household Goods and Services and listed in the Directory of Certified Insulation Materials. Urea formaldehyde foam insulation, flame spread index and smoke development index must meet requirements for multifamily and nonresidential buildings.

11.3.2.2 Ceiling and Roof Insulation

11.3.2.3 Mandatory Requirements

A. Attic Roof

§160.1(a)1

Roof/ceiling construction assemblies with an attic space must have at least R-22 insulation between wood framing members or a maximum U-factor of 0.043. Some areas of the roof/ceiling can be greater than the maximum U-factor if other areas have lower U-factors such that the weighted average U-factor for the overall ceiling/roof is 0.043 or less. Metal framed assemblies must also have a weighted U-factor of 0.043 or less.

If insulation is not penetrated by framing, such as rigid insulation laid over a structural deck, then the rigid insulation can have a rated R-value of less than R-22 so long as the total roof/ceiling assembly U-factor is not greater than U-0.043.

Loose fill insulation must be blown in evenly and insulation levels must be documented on the certificate of installation. The insulation level can be verified by checking that the depth of insulation conforms to the manufacturer’s coverage chart for achieving the required R-value. The insulation also must meet the manufacturer’s specified minimum weight per square foot for the corresponding R-value.

B. Non Attic Roof

§160.1(a)2 and 3

For roof/ceiling construction assemblies without an attic space, the maximum weighted average U-factor is 0.098 for metal building and 0.075

for wood framing and others. If insulation is installed at the roof, vents or openings that penetrate the roof deck to the outdoor are prohibited.

Regardless of whether or not there is an attic space, insulation mustmust be installed in direct contact with the air barrier.

C. Wet Insulation Systems

§110.8(h)

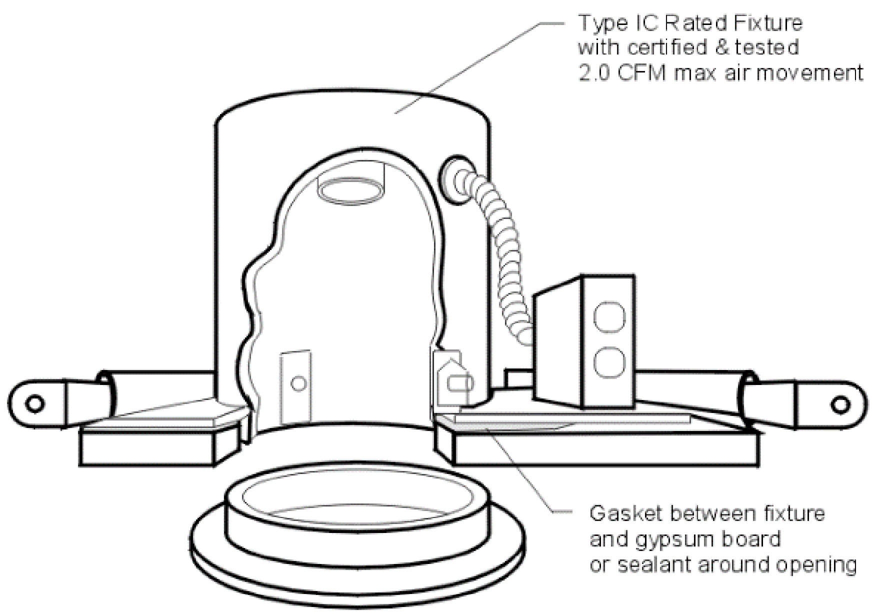
Wet insulation systems are covered in Section 3.2.4.1 for multifamily and nonresidential buildings.

D. Recessed Luminaires

§160.5(a)1C

Luminaires recessed in insulated ceilings can create thermal bridging through the assembly. Not only does this degrade the performance of the ceiling assembly, but it can permit condensation on a cold surface of the luminaire if exposed to moist air, as in a bathroom.

Figure 11-1. IC-Rated Luminaire (Light Fixture)



Luminaires recessed in insulated ceilings must meet three requirements.

1. They must be listed as defined in the Article 100 of the California Electric Code for zero clearance insulation contact (IC) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Code Council (ICC). This enables insulation to be in direct contact with the luminaire.

2. The luminaire must have a label certified as per §160.5(a) for airtight (AT) construction. Airtight construction means that leakage through the luminaire will not exceed 2.0 CFM when exposed to a 75 Pa pressure difference, when tested in accordance with ASTM E283.
3. The luminaire must be sealed with a gasket or caulk between the housing and ceiling.

11.3.3 Prescriptive Requirements

§170.2(a)1B, Table 170.2-A

The Energy Code is designed to offer flexibility to builders and designers of multifamily newly constructed buildings in terms of achieving the intended energy efficiency targets. Thus, the Energy Code offers several compliance options for roof insulation in multifamily buildings, as shown in Table 11-6.

Table 11-6: Summary of Multifamily Roof Insulation Options

Roof / Ceiling Insulation Option	Attic Space	Below Roof Deck Insulation	Ceiling Insulation	Radiant Barrier	Duct and Air Handler Location
B	Yes, ventilated	Required in climate zones 4 and 8-16	Yes	Required in certain climate zones	Allowed in ventilated attic
C	Yes, ventilated	Not required	Yes	Required in certain climate zones	Within conditioned space
D	No	As needed to meet assembly U-factor requirements	As needed to meet assembly U-factor requirements	N/A	Within conditioned space

Source: California Energy Commission

Option B has a vented attic space and uses a combination of ceiling insulation and below roof deck insulation.

Option C also has a vented attic space but uses ceiling insulation only.

Option D has no attic space and uses U-factor requirements instead of insulation levels.

The prescriptive requirements for Option B and Option C assume that the building is built with the following construction practices:

1. The attic is ventilated with an appropriate free vent area as described below.
2. The roof is constructed with standard wood rafters and trusses.

3. For Option B, the outermost layer of the roof construction is either tiles or a roofing product installed with an air gap between it and the roof deck.
4. The air handler and ducts are in the ventilated attic for Option B and are otherwise in conditioned space for Option C.
5. The air barrier is located at the ceiling (except cathedral and sealed attic roof/ceiling systems).

If a building design does not meet all of these specifications, for example an unvented attic, it must comply through the performance approach as described in Section 11.1.9.10.

Section 170.2 requires different values of roof and ceiling insulation, depending on whether Option B or Option C is chosen. Table 11-7 shows a prescriptive requirements checklist for each option based on Table 170.2-A.

Table 11-7: Prescriptive Insulation Options

Ventilated Attics	**Ventilated Attics with Ducts in Conditioned Space**	**No Attic**
Option B	**Option C**	**Option D**
☐ Vented attic ☐ R-19 (CZ 4, 8-9, 11-15) or R-13 (CZ 10, 16) **below roof deck** batt, spray in cellulose/fiberglass secured with netting, or spray foam ☐ R-38 (CZ 1, 2, 4, 8-16) ceiling insulation or R-30 (CZ 3 and 5-7) ☐ Radiant barrier (CZ 2, 3, 5-7) ☐ Air space between roofing and the roof deck	☐ Vented attic ☐ R-38 (CZ 1, 11-16) ceiling insulation or R-30 (CZ 2-10) ☐ R-6 or R-8 ducts (climate zone-specific) ☐ Radiant barrier (CZ 2-15)	☐ No attic space ☐ Maximum U-factor of 0.041 for metal buildings ☐ Maximum U-factor of 0.028 (CZ 1-2, 4, 8-16) or 0.034 (CZ 3, 5-6) or 0.039 (CZ7)

Source: California Energy Commission

Below Roof Deck Insulation (**Option B).** In a vented attic, air-permeable or air-impermeable insulation (batt, spray foam, loose-fill cellulose, or fiberglass) should be placed directly below the roof deck between the truss members and secured in place to provide a thermal break. Figure 11-2 shows an example of insulation details in an Option B attic. Insulation must be in direct contact with the roof deck and secured by the insulation adhesion, facing, mechanical fasteners, wire systems, a membrane material, or netting. Batts supported with cabling or other mechanical methods from below mustmust have supports that are less than or equal to 16″ apart and no further than 8″ from the end of the batt. Figure 11-3 shows the placement and provides example attachment methods for below-deck insulation.

When batt thickness exceeds the depth of the roof framing members, full-width batts must be used to fit snugly and allow batts to expand beyond the framing members. Full coverage of the top chord framing members by insulation is recommended as best practice but is not required.

Figure 11-2: Details of Option B Assembly

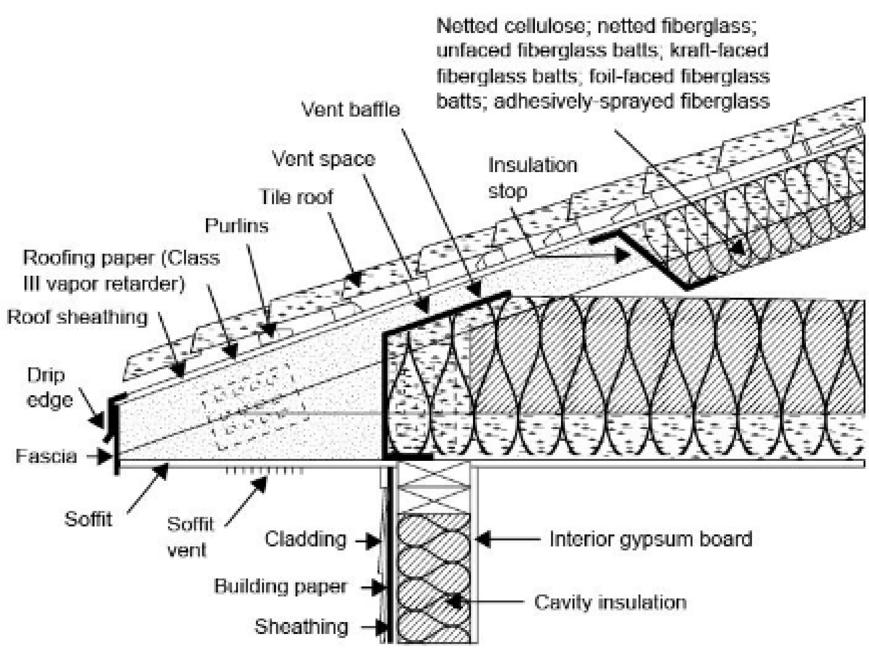
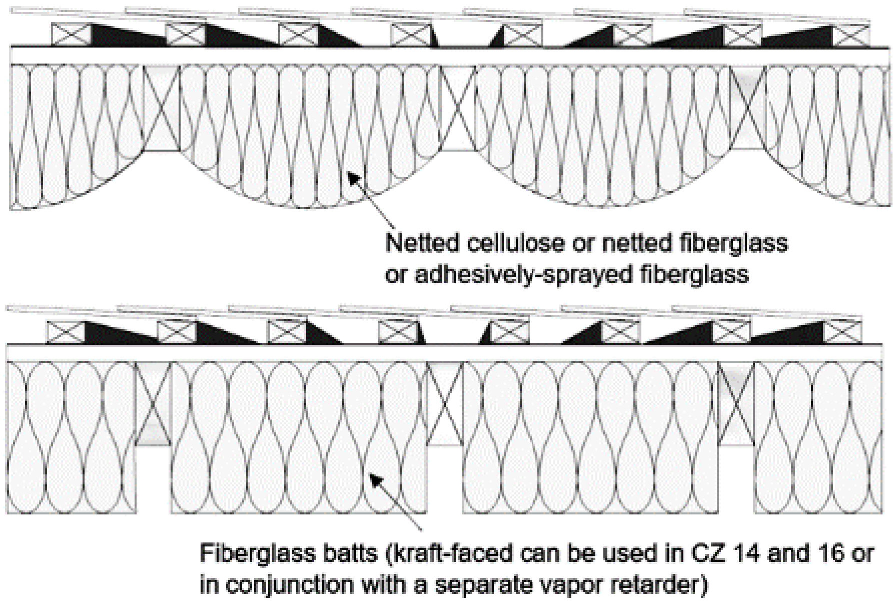


Figure 11-3: Placement of Insulation Below the Roof Deck



When insulation is installed below the roof deck to meet the prescriptive requirements of Option B, a radiant barrier is not required.

Vapor Retarders (Option B). Attic vapor retarders are not required by the Energy Code in most climates when using spray foam, blown-in insulation, or unfaced batts, and when sufficient attic ventilation is maintained. Although not required, the use of vapor retarders can provide additional security against possible moisture buildup in attic and framed assemblies. In climate zones 14 and 16, a Class I or Class II vapor retarder must be used to manage moisture[1] as stated in the California Building Code (CBC), Title 24, Part 2.5, §R806.2.

Attic Ventilation (Options B and C)

Proper attic ventilation occurs at two points at the roof: the soffit (or eave) vents and the ridge vents.

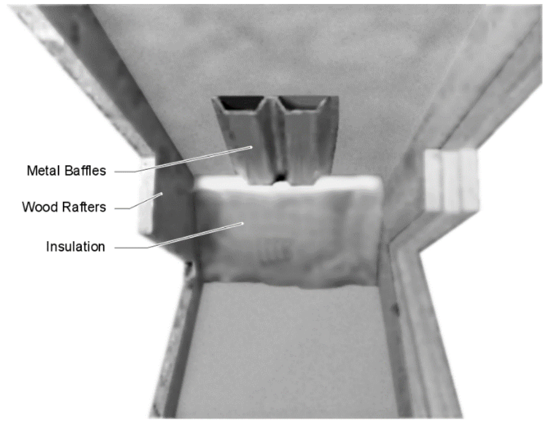
When installing insulation below the roof deck, vent baffles and insulation barriers should be used to maintain proper ventilation space. Proper airflow through the space helps remove moisture and prevents any associated issues.

Where ceiling insulation is installed next to eave or soffit vents, a rigid baffle should be installed at the top plate to direct ventilation air up and over the ceiling insulation. (See Figure 11-4.) The baffle should extend beyond the height of the ceiling insulation and should have sufficient clearance between the baffle and roof deck at the top. There are several acceptable methods for maintaining ventilation

. [1] Insulation Contractors Association of America. (2004). Technical Bulletin No. 6 Use of Vapor Retarders.

air, including preformed baffles made of cardboard or plastic. In some cases, plywood or rigid foam baffles are used.

Figure 11-4: Baffles at the Eave in Attics



The California Building Code (CBC) requires a minimum vent area to be provided in roofs with attics, including enclosed rafter roofs that create cathedral or vaulted ceilings. Check with the local building jurisdiction to determine which of the two CBC ventilation requirements are to be followed:

1. CBC, Title 24, Part 2, Vol. 1, Section 1203.2 requires that the net-free ventilating area mustmust not be less than 1/300 of the area of the space ventilated.
2. CBC, Title 24, Part 2.5, Section R806.2 requires that the net-free ventilating area mustmust not be less than 1/150 of the area of the space ventilated. This ratio may be reduced to 1/300 if a ceiling vapor retarder is installed in climate zones 14 and 16.

If meeting Option 1 above, a minimum of 40 percent and not more than 50 percent of the vents must be located at least 3 feet (ft.) above the eave or cornice vents in the upper portion of the space being ventilated.

Insulation mustmust not block the free flow of air, and a minimum 1-inch air space mustmust be provided between the insulation and the roof sheathing and at the location of the vent.

Ventilated openings are covered with corrosion-resistant wire cloth screening or similar mesh material. When part of the vent area is blocked by meshes or louvers, the resulting net-free area of the vent must be considered to determine if ventilation requirements are met.

Many jurisdictions in California are covered by Wildland Urban Interface (WUI) regulations where specific requirements for construction materials must be used to improve building fire resistance. These regulations require special vents that are expressly tested to resist the intrusion of flame and embers. Check with the building department to ensure compliance with local codes.

Ducts and Air Handlers Located in Conditioned Space. Ducts may be located and verified to be in conditioned space instead of installing insulation at the roof deck. If complying with this option, ceiling and duct insulation must be installed at the values specified in Table 170.2-B for Option C, and a radiant barrier is required in most climate zones.

HERS Verification (Option C). Locating ducts in conditioned space does not alone qualify for this requirement; a HERS Rater must test and verify for low leakage ducts within conditioned space and verify that the ducts are insulated to a level required in Table 170.2-K of the Energy Code.

Design strategies that can be used to prescriptively comply with Option C include dropped ceilings (dropped soffit), plenum or scissor truss to create a conditioned plenum box, and open-web floor truss. The ducts and equipment must be within the air barrier of the building. Locating ducts within an unvented attic does not meet Option C requirements.

Ceiling Insulation (Options B and C). Insulation coverage should extend far enough to the outside walls to cover the bottom chord of the truss. However, insulation should not block eave vents in attics because the flow of air through the attic space helps remove moisture that can build up in the attic and condense on the underside of the roof deck. This can cause structural damage and reduce the effectiveness of the insulation.

Based on area-weighted averaging, ceiling insulation may be tapered near the eave, but it must be applied at a rate to cover the entire ceiling at the specified level. An elevated truss, or raised heel truss, is not required but may be desirable in some applications.

11.3.3.1 Performance Approach

In the performance approach, the standard design is based on the roof type. If the proposed design has an attic, prescriptive requirement Option B serves as the standard design, and Option D if there is no attic. An unvented attic must comply through the performance approach.

Example 11-6: Unventilated Attics

Question

Does an unventilated attic with insulation at the roof deck comply under the prescriptive requirements?

Answer

No. The entire attic must be a ventilated space with the building air barrier located at the ceiling with standard trusses to comply with the prescriptive requirements. This project must comply through the performance approach.

Example 11-7: Insulation Above the Roof Deck

Question

Does a ventilated attic with insulation above the roof deck comply under the prescriptive requirements?

Answer

No. The insulation must be located below the roof deck between the roof rafters to comply with the prescriptive requirements. If insulation is above the roof deck, the project must comply through the performance approach.

Example 11-8: Asphalt Shingles

Question

A building with asphalt shingle roofing, having no air gap, has a ventilated attic with insulation installed below the roof deck between the roof rafters (HPVA) and at the ceiling meeting prescriptive insulation levels. Does this building comply with the prescriptive requirements?

Answer

No. The roofing product must be of a type that is installed with an air gap between the product and the roof deck, such as concrete tile, to comply with the prescriptive requirements. If a roofing product with no air gap between the product and the roof deck is installed, the project must comply through the performance approach.

Example 11-9: Gable Ends in High Performance Ventilated Attics

Question

In addition to the roof underdeck, do gable end walls in high performance ventilated attics (HPVA) need to be insulated?

Answer

No. Gable end walls do not need to be insulated when designing and installing a HPVA.

Example 11-10: Attic Insulation Placement

Question

When installing roof/ceiling insulation, does the insulation need to be installed on the entire roof/ceiling, including areas over unconditioned space?

Answer

It depends. The insulation should be installed at the roof/ceiling in one of the following ways:

(1) If the attic is an open or undivided space, then the entire roof/ceiling should be insulated. This includes portions of the roof/ceiling over an unconditioned space such as a garage.

(2) If the attic has a continuous air barrier separating the attic over unconditioned space from the attic over conditioned space, then only the portions of the roof/ceiling over conditioned space should be insulated. It is recommended, but not required, that the air barrier also be insulated.

11.3.3.2 Radiant Barrier

11.3.3.3 Mandatory Requirements

§110.8(j)

The radiant barrier is a reflective material that reduces radiant heat transfer into the attic from solar heat gain in the roof. Radiant barriers must have an air space next to the foil side to provide its energy benefit. When a radiant barrier is installed, the product must meet mandatory requirements in §110.8(j). The radiant barrier must have an emittance of 0.05 or less. The product must be tested according to ASTM C1371 or ASTM E408 and must be certified by the California Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation and listed in its Consumer Guide and Directory of Certified Insulation Material, at https://bhgs.dca.ca.gov/consumers/ti_directory.pdf.

11.3.3.4 Prescriptive Requirements

§170.2(a)1C, RA4.2.1

The prescriptive requirements call for Option C vented attics to have a radiant barrier in climate zones 2 through 15, while Option B vented attics require a radiant barrier in climate zones 2, 3, and 5 through 7.

Installation. The most common way of meeting the radiant barrier requirement is to use roof sheathing that has a radiant barrier bonded to it by the manufacturer. Some oriented strand board (OSB) products have a factory-applied radiant barrier. The sheathing is installed with the radiant barrier (shiny side) facing down toward the attic space.

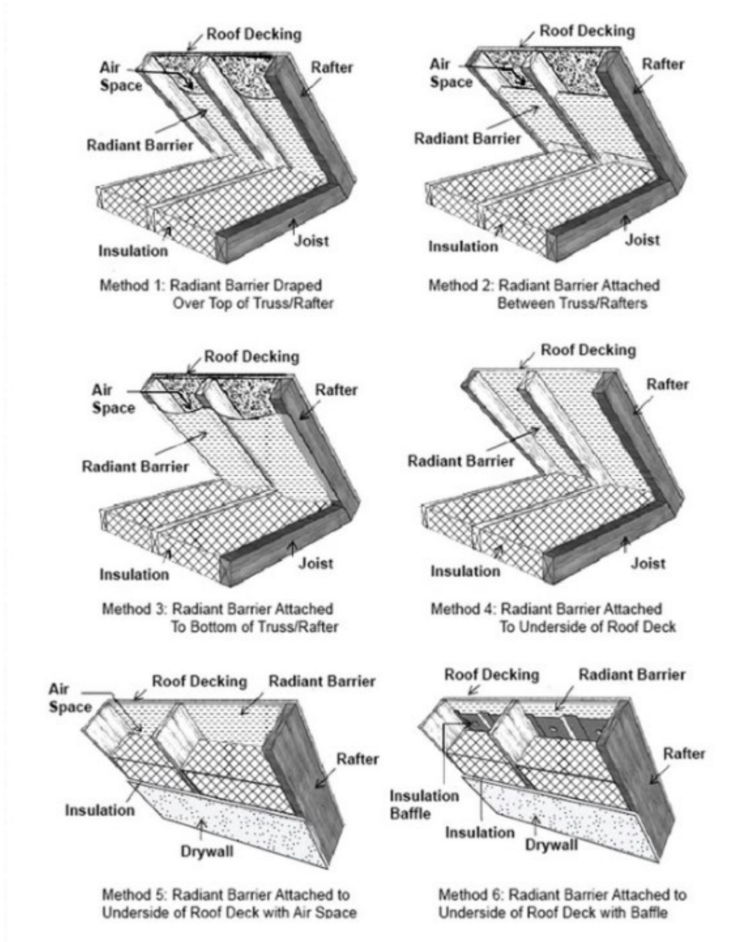
Alternatively, a radiant barrier material that meets the same ASTM test and moisture perforation requirements that apply to factory-laminated foil can be field-laminated. Field lamination must use a secure mechanical means of holding the foil-type material to the bottom of the roof decking such as staples or nails that do not penetrate all the way through the roof deck material. Roofs with gable ends must have a radiant barrier installed on the gable ends to meet the radiant barrier requirement.

Other acceptable methods are to drape a foil type radiant barrier over the top of the top chords before the sheathing is installed, stapling the radiant barrier between the top chords after the sheathing is installed, and stapling the radiant barrier to the underside of the truss/rafters (top chord). For these installation methods, the foil must be installed with spacing requirements as described in Reference Appendices, Residential Appendix RA4.2.1.

Installation of radiant barriers is somewhat more challenging in the case of closed rafter spaces, particularly when roof sheathing is installed that does not include a laminated foil-type radiant barrier. Radiant barrier foil material may be field-laminated after the sheathing has been installed by laminating the foil to the roof sheathing between framing members. This construction type is described in the Residential Reference Appendices RA4.2.1.1. See Figure 11-5 for drawings of radiant barrier installation methods.

For closed rafter spaces, such as a cathedral ceiling, the required air space for radiant barriers mustmust be provided and must meet the ventilation requirements of the California Building Code (CBC), Title 24, Part 2.5, Section R806.1.

Figure 11-5: Methods of Installation for Radiant Barriers



11.3.3.5 Performance Approach

In the performance approach, radiant barriers are modeled apart from the U-factor. The duct efficiency also is affected by the presence of a radiant barrier when using the performance approach.

11.3.3.6 Roofing Products

11.3.3.7 Roofing Products Mandatory Requirements

§10-113, 110.8(j)

See Section 3.2.4.1 for mandatory requirements for roofing products, rating and labeling, and field-applied liquid coatings applicable across multifamily and nonresidential buildings.

11.3.3.8 Roofing Products Prescriptive Requirements

§170.2(a)1A, Table 170.2

Energy-efficient cool roofs are prescriptively required based on the roof slope and climate zones. The prescriptive requirements are based on aged solar reflectance and thermal emittance, or solar reflectance index (SRI), as summarized in Table 11-8. For steep-sloped roofs, the requirements also differ depending on whether roof/ceiling Option B, C, or D is selected. If a cool roof is being installed to comply with the Energy Code, it must meet the mandatory product and labeling requirements of Section 110.8(i) of the Energy Code.

Table 11-8: Prescriptive Cool Roof Requirements

Roof Type	Climate Zone	Minimum Three-Year Solar Reflectance	Minimum Thermal Emittance	Minimum SRI
Steep-sloped, Option B and C	10-15	0.20	0.75	16
Steep-sloped Option D	2-15	0.20	0.75	16
Low-sloped Option B and C	13 and 15	0.63	0.75	75
Low-sloped Option D	9-11 and 13-15	0.63	0.75	75

Source: California Energy Commission

There are two exceptions to meeting these prescriptive requirements:

1. Roof area with building-integrated photovoltaic panels or building-integrated solar thermal panels.
   OR
2. Roof constructions that have a weight of at least 25 pounds per square foot, including EPDM with stone ballast and slate roofing.

11.3.3.9 Roofing Products Performance Approach

The performance approach can be used to trade off the prescriptive cool roof requirements or increase solar reflectance or reduce emittance for additional credit.

If a manufacturer does not obtain a Cool Roof Rating Council (CRRC) certificate for its roofing products, the following default aged solar reflectance and thermal emittance values must be used for compliance:

1. For asphalt shingles: 0.08 aged solar reflectance (ASR) and 0.75 thermal emittance (TE)
2. For all other roofing products: 0.10 aged ASR and 0.75 TE

11.3.3.10 Wall Insulation

Requirements for wall U-factor and insulation are grouped by a combination of factors: wall assembly fire rating and construction type. In prescriptive requirements, all framed walls regardless of the framing material (wood, metal, or others) are subdivided into those with one-hour or lower fire rating and those with higher than one-hour fire rating. This allows high-fire rating (one-hour or higher) wall types, which have constructability limitations and are more costly to insulate, to adhere to less stringent U-factor requirements than walls with lower fire ratings (lower than one-hour).

Additionally, metal buildings and mass walls have their own subcategories for requirements.

11.3.3.11 Wall Insulation Mandatory Requirements

§160.1(b)

Above grade walls separating conditioned spaces from other spaces must adhere to the requirements below, based on the material, size, and location of the wall assemblies:

2x4 inch wood-framed walls above grade mustmust have a U-factor not exceeding 0.102. This requirement is met with at least R-13 insulation installed in the cavities between framing members.

2x6 inch or greater wood-framed walls above grade mustmust have a U-factor not exceeding 0.071. This requirement is met with at least R-20 insulation installed in the cavities between framing members.

Demising partitions and knee walls. Demising and knee walls must not exceed minimum U-factor requirements of 0.099 for wood framing and 0.151 for metal framing.

Metal building, mass walls, and spandrel panels and curtain wall. Each of the wall construction must not exceed the U-factor requirement in Table 11-9.

All other wall types (not listed) above grade must meet a maximum U-factor of 0.102.

Table 11-9: Wall Construction U-Factor Requirements

Wall Construction	U-factor Not to Exceed
Metal Building	0.113
Metal Framed	0.151
Light Mass Wall	0.440
Heavy Mass Wall	0.690
Spandrel Panel and Curtain Wall	0.280

Source: California Energy Commission

11.3.3.12 Wall Insulation Prescriptive Requirements

§170(a)2, Table 170.2-A

The prescriptive requirements in Table 170.2-A for low fire rating (0-hour or 1-hour) framed walls are a U-factor of 0.051 in climate zones 1-5 and 8-16, and a U-factor of 0.065 in climate zones 6 and 7.

The U-factor requirements for high fire rating walls (1-hour or greater) are a U-factor of 0.059 for climate zones 1-5, 8-10, 12, and 13, and a U-factor of 0.051 for climate zone 11 and 14-16. U-factor requirements for climate zones 6 and 7 are 0.065 for both high fire rating and low fire rating framed walls.

A wall's fire-resistance rating is determined by the fire code and is measured in hours. Chapter 6 of the California Building Code (CBC) describes fire-resistance rating in detail, and a building's specific rating is ultimately decided upon by the local building official. The fire rating for a building's exterior walls depends on the construction type, based on the building's number of stories, building height, occupancy type, and fire-suppression system type. A wall's fire-resistance rating can also vary due to fire-separation distance, though for residential occupancy types, fire-separation distance never changes a wall's rating from 1-hour to 2-hour (or more). Code officials use CBC Tables 601, 602, 504.3 and 504.4 in combination to make the wall fire-rating determinations. The determination method is generally well understood, and fire-resistance rating info is readily available from the building's architect. Generally, higher buildings with six or more stories and heavy-timber buildings have high fire-ratings, while low or mid-rise buildings of five or fewer stories have a low-fire rating. In most cases, all walls of a specific building will fall under one of the two categories used in Table 170.2-A.

The designer may choose any wall construction from Reference Appendices, Joint Appendix JA4 (Tables 4.3.1 and 4.3.4) that has a U-factor equal to or less than the prescribed level, depending on the climate zone.

Wood Frame. JA4 Table 4.3.1 shows that a 2x6 wood-framed wall at 16-inches-on-center can achieve a U-factor of 0.048 with R-21 batt insulation in the cavity and R-5 exterior insulation.

Metal Frame. Metal-framed assemblies will require rigid insulation to meet the maximum U-factor criteria. U-factors for metal-framed walls are given in Reference Appendices, Joint Appendix JA4 Table 4.3.4 and can be calculated using Energy Commission-approved compliance software.

Calculating U-factors. U-factors can be calculated by building the construction assembly in Commission-approved compliance software, including the inside finish, sheathing, cavity insulation, and exterior finish.

Light and Heavy Mass Walls by Heat Capacity. The prescriptive requirements have separate criteria for mass walls. Mass walls may be light or heavy mass walls depending on their heat capacity. Light mass walls have at least 7.0 and less than 15.0 Btu/ft^2-°F, and heavy mass walls have at least 15.0 Btu/ft^2-°F in heat capacity. Light mass walls have prescriptive requirement of U-factor not exceeding 0.077 and with additional R 13 interior insulation on the interior surface of the mass wall for climate zones 1-15. The requirements are more stringent in climate zone 16, with a U-factor if 0.059 and with R 17 interior insulation.

For heavy mass walls, the U-factor requirements are 0.650 for climate zones 2-5 and 10, 0.690 for climate zones 6-9, 0.184 for climate zones 11, 14-15, 0.253 for climate zones 1 and 12, 0.211 for climate zone 13, and 0.160 for climate zone 16.

Mass walls with insulation applied to both the interior and exterior, such as insulated concrete forms (ICF), must meet the requirements for mass walls with interior insulation. Placement of insulation on mass walls will affect the thermal mass properties of a building. When the prescriptive compliance approach is used, the continuous insulation must be installed integral with or on the exterior or interior of the mass wall.

Calculating the U-Factor. To calculate the effective U-factor of a furred wall using the tables in Reference Appendices, Joint Appendix JA4:

1. Select a U-factor from JA4 Table 4.3.5 (Hollow Unit Masonry) or 4.3.6 (Solid Unit Masonry or Concrete) consistent with the type of wall.
2. Select the appropriate effective R-value for interior or exterior insulation layers from JA4 Table 4.3.14.
3. Use Equation 4-1, and the values selected, to calculate the U-factor of the construction assembly with the continuous insulation.
4. Compare the U-factor; it must be equal to or greater than the mass prescriptive U-factor from Energy Code Table 170.2-A to comply.

The U-factor of furred concrete or masonry walls can also be determined by building the construction assembly in Commission-approved compliance software.

Example 11-11: Wall Assembly Not Found in Reference Appendices, Joint Appendix JA4

Question 1

For a new wall, if 2 inches of medium–density, closed-cell spray polyurethane foam (ccSPF) is used in combination with R-13 batt insulation in the cavity of a 2x6 wood framed wall with 16” on center spacing, without continuous insulation added, what is the total U-factor for the wall assembly?

Answer 1

Medium-density ccSPF is given a default value of R-5.8 per inch, as per JA4 Table 4.1.7. When 2 inches of ccSPF is added to R-13 batt insulation, the total cavity insulation is rounded to R-25. The assembly U-factor was calculated to be 0.065 using Commission-approved compliance software.

Question 2

Does this assembly meet prescriptive compliance requirements in climate zones 6 and 7?

Answer 2

Yes. The assembly does meet the minimum mandatory wall insulation U-factor requirement of 0.071, as well as the prescriptive U-factor requirement of 0.065 in climate zones 6 and 7.

Question 3

How about in other climate zones?

Answer 3

No. The assembly does not meet the prescriptive compliance U-factor requirement of 0.051 in climate zones 1-5 and 8-16 for multifamily buildings. To meet the prescriptive requirement for those climate zones, other wall assemblies may be used, and/or advanced wall system (AWS) techniques may be used to reduce the framing factor. Alternatively, the project may be shown to comply with the Energy Code using the performance approach.

Question 4

How do I determine the U-factor value of metal framed wall assemblies?

Answer 4

Refer to Reference Appendices, Joint Appendix JA Tables 4.3.4 for U-factors correspond with metal frame walls with framing members 18 gauge or thinner, and to JA Table 4.3.3 for thicker framing members. The JA tables display the U-factor as a function of framing size, spacing, cavity and continuous insulation levels.

11.3.3.13 Raised-Floor Insulation

11.3.3.14 Raised-Floor Mandatory Requirements

§160.1(c)

Wood-framed floors over unconditioned space must have at least R-19 insulation installed between framing members, or the construction must have a U-factor of 0.037 or less. The equivalent U-factor is based on R-19 insulation in a 2x6, 16-inch on center wood-framed floor with a crawl space.

Other types of raised floors, except for concrete raised floors (concrete raised floors have a mandatory requirement of 0.269 maximum U-factor) must meet a maximum U-factor of 0.071. In all cases, some areas of the floor can have a U-factor greater than the requirement as long as other areas have a U-factor that is lower than the requirement and the area-weighted average U-factor is less than that described above.

Heated slab floors must meet special insulation requirements that are described in Section 11.1.9.5.

11.3.3.15 Raised-Floor Prescriptive Requirements

§170.2(a)5, Table 170.2-A

The prescriptive requirements differ for concrete raised floors and wood-framed floors. While the requirements for framed floors are the same in all climate zones, the requirements for (concrete) raised mass floors differ.

Wood Framed Raised Floors. The prescriptive U-factor requirement is the same as the mandatory level, at a maximum area-weighted U-factor of 0.037. Alternatively, the prescriptive requirement can be met by having a minimum of R-19 insulation installed between wood framing for framed raised floors in all climate zones.

Concrete Raised Floors. Concrete floors separating multifamily habitable space from a parking garage or other unconditioned spaces are considered exterior raised floors. Insulation requirements for concrete raised floors differ by climate zone, summarized in Table 11-10.

Table 11-10: Insulation Requirements for Concrete Raised Floors per Table 170.2-A

Climate Zone	1,2,11,13,14,16	12,15	3-10
U-Factor	< 0.092	< 0.138	< 0.269
R-Value of Continuous Insulation	> R-8	> R-4	No Req.

Source: California Energy Commission

Other Raised Floors, including metal framed floors. The prescriptive U-factor is 0.048 in climate zone 1, and 0.39 in climate zones 2 and 14-16. In climate zones 3-13, the prescriptive requirement matches the mandatory requirement at 0.071 U-factor.

Installation. Floor insulation should be installed in direct contact with. the subfloor so that there is no air space between the insulation and the floor. Support is needed to prevent the insulation from falling, sagging, or deteriorating. Options for support include netting stapled to the underside of floor joists, insulation hangers running perpendicular to the joists, or other suitable means. Insulation hangers should be spaced at 18 inches or less before rolling out the insulation. Insulation hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration. Netting or mesh should be nailed or stapled to the underside of the joists. Floor insulation should not cover foundation vents.

11.3.3.16 Slab Insulation

A. Slab Insulation Mandatory Requirements

E. Slab Insulation Products

§110.8(g), Table 110.8-A

The mandatory requirements state that the insulation material must be suitable for the application. Insulation material in direct contact with soil, such as perimeter insulation, must have a water absorption rate no greater than 0.3 percent when tested in accordance with ASTM C272 Test Method A, 24-Hour Immersion, and a vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM E96.

The insulation must be protected from physical and UV degradation by either installing a water-resistant protection board, extending sheet metal flashing below grade, choosing an insulation product that has a hard durable surface on one side, or by other suitable means.

The top of the insulation must be protected with a rigid material to prevent intrusion of insects into the building foundation.

A common location for the slab insulation is on the foundation perimeter. Insulation that extends downward to the top of the footing is acceptable. Otherwise, the insulation must extend downward from the level of the top of the slab, down 16 inches (40 cm) or to the frost line, whichever is greater.

For below-grade slabs, vertical insulation mustmust be extended from the top of the foundation wall to the bottom of the foundation (or the top of the footing) or to the frost line, whichever is greater.

F. Heated Slab Floor Insulation

§110.8(g)

Material and installation specifications for heat slab floors mustmust adhere to the following:

1. Insulation values as shown in Table 110.8-A of the Energy Code
2. Protection from physical damage and UV light deterioration
3. Water absorption rate no greater than 0.3 percent (ASTM C272)
4. Water vapor permeance no greater than 2.0 perm/inch (ASTM E96)

See Section 11.5.6.4 for more details.

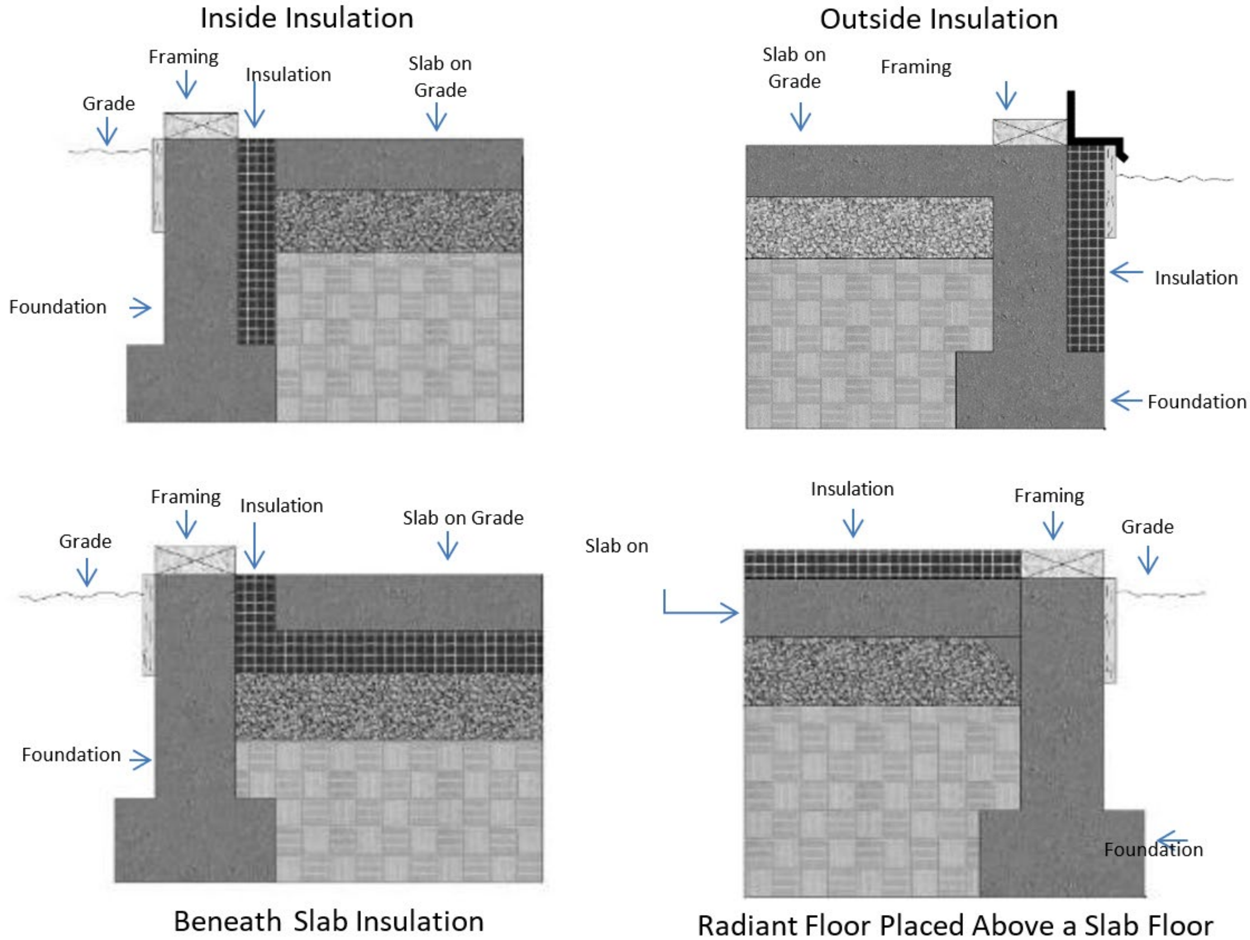
B. Slab Insulation Prescriptive Requirements

§170(a)5B, Table 170.2-A

Tables 170.2-A of the Energy Code require slab insulation for buildings up to three habitable stories but only for unheated slabs in climate zone 16. All heated slabs must meet mandatory insulation requirements in §110.8(g).

For unheated slabs in climate zone 16, a minimum of R-7 slab-edge insulation or a maximum U-factor of 0.58 must be achieved. The insulation must be installed to a minimum depth of 16 inches or to the bottom of the footing, whichever is less. The depth is measured from the top of the insulation, as near the top of slab as practical, to the bottom edge of the insulation.

Figure 11-6: Allowed Slab Edge Insulation Placement



Perimeter insulation is not required along the slab edge between conditioned space and the concrete slab of an attached unconditioned enclosed space such as a garage or covered patio.

11.3.3.17 Opaque Doors

170.2(a)4, Table 170.2-A

An opaque door is an installed swinging door separating conditioned space from outside or adjacent unconditioned space with less than 25 percent glazed area. A door that has 25 percent or more glazed area is a glazed door and is treated like a fenestration product. The requirement is applicable to doors for individual dwelling units and in common use area.

Opaque dwelling unit entry doors between conditioned and unconditioned space are prescriptively required to have an area-weighted average U-factor no greater than U-0.20, per Table 170.2-A. Swinging common use entry doors on separating conditioned and unconditioned space prescriptively require a 0.70 U-factor. Swinging doors between unconditioned and conditioned space that are required to have fire protection are exempt from the prescriptive requirement. As an example, this may include a fire protection door that separate a conditioned dwelling units and unconditioned corridor space. Non-swinging entry doors for common use areas must have a 1.45 U-factor requirement to meet prescriptive requirements, except in climate zones 1 and 16 where the U-factor requirement is 0.50. The U-factor must be rated in accordance with NFRC 100, or the applicable default U-factor defined in Reference Appendices, Joint Appendix JA4, Table 4.5.1 must be used.

At the field inspection, the field inspector verifies that the door U-factor meets the energy compliance values by checking the NFRC label sticker on the product. When manufacturers do not rate the thermal efficiencies by NFRC procedures, the Energy Commission default values must be used and documented on a temporary default label. Default U-factors values for various door types are shown in Table 11-11.

Table 11-11: Default U-Factors for Doors per JA Table 4.5.1

Description	U-factor (Btu/ °F-ft²)
Uninsulated single-layer metal swinging doors or non-swinging doors, including single-layer uninsulated access hatches and uninsulated smoke vents:	1.45
Uninsulated double-layer metal swinging doors or non-swinging doors, including double-layer uninsulated access hatches and uninsulated smoke vents:	0.70
Insulated metal swinging doors, including fire-rated doors, insulated access hatches, and insulated smoke vents:	0.50
Wood doors, minimum nominal thickness of 1-3/4 in. (44 mm), including panel doors with minimum panel thickness of 1-1/8 in. (28 mm), and solid core flush doors, and hollow core flush doors:	0.50
Any other wood door:	0.60
Uninsulated single layer metal roll up doors including fire rated door	1.45
Insulated single layer metal sectional doors, minimum insulation nominal thickness of 1-3/8 inch; expanded polystyrene (R-4 per inch).	0.179

Source: California Energy Commission

11.3.3.18 Vapor Retarder

§160.1(d)2

In climate zones 14 and 16, a continuous Class I or Class II vapor retarder, lapped or joint sealed, must be installed on the conditioned-space side of all insulation in all exterior walls, on the roof decks of vented attics with above-deck or below-deck air-permeable insulation, and in unvented attics with air-permeable insulation.

Buildings with unvented or controlled-ventilation crawl spaces in all climate zones must have a Class I or Class II vapor retarder placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation in accordance with RA4.5.1.

Vapor retarder class is a measure of the ability of a material or assembly to limit the amount of moisture that passes through the material or assembly. Vapor retarder classes are defined in Section 202 of the California Building Code (CBC).

Testing for vapor retarder class is defined using the desiccant method of ASTM E96.

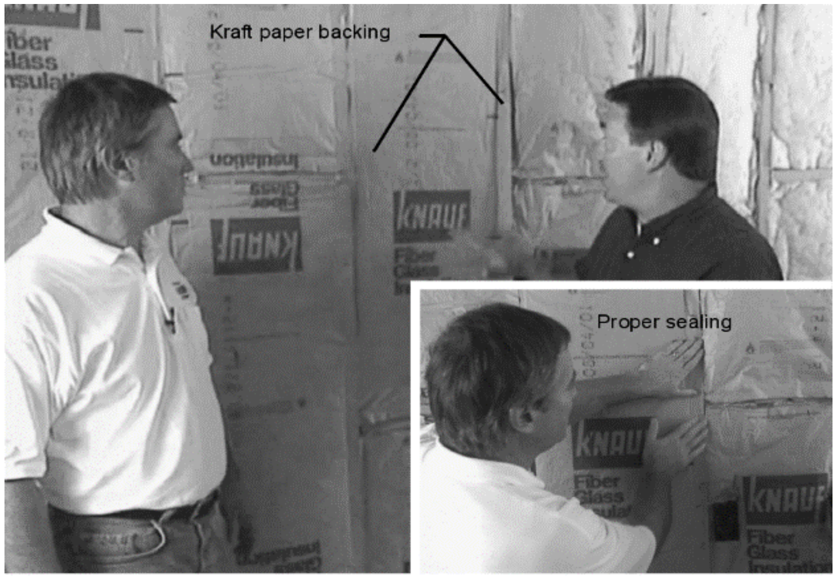
1. Class I: 0.1 perm or less
2. Class II: 0.1 < perm < 1.0 perm
3. Class III: 1.0 < perm < 10 perm

Following are common vapor retarder product types:

1. Foil and other facings on gypsum board can provide moisture resistance, and product literature shows conformance to ASTM E96.
2. Kraft paper facing on thermal batt insulation material is typically a Class II vapor retarder. Faced batts may have flanges for fastening to assembly framing. Fastening flanges may be face- or inset-stapled or not stapled at all, as the flanges provide no moisture control. Face stapling of flanged thermal batts helps ensure the insulation material is installed fully and properly within the framed cavity. Flangeless batts are also common and require no fastening as these materials maintain installation integrity through friction-fitting within the cavity of framed assemblies. In all cases, the insulation must be installed properly.
3. Interior painted surfaces may also serve as vapor retarders if the paint product has been tested and shown to comply with the vapor retarder requirements. The effectiveness of vapor retarder paint depends upon the installed thickness (in mils). These products often require more than one layer to achieve the tested perm rating, and care must be shown by the installer of the paint and for inspection by the building official.
4. Closed-cell spray polyurethane foam (ccSPF) products can provide Class I or Class II vapor retarder performance, depending on thickness.

For all types of vapor retarders, care should be taken to seal penetrations, such as electric outlets on exterior walls.

Figure 11-7: Typical Kraft-faced Vapor Retarder Facing



11.3.3.19 Mandatory Air Sealing and Air Leakage

A. Joints and Other Openings

§110.7

See Section 3.2.3.1 for requirements related to infiltration and air leakage applicable across multifamily and nonresidential buildings.

B. Fireplaces, Decorative Gas Appliances, and Gas Logs

§160.1(f)

Closeable metal or glass doors must cover the entire firebox opening for fireplaces, decorative gas appliances, and gas logs in dwelling unit and common use areas. A combustion air intake no smaller than 6 square inches in area, with a tight-fitting damper or combustion-air control must also be installed. A flue damper with accessible control is also required.

11.3.3.20 Quality Insulation Installation (QII)

11.3.3.21 QII Prescriptive Requirements

§170.2(a)6, Table 170.2, RA 3.5

All insulation mustmust be installed according to manufacturer specifications, throughout the building. In multifamily buildings up to three habitable stories, a third-party HERS Rater is required to verify the integrity of the installed insulation. The installer mustmust provide evidence to the HERS Rater using compliance documentation that all insulation specified is installed to meet specified R-values and assembly U-factors.

To meet QII, two primary installation criteria must be adhered to, and they both must be field-verified by a HERS Rater. They include air sealing of the building enclosure (including walls, ceiling/roof, and floors), as well as proper installation of insulation. Refer to Reference Appendices, Residential Appendix RA3.5 for more details.

Many multifamily insulation installations have flaws that degrade thermal performance. Four problems are generally responsible for this degradation

1. There is an inadequate air barrier in the building envelope or holes and gaps within the air barrier system that allow air leakage.
2. Insulation is not in contact with the air barrier, creating air spaces that short-circuit the thermal break of the insulation.
3. The insulation has voids or gaps, resulting in portions of the construction assembly that are not properly insulated and, therefore, have less thermal resistance than other portions of the assembly.
4. The insulation is compressed, creating a gap near the air barrier and/or reducing the thickness of the insulation.

QII requires third-party HERS inspection to verify that an air barrier and insulation are installed correctly. Guidance for QII is provided in the Reference Appendices, Residential Appendix RA3.5. QII applies to framed and non-framed assemblies, including the following:

Table 11-12: Framed Assemblies vs. Non-Framed Assemblies

Framed Assemblies	Framed assemblies include wood and steel construction insulated with batts of mineral fiber, mineral and natural wool, or cellulose; loose-fill insulation of mineral fiber, mineral and natural wool, cellulose, or spray polyurethane foam (SPF). Rigid board insulation may be used on the exterior or interior of framed or non-framed assemblies.
Non-framed Assemblies	Nonframed assemblies include structural insulated panels (SIP), insulated concrete forms (ICF), and mass walls of masonry, concrete and concrete sandwich panels, log walls, and straw bale.

Source: California Energy Commission

Table 11-13 provides information on applicability and installation tips and examples for QII practices.

Table 11-13: Installer Tips for Implementing QII

QII Scheduling	In a multifamily building, it is typically necessary to coordinate and schedule multiple site visits to capture the totality of the both the air-sealing, and installed insulation portions of the QII inspection requirements. The HERS Rater must see the entirety of the envelope twice. Once to inspect air-sealed cavities before insulation is installed and again to inspect insulation before it is covered with drywall or other internal finishes. QII coordination and scheduling should account for the following: Staged construction timing between floors or building-zones for hanging insulation and covering it with internal finishes.

	Special interior finishes or structures that may close wall cavities off. For example – bathtubs, tiling, cabinets, and stairwells. Interior finishes being installed soon after insulation is installed. At some sites, contractors will hang drywall on the same day the insulation is installed. The HERS Rater must inspect the insulation in that small time window.
Applies to all Insulation	QII applies to the whole building (roof/ceilings, walls, and floors). Combinations of insulation types (hybrid systems) are allowed.
Air Barriers	An air barrier mustmust be installed for the entire envelope.
Insulated Headers	Headers mustmust meet one of the following criteria for QII: Two-member header with insulation in between. The header and insulation must fill the wall cavity. There are prefabricated products available that meet this assembly. Example: a 2x4 wall with two 2x nominal headers, or a 2x6 wall with a 4x nominal header and a 2x nominal header. Insulation is required to fill the wall cavity and must be installed between the headers. Two-member header, less than the wall width, with insulation on the interior face. The header and insulation must fill the wall cavity. Example: a 2x6 wall with two 2x nominal headers. Insulation is required to fill the wall cavity and must be installed to the interior face of the wall. Single-member header, less than the wall width, with insulation on the interior face. The header and insulation must fill the wall cavity. Example: a 2x4 wall with a 3-1/8-inch-wide header, or 2x6 wall with a 4x nominal header. Insulation is required to fill the wall cavity and must be installed to the interior face of the wall. Single-member header, same width as wall. The header must fill the wall cavity. Example: a 2x4 wall with a 4x nominal header or a 2x6 wall with a 6x nominal header. No additional insulation is required because the header fills the cavity, provided that the entire wall has at least R-2 insulation.
Panel Box Headers	Wood structural panel box headers may also be used as load-bearing headers in exterior wall construction, when built in accordance with 2019 California Residential Code (CRC) Figure R602.7.3 and Table R602.7.3.
Structural Bracing, Tie-Downs, Steel Structural Framing	Metal bracing, tie-downs, or steel structural framing can be used to connect to wood framing for structural or seismic purposes, and comply with QII if: Metal bracing, tie-downs, or steel structural framing is identified on the structural plans. Insulation is installed in a manner that minimizes the thermal bridging through the structural framing assembly. Insulation fills the entire cavity and/or adheres to all six sides and ends of structural assemblies that separate conditioned from unconditioned space. The structural portions of assemblies are airtight.

Source: California Energy Commission

A. Air Barrier

RA 3.5

An air barrier mustmust be installed enclosing the entire building. The air barrier must be installed in a continuous manner across all components of framed and non-framed envelope assemblies. The installer mustmust provide evidence with compliance documentation that the air barrier system meets one or more of the air barrier requirements. More detailed explanation is provided in Reference Appendices, Residential Appendix RA3.5. Documentation for the air barrier includes product data sheets and manufacturer specifications and installation guidelines.

As part of QII for multifamily buildings up to three habitable stories, a third-party HERS Rater is required to verify that the air barrier has been installed properly and is integral with the insulation being used throughout the building.

B. QII Performance Requirements

When using the performance approach for a multifamily building up to three habitable stories, QII may be traded off with other efficiency features. However, the compliance modeling software assumes QII and full insulation effectiveness in the standard design. The compliance modeling software automatically reduces the effectiveness of insulation for the proposed design in projects that do not pursue QII, with the assumption that QII results in a properly installed system. Poor installation practices compromise the effectiveness of the air barrier and insulation products and results in worse envelope thermal performance than assumed in the standard design.

Similar increases in heat loss and heat gain are experienced for roof/ceilings where construction and installation flaws are present. The reduction in effectiveness reflects standard industry installation practices and allows for full insulation credit to be taken for HERS verified quality insulation installation.

QII is not a compliance option for multifamily buildings with four or more habitable stories.

11.3.3.22 Advanced Opaque Envelope Options Requiring the Performance Approach

The performance approach offers increased flexibility and compliance credits for certain assemblies. For buildings up to three habitable stories this often includes compliance credits requiring HERS verification. The proposed design used under the performance approach is compared to the standard design, which is determined by the prescriptive requirements. This section describes several envelope assemblies and techniques that require use of the performance approach. See the Residential Compliance Manual Section 3.6 for extensive detailed descriptions and illustrations.

Advanced Building Practices. Common strategies for exceeding the minimum energy performance level set by the 2022 Energy Code include:

- Higher insulation levels.
- More efficient fenestration.
- Reduced building infiltration.
- Use of cool roof products.
- Better framing techniques (such as the use of raised-heel trusses that accommodate more insulation).
- Reduced thermal bridging across framing members.
- Use of non-framed assemblies or panelized systems (such as SIPs and ICFs).
- More efficient heating, cooling, and water-heating equipment.

11.3.3.23 Alternative Construction Assemblies

This section describes several advanced construction assemblies. These three assemblies are included in the Reference Appendices, Joint Appendix JA4 U-factor tables for use in the compliance software.

Structural Foam Wall Systems The high performance structural foam wall assembly is an advanced assembly system that consists of closed cell spray polyurethane foam (ccSPF) placed in the cavity bonded to wood framing and continuous rigid board insulation on the exterior of the frame. The bond that occurs between the ccSPF, the framing, and the continuous rigid insulation can provide code-compliant wind and seismic structural load resistance without the use of OSB sheathing

A builder can configure the thicknesses of the cavity ccSPF, rigid insulation, and alternative cavity insulation to attain U-factors of 0.050 or better in 2x4 at 24" on center assembly. The structural foam wall assembly can be combined with advanced framing techniques to increase energy and resource efficiency while reducing material and labor costs.

Structural Insulated Panels (SIPs) Structural insulated panels (SIPS) are a non-framed advanced construction system that consists of rigid foam insulation sandwiched between two sheets of board. The board can be sheet metal, plywood, cement, or oriented strand board (OSB), and the foam can be expanded polystyrene foam (EPS), extruded polystyrene foam (XPS) or polyurethane (PUR), or polyisocyanurate (ISO) foam. Little or no structural framing penetrates the insulation layer.

SIPs combine several components of conventional building, such as studs and joists, insulation, vapor barrier, and air barrier. They can be used for many different applications, such as exterior walls, roofs, floors, and foundation systems. Reference Appendices, Joint Appendix JA4 Table 4.3.2 has U-factors for SIPS wall assemblies, and JA4 Table 4.4.3 has U-factors for SIPS floor constructions. U-factors used for compliance must be taken from these tables or by using Commission-approved compliance software.

Insulating Concrete Forms (ICF) Insulating concrete forms (ICFs) are a system of interlocking formwork for concrete that stays in place as permanent building insulation and can be used for cast-in-place reinforced above- and below-grade concrete walls, floors, and roofs. The insulating panels are made from expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid insulation boards, polyurethane (PUR), composites of cement and EPS, and composites of cement and shredded wood fiber. ICF wall assemblies provide three energy efficiency benefits:

1. Continuous rigid insulation on both sides of a high-mass core
2. Elimination of thermal bridging from wood framing components
3. A high degree of airtightness inherent to this method of construction

The thermal aspects of ICFs are represented in Reference Appendices, Joint Appendix JA4 Table 4.3.13.

B. Advanced Wall Framing

Advanced wall systems (AWS), or advanced framing, refer to a set of framing techniques and practices that minimize the amount of wood necessary to build a structurally sound, safe, durable, and energy-efficient building. AWS improves energy and resource efficiency while reducing first costs.

Reducing the amount of framing (wood or metal) in exterior walls improves energy efficiency with more insulation, a reduced framing factor and reduced thermal bridging. The standard framing factor for a wood-framed 2x4 wall at 16” on center is 25 percent. When AWS is used, the framing factor is reduced to 17 percent, reflecting improved energy performance.

Double and Staggered Wall Assemblies. Double-wall and staggered-wall systems were developed to better accommodate electrical and plumbing systems, allow higher levels of insulation, and provide greater sound reduction. The advantages of these types of wall systems are:

1. Smaller dimensional lumber can be used.
2. It is easier to install insulation properly.
3. It eliminates thermal bridging through the framing.
4. It reduces sound transmission through the wall.

11.3.3.24 Roofs

Roof techniques and assemblies required to use the performance approach include:

- Unvented attics
- Above-deck insulation
- Insulated roof tiles
- Raised heel, extension truss, or energy truss
- Nail base insulation panels

11.3.3.25 Unvented Attics

Attic ventilation is the traditional way of controlling temperature and moisture in an attic. In an unvented attic assembly, insulation is applied directly at the roofline of the building, either above or below the structural roof rafter. The roof system becomes part of the insulated building enclosure. The thermal boundary of the building results in an unvented attic space between the ceiling gypsum board and the insulated roof above.

Gable Ends in Unvented Attics. In unvented attics, where insulation is applied directly to the underside of the roof deck, framing for gable ends that separate the unvented attic from the exterior or unconditioned space should be insulated to meet or exceed the wall R-value of the adjacent exterior wall construction. The side of air-permeable insulation exposed to the unconditioned attic space should be completely covered with a continuous air barrier.

11.3.3.26 Above-Deck Insulation

Above-deck insulation requires insulation above the roof rafters, directly in contact with the roof deck to improve thermal integrity of the roof system. An air space between the roofing and the roof deck provides additional benefit. Above-deck insulation can be implemented with either asphalt shingles or clay/concrete tiles. Details for above-deck insulation details differ depending on the type of roof tiles. Refer to the Residential Compliance Manual Section 3.6 for detailed descriptions.

11.3.3.27 Insulated Roof Tiles (IRT)

Insulated roof tile (IRT) can improve the thermal performance of the roof assembly and lower attic temperatures. IRT combines concrete or clay tiles with insulation as a packaged product. Most of the increase in R-value is due to the integration of insulation into the roofing product itself. Additional thermal performance can be gained by combining IRT with rigid foam insulation inserts. These tiles are lighter than typical roof tiles and have better thermal performance than traditional tiles due to the insulating core. IRT can reduce radiant losses and maintain warmer roof deck temperatures, thereby reducing the potential for condensation.

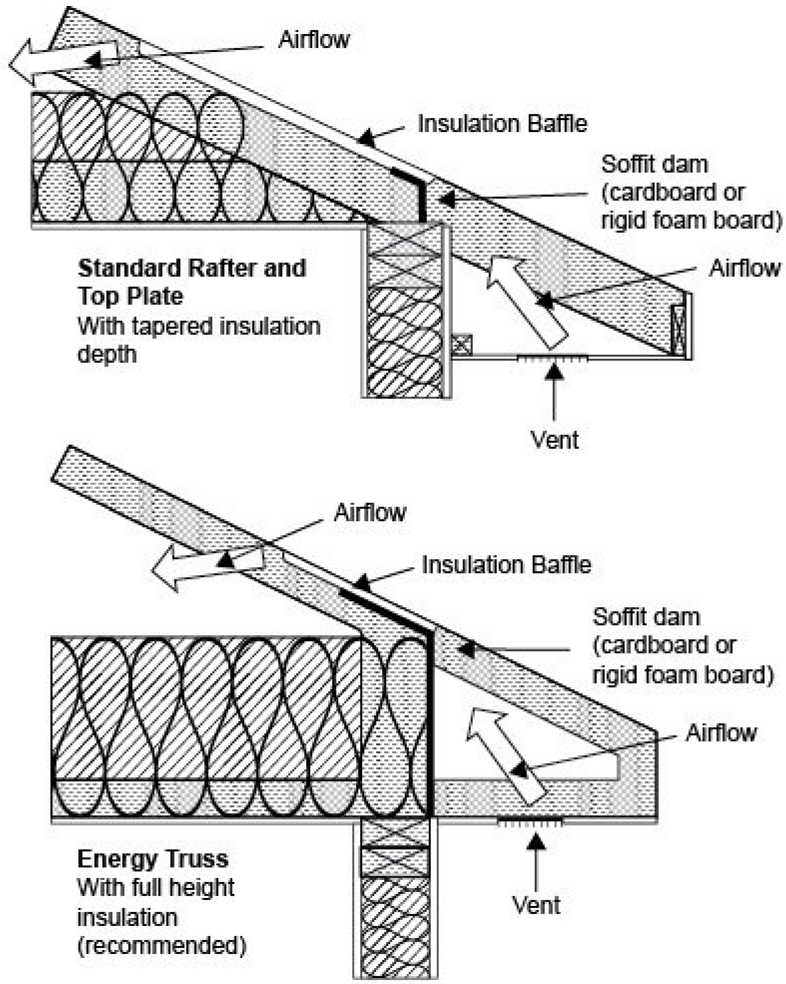
11.3.3.28 Raised Heel, Extension Truss, or Energy Truss

Raised heel or extension trusses allow full depth, uncompressed insulation at the ceiling to continue to the ceiling edge where the wall and ceiling meet. The roof truss is assembled with an additional vertical wood framed section at the point where the truss bears on the wall. The vertical section raises the top chord and provides increased space that can be filled with insulation. See Figure 11-9 for details of a raised heel truss. Benefits of this strategy include:

- Realizing the full benefit of ceiling insulation.
- Providing more space for air handler and duct systems if located in the attic.

Similar construction methods include framing with a rafter on a raised top plate or using spray foam or rigid foam at the edge.

Figure 11-8: Standard Truss vs. Raised Heel Energy Truss



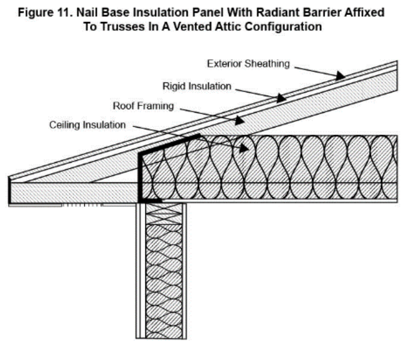
Source: California Energy Commission

11.3.3.29

11.3.3.30 Nail Base Insulation Panel

The nail base insulation panel is a deck insulation strategy that consists of exterior-facing OSB, or other structural sheathing laminated to continuous rigid insulation, which is fastened directly to roof framing (Figure **11-10**). This saves the time and expense of installing a structural sheathing layer above and below the rigid insulation. The nail base insulation panel creates a nailing surface for attaching roof cladding. Suitable for vented and unvented attic assemblies, the exposed underside of the rigid insulation has a facer that provides a radiant barrier, as well as ignition/thermal barrier protection as required by code.

Figure 11-9. Nail Base Insulation Panel with Radiant Barrier Affixed to Trusses in A Vented Attic Configuration



11.3.3.31 Thermal Mass

Thermal mass consists of exposed mass walls, tiled or exposed concrete floors and other heavy elements within the building envelope that can help stabilize indoor temperatures.

Mass walls typically fall into two categories:

- **Masonry.** Masonry includes solid or hollow-core clay and concrete units. Concrete masonry units (CMU) are made from a mixture of Portland cement and aggregates under controlled conditions. Other masonry unit types include cast stone and calcium silicate units.
- **Concrete and concrete sandwich panels.** Concrete and concrete sandwich panels typically use a precast form by casting concrete in a reusable mold or "form" that is then cured in a controlled environment, transported to the construction site, and lifted into place. Precast stone is distinguished from precast concrete by using a fine aggregate in the mixture, giving the appearance of naturally occurring rock or stone.

When the performance method is used, credit is offered for increasing thermal mass in buildings. This procedure is automated in Energy Commission-approved compliance software.

11.3.4 Fenestration

The size, orientation, and types of fenestration products, such as windows, glazed doors, dynamic glazing, window films, and skylights, have a significant impact on energy use and heating and cooling loads in the building and can dramatically affect the overall energy performance of a building.

Any door that is 25 percent or greater glass is considered a glazed door and must comply with the mandatory requirements and other requirements applicable to a fenestration product. Vertical fenestration in demising walls (between conditioned spaces) are required to comply with the area-weighted average U-factor requirement in Table 170.2-A.

Several factors affect window performance. For fenestration with NFRC ratings, the following performance features are accounted for in the U-factor and SHGC ratings:

Frame materials, design, and configuration (including cross-sectional characteristics). Fenestration can be framed in many materials. The most common include vinyl, wood, fiberglass, aluminum, or composites of these materials. Frames made of low-conductance materials like wood, vinyl, and fiberglass are better insulators than metal. Some aluminum-framed units have thermal breaks that reduce the conductive heat transfer through the framing element compared with similar units having no such conductive thermal break.

Number of panes of glazing, low-emissivity (low-e) coatings, tints, fill gases, cavity dimensions, and spacer construction. Windows compliant with the prescriptive requirements are likely to have at least double-glazing with a low-emissivity (low-e) coating and argon gas fill with an improved spacer. The choice of low-e coating is particularly important as cooling climates will generally benefit from a low SHGC coating, while heating climates may benefit from a high SHGC coating. Adding glazing layers such as triple glazing and low-emissivity coatings such as those facing the conditioned space are two likely improvements.

Window components, such as tints and coatings, reduce visual transmittance (VT), reducing light to interior spaces and increasing energy for interior lighting. VT requirements for multifamily buildings four or more habitable stories allow for daylighting and daylighting controls on interior light fixtures.

11.3.4.1 Fenestration Types

Section 3.3.1 includes fenestration and category definitions applicable across nonresidential and multifamily buildings. Prescriptive multifamily fenestration requirements depend on which of the following window types are installed.

- **Curtainwall, window wall, or storefront** windows consist of metalized or glass panels often hung outside structural framing to create exterior wall elements around fenestration and between floors.
- **NAFS Performance Class AW (architectural windows)** adhere to industry standard – AAMA/ WDMA/ CSA 101/ I.S.2/ A440 NAFS-2017 North American Fenestration Standard/ Specification, which includes testing requirements for fenestration products based on air leakage resistance, water penetration resistance, uniform load resistance and forced-entry resistance. The Performance Classes are designated R, LC, CW, and AW in order of performance. Higher rated products typically rely on metal window framing materials which lead to high thermal bridging in the window frame and thus higher U-factors. Windows must be certified as NAFS rated to qualify for the category.

  Performance Class AW windows are significantly more expensive than lower-rated products and are unlikely to be specified unless necessary. The architect calculates the building’s wind loads to determine if Class AW windows are needed. There is no specific code that regulates this decision. It is ultimately at the discretion of the architect and building owner.

- **All other fenestration** includes operable windows, punched fixed windows, glass doors, and skylights that do not qualify as NAFS Performance Class AW.

11.3.4.2 Fenestration Mandatory Requirements

§110.6(a), Table 110.6-A, 160.1(e)

Mandatory requirements for fenestration products, labeling, and air leakage for multifamily and nonresidential buildings are covered in Section 3.3.2.

The area-weighted U-factor of all fenestration, including skylights, may not exceed 0.58.

Exception for Greenhouse/Garden Windows. Compared to other fenestration products, the NFRC-rated U-factor for greenhouse windows are comparatively high. Section 160.1(e)1 includes an exception from the U-factor requirement for dual-glazed greenhouse or garden windows that total up to 30 ft² of rough opening area per dwelling unit.

11.3.4.3 Fenestration Prescriptive Requirements

§170.2(a)3A, Table 170.2-A

11.3.4.4 Fenestration Area

Multifamily buildings have three prescriptive fenestration area limitations. All three must be met for prescriptive compliance.

1. Total combined vertical fenestration and skylight area may not exceed 20 percent of the conditioned floor area (CFA)
2. Total vertical fenestration may not exceed 40 percent of the gross exterior wall area.
3. Total skylight area may not exceed 5 percent of the gross exterior roof area.

11.3.4.5 Fenestration Properties

Prescriptive fenestration requirements, for vertical and skylight fenestration, for multifamily buildings refer to Table 170.2-A. The maximum fenestration U-factor and maximum relative solar heat gain coefficient (RSHGC), and minimum visible transmittance (VTT depend on window type and climate zone. The required RSHGC additionally depends on whether a multifamily building is three or fewer or four or more habitable stories. Only buildings with four or more habitable stories are subject to VT requirements.

Relative solar heat gain coefficient (RSHGC) allows for an external shading correction from exterior shading devices and overhangs. A fenestration product with an SHGC greater than prescriptively required may qualify if an opaque exterior shading device or overhang is used and the combined area-weighted average complies with the prescriptive requirements. Balconies that extend above glazing are common overhangs in multifamily buildings. See Section 3.3.3 for more information about SHGC and Overhang Factor.

For credit, exterior shading devices must be permanently attached as opposed to being attached using clips, hooks, latches, snaps, or ties.

The window property requirements for each fenestration type are as follows.

Curtainwall or storefront fenestration has a maximum U-factor of 0.38 in Climate Zones 1 and 16 and 0.41 in Climate Zones 2 through 15. For multifamily buildings with four or more habitable stories, the maximum RSHGC is 0.35 in Climate Zone 1, 0.26 in Climate Zones 2 through 13 and 15, and 0.25 in Climate Zones 14 and 16. Multifamily buildings up to three habitable stories in Climate Zones 1, 3, 5, and 16 have no RSHGC requirements. Minimum VT is 0.46 across all climate zones for buildings with four or more habitable stories.

Performance Class AW rated fenestration has a maximum U-factor of 0.38 in Climate Zones 1 and 16 and 0.40 in Climate Zones 2 through 15. The maximum RSHGC in Climate Zone 1 is 0.35 and 0.24 in all other climate zones. Multifamily buildings up to three habitable stories in Climate Zones 1, 3, 5, and 16 have no RSHGC requirements. Minimum VT is 0.37 across all climate zones for buildings with four or more habitable stories.

All other fenestration has a maximum U-factor of 0.30 in Climate Zones 1 through 5 and 8 through 16 and 0.34 in Climate Zones 6 and 7. The maximum RSHGC is 0.23 for buildings in Climate Zones 2, 4, and 6 through 15. Multifamily buildings up to three habitable stories in Climate Zones 1, 3, 5, and 16 have no RSHGC requirements. There is no VT requirement for fenestration in the "all other" category.

The requirements apply to fenestration products without consideration of insect screens or interior shading devices. With some exceptions, some fenestration products may exceed the prescriptive requirement as long as the U-factor and RSHGC of windows, glazed doors, and skylights can be area weight-averaged together to meet the prescriptive requirement using the certificate of compliance document in Appendix A of this manual.

See Table 170.2-A for summarizes of climate zone-specific prescriptive requirements by fenestration type.

Exceptions to the prescriptive fenestration requirements include:

- **Glazed Doors.** Each new dwelling unit may have up to 3 ft2 of glass in a door that do not meet the prescriptive U-factor and RSHGC requirements.
- **Skylights.** Each new dwelling unit with roof area may have up to 16 ft2 of skylight area that does not meet the prescriptive U-factor and SHGC requirements. The exempted skylight must have a maximum 0.55 U-factor and a maximum SHGC of 0.30. See Exception 2 of §170.2(a)3Bii.
- **Chromogenic Glazing.** If a multifamily building includes chromogenic type glazing that is automatically controlled, the lowest U-factor and lowest SHGC must meet the prescriptive requirements. This type of product cannot be weight

averaged with nonchromogenic products as per Exception to Section 170.2(a)3Bii and Section 170.2(a)3Biii.

- **Bay Windows.** Bay windows with no rating for the entire unit (where there are multiple windows that make up the bay) and with factory-installed or field-installed insulation must comply accounting for the performance characteristics of each component separately.

First story display perimeters and where overhangs are prohibited by code can have a maximum RSGHC of 0.56 and do not need to meet the RSHGC requirements in Table 170.2-A. U-factor and VT requirements of Table 170.2-A apply.

11.3.4.6 Fenestration in the Performance Approach

§170.1

The performance approach offers increased flexibility as well as compliance credits for high performance fenestration. The compliance software compares whole building energy use, as calculated with the proposed window properties, area, and orientation, to whole building energy use as calculated with prescriptive U-factor and RSHGC values. The following are fenestration strategies for improved energy performance.

A. Fenestration Area and Orientation

The performance approach accounts for fenestration area and orientation, which impact energy use. The standard design window orientations match the proposed design. While there is no compliance credit for window placement across orientations, window placement to avoid solar heat gain will result in lower cooling loads and can lower the overall energy budget in the building and therefore reduce the size of the solar PV system required to offset energy use.

For buildings with glazing areas less than or equal to 20 percent of the conditioned floor area (CFA) and less than or equal to 40 percent of the exterior wall area, the standard design fenestration for a newly constructed building is modeled with the same glazing area as the proposed building. For buildings with more than 20 percent of the CFA or more than 40 percent exterior wall area, the standard design glass area is limited to the lower of 20 percent of the CFA or 40 percent of the exterior wall area. The software reduces fenestration area proportionate to total fenestration area across each orientation in the standard design.

B. Improved Fenestration Performance

The fenestration weighted average U-factor and RSHGC in the standard design for newly constructed buildings is defined in Table 170.2-A, dependent on window type and climate zone. High-performance fenestration that performs better than the prescriptive requirements provide credit through the performance method. The magnitude of the effect of a lower U-factor will vary by climate zone. In mild coastal climates, the benefit from reducing fenestration U-factor will be smaller than in more extreme climates. In hot climates, choosing a window with an SHGC lower than prescriptively required will reduce the cooling loads compared to the standard design. Window film and dynamic glazing are also two options for improved window performance. Section 3.3.3.2 incudes more information on these options.

C. Fixed Permanent Shading Devices

Overhangs or side fins that are attached to the building and shading from the building itself can be accounted for in the performance approach and impact building heating and cooling loads. See Section 3.5.1.4 for more information on modeling overhangs and vertical shading fins.

Example 11-12: Multiple Window Types in a Project

Question

My building will have a combination of window types, including fixed, operable, wood, metal, and so forth, some of which are field-fabricated. What are the options for showing compliance with the standards?

Answer

All windows must meet the mandatory requirements of §110.6 and §110.7 and the mandatory maximum area-weighted average U-factor of 0.58 from §160.1(e)1, unless exempted. For field-fabricated windows, you must select U-factors and SHGC values from the default tables (Table 110.6-A and Table 110.6-B of the Energy Code). Windows that are not field-fabricated must be labeled with NFRC-certified or default efficiencies. Few fenestration products in the default tables meet the mandatory maximum U-factor of 0.58 on their own.

If the area-weighted average U-factors or SHGC values do not comply with the prescriptive requirements in Table 170.2-A, the performance method must be used. To simplify data entry into the compliance software, you may choose the U-factor from Table 110.6-A of the Energy Code that is the highest of any of the windows planned to be installed and use this for all windows for compliance. However, you must use the appropriate SHGC from Table 110.6-B for each window type being installed.

11.3.5 Daylighting

Enclosed conditioned and unconditioned spaces greater than 5,000 ft^2 and with ceiling heights exceeding 15 feet must meet daylighting requirements as described in Section 3.3.4.2E.

11.3.6 Additions and Alterations

11.3.6.1 Additions

Additions to all multifamily building dwelling units and common use areas mustmust meet the mandatory envelope requirements for newly constructed buildings including:

- Ceiling and roof insulation (see Section 11.1.8.20)
- Wall insulation (See Section 11.1.9.30)
- Floor insulation (See Section 11.3.1.6A and 11.1.9.5A)

- Vapor retarder (See Section 11.1.9.7)
- Fireplace, decorative gas appliances, and gas log provisions (See Section 11.1.9.8)
- Fenestration U-factor of 0.58 (See Section 11.1.10.2)

Prescriptive requirements for additions match those for newly constructed buildings (See Sections 11.1.8 and 11.1.10) with some modifications that depend on the conditioned floor area of the addition.

For additions greater than 700 square feet (ft^2):

- Fenestration area must not exceed 175 square feet or 20 percent of the addition floor area.
- Extensions of existing framed walls may retain the dimensions of the existing wall. In these cases, R-15 insulation must fill cavities in 2x4 stud walls and R-21 in 2x6 stud walls.
- If siding is not removed during construction, no continuous insulation is required on existing walls. In these cases, R-15 insulation must fill cavities in 2x4 stud walls and R-21 in 2x6 stud walls.
- The air sealing elements of QII are not required in cases where unconditioned space is being converted to conditioned space when the existing air barrier is not being removed or replaced.
- Additions that increase the area of the roof by 2,000 square feet or less are exempt from the solar ready requirements of Section 160.8.

For additions 700 square feet or less:

- Overall roof and ceiling assemblies are required to achieve an overall U-factor of 0.025 or less in Climate Zones 1,2,4, and 8-16 and a U-factor of 0.031 in Climate Zones 3, 5, 6, and 7. A wood framed assembly would need R-38 insulation to achieve a 0.025 U-factor and R-30 insulation for a 0.031 U-factor.
- Radiant barrier is required in buildings up to three habitable stories in Climate Zones 2-15.
- Extensions of existing framed walls may retain the dimensions of the existing wall. In these cases, R-15 insulation must fill cavities in 2x4 stud walls and R-21 in 2x6 stud walls.
- Fenestration U-factor, RSHGC, and VT must meet requirements of Table 180.2-B (See Section 11.1.12.2)
- QII is not required.
- Additions up to 300 sq. ft. are exempt from the prescriptive roof product requirements.

11.3.6.2 Alterations

11.3.6.3 Roof Alterations

Roofs with more than 50 percent of the roof area or 2,000 square feet of roof (whichever is less) being recovered or recoated are required to have minimum aged solar reflectance and thermal emittance, or solar reflectance index (SRI), determined by slope and climate zone. Low-sloped roofs in Climate Zones 2, 4, and 6 through 15 mustmust have a minimum aged solar reflectance of 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of 75. This requirement may alternatively be met through roof deck insulation, as summarized by Climate Zone in Table 11-14. Climate Zones 1, 3, and 16 do not have cool roof requirements.

Table 11-14: Roof/Ceiling Insulation Tradeoff for Low-Sloped Aged Solar Reflectance (Table 180.2-A)

Minimum Aged Solar Reflectance	Roof Deck Continuous Insulation R-value (Climate Zones 6-7)	Roof Deck Continuous Insulation R-value (Climate Zones 2, 4, 8-15)
0.60	2	16
0.55	4	18
0.50	6	20
0.45	8	22
No requirement	10	24

Source: California Energy Commission

Steep-sloped roofs in Climate Zones 4 and 8 through 15 require a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16. Equivalence may be demonstrated through:

- A 0.025 U-factor ceiling assembly; or
- An attic radiant barrier, not installed directly above spaced sheathing; or
- R-2 or greater insulation above or below the roof deck; or
- No ducts in the attic in Climate Zones 2, 4, 9, 10, 12, or 14.

Roof area covered by building integrated photovoltaic panels or building integrated solar thermal panels is not required to meet the minimum requirements for aged solar reflectance and thermal emittance, or SRI. Roof constructions with a weight of at least 25lb/ft^2 are also exempt from the aged solar reflectance and thermal emittance or SRI requirement.

In Climate Zones 1,2,4, and 8 through 16, low-sloped roofs mustmust additionally be insulated to R-14 continuous insulation or 0.039 U-factor. Roofs with new R-10 insulation above deck are exempt from this requirement.

Vented attics in Climate Zones 1-4 and 8-16 are required to have insulation installed to a weighted U-factor or 0.020, or R-49 ceiling insulation. Buildings with existing R-19 or greater insulation at the ceiling level in Climate Zones 1, 3, 4, and 9 are exempt from this requirement.

Vented attics in Climate Zones 2 and 11-16 are required to air seal accessible areas of the ceiling plane between the attic and conditioned space per §110.7. Dwelling units with existing R-19 or greater insulation at the ceiling level are exempt from this requirement. Dwelling units with atmospherically vented space or water heating appliances within the pressure boundary of the dwelling unit are also exempt.

In vented attics in Climate Zones 1-4 and 8-16, recessed downlight luminaires in the ceiling mustmust be covered with insulation to the same depth as the rest of the ceiling. Luminaires not rated for insulation contact must be replaced or fitted with a fire-proof cover that allows for insulation to be installed directly over the cover. Dwelling units with existing R-19 or greater insulation at the ceiling level are exempt from this requirement in Climate Zones 1-4 and 8-10.

Attic ventilation must comply with California Building Code (CBC) requirements.

Exemptions for the roof insulation requirements for ventilated attics include:

- Dwelling units with at least R-38 existing insulation installed at the ceiling level
- Dwelling units where the alteration would directly cause the disturbance of asbestos
- Dwelling units with knob and tube wiring located in the attic
- Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space mustmust be filled with insulation
- Where the attic space above the altered dwelling unit is shared with other dwelling units and the requirements are not triggered for the other dwelling units.

11.3.6.4 Wall Alterations

Walls separating conditioned space from unconditioned space, with the exception of mass walls, must be insulated to a mandatory minimum R-value between framing members or area-weighted U-factor, dependent on the assembly type:

- Metal building walls: R-13 insulation or 0.113 assembly U-factor
- Metal framed walls: R-13 insulation or 0.217 assembly U-factor
- Wood framed and other walls: R-11 insulation or 0.110 assembly U-factor
- Spandrel panel and curtain walls: R-4 insulation or 0.280 assembly U-factor

11.3.6.5 Floor Alterations

Floors separating conditioned space from unconditioned space must be insulated to a mandatory minimum R-value or area-weighted U-factor, dependent on the assembly type:

- Raised framed floors: R-11 insulation or 0.071 U-factor
- Raised mass floors: R-6 insulation or 0.111 U-factor

11.3.6.6 Fenestration Alterations

The area-weighted U-factor of all fenestration, including skylights, may not exceed the mandatory maximum of 0.58.

Alterations that replace existing fenestration of the same total area can meet prescriptive requirements by meeting the maximum U-factor, RSHGC, ad VT requirements of Table 180.2-B for each window replaced or an area weighted U-factor and RSHGC across all replaced windows from Table 170.2-A. Where 150 square feet or less of the building's vertical fenestration is replaced, the building is exempt from the RSHGC and VT requirements.

Alterations that add fenestration are required to meet the total fenestration area requirements and the U-factor, RSHGC, and VT requirements of §170.2(a)3 and Table 170.2-A. Alterations that add vertical fenestration area of up to 50 ft^2 to the building are exempt from this requirement. Alterations that add skylight area up to 16 ft^2 to the building are exempt from fenestration area and Table 170.2-A requirements but may meet not exceed a U-factor of 0.55 or an RSHGC of 0.30.

See Section 11.1.10.3 for Table 170.2-A requirements. See Table 180.2-B for Altered Fenestration Maximum U-Factor and Maximum SHGC.

11.3.6.7 Door Alterations

Alterations that add exterior door area mustmust meet the U-factor requirement of §170.2(a)4 (See Section 11.1.9.6).

11.3.7 Code in Practice

11.3.7.1 Garden Style Multifamily Case Study

The Garden Style Multifamily Case Study considers a new two-story garden style multifamily building in Burbank, California (Climate Zone (CZ) 9). This is a sample project created for training purposes, and it consists of 7,216 ft^2 of conditioned floor area with eight dwelling units and no common use areas. The case study tables in this chapter compare the proposed building envelope features to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Figure 10: Garden Style Multifamily: South (Front) and West (Left) Elevations

Figure 11: Garden Style Multifamily: North (Rear) and East (Right) Elevations

Figure 12: Garden Style Multifamily: 1st Floor, 1-Bedroom Apartment

Table 11-15: Garden Style Multifamily Case Study Compared to Mandatory and Prescriptive Envelope Requirements (Climate Zone 9) Total Conditioned Floor Area and Fenestration

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Multifamily Building	New two-story garden style multifamily building, eight dwelling units, no common use areas, Burbank, CA	Sections 110.6, 110.7, 110.8, 160.1	Section 170.2(a), Table 170.2-A New multifamily building less than or equal to three habitable stories, Climate Zone (CZ) 9	Case study Mandatory and Prescriptive compliance rated for each feature below as "Yes" (complies), "No" (does not comply) or "N/A" (not applicable). If "No", see compliance options provided.
Total Conditioned Floor Area (CFA)	1st Floor: (122′ x 30′) – 4(26 ft²) = 3,556 ft² 2nd Floor: (122′ x 30′) = 3660 ft² Total = 7,216 ft²	7,216 ft²	7,216 ft²	
Fenestration	Manufactured NFRC-rated dual pane low-e glass, vinyl frame, operable, no shading			
U-factor	NFRC-rated U-factor = 0.30	All CZ: ≤ 0.58	CZ 9: ≤ 0.30	Mandatory: Yes Prescriptive: Yes
RSHGC	NFRC-rated RSHGC = 0.23	N/A	CZ 9: ≤ 0.23	Mandatory: N/A Prescriptive: Yes
Total Fenestration Area	N: 2(150) = 300 ft² E: 2(25) = 50 ft² S: 2(150) = 300 ft² W: 2(25) = 50 ft² Total = 700 ft² Window-Wall Ratio (WWR): 700 / 4,898 = 14.3% Window-Floor Ratio	N/A	*The smaller of* 40% WWR: 0.40 x 4,898 ft² = 1,959 ft² *and* 20% WFR: 0.20 x 7,216 ft² = 1,443 ft² Total ≤ 1,443 ft²	Mandatory: N/A Prescriptive: Yes

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
	(WFR): 700 / 7,216 = 9.7%			

Table 11-16: Roof, Wall, and Floor, plus Verifications Case Studies

Roof and Ceiling: Insulation, Radiant Barrier and Roofing

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Roofing: Aged Solar Reflectance	Steep-sloped (≥2:12), CRRC-rated Aged Solar Reflectance = 0.20	N/A	Option B: Steep-sloped (≥2:12): CZ 9: NR	Mandatory: N/A Prescriptive: Yes
Roofing: Thermal Emittance	Steep-sloped (≥2:12), CRRC-rated Thermal Emittance = 0.75	N/A	Option B: Steep-sloped (≥2:12): CZ 9: NR	Mandatory: N/A Prescriptive: Yes

Wall Insulation

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Demising walls at exterior closets	R-21 wood frame, 5/8" gypsum board: U-factor=0.065	Wood frame demising walls: U-factor ≤ 0.099	Wood frame demising walls: U-factor ≤ 0.099	Mandatory: Yes Prescriptive: Yes
Opaque exterior doors (< 25% glass)	Fire rated dwelling unit entry doors with U-factor = 0.20	N/A	All CZ: Dwelling unit entry doors: U-factor ≤ 0.20	Mandatory: N/A Prescriptive: Yes

Floor Insulation

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Floors over exterior closets	R-19 wood framed demising floors	U-factor ≤ 0.037 or insulation R-value ≥ R-19 in wood framing	U-factor ≤ 0.037 or insulation R-value ≥ R-19 in wood framing	Mandatory: Yes Prescriptive: Yes
Verifications	HERS QII Enclosure Air Leakage (tied to exhaust fan ventilation)	Mandatory Enclosure Air Leakage (tied to exhaust fan ventilation)	CZ 9: HERS QII required for multifamily buildings less than or equal to three habitable stories	Mandatory: Yes Prescriptive: Yes

Source: California Energy Commission

Note that the 2022 Energy Code has a new prescriptive calculation method for total allowed fenestration area. Instead of requiring either a percentage of the conditioned floor area or a percentage of the gross wall area, the 2022 Energy Code limits multifamily buildings to the smaller of 20 percent of the conditioned floor area and 40 percent of the gross exterior wall area. In this example, 20 percent of the conditioned floor area equals 1,443 ft² and 40 percent of the exterior wall area equals 1,959 ft², so the Prescriptive total fenestration area cannot be more than 1,443 ft². The proposed total fenestration area is only 700 ft², so it meets the Prescriptive requirement.

The building envelope meets all mandatory requirements and some prescriptive requirements except for the exterior wall insulation and the roof design in combination with the duct location.

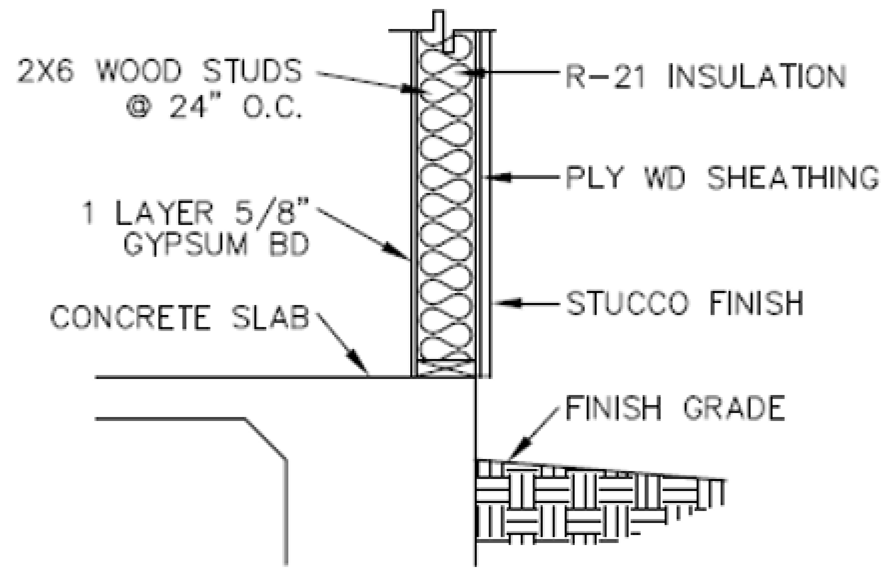
The exterior framed walls for this example building need a U-factor less than or equal to 0.051 to comply with the prescriptive approach, but the proposed design has framed wall U-factor equal to 0.065. Per Reference Appendices. Joint Appendix JA4 Table 4.3.1(a) one option for Prescriptive compliance would be to add R-4 continuous insulation to the planned wall assembly for a U-factor of 0.049.

The proposed design has ducts in a vented attic with R-30 ceiling insulation, but no roof insulation. Prescriptive Option B allows ducts in the attic, but that option also requires ceiling insulation, below-deck roof insulation, and an air space between the roofing material and the roof sheathing. Prescriptive Option C allows just ceiling insulation, but only if the ducts and the air handling units are all in conditioned space. The design team could make changes to the roof design or duct location to comply prescriptively, but they may not want to.

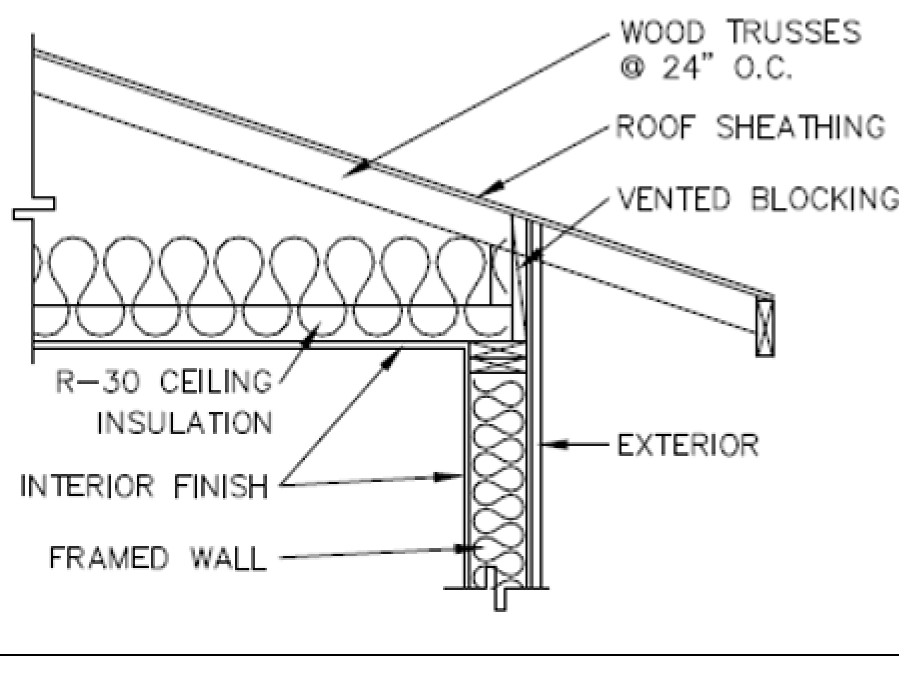
If the design team chooses to keep the original wall insulation and proposed roof construction combined with duct location, then the project will need to show compliance using the Performance Approach.

Figure 13: R-21 Framed Wall and R-30 Attic Roof Details

1 Hour Fire-Rated R-21 Wood Framed Wall



R-30 Vented Attic Roof with Wood Framed Raised Heel Truss



11.3.7.2 Mid-Rise Multifamily Case Study

The Mid-Rise Multifamily Case Study covers a new five-story multifamily building in Sacramento, California (Climate Zone (CZ) 12). This is a sample project created for training purposes, and it includes 112,044 square feet (ft²) of conditioned floor area with 88 dwelling units, shared residential corridors, laundry rooms, fitness center and lounge, plus ground floor retail. The case study tables in this chapter compare the proposed building envelope features to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Figure 14: Mid-Rise Multifamily: North and West View

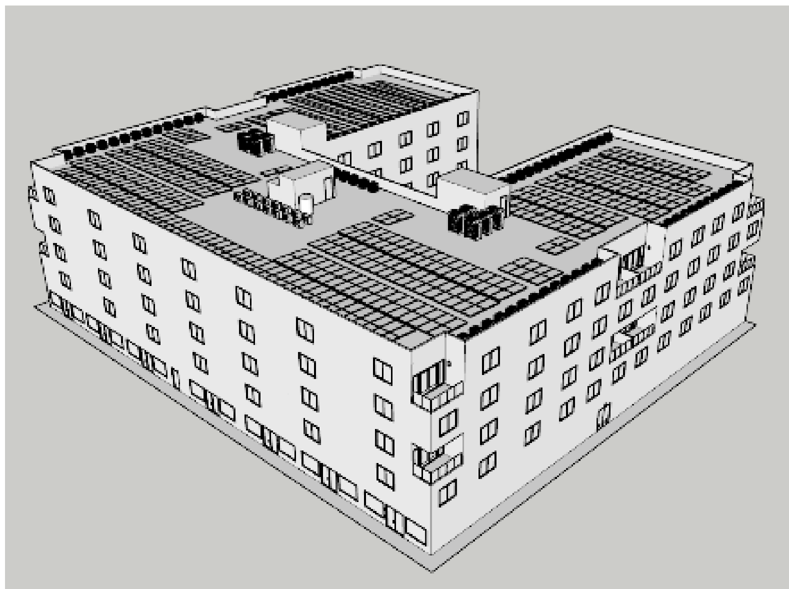


Figure 15: Mid-Rise Multifamily: South and East View

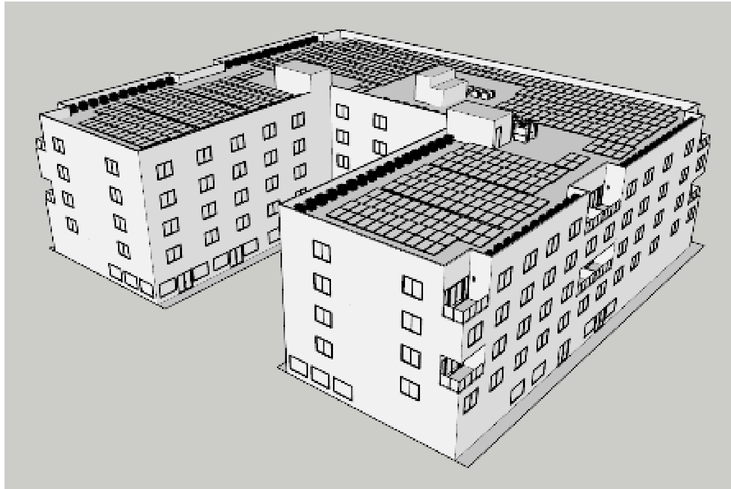


Table 11-17: Mid-Rise Multifamily Case Study Compared to Mandatory and Prescriptive Envelope Requirements (Climate Zone 12)

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Mid-Rise Multifamily Building	New five-story mid-rise multifamily building, 88 dwelling units, multifamily common use areas, ground floor retail, Sacramento, CA	Sections 100.0(f), 110.6, 110.7, 110.8, 120.7, 160.1	Section 100.0(f), Section 170.2(a), Table 170.2-A Section 140.3, Table 140.3-B New mixed occupancy multifamily plus nonresidential building ≥ four stories, Climate Zone (CZ) 12	Case study Mandatory and Prescriptive compliance rated for each feature below as "Yes" (complies), "No" (does not comply) or "N/A" (not applicable). If "No", see compliance options provided.
Conditioned Floor Area (CFA)	Dwelling Units: 78,384 ft²	78,384 ft²		
	Common Use Multifamily: 17,487 ft²	17,487 ft²		
	Nonresidential: 16,173 ft²	16,173 ft²		
	Total: 112,044 ft²	112,044 ft²		

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Total Percent Multifamily in Mixed Occupancy Building	(78,384 + 17,487)/ 112,044 = 85.6%	Mandatory features required for each occupancy type	Because multifamily is ≥ 80% of total CFA, the whole building envelope has the option of complying with multifamily Prescriptive, or could comply by separate occupancies	

Total Conditioned Floor Area and Fenestration

Source: California Energy Commission

Figure 16: Section 100.0(f) Exception 1 for Mixed Occupancy

Mixed Occupancy. When a building is designed and constructed for more than one type of occupancy (residential and nonresidential), the space for each occupancy shall meet the provisions of Part 6 applicable to that occupancy.

EXCEPTION 1 to Section 100.0(f): If one occupancy constitutes at least 80 percent of the conditioned floor area of the building, the entire building envelope, HVAC, and water heating may be designed to comply with the provisions of Part 6 applicable to that occupancy, provided that the applicable lighting requirements in Sections 140.6 through 140.8, 150.0(k), or 160.5 and 170.2(e) are met for each occupancy and space, and mandatory measures in Sections 110.0 through 130.5, 150.0, and 160.0 through 160.9 are met for each occupancy and space.

Table 11-18: Fenestration Case Studies Types and Locations

1st Floor: Mixed Occupancy: Retail (Nonresidential) and Multifamily Common Use

Storefront Fixed, Swinging Doors: NFRC-Rated dual pane low-e glass, thermal break metal frame

2nd-5th Floors: Multifamily Dwelling Units and Multifamily Common Use

Horizontal Sliders, Sliding Glass Doors, Fixed Sidelites: Manufactured NFRC-rated, Architectural Window (AW) Performance Grade, dual pane, low-e glass, vinyl frame

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
U-factor: All NFRC-rated	1st: Storefront Fixed: U-factor = 0.32	Multifamily (MF): ≤ 0.58 Retail: N/A	CZ 12: MF: ≤ 0.41 CZ 12: Retail: ≤ 0.41	Mandatory: Yes Prescriptive: Yes
	1st: Storefront Glazed Doors: U-factor = 0.41	MF: ≤ 0.58 Retail: N/A	CZ 12: MF: ≤ 0.41 All CZ: Retail: ≤ 0.45	Mandatory: Yes Prescriptive: Yes
	2nd-5th: AW Sliders: U-factor = 0.29	MF: ≤ 0.58	CZ 12: MF: ≤ 0.40	Mandatory: Yes Prescriptive: Yes

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
	3rd, 5th: AW Fixed: U-factor = 0.26	MF: ≤ 0.58	CZ 12: MF: ≤ 0.40	Mandatory: Yes Prescriptive: Yes
	3rd, 5th: AW Glazed Doors: U-factor = 0.29	MF: ≤ 0.58	CZ 12: MF: ≤ 0.40	Mandatory: Yes Prescriptive: Yes
RSHGC: **All NFRC-rated**	Storefront Fixed: RSHGC = 0.22	N/A	CZ 12: MF: ≤ 0.26 CZ 12: Retail: ≤ 0.26	Mandatory: N/A Prescriptive: Yes
	Storefront Glazed Doors: RSHGC = 0.19	N/A	CZ 12: MF: ≤ 0.26 CZ 12: Retail: ≤ 0.23	Mandatory: N/A Prescriptive: Yes
	AW Sliders: RSHGC = 0.22	N/A	CZ 12: MF: ≤ 0.24	Mandatory: N/A Prescriptive: Yes
	AW Fixed: RSHGC = 0.22	N/A	CZ 12: MF: ≤ 0.24	Mandatory: N/A Prescriptive: Yes
	AW Glazed Doors: RSHGC =0.22	N/A	CZ 12: MF: ≤ 0.24	Mandatory: N/A Prescriptive: Yes
Visible Transmittance (VT)	Storefront Fixed: VT = 0.47	N/A	All CZ: MF: ≥ 0.46 All CZ: Retail: ≥ 0.46	Mandatory: N/A Prescriptive: Yes
	Storefront Glazed Doors: VT = 0.41	N/A	All CZ: MF: ≥ 0.46 All CZ: Retail: ≥ 0.17	Prescriptive: MF: No, Retail: Yes Compliance Options: 1. Change to VT ≥ 0.46 2. Performance Approach
	AW Sliders: VT = 0.52	N/A	All CZ: MF: ≥ 0.37	Mandatory: N/A Prescriptive: Yes
	AW Fixed: VT = 0.53	N/A	All CZ: MF: ≥ 0.37	Mandatory: N/A Prescriptive: Yes
	AW Glazed Doors: VT = 0.52	N/A	All CZ: MF: ≥ 0.37	Mandatory: N/A Prescriptive: Yes

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Multifamily: Total Fenestration Area, Window Wall Ratio (WWR), Window Floor Ratio (WFR)	Total Fenestration: 6,802 ft² Walls: 36,030 ft² CFA: 95,871 ft² WWR: 6,802 / 36,030 = 18.9% WFR: 6,802 / 95,871 = 7.1%	N/A	*The smaller of* 40% WWR: 14,412 ft² and 20% WFR: 19,174 ft² Total Fenestration ≤ 14,412 ft²	Mandatory: N/A Prescriptive: Yes
Retail: Total Fenestration Area, WWR	Total Fen.: 1,442 ft² Walls: 6,702 ft² WWR: 21.5%	N/A	≤ 40% WWR: Total Fenestration ≤ 2,681 ft²	Mandatory: N/A Prescriptive: Yes

Source: California Energy Commission

Table 11-19: Roof, Wall, and Floor, plus Verifications Case Studies

Roof and Ceiling: Insulation, Radiant Barrier and Roofing

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
5th Floor: Rafter Roof 2nd and 4th Floor: Deck Roofs (same insulation and framing)	Roof Insulation: 2x12 wood framing 24" o.c., R-30 cavity insulation: U-factor = 0.033 Radiant Barrier: No	Wood framed non-attic roofs require an area-weighted U-factor ≤ 0.075	Option D: For CZ 12, wood framed non-attic roofs require an area-weighted U-factor ≤ 0.028 Radiant Barrier: NR	Mandatory: Yes Prescriptive: No Compliance Options: 1. Change to R-38 cavity insulation in 2x12 wood framing 24" o.c. for a U-factor = 0.028 2. Performance Approach
Roofing: Aged Solar Reflectance	Low-sloped (<2:12), No cool roof	N/A	Option D: Low-sloped (<2:12): CZ 12: NR	Mandatory: N/A Prescriptive: Yes
Roofing: Thermal Emittance	Low-sloped (<2:12), No cool roof	N/A	Option D: Low-sloped (<2:12): CZ 12: NR	Mandatory: N/A Prescriptive: Yes

Wall Insulation (Note: Mandatory maximum U-factors must be met for Performance compliance options.)

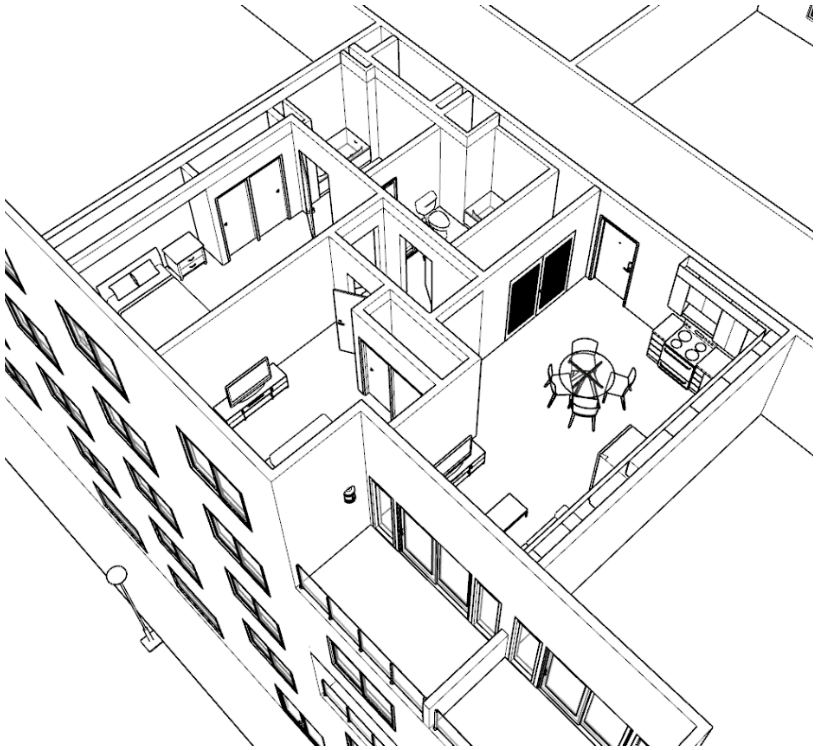
	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
1st Floor West elevation and 1st-	8" solid concrete	MF and Retail:	CZ12: MF and Retail:	Mandatory: No

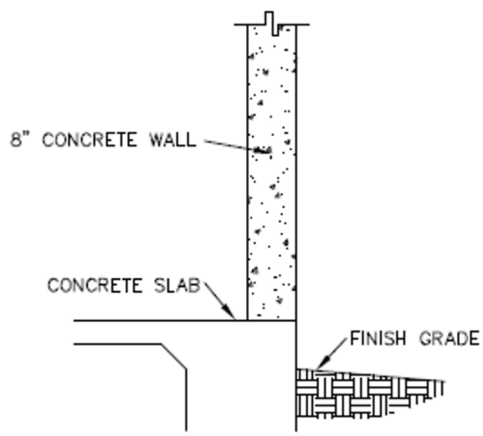
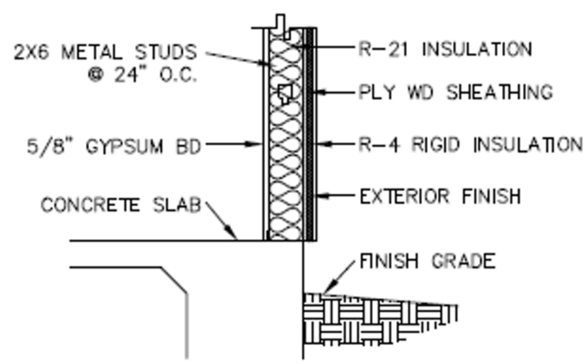
	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
5th Floor stairwells: 8" concrete	U-factor = 0.740	Heavy mass wall U-factor ≤ 0.690	Heavy mass wall U-factor ≤ 0.253	Prescriptive: No Compliance Options: 1. Add R-3 continuous insulation to walls for U-factor = 0.230 2. Performance Approach
1st Floor: All others: ≤ 1 hr. fire-rated metal frame	6" metal frame 24" o.c., R-21 cavity insulation, R-4 continuous insulation, 5/8" gypsum board: U-factor = 0.098	MF and Retail: Metal framed walls: U-factor ≤ 0.151	MF: All CZ: Framed wall ≤1 hr. fire rated: U-factor ≤ 0.051 Retail: CZ12: Metal framed U-factor ≤ 0.055	Mandatory: Yes Prescriptive: No Compliance Options: 1. Change to R-14 continuous insulation for U-factor ≤ 0.049 2. Performance Approach
2nd-5th Floors: > 1 hr. fire-rated wood framed walls	2x6 wood frame 24" o.c., R-21 cavity insulation, R-4 continuous, (2) 5/8" gypsum board: U-factor = 0.049	Nominal 2x6 wood framed walls: U-factor ≤ 0.071	CZ12: Framed wall >1 hr. fire rated: U-factor ≤ 0.051	Mandatory: Yes Prescriptive: Yes

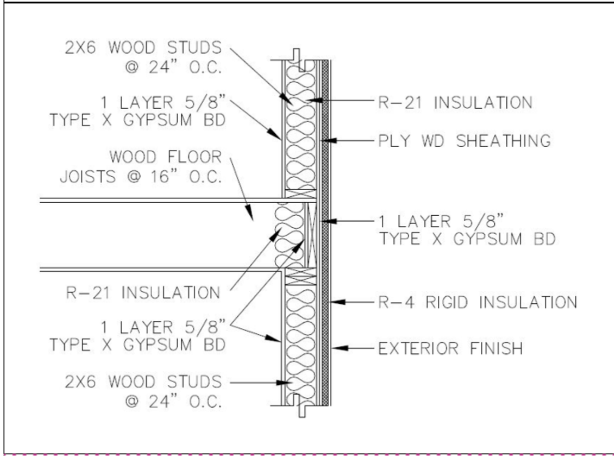
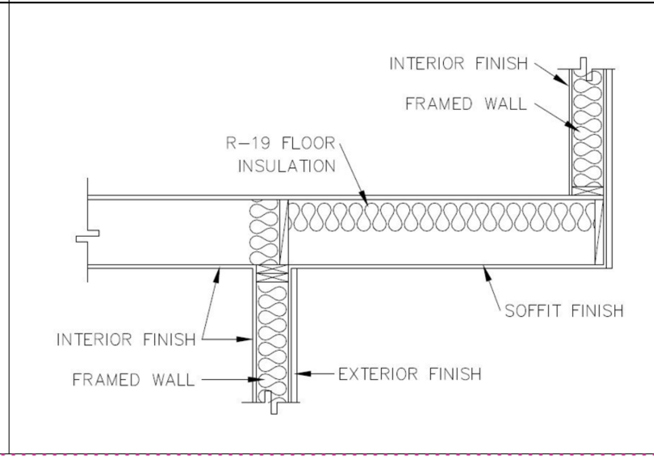
Floor Insulation

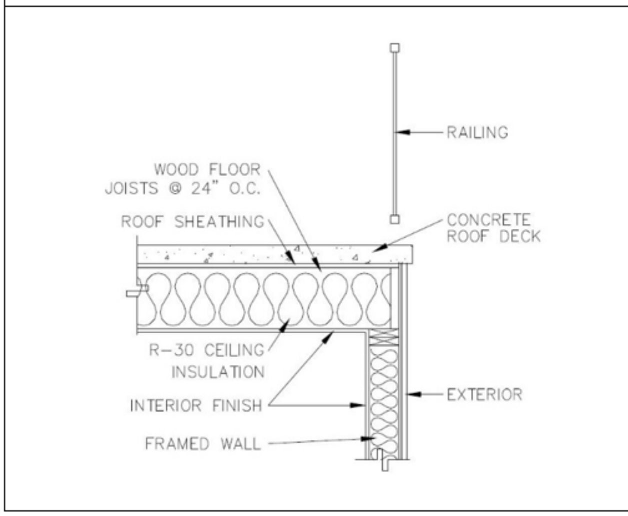
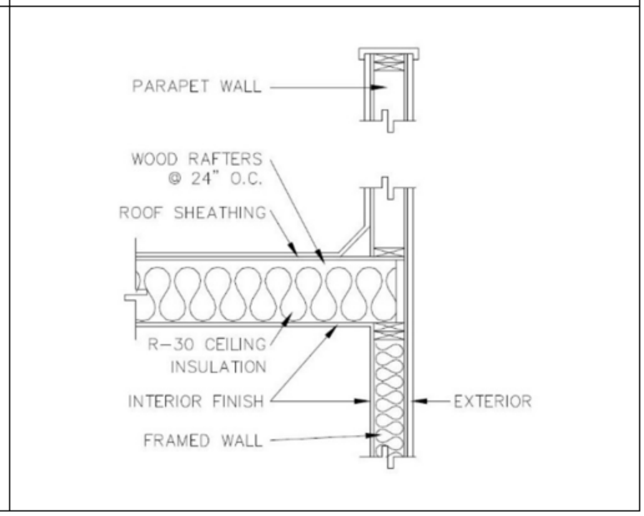
	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Slab on grade	Uninsulated	NR	NR	Mandatory: Yes Prescriptive: Yes
Raised Floor over inset balcony on floor below	R-19 wood framed floors	U-factor ≤ 0.037 or insulation R-value ≥ R-19 in wood framing	U-factor ≤ 0.037 or insulation R-value ≥ R-19 in wood framing	Mandatory: Yes Prescriptive: Yes
Verifications	None	N/A	N/A	Mandatory: N/A Prescriptive: N/A

Figure 17: Mid-Rise Multifamily: 5th Floor, 2-Bedroom Apartment, Plan View with North and East Elevations



8" Concrete Wall	1st Floor: Metal Framed Wall
	

2nd – 5th Floors: R-21+R-4 Wood Framed Wall	R-19 Wood Framed Raised Floor over Balconies
	

2nd and 4th: R-30 Wood Framed Deck Roof	5th Floor: R-30 Wood Framed Rafter Roof
	

This case study is a mixed occupancy building with 85.6 percent multifamily dwelling units and common use areas and 14.4 percent nonresidential retail spaces. According to Energy Code Section 100.0(f) Exception 1, if one occupancy in a mixed use building is at least 80 percent of total conditioned floor area, the whole building has the option of complying with the Prescriptive requirements of the dominant occupancy. Note that each separate occupancy type still has to comply with its own lighting requirements and mandatory requirements.

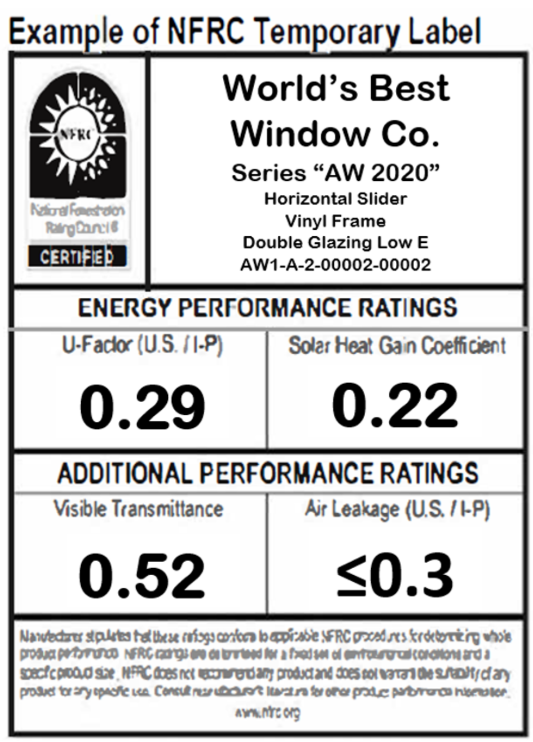
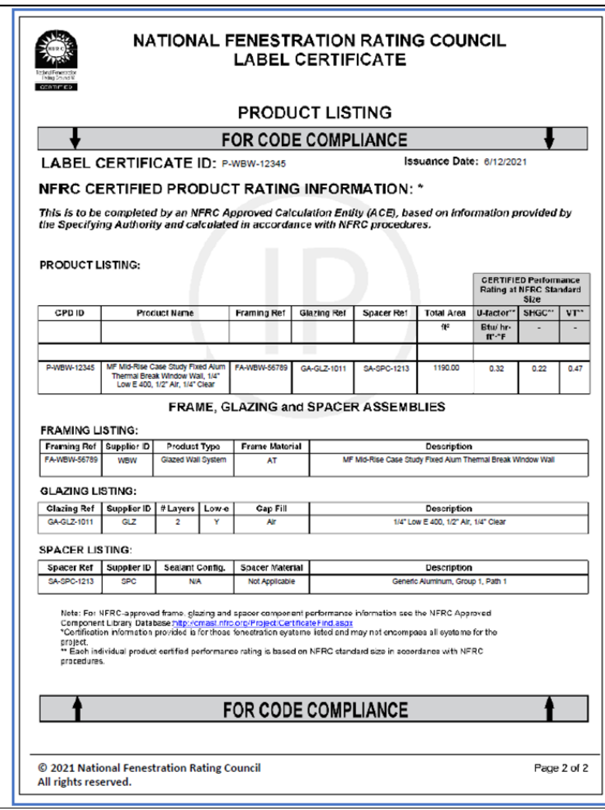
For this case study, the whole building envelope could either meet multifamily prescriptive requirements, or the nonresidential and multifamily areas could comply separately. Based on the results shown in the comparison table, it probably makes sense to show compliance separately for the retail and multifamily areas in this case study. All of the case study envelope features at least meet Mandatory U-value requirements, except for the uninsulated concrete walls on the west side of the first floor and at the stairwells.

There is no alternative to meeting Mandatory requirements, even for performance method compliance. Those concrete walls will have to have a maximum U-factor of

0.690 instead of the proposed U-factor of 0.740 for the project overall to comply at all.

The table also shows several design features that meet mandatory requirements, but do not comply prescriptively. If even one measure misses the prescriptive requirements, the overall project fails prescriptive compliance. In that situation, the project owners and design team would need to make changes to the design to show prescriptive compliance or else work with an energy analyst to evaluate the building using the performance approach to find trade-offs between different building features. Note that the Performance Approach usually works best when modeling the building envelope together with other building components such as the mechanical and water heating systems, since that may allow more opportunities for trade-offs.

Figure 18: NFRC Label (Units) AW Rating & NFRC certificate (Storefront)

NFRC Label Dwelling Units: AW Rating	NFRC Certificate: Storefront
	

NATIONAL FENESTRATION RATING COUNCIL
LABEL CERTIFICATE

PRODUCT LISTING

FOR CODE COMPLIANCE

LABEL CERTIFICATE ID: P-WBW-12345 Issuance Date: 6/12/2021

NFRC CERTIFIED PRODUCT RATING INFORMATION: *

This is to be completed by an NFRC Approved Calculation Entity (ACE), based on information provided by the Specifying Authority and calculated in accordance with NFRC procedures.

PRODUCT LISTING:

CPD ID	Product Name	Framing Ref	Glazing Ref	Spacer Ref	Total Area	CERTIFIED Performance Rating at NFRC Standard Size: U-factor**	SHGC**	VT**
					ft²	Btu/ hr-ft²-°F	-	-
P-WBW-12345	MF Mid-Rise Case Study Fixed Alum Thermal Break Window Wall, 1/4" Low E 400, 1/2" Air, 1/4" Clear	FA-WBW-56789	GA-GLZ-1011	SA-SPC-1213	1190.00	0.32	0.22	0.47

FRAME, GLAZING and SPACER ASSEMBLIES

FRAMING LISTING:

Framing Ref	Supplier ID	Product Type	Frame Material	Description
FA-WBW-56789	WBW	Glazed Wall System	AT	MF Mid-Rise Case Study Fixed Alum Thermal Break Window Wall

GLAZING LISTING:

Glazing Ref	Supplier ID	# Layers	Low-e	Gap Fill	Description
GA-GLZ-1011	GLZ	2	Y	Air	1/4" Low E 400, 1/2" Air, 1/4" Clear

SPACER LISTING:

Spacer Ref	Supplier ID	Sealant Config.	Spacer Material	Description
SA-SPC-1213	SPC	N/A	Not Applicable	Generic Aluminum, Group 1, Path 1

Note: For NFRC-approved frame, glazing and spacer component performance information see the NFRC Approved Component Library Database http://cmast.nfrc.org/ProjectCertificateFind.aspx
*Certification information provided is for those fenestration systems listed and may not encompass all systems for the project.
** Each individual product certified performance rating is based on NFRC standard size in accordance with NFRC procedures.

FOR CODE COMPLIANCE

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Source: California Statewide CASE team

Figure 19: 1st : 8" Concrete Wall (2022 Ref. App. Fig. 4.3.6)

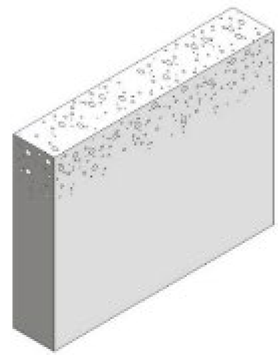


Figure 20: Metal Framed Wall

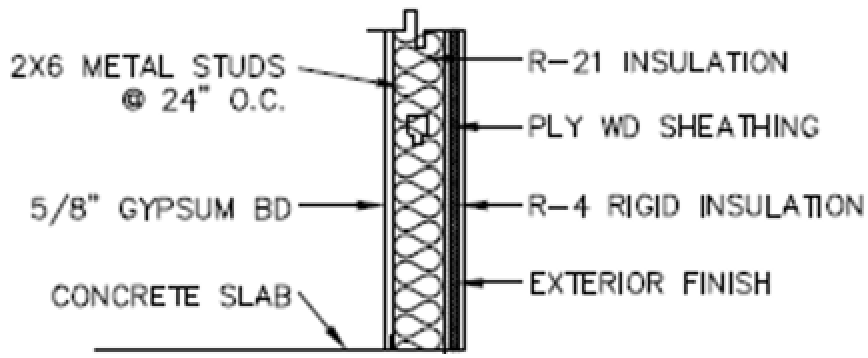


Figure 21: 1 Hour Fire-Rated R-21 Wood Framed Wall

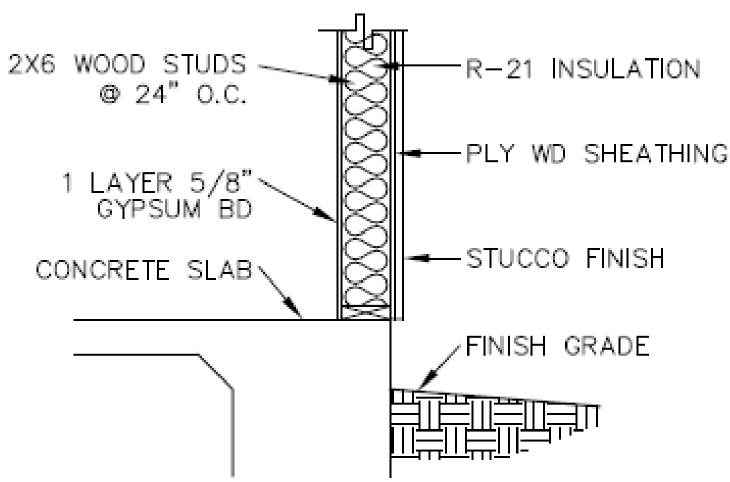


Figure 22: 5th: Wood Frame Rafter Roof (2022 Ref. App. Fig. 4.2.2)

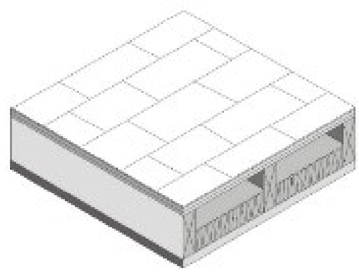


Figure 23: 2nd and 4th: Deck Roofs (2022 Ref. App. Fig. 4.2.2)

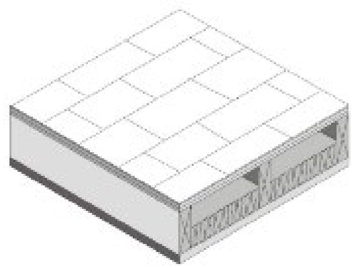
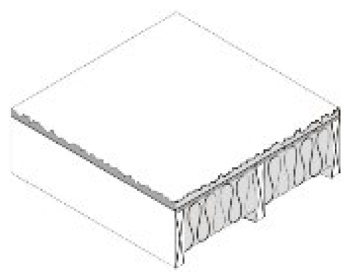


Figure 24: 4th: Raised Floor (2022 Ref. App. Fig. 4.4.2)



On a different note, this case study highlights that there are separate Prescriptive multifamily fenestration U-factor, RSHGC and visible transmittance (VT) requirements for products certified to meet the North American Fenestration Standard/Specification (NAFS) for an Architectural Windows (AW). AW performance grade windows are designed to withstand high wind loads or other physical loads, and for this study the design team determined that they were needed for all of the dwelling units to address a very windy site location. AW performance grade fenestration is generally seen in high-rise and mid-rise buildings. U-factor, RSHGC and VT values for AW performance grade fenestration still need to be determined through NFRC rating or other methods defined in Energy Code Section 110.6.

11.4 Building Indoor Air Quality and Ventilation Requirements

This section addresses the requirements for indoor air quality (IAQ) and ventilation in multifamily buildings and is organized as shown in Table 11-20. Sections 11.4.1 through 11.4.5 discuss IAQ and ventilation requirements for dwelling units, and Section 11.4.6 discusses ventilation requirements for common use areas, including corridors, community rooms, common laundry rooms, exercise facilities, and other areas outside of dwelling units.

Table 11-20: Overview of Indoor Air Quality and Ventilation Requirements in the Energy Code and Compliance Manual Organization

Ventilation System Application	Mandatory Requirements	Prescriptive Requirements	Performance Approach Requirements	Manual Section
Ventilation System Serving Individual Dwelling Units	§160.2	§170.2(c)3,3Biii,3Biv,4A	§170.1	11.4.2
Central Ventilation Systems Serving Dwelling Units	§160.2	N/A	N/A	11.4.3
Air Moving Equipment	§160.2(b)2	N/A	N/A	11.4.4
Dwelling Unit Additions and Alterations	N/A	§180.1(a)2 §180.2(b)5	§180.1(b)5	11.4.6
Common Use Area Ventilation Requirements	§160.2(c) §160.2(d) §160.3(d)1	§170.2(c)4	§170.1	4.3
Other Requirements	§160.2(b)2	N/A	N/A	11.4.5

Source: California Energy Commission

Heating and cooling requirements for multifamily dwelling units are provided in Section 11.5.

11.4.1 What's New for the 2022 Energy Code

The following is an overview of the new multifamily IAQ and ventilation requirements for the *2022 Building Energy Efficiency Standards* (Energy Code).

11.4.1.1 Mandatory Features and Devices

For dwelling units:

- Unitary energy recovery ventilators (ERVs) and heat recovery ventilators (HRVs) (one unit serving each dwelling unit) are required to meet a maximum fan efficacy of 1.0 W/CFM.
- If a vented range hood is used for the exhaust system in the dwelling unit kitchen, the range hood must either meet a minimum capture efficiency or airflow dependent on the range fuel and the floor area of the dwelling unit to ensure adequate removal of cooking-related pollution.
- Central ventilation duct systems that provide continuous ventilation airflow or serve as part of dwelling units' balanced ventilation must be sealed to ensure leakage does not exceed:
  - 10% of the central (e.g., rooftop) fan airflow rate at 50 Pa (0.2 inches w.c.) for central ventilation duct serving more than six dwelling units
  - 6% of the central fan airflow rate at 25 Pa (0.1 inches w.c.) for central ventilation duct serving six or fewer dwelling units
- Updated ventilation requirements based on applicable sections of 2019 ASHRAE 62.2 and added clarification language.
- Filter racks or grilles must use a gasket or sealing to prevent air from bypassing the filter.

For common use areas:

- Common use areas are required to have occupant sensing ventilation controls if the space conditioning zones are permitted to have ventilation air reduced to zero or if occupant sensors are used to comply with lighting requirements. Occupant sensor ventilation control devices must comply with §160.2(c)E.
- Filter racks or grilles must use a gasket or sealing to prevent air from bypassing the filter.

11.4.1.2 Prescriptive Requirements

For dwelling units:

- In Climate Zones 4-10, if the ventilation system is a balanced system without heat or energy recovery, the fan efficacy must be 0.4 W/CFM or less.
- In Climate Zones 1-2 and 11-16, for projects following the balanced ventilation path, the prescriptive approach requires an ERV or HRV.
  - Unitary ERV or HRV equipment (one unit serving each dwelling unit) must be field verified to have a sensible heat recovery efficiency of at least 67% and fan efficacy less than or equal to 0.6 W/CFM.

- Central ERV or HRV equipment (one unit serving multiple dwelling units) must be field verified to have a minimum sensible heat recover effectiveness of 67%, have minimum fan efficacy as required in §170.2(c)4a, and include a bypass or free cooling function whereby the intake air bypasses the heat exchanger during favorable outdoor air temperatures.

For common use areas:

- Common use areas using a dedicated outdoor air system (DOAS) to condition, temper, or filter 100% outdoor air separate from local or central space-conditioning systems serving the same space must meet new criteria specified in §170.2(c)4N. This includes requirements for heat recovery, an energy recovery bypass or control to directly economize with ventilation air, modulating fan speed control capabilities, fan efficacy requirements, and (for airflows > 1,000 cfm) demand control ventilation requirements.
- Common use area fan systems that operate to criteria shown in Table 170.2-I or Table 170.2-J need to include an exhaust air heat recovery system that meet the requirements in §170.2(c)4O

11.4.1.3 Additions and Alterations

New to the Energy Code, there are explicit triggers for whole-dwelling unit mechanical ventilation system alterations including ventilation fans, air filters, and local mechanical exhaust systems.

There are no new requirements common use areas for additions or alterations. Additions to the common use area should follow the nonresidential building requirements. Any newly installed space conditioning system must meet the ventilation requirements in §120.1 (Requirements for Ventilation and Indoor Air Quality) for both the prescriptive and performance approaches.

11.4.2 Dwelling Unit IAQ and Mechanical Ventilation

As multifamily buildings have been tightened to improve energy performance, the dilution of indoor air through natural ventilation has been significantly reduced. As a result, the importance of controlling indoor pollutants generated by kitchen ranges during food preparation and (where applicable) from gas stoves. Cleaning products, furniture, dry cleaning, personal care products, and other sources may have increased. Without local exhaust to remove pollutants from areas such as kitchens and bathrooms, and dwelling unit ventilation to dilute pollutants throughout the dwelling unit, IAQ will be poor. This can negatively impact occupant health and (due to high relative humidity) the integrity of the building.

This section covers typical design solutions, energy consumption issues, and other requirements specified by ASHRAE Standard 62.2 as amended in the Energy Code.

11.4.2.1 Dwelling Unit Mandatory Requirements

§160.2

A. Overview of Requirements

Multifamily dwelling units must meet the requirements of ASHRAE Standard 62.2-2019 including Addenda v and d subject to the amendments specified in §160.2(b)2A. A copy of this version of ASHRAE Standard 62.2 may be obtained at the following link: www.techstreet.com/ashrae/standards/ashrae-62-2-2019?product_id=2087691

As part of mandatory requirements, all dwelling units must have mechanical ventilation, Minimum Efficiency Reporting Value (MERV) 13 air filtration on space conditioning systems, and ventilation systems that provide outside air to the occupiable space of a dwelling. Opening and closing windows and continuous operation of central fan-integrated ventilation systems are not allowable options for meeting dwelling unit ventilation requirements. The requirements of ASHRAE Standard 62.2 focus on providing continuous whole-dwelling unit mechanical ventilation, as well as local exhaust ventilation at known sources of pollutants or moisture, such as kitchen, bathroom, and laundry. The key mandatory requirements for mechanical ventilation for most newly constructed multifamily buildings are:

- A whole-dwelling unit mechanical ventilation system must be provided. Typical solutions are described in Section 11.4.2.10 Dwelling Unit Ventilation Strategies section below. The airflow rate provided by the system mustmust be confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.7.
- Dwelling units must either use balanced ventilation or meet a compartmentalization (dwelling unit air sealing) requirement.
- Kitchens and bathrooms must have local exhaust systems vented to the outdoors.
- Clothes dryer exhaust must be vented to the outdoors.

The following additional IAQ design mandatory requirements apply:

- Ventilation air mustmust come from outdoors and must not be transferred from adjacent conditioned spaces, garages, or unconditioned spaces.
- Combustion appliances must be properly vented, and exhaust systems must be designed to prevent back drafting.
- Walls and openings between the dwelling unit and adjacent spaces, such as adjacent units, a common corridor, trash chute, parking garage, or other spaces must be sealed or gasketed.
- Mechanical systems, including ventilation systems, that supply air to habitable spaces mustmust be designed to filter recirculated air and outdoor air through a MERV 13 filter or better and mustmust be designed to accommodate the rated pressure drop of the system air filter at the designed airflow rate.
- Dedicated outdoor air inlets that are part of the ventilation system design mustmust be located away from known sources of outdoor contaminants.

- A carbon monoxide alarm mustmust be installed in each dwelling unit in accordance with NFPA Standard 720.
- Air-moving equipment used to meet the whole-dwelling unit ventilation requirement and the local exhaust requirement, including kitchen local mechanical exhaust, mustmust be rated by HVI or AHAM, which provides ratings for kitchen local mechanical exhaust, for airflow and sound:
  - Whole-dwelling unit ventilation and continuously operating local exhaust fans must be rated at a maximum of 1.0 sone (measurement of sound).
  - Demand-controlled local exhaust fans must be rated at a maximum of 3.0 sone.
  - Kitchen exhaust fans must be rated at a maximum of 3.0 sone at one or more airflow settings greater than or equal to 100 CFM. (As described in Section 11.4.2 0, the Standard requires kitchen range hoods to have a higher airflow than 100 CFM, but the range hoods must be tested for sound at a minimum of 100 CFM.)
  - Remotely located air-moving equipment (mounted outside habitable space, bathrooms, toilets, and hallways) is exempt from the sound requirements provided there is at least 4 ft. of ductwork between the fan and the interior grille. Kitchen range hoods are also exempt from the sound requirements provided they have a minimum airflow setting exceeding 400 cfm.
- For central ventilation systems serving multiple dwelling units, ducts must be sealed, balanced, and (for some systems) tested for leakage.

11.4.2.2 Summary of Field Verification and Testing Requirements by a HERS Rater or ATT

Compliance with the Standard requirements must be verified by the enforcement agency, except for the following requirements. Table 11-1 shows the ventilation and IAQ HERS Verifications that must be conducted by either a HERS Rater or ATT, where “stories” refers to habitable stories. As shown, the Energy Code generally requires that some HERS raters verify some features and that ATTs verify others. NA1.9 allows ATTs to serve as HERS raters in multifamily buildings with four or more stories. The builder is free to choose either a HERS Rater or ATT to perform the eligible HERS verifications, but that choice must be approved by the enforcement agency (NA1.9.1).

Table 11-21: Ventilation and IAQ Field Verification and Testing Requirements by a HERS Rater or ATT

Feature	Verification Requirement	Authorized for verification: HERS Rater and/or ATT
Dwelling unit air leakage (compartmentalization)	Conduct air leakage test, also known as an individual dwelling unit blower door test, for a sample of dwelling units	HERS Rater
ERV/HRV	Verify ERV/HRV HVI-listing and compliance based on nominal airflow	HERS Rater
ERV/HRV	Verify nominal sensible recovery efficiency, and fan efficacy / fan power allowance	HERS Rater for three stories or lower, ATT for four stories or higher
ERV/HRV	Conduct functional bypass testing for central ERV/HRV (per NA 7.18.4)	ATT, for buildings four stories or higher (no equivalent requirement for buildings three stories or lower)
Kitchen exhaust	Verify using listings in HVI or AHAM-directories for compliance based on nominal airflow or capture efficiency, and sound	HERS Rater
Central ventilation duct sealing	Conduct a leakage test measurement (NA 7.18.3)	ATT, for buildings four stories or higher (no equivalent requirement for buildings three stories or lower)

Source: California Energy Commission

For HERS verification requirements, HERS raters must follow procedures in Residential Appendix RA3.7 and ATTs must follow procedures in Nonresidential Appendix NA2.1. Section 11.4.8 provides more detail on compliance and enforcement.

11.4.2.3 Differences between Energy Code and ASHRAE Standard 62.2

The Energy Code mandatory requirements include the adopted 2019 ASHRAE Standard 62.2 with amendments. The key differences in the Energy Code compared to the 2019 ASHRAE Standard 62.2 include the following:

- While ASHRAE Standard 62.2 requires compartmentalization but does not require balanced ventilation, the Energy Code provide two options for compliance with dwelling unit ventilation: 1) installation of a balanced ventilation system or 2) installation of an exhaust or supply-only system accompanied by compartmentalization: sealing to a leakage rate of not more than 0.3 CFM50 per square feet of dwelling unit enclosure surface area.

- The Energy Code require MERV 13 filtration for all recirculated air and outdoor air, including outdoor air provided by supply air ventilation systems or the supply side of balanced ventilation systems, while ASHRAE Standard 62.2 requires MERV 6 filtration for HVAC systems with at least 10 ft. of ductwork. The additional filtration requirements in the Energy Code are important for reducing particulate matter which can pose a health to residents.
- Both standards require kitchen exhaust systems vented to the outdoors and allow three systems for kitchen exhaust systems in multifamily dwelling units: 1) demand-controlled range hood, 2) downdraft exhaust or 3) continuous kitchen exhaust for enclosed kitchens only.
    - For demand-controlled range hoods, the Energy Code require that they either meet a minimum airflow or capture efficiency that depends on the type and dwelling unit floor area as shown in Table 11-22. There are no capture efficiency requirements in ASHRAE Standard 62.2. Additionally, the required minimum hood airflows are higher in the Energy Code, as shown in Table 11-22, than the requirement in ASHRAE Standard 62.2, which is 100 CFM for all demand-controlled range hoods.

Table 11-22: Minimum Capture Efficiency (CE) or Airflow (CFM) for Demand-Controlled Range Hoods

Dwelling unit floor area (sq. ft)	Hood over electric range	Hood over gas range
≤ 750	65% CE or 160 CFM	85% CE or 280 CFM
750 – 1,000	55% CE or 130 CFM	85% CE or 280 CFM
> 1,000 – 1,500	50% CE or 110 CFM	80% CE or 250 CFM
>1,500	50% CE or 110 CFM	70% CE or 180 CFM

Source: California Energy Commission

- For downdraft and continuous kitchen exhaust requirements, the Energy Code and ASHRAE Standard 62.2 are the same.

The verification protocol for kitchen exhaust systems remains the same. Kitchen range hood fans are required to be verified by a HERS Rater. The verification protocol requires comparing the installed model to ratings in the Home Ventilating Institute (HVI) or Association of Home Appliance Manufacturers (AHAM) directory of certified ventilation products to confirm the installed range hood is rated to meet the required airflow in the Energy Code, as well as the sound requirements specified in ASHRAE Standard 62.2. See the section, ***Requirements for Kitchen Exhaust*** below for more detail. Kitchen range hood fans that exhaust more than 400 CFM at minimum speed are exempt from the sound requirement.

Limiting the sources of indoor pollutants is an important method for protecting IAQ. The United States Environmental Protection Agency (EPA) provides information and resources on improving IAQ. For more information, see the EPA's Indoor Air Quality webpage: /www.epa.gov/indoor-air-quality-iaq.

11.4.2.4 Dwelling Unit Ventilation Strategies

This section provides typical strategies for providing outdoor air for whole-dwelling unit ventilation. Local exhaust systems, which provide spot ventilation to remove polluted air from areas such as bathrooms and kitchen, are described in the section 11.4.2.1 0 Dwelling Unit Local Exhaust .

Multifamily projects can use either of the following strategies:

- Unitary ventilation system, in which each dwelling unit has its own ventilation system. These are often simpler designs and use packaged equipment, but present more systems to maintain, may require maintenance by the resident (or at least their cooperation to provide access), and can require more wall penetrations.
- Central ventilation systems, in which a centrally located (typically rooftop) fan and centralized ductwork serves multiple dwelling units. These can streamline maintenance and reduce exterior wall penetrations. For ERVs and HRVs, centralized equipment provides economies of scale for features such as bypass, which provides significant energy savings during the cooling season. However, centralized ventilation systems reduce the occupiable square footage in a building and can increase penetrations between units, which should be sealed for IAQ concerns.

There are generally three system types available for meeting the mandatory whole-dwelling unit ventilation requirements:

1. **Exhaust ventilation:** air is exhausted from the dwelling unit and replaced by infiltration—i.e., air entering the dwelling unit through cracks and leaks in the dwelling unit air barrier.
2. **Supply ventilation:** filtered outdoor air is supplied directly to the dwelling unit
3. **Balanced ventilation:** combination of exhaust and supply in which air is exhausted from a dwelling unit and outdoor air is supplied directly to the dwelling unit at the same rate (within 20%).

For the mandatory requirements of the Energy Code, §160.2(b)2Aivb requires the whole-dwelling unit ventilation system to either be a balanced system or a supply or exhaust system with compartmentalization testing. See section 11.4.2.10 for details on compartmentalization testing. Multifamily buildings must use one approach for compliance (either balanced ventilation, or supply or exhaust-only ventilation with compartmentalization throughout the entire building, per §160.2(b)2Aivb. Multifamily projects could implement both balanced ventilation and compartmentalization for best practice but are not required to do so.

Natural ventilation does not satisfy requirements for dwelling unit ventilation. All dwelling unit ventilation systems need to have a mechanical fan.

A. Exhaust-only

In an exhaust-only system, air is drawn from the dwelling unit and exhausted to the outdoors. Outdoor air enters the unit through infiltration. This infiltration air will include both outdoor air, as well as air from adjacent spaces in the building (e.g., corridor, adjacent units). While not prohibited, exhaust-only ventilation systems are not good practice in dwelling units that will have difficulty drawing adequate outside air due to limited exterior wall area.

Exhaust ventilation is typically provided using a continuously operating ceiling-mounted fan. Projects may use intermittent fans for meeting the dwelling unit ventilation rate, but these must be on a schedule to ensure that the minimum ventilation rate is met. Examples of intermittent ventilation systems can be found in ASHRAE 62.2 Section 4.5. Intermittent ventilation systems must be certified to the Energy Commission.

All fans must meet sound requirements: maximum of one sone for continuously operated and 3 sones for intermittent. Remotely located fans (fans mounted outside habitable spaces[2], bathrooms, toilets, and hallways) are exempt from the sound requirements if there is at least four feet of ductwork between the fan and the interior grille. For larger units, more than one fan may be needed to meet ventilation air requirements. The same fan can be used to meet dwelling unit and local (bathroom or laundry) exhaust ventilation requirements. Inline fans (fans mounted in line with ductwork) can be used to exhaust air from one or more bathrooms.

While not required, some multifamily units include passive air inlets, such as Z-ducts or trickle vents, to increase the rate of fresh air that enters the unit beyond natural infiltration. Since there is no filter in an exhaust-only dwelling unit ventilation system, MERV 13 filtration is not applicable to exhaust-only ventilation or air that enters via passive air inlets. However, MERV 13 filtration is still required in the dwelling unit for the separate space conditioning (heating or cooling) system, if it is a forced air system with ductwork exceeding 10 feet in length. Figure 11-26 provides an example of an exhaust-only ventilation strategy. While this example is shown for a garden style unit, the same approach could be used for a dwelling unit on a common corridor (in a building with a common entry).

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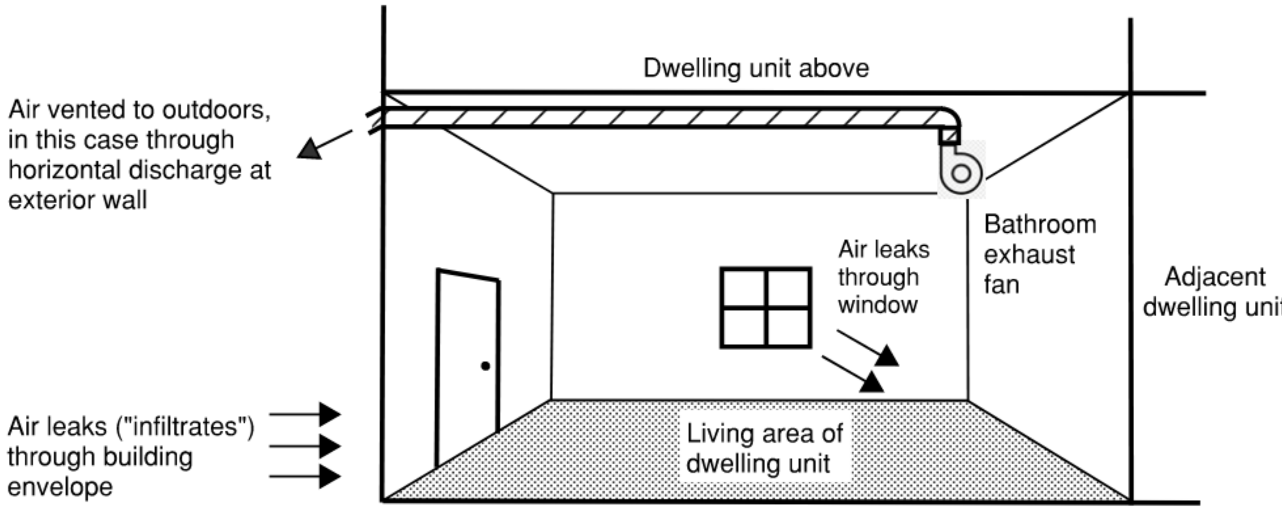
[2] Based on the definition in ASHRAE Standard 62.2, a habitable space is intended for continual human occupancy; and hallways, storage areas, closets, or utility rooms could be considered not habitable.

Figure 11-25: Exhaust Ventilation Example



Bathroom exhaust fans may serve a dual purpose to provide whole-dwelling unit ventilation operating at a low constant airflow rate and to provide local demand-controlled ventilation at a higher airflow rate, or boost, when needed. For these system types, the continuous whole-dwelling unit airflow operation must have an ON/OFF override, which may be located in the bathroom or in a remote accessible location. The boost function is controlled by a separate wall switch located in the bathroom or by a motion sensor or humidistat located in the bathroom.

A kitchen exhaust fan in an enclosed kitchen may also serve a dual purpose of whole-dwelling unit ventilation and kitchen ventilation if it meets both the minimum dwelling unit ventilation rate and the minimum requirement for kitchen exhaust (described in the Section Dwelling Unit Local Exhaust).

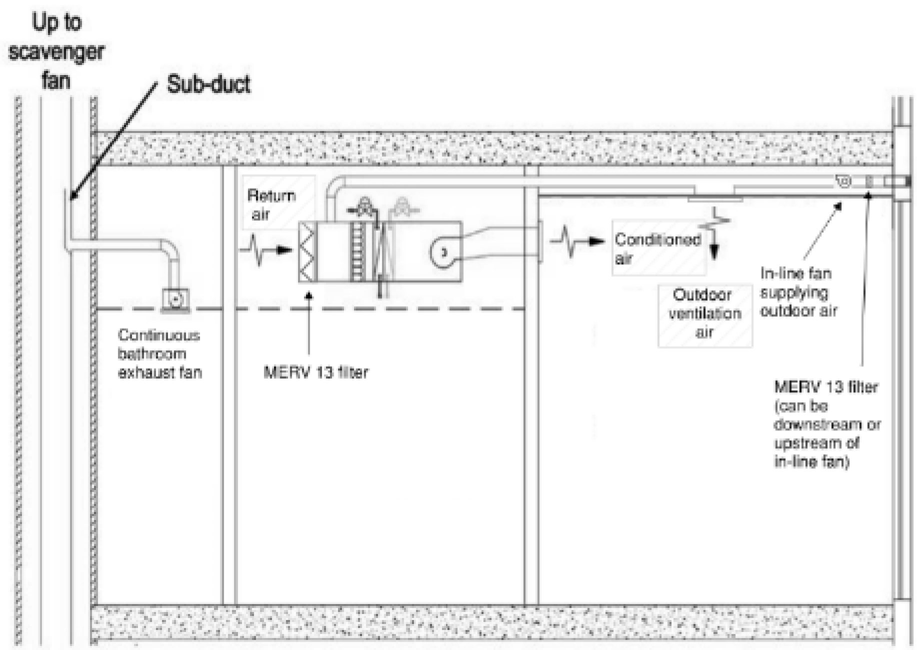
B. Supply Ventilation

Supply ventilation systems draw outdoor air into the unit using a dedicated supply fan. Indoor air escapes through leaks in the building envelope (exfiltration). Space conditioning system air handling units cannot be used to provide supply ventilation, unless they meet the Central Fan-Integrated Ventilation approach described in Section 11.4.2.10D.

Continuously operating ventilation fans must meet mandatory sound requirement of one sone or less. For larger dwelling units, more than one fan may be used. Remotely located fans (fans mounted outside habitable space, bathrooms, toilets, and hallways) are exempt from the sound requirements if there is at least four feet of ductwork between the fan and the interior grille.

§160.2(b)1 requires that outside air be filtered using MERV 13 (or greater) particle removal efficiency rated air filters. The filters must be accessible to facilitate replacement. Supply systems may locate the MERV 13 air filter either upstream or downstream of the fan as long as the incoming outdoor air is filtered prior to delivery to the dwelling unit's occupiable space. An example of MERV 13 filter placement in air handling units is shown in Figure 11-27. Fans may be located in dropped ceiling spaces, mechanical closets, or other spaces dedicated for installation of mechanical equipment. As required in §10-103(b), builders must provide information to building operators and occupants for the operation of any equipment that requires filter replacement.

Figure 11-26: MERV 13 Locations for Ventilation and Space Conditioning Air Handler Unit in Example Scenario



The outdoor air inlet should be located to avoid areas with contaminants such as smoke produced in barbeque areas, products of combustion emitted from gas appliance vents, and vehicle emissions from parking lots or garages. Air may not be drawn from attics or crawlspaces.

To minimize drafts and optimize distribution, supply air can be ducted directly to bedrooms and living areas using an appropriately sized and sealed ventilation-only duct system or by connecting to the HVAC supply plenum. However, distribution of supply air is best practice but not required.

C. Balanced Ventilation

Balanced systems use an exhaust fan and a supply fan to move approximately the same volume of air into and out of the dwelling. To be considered a balanced ventilation system, the total supply airflow and the total exhaust airflow must be within 20 percent of each other. Specifics on measuring airflows to determine compliance are found in RA3.7.4.1.2. Balanced ventilation may be a single packaged unit containing supply and exhaust fans that moves approximately the same airflow, or it may use separate fans. In both cases, air supplied from outdoors must be filtered. (See Section 0: Dwelling Unit Air Filtration for air filter requirements.) Balanced ventilation can incorporate heat recovery. As described in Section 11.4.2.2, heat recovery is required in certain climate zones under the prescriptive path.

§160.2(b)2Aivb requires the whole-dwelling unit ventilation system to either be a balanced system or a supply or exhaust system with compartmentalization testing. The Energy Code encourage the use of balanced ventilation in §160.2(b)2Aiv, since exhaust-only systems bring in air from adjacent spaces, which can negatively impact IAQ.

Some balanced systems are small HRVs or ERVs that are packaged systems. HRVs and ERVs temper incoming air with outgoing air, which reduces the thermal effect of ventilation on heating and cooling loads, but the dual fans increase electrical energy use. HRVs and ERVs are discussed in Section 11.4.2.2.

Like supply ventilation systems, balanced systems are required to be equipped with MERV 13 or better filters to remove particles from the intake airflow prior to delivery to the dwelling unit’s occupiable space per §160.2(b)1.

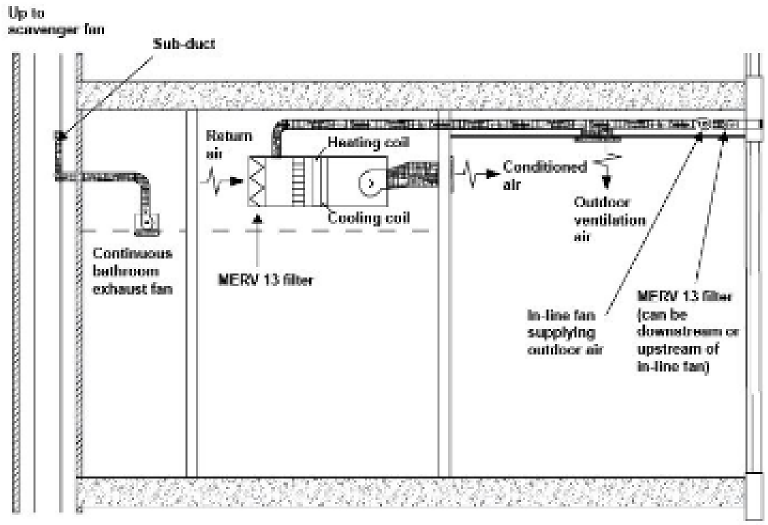
Balanced systems must comply with the same minimum separation distance between intake and exhaust as supply-ventilation systems. The outdoor air inlet should be located to avoid areas with contaminants such as smoke produced in barbeque areas, products of combustion emitted from gas appliance vents, and vehicle emissions from parking lots or garages. Air may not be drawn from attics or crawlspaces.

Balanced ventilation systems may be either unitary (each dwelling unit has own ventilation system) or central systems. Examples of unitary and central balanced systems are provided below.

Unitary Balanced Ventilation

An example of a balanced ventilation system which couples a continuous exhaust fan with an in-line fan that directly supplies outdoor air is shown in Figure 11-28.

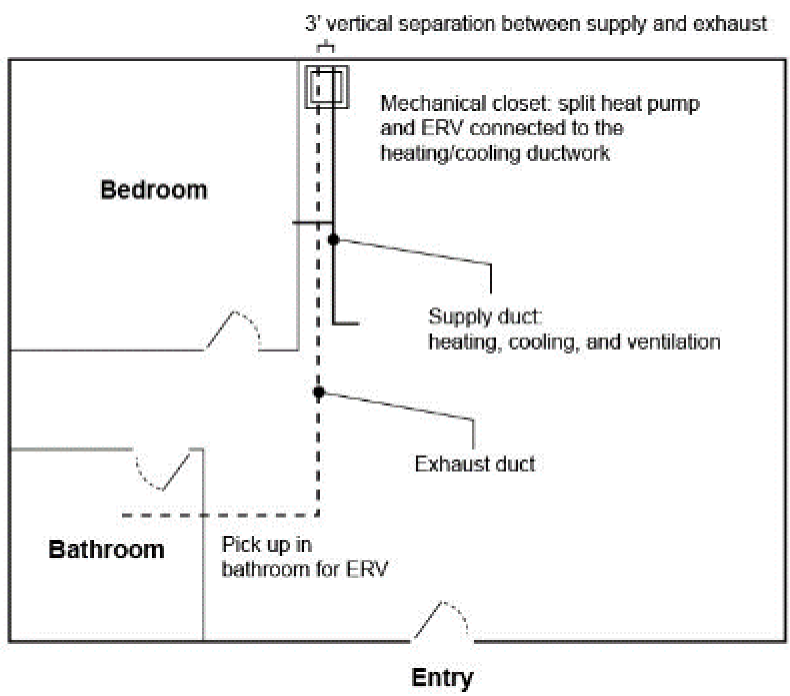
Figure 11-27: Example of Balanced Ventilation Without Heat Recovery: Discrete Supply In-Line Fan with Continuous Bath Exhaust



Strategies other than an inline fan for providing outdoor air include packaged terminal unit (or packaged terminal air conditioning - PTAC) or supply fans.

An ERV or HRV balanced ventilation is shown in Figure 11-29.

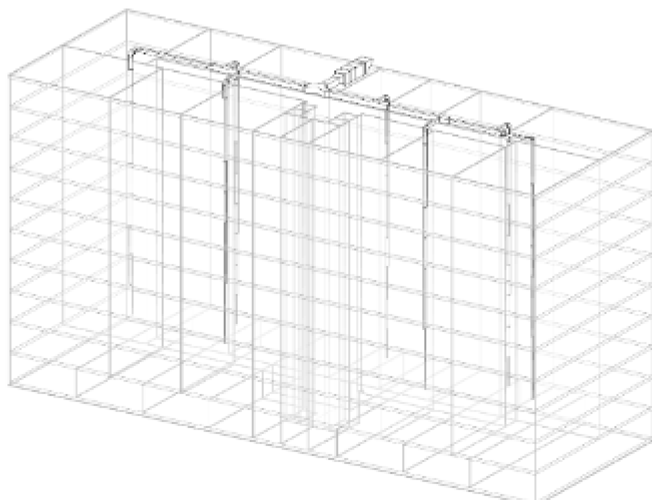
Figure 11-28: Example of Balanced Ventilation with Heat Recovery: Unitary ERV



Central Balanced Ventilation

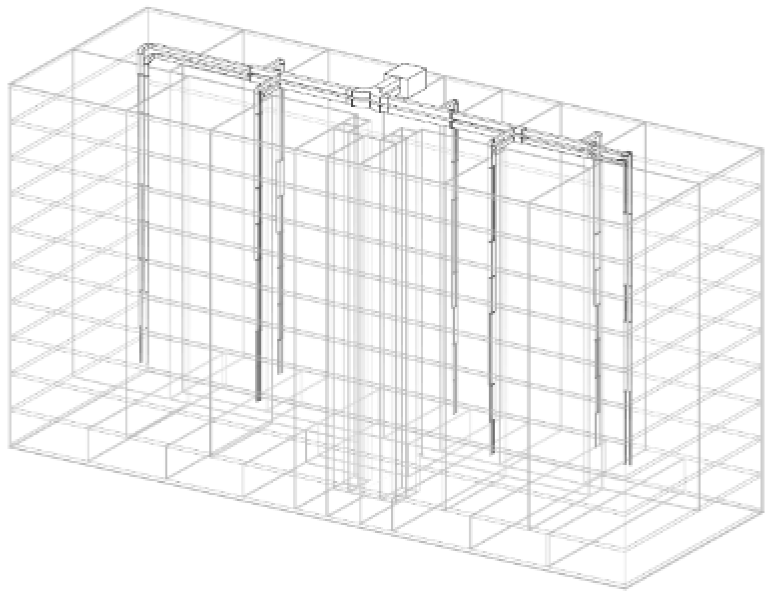
A central balanced ventilation system provides supply-air to and exhaust air from multiple dwelling units. A central balanced ventilation approach could use a dedicated outdoor air system (DOAS) for supplying outdoor air to units and unitary bathroom exhaust. Figure 11-30 shows an example schematic of DOAS; note, the unitary bathroom exhaust is not shown. Because the building in this diagram assumes that the bottom floor is commercial space, the system does not serve this floor.

Figure 11-29: Dedicated Outdoor Air System (DOAS) for Supplying Fresh Air to Dwelling Units



Alternatively, balanced ventilation could be provided by a rooftop HRV or ERV. For the prescriptive path in Climate Zones 1, 2, and 11- 16, the Energy Code require that a central HRV or ERV include a bypass or *free cooling* function that enables the HRV or ERV to bring in fresh air from the outdoors. This function allows incoming air to bypass the heat or energy recovery component when the enthalpy of the outdoor air is within certain temperature and relative humidity limits.

Figure 11-30: Central Balanced Ventilation Strategies: DOAS and Central ERV



As shown in the figures above, each rooftop supply fan, HRV, or ERV would connect (via rooftop ductwork) to vertical shafts. In the example, six vertical shafts serve two dwelling unit from each floor, and one vertical shaft serves one dwelling unit per floor. While not shown in the figure for simplicity, each shaft would need a short horizontal run-out to the dwelling units on each floor and fire smoke dampers (FSDs) at the entry of this duct to the dwelling unit.

Alternatively, central ERVs or HRVs could be located throughout the building (such as one on each floor or for each wing) and serve a cluster of units.

D. Central Fan-Integrated Ventilation

A central fan integrated (CFI) ventilation system is a configuration where the ventilation ductwork is connected to the space conditioning duct system, to enable distribution of ventilation air to the dwelling unit when the space conditioning system air handler is operating. This strategy mixes the outdoor air with the large volume of return air from the dwelling unit before being distributed. CFI ventilation systems consume a relatively high amount of energy compared to the other ventilation types because it uses the air handler fan. The Energy Code includes the following requirements specific to CFI ventilation systems:

1. Continuous Operation is Prohibited – The continuous operation of a space conditioning air handler is prohibited in providing whole-dwelling unit ventilation.

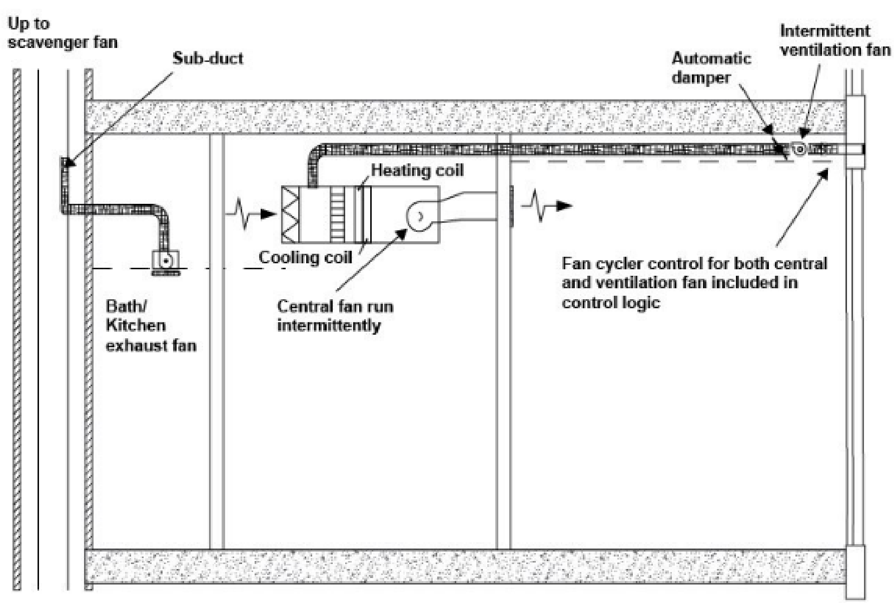
2. Outdoor Air Damper(s) – A motorized damper must be installed on any ventilation duct that connects outdoor air to the space conditioning duct system

and must prevent airflow into or out of the space conditioning duct system when the damper is in the closed position.

3. Damper Control – The outdoor air damper must be controlled to be in the open position only when outdoor air is required for whole-dwelling unit ventilation and must be in the closed position when outdoor air is not required. The damper must be in the closed position when the air handler is not operating. If the outdoor airflow is fan-powered, then the outdoor air fan must not operate when the outdoor air damper is in the closed position.

4. Variable Ventilation Control – CFI ventilation systems must have controls that track outdoor air ventilation run time, and either open or close the motorized damper depending on whether the required whole-dwelling unit ventilation airflow rate is being met. During periods when space conditioning is not called for by the space conditioning thermostat, the controls must operate the air handler fan and the outdoor air damper(s) when necessary to ensure the required whole-dwelling unit ventilation airflow rate is met. This control strategy must be in accordance with ASHRAE 62.2 section 4.5 which requires controls to operate the fan at least once every three hours, and the average whole-dwelling unit ventilation airflow rate over any 3-hour period must be greater than or equal to the required whole-dwelling unit ventilation airflow rate.

Figure 11-31: Example of Central Fan-Integrated (CFI) Ventilation with MERV 13 Filtration



§160.2(b)1 requires that outside air be filtered using minimum MERV 13 particle removal efficiency rated air filters. Filters must be accessible to simplify replacement. For CFI systems, the filters must be installed upstream of the cooling or heating coil; thus, the filter rack provided at the inlet to the air handler may be used. In this case, it is not necessary to provide another MERV 13 or greater filter within the outdoor air duct. Otherwise, filters must be provided at the return grill(s) for the central fan, and another filter must be provided in the outside air ductwork before the point the outside air enters the return plenum of the central fan.

For a CFI ventilation system, both the central forced-air system fan total airflow and the much smaller outdoor ventilation airflow rate must be verified by a HERS Rater.

CFI ventilation systems, devices, and controls may be approved for use for compliance with the HERS field verification requirements for whole-dwelling unit mechanical ventilation in accordance with RA3.7.4.2. CFI ventilation systems are considered intermittent mechanical ventilation systems and must be certified to the Energy Commission that the CFI ventilation system will meet the minimum whole-dwelling unit ventilation requirements.

A listing of certified CFI ventilation systems is posted at the following URL:

http://www.energy.ca.gov/title24/equipment_cert/imv/

The outside air ducts for CFI ventilation systems are not allowed to be sealed/taped off during duct leakage testing. However, CFI outdoor air ductwork that uses controlled motorized dampers that open only when outdoor air ventilation is required and close when outdoor air ventilation is not required may be closed during duct leakage testing.

Because CFI ventilation systems can use a large amount of electricity annually compared to other ventilation system types, the air handlers used in CFI ventilation systems are required to meet the fan watt draw requirements given in Section 150.0(m)13B in all climate zones.

11.4.2.5 Dwelling Unit Ventilation Rate

This section discusses calculation of ventilation rates and necessary ventilation control systems to meet mandatory requirements.

E. Total Ventilation Rate (Q_{tot})

The total ventilation rate Q_{tot} is the volume of ventilation air provided by mechanical ventilation provided from multifamily dwelling units fans, as follows:

$$\boldsymbol{Q_{tot} = 0.03A_{floor} + 7.5(N_{br} + 1)}$$ **Equation 11-1**

Where:

Q_{tot} = total required ventilation rate (CFM)

A_{floor} = conditioned floor area (sq. ft)

N_{br} = number of bedrooms (not less than one)

Dwelling units cannot use a building infiltration credit to reduce the required whole-dwelling unit mechanical ventilation rate, since it is difficult to determine whether that infiltration is truly outdoor air, or it comes from adjacent spaces in the building.

Example 11-13: Dwelling Unit Ventilation Rate Required for Studio

Question

I am building a multifamily dwelling unit that includes 600 sq. ft studios. What is the minimum ventilation rate for the studios?

Answer

Referring to Equation 11-1, the floor area is 600 sq. ft., and the number of bedrooms is assumed to be one (since that is the minimum number of bedrooms allowed for the calculation). The minimum ventilation rate then becomes 0.03 x 600 + 7.5 x (1+1) = 33 CFM

Example 11-14: Dwelling Unit Ventilation Rate Required for 2-bedroom Units

Question

I am building a multifamily dwelling unit that includes 2-bedroom units that are 1,050 sq. ft each. What is the minimum ventilation rate for those units?

Answer

Referring to Equation 11-1, the floor area is 1,050 sq. ft and the number of bedrooms is two. The minimum ventilation rate then becomes 0.03 x 1,050 + 7.5 x (2+1) = 54 CFM

F. Continuous, Scheduled, and Smart Ventilation Systems

Dwelling unit ventilation systems may operate continuously or on a short-term basis. If fan operation is not continuous, the average ventilation rate over any three-hour period must be greater than or equal to the ventilation rate calculated using Equation 11-1.

The Energy Code allows for scheduled ventilation and real-time control. A control method must be chosen so that the relative exposure does not exceed specified peak and average relative exposure limits of ASHRAE Standard 62.2. Normative Appendix C provides direction on calculating the relative exposure and provides standardized calculations for complex ventilation controls implemented by use of digital controls that rely on the manufacturer's product-specific algorithms or software. Users installing any type of intermittent ventilation control system (scheduled or real-time) must submit an application to the Energy Commission to have the control approved. The manufacturers must provide documentation that the system will perform to provide the required whole-dwelling unit mechanical ventilation. Listings of systems approved by the Energy Commission and certified by the manufacturer are located at the following link: www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment-6

Designers should calculate the value for F_{an} as shown in Equation 11-1 and record it on the certificate of compliance. The compliance software approach uses Equation 11-1. in the calculation

Time-of-day timers or duty-cycle timers can be used to control intermittent/variable dwelling unit ventilation. The system must operate automatically without intervention by the occupant. Some controls look back over a set time interval to determine if the CFI system air handler has already operated for heating or cooling before it turns on the air handler for ventilation-only operation.

Example 11-15: Thermostatic Control

Question

Ventilation air is provided whenever the air handler operates via a duct run connecting the return side of the central air handler to the outdoors. The system is estimated to run on calls for heating and cooling about 40% of the time, averaged over the year. If it is assumed that the air handler runs only 25% of the time, and the airflow is sized accordingly, can the system be allowed to run under thermostatic control?

Answer

No. A system under thermostatic control will go through periods with little or no operation when the outdoor temperature is near the indoor set point, or if the system is in setback mode. An intermittently/variably operating ventilation system must be controlled by a timer that will cycle at least once every three hours to assure that adequate ventilation is provided regardless of outdoor conditions. Alternatively, a more complex control may be used if it complies with the requirements in ASHRAE Standard 62.2 Appendix C. These systems must be approved by the Energy Commission before being allowed for use for compliance with the required dwelling unit ventilation.

Cycle timer controls are available that keep track of when (and for how long) the system operates to satisfy heating/cooling requirements in the dwelling unit. These controls turn on the central fan to provide additional ventilation air when heating/cooling operation of the central fan has not already operated for a long enough period to provide the required ventilation. When choosing cycle timer controls for compliance, it is necessary to use models that have been approved by the Energy Commission for use for compliance with whole-dwelling unit mechanical ventilation.

G. Control and Operation

From ASHRAE Standard 62.2, Section 4.4, Control and Operation. A readily accessible manual ON-OFF control, including but not limited to a fan switch or a dedicated branch-circuit overcurrent device, must be provided. Controls must include text or an icon indicating the system's function.

Exception: For multifamily dwelling units, the manual ON-OFF control must not be required to be readily accessible.

From Standards Section 160.2(b)2Aix: Compliance with ASHRAE Standard 62.2 Section 4.4 (Control and Operation) must require manual ON-OFF switches associated with whole-dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: "This switch controls the indoor air quality *ventilation for the home. Leave switch in the "on" position at all times unless the outdoor air quality is very poor."*

While dwelling unit ventilation systems should operate (i.e., be in the ON position) in almost all circumstances, the Energy Code require a manual ON-OFF control, with the purpose of allowing occupants or staff to temporarily turn off the system for extreme events, such as during wildfires. The dwelling unit ventilation system dilutes pollutants that can worsen IAQ such as particulate matter; combustion gases due to imperfect exhaust systems; volatile organic compounds from personal care products, dry cleaning, and other sources; and other pollutants. The dwelling unit ventilation system also reduces relative humidity, which can cause mold or damage the building.

In alignment with ASHRAE Standard 62.2, while the Energy Code require that the manual ON-OFF control be accessible to the occupants in single-family units, there is an exception for multifamily units; it is not required to be readily accessible to the dwelling unit occupants. For multifamily buildings, manual ON-OFF control may be accessible to occupants or only to building maintenance staff. The control strategy where it is only accessible to maintenance staff may be appropriate for multifamily buildings that use central ventilation systems and possibly unbalanced (supply-only or exhaust-only) system types (for which the Energy Code require that all the ventilation systems in the building operate continuously). Continuous operation of all ventilation fans in the building tends to minimize ventilation fan-induced pressure differences between adjoining dwellings, thus, reducing the leakage of transfer air between dwelling units. However, designers should consider the possibility of wildfire smoke or other outdoor air pollution events that could impact the IAQ of dwelling units and ensure there is a means for occupants or maintenance staff to quickly turn off dwelling unit ventilation systems in the circumstances when these systems may inadvertently degrade IAQ. The ventilation system should be returned to the ON position after the extreme event passes.

Example 11-16: Control Options

Question

A bathroom exhaust fan is used to provide dwelling unit ventilation for a dwelling unit. The fan is designed to be operated by a typical wall switch. Is a label on the wall plate necessary to comply with the requirement that controls be "appropriately labeled"?

Answer

Yes. Since the fan is providing the required dwelling unit ventilation, a label is needed to inform the occupant that this switch controls the indoor air quality ventilation for the dwelling unit and directs the occupant to leave it on unless the outdoor air quality is very poor. If the exhaust fan were serving only the local exhaust requirement for the bathroom, then a label would not be required.

11.4.2.6 Dwelling Unit ERV/ HRV Fan Efficacy and Heat Recovery

There is a mandatory requirement that all HRVs and ERVs serving a single dwelling unit must have a fan efficacy of one W/CFM or less. HRVs and ERVs meeting the prescriptive path for multifamily dwelling units using balanced ventilation in Climate Zones 1, 2 and 11-16 must meet more stringent fan efficacy, as described in Section 11.4.2.2.

Fan efficacy is calculated as the Power Consumed in Watts divided by the Net Airflow in CFM. Sensible recovery efficiency is directly reported in the HVI database. If the HVI database or other CEC approved directories do not list the fan energy for the installed model or the proposed product is a large central ERV/HRV whose airflow rate exceeds the maximum listed in the HVI database, use information from the manufacturer's published documentation.

11.4.2.7 Dwelling Unit Local Exhaust

The Energy Code specify local exhaust requirements, but do not adopt ASHRAE Standard 62.2 Section 5 (Local Exhaust). However, the Energy Code are based on the local exhaust requirements in ASHRAE Standard 62.2 Section 5, with the exception of kitchen exhaust. This section provides an overview of demand-controlled local exhaust, continuous local exhaust, and special requirements for kitchen exhaust in the Energy Code. The Energy Code follows the ASHRAE 62.2 definitions for kitchens and bathrooms for these ventilation requirements. Kitchens are any rooms containing cooking appliances, and bathrooms are any rooms containing a bathtub, shower, spa, or other similar source of moisture. A room containing only a toilet is not required to have an exhaust fan; ASHRAE 62.2 assumes there is an adjacent bathroom with local exhaust.

H. Demand Controlled Local Exhaust

Local exhaust (sometimes called spot ventilation) has long been required by building codes and ASHRAE standards for bathrooms and kitchens to remove moisture, odors, and (for kitchens) particulate matter and combustion gases (from gas ranges) at the source.

The Energy Code require bathroom fans with a minimum exhaust airflow of 50 CFM and a sound rating of no more than three sone. To reduce exposure to cooking contaminants, the Energy Code require that kitchen range hoods be capable of exhausting between 110 and 280 CFM depending on dwelling unit size and range type (gas or electric).

Example 11-17: Local Exhaust Required for Toilet

Question

I have dwelling units in my multifamily building with 1½ baths. The half-bath consists of a room with a toilet and sink. Is local exhaust required for the half bath?

Answer

No. Local exhaust is required only for bathrooms, which are defined by the ASHRAE Standard 62.2 as rooms with a bathtub, shower, spa, or some other similar source of moisture. This does not include a toilet or a simple sink for hand-washing.

Example 11-18

Question

The master bath suite in a dwelling unit has a bathroom with a shower and sink. The toilet is in a separate, adjacent room with a full door. Where do I need to install local exhaust fans?

Answer

The standards require local exhaust only in the bathroom, not the separate toilet room.

The Energy Code require that local exhaust fans be designed to be operated by the occupant. This usually means that a wall switch or some other control is readily accessible. There is no requirement to specify where the control or switch needs to be located, but bathroom exhaust fan controls are generally located next to the light switch, and kitchen exhaust fan controls are generally integrated into the range hood or mounted on the wall or counter adjacent to the range hood.

Bathrooms can use a variety of exhaust strategies, including ceiling-mounted exhaust fans or remotely mounted fan ducted to two or more exhaust grilles. Demand-controlled local exhaust can be integrated with the dwelling unit ventilation system to provide both functions.

The control can be a manual switch or automatic control like an occupancy sensor. Some exhaust fans have multiple speeds, and some fan controls have a delay-off function that operates the exhaust fan for a set time after the occupant leaves the bathroom. Title 24, Part 11 (CALGreen) specifies additional requirements for the control and operation of demand-controlled local exhaust. For example, §4.506 requires bathroom exhaust fans to be ENERGY STAR compliant and (unless functioning as a component of a whole house ventilation system) to be controlled with a humidity control.

I. Continuous Local Exhaust

The airflow requirements from ASHRAE Standard 62.2 for continuous exhaust are adopted into the Energy Code and shown in Table 11-23.

Table 11-23: Continuous Local Ventilation Exhaust Airflow Rates (Table 160.2F from the Energy Code)

Application	Airflow
Enclosed Kitchen	5 ACH, based on kitchen volume
Bathroom	20 CFM (10 L/s)

Source: California Energy Commission

The Energy Code allows the designer to install a local exhaust system that operates without occupant intervention continuously and automatically. Continuous local exhaust is generally specified when the local exhaust ventilation system is combined with a continuous dwelling unit ventilation system. For example, if the dwelling unit ventilation is provided by a continuously operating exhaust fan located in the bathroom, this fan may also satisfy the local exhaust requirement for that bathroom, provided the fan provides airflow greater than or equal to the minimum continuous local ventilation airflow rate. Many builders install a two-speed fan that runs at low speed continuously to satisfy the dwelling unit ventilation system requirement, but that can increase to a higher speed to meet the demand-controlled bathroom exhaust requirement using a wall switch. A continuous local exhaust system may also include a *pickup*, which refers to an interior grille that is ducted to a remote fan, which could be ducted to an HRV or ERV.

Continuously operating bathroom fans must operate at a minimum of 20 CFM and a sound rating of no more than one sone. Continuous kitchen exhaust fans must operate at a minimum of five kitchen air changes per hour (ACH).

J. Requirements for Kitchen Exhaust

Kitchen exhaust is important to remove pollution created during cooking processes, including fine particles (PM2.5) and relative humidity; combustion gases such as nitrogen dioxide (NO2) and carbon monoxide (CO) from natural gas and propane-fueled cooktops and ovens; and odors. The most effective method in removing pollutants generated from cooking is to use a vented kitchen range hood, which removes pollutants above the cooking surface before they mix with the air in the rest of the home. The 2022 Energy Code incorporates a new metric for local exhaust called capture efficiency. Capture efficiency is determined in accordance with ASTM E3087 as the fraction of emitted tracer gas that is directly exhausted by a range hood.

The Energy Code allow different options for kitchen exhaust including intermittent (typically demand-controlled) range hoods, a continuously operating fan in the kitchen, or a downdraft fan. For the demand-controlled option, the Energy Code allow the traditional airflow (in cubic feet per minute, or CFM) path for compliance or a capture efficiency path.

Under the Energy Code, dwelling units can use any one of the following options for kitchen exhaust:

- A demand-controlled, vented range hood with at least one setting with a capture efficiency (CE) that meets or exceeds the values shown in Table 11-24.
- A demand-controlled, vented range hood with an airflow that meets or exceeds the exhaust rates shown in Table 11-24.

- A demand-controlled, vented downdraft kitchen exhaust fan (not represented in the table below) in enclosed kitchens with a minimum airflow of 300 cfm or a capacity of 5 air changes per hour. In a nonenclosed kitchen, the fan must have a minimum airflow of 300 cfm (no air changes per hour option).
- For enclosed kitchens only: Continuous exhaust system with a minimum airflow equal to five kitchen air changes per hour.

Table 11-24: Kitchen Range Hood Airflow Rates (CFM) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type

Dwelling Unit Floor Area (sq. ft)	Hood Over Electric Range	Hood Over Natural Gas Range
>1500	50% CE or 110 CFM	70% CE or 180 CFM
>1000 - 1500	50% CE or 110 CFM	80% CE or 250 CFM
750-1000	55% CE or 130 CFM	85% CE or 280 CFM
<750	65% CE or 160 CFM	85% CE or 280 CFM

Source: from Table 160.2-G in the Energy Code

The capture efficiency path (Option 1) is specific to the Energy Code. The minimum capture efficiency or airflow requirement for the range hood is the minimum required to adequately capture the moisture, particulates, and other products of cooking and/or combustion. While many products do not have published capture efficiency results as of the time of the publication of this manual, Option 1 is intended to be a forward-looking approach and will support future listings.

While capture efficiency is the metric that directly measures pollutant removal, the airflow path (Option 2) is provided because capture efficiency generally increases with airflow, and the HVI and AHAM databases list airflow for kitchen exhaust appliances. ASHRAE Standard 62.2 includes a similar path as Option 2, but with lower required airflows (minimum 100 CFM). Because there is less air available for dilution in small dwelling units, the Energy Code set higher minimum requirements for smaller dwelling units. Because gas ranges emit NO2 and CO, in addition to the PM2.5 released from cooking processes, the capture efficiency and airflow requirements are higher for hoods over gas ranges.

The vented downdraft compliance option (Option 3) and continuous kitchen exhaust option (Option 4) are taken directly from ASHRAE Standard 62.2. The definition of an "enclosed kitchen", which must be met to use continuous kitchen exhaust, is also taken from ASHRAE Standard 62.2, and is defined as "permanent openings to interior adjacent spaces do not exceed a total of 60 square feet”. Only in enclosed kitchens, the exhaust requirement can also be met with either a ceiling or wall-mounted exhaust fan or with a ducted fan or ducted ventilation system that can provide at least five air changes of the kitchen volume per hour.

Recirculating range hoods that do not exhaust pollutants to the outside cannot be used to meet the Energy Code requirements, unless paired with an exhaust system exhausting to the outside that can provide at least one of the following:

1. Continuous or demand-controlled operation in an enclosed kitchen providing five air changes of the kitchen volume per hour, or
2. Demand-controlled operation in an enclosed or unenclosed kitchen providing at least 300 cfm of exhaust.

Generally, HRV/ERV manufacturers do not recommend that kitchen exhaust pass through HRV or ERV equipment, because the heat, moisture, grease, and particulates could damage heat exchange core.

The Energy Code do not explicitly specify a static pressure at which range hoods should be measured for airflow. However, the Energy Code require that range hoods be listed in the HVI or AHAM product directories, and both of those directories list range hood airflows at 0.1” w.c. (and some at 0.25” w.c.), since 0.1” is the basic rating point for range hoods in HVI Standard 920. Note that some product airflows are listed at working-speed at lower static pressures, but working-speed airflows can only be used for compliance with the sound requirement, not airflow requirement.

Example 11-19: Continuous Kitchen Exhaust Solution

Question

I’m building a multifamily building project where the kitchen is partially enclosed. There’s a bedroom along one wall, but the kitchen is open to the rest of the living area by a 7 ft wide by 8 ft tall opening. I’d like to use continuous kitchen exhaust, which can double for dwelling unit ventilation. Is that allowable?

Answer:

The definition of an enclosed kitchen is one whose permanent openings to interior adjacent spaces do not exceed a total of 60 sq. ft. At 8 ft x 7 ft = 56 sq. ft, your kitchen just meets that definition, so you could use continuous kitchen exhaust. Dwelling unit ventilation needs heat or energy recovery if the project is in climate zones 1, 2, or 12-16. We would not recommend ducting kitchen exhaust to the ERV or HRV, given the HRV/ERV manufacturer restrictions.

The Energy Code require either field-measurement of kitchen exhaust airflow or meeting prescriptive duct sizing requirements. When complying using prescriptive duct sizing requirements, the Energy Code require range hood airflow at a static pressure of 0.25” of w.c. Section 11.4.4.3 Duct Sizing provides more detail.

The Energy Code require verification that range hoods are HVI- or AHAM-certified to provide at least one speed setting at which they can deliver at least 100 CFM at a sound level of 3 sones or less. (This rating point of 100 CFM is lower than the minimum air flow required for pollutant removal.) Verification must be in accordance with the procedures in *Reference Residential Appendix* RA3.7.4.3. Range hoods that have a minimum airflow setting exceeding 400 CFM are exempt from the sound requirement. HVI listings are available at: https://www.hvi.org/hvi-certified-products-directory. AHAM listings are available at: https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification.

The Energy Code limits exhaust airflow when atmospherically vented combustion appliances are located inside the pressure boundary. The demand-controlled range hood airflow and capture efficiency requirements will often exceed this exhaust airflow limit for typical multifamily dwelling units. Therefore, most multifamily dwelling unit with atmospherically vented appliances will need a makeup air fan. Refer to Section 11.4.5.3 for more information.

Example 11-20: Ceiling or Wall Exhaust vs Demand-Controlled Range Hood in an Enclosed Kitchen

Question

I am building a multifamily building, where each unit has an enclosed kitchen that is 12 ft. x 14 ft. with a 10 ft. ceiling. What size ceiling exhaust fan or range hood fan is required if I want to use continuous ventilation? What about if I use a demand-controlled range hood? The units are a mix of sizes but include 800, 1025, and 1200 sq. ft units. We are planning to use natural gas ranges.

Answer

If a range hood exhaust is not used, either 300 CFM or 5 kitchen ACH minimum airflow is required. The kitchen volume is 12 ft. x 14 ft. x 10 ft. = 1,680 ft^3. Five air changes are a flow rate of 1,680 ft^3 x 5/ hr. ÷ 60 min/hr. = 140 CFM. So, this kitchen must have a ceiling or wall exhaust fan of 140 CFM if you want to use the continuous exhaust approach. That would end up consuming significant energy, so we would not recommend it.

We would recommend you install a demand-controlled range hood instead. The minimum flow rate depends on the size of the units. If all units have natural gas ranges, the minimum flow rate would be 280 CFM for the 800 sq. ft units, and 250 CFM for the 1025 and 1200 sq. ft units. If you installed electric ranges (induction or resistance types), the minimum flow rate would be 130 cfm for the 800 sq. ft. units, and 110 cfm for the 1,025 and 1,200 sq. ft units.

The verification protocol for kitchen exhaust systems remains the same compared with the 2019 Energy Code procedures. The only difference is that an option of using capture efficiency (instead of airflow) has been added to verify the kitchen exhaust system.

- Manufacturers must test the range hood air flow and/or capture efficiency, which will be available in the HVI or AHAM database to reference for verification.
- Kitchen exhaust systems are required to be verified by a HERS Rater or ATT, depending upon the number of habitable stories in the building. The verification protocol requires comparing the installed model to ratings in the HVI or AHAM directory of certified ventilation products to confirm the installed range hood is rated to meet the required capture efficiency or airflow in the Energy Code. The HERS rater or ATT should also confirm the range hood meets the sound requirements specified in the Energy Code.

11.4.2.8 Dwelling Unit Ventilation Airflow Measurement

K. Whole-dwelling Unit Ventilation System

§160.2(b)2Avii requires airflow measurement of the whole-dwelling unit ventilation system. The purpose is to ensure that the specified ventilation rate is delivered to the unit.

All whole-dwelling unit ventilation systems must demonstrate compliance by direct airflow measurement using a flow hood (such as shown in Figure 11-33), flow grid, or other approved measuring device. HERS verification of whole-dwelling unit ventilation airflow is required for newly constructed buildings and existing buildings with additions greater than 1,000 sq. ft or an increase in the number of dwelling units.

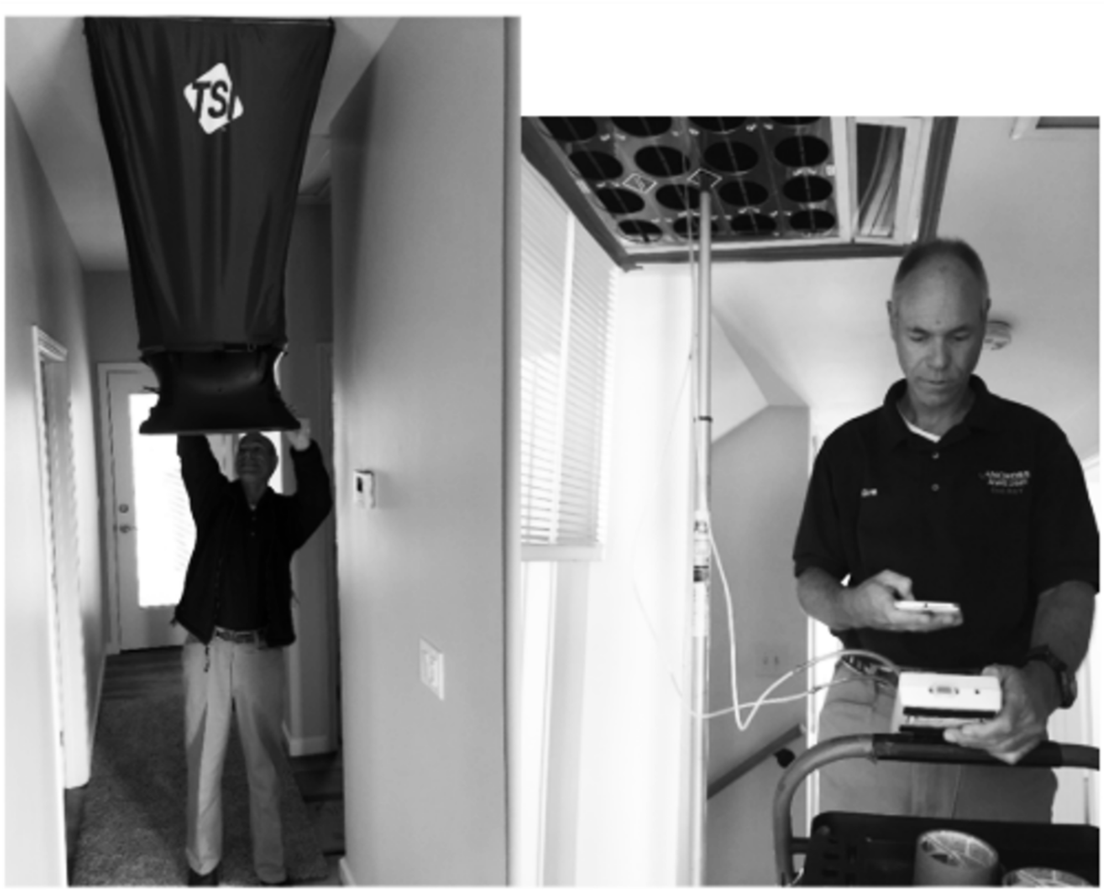
Residential Appendix RA3.7.4 (for multifamily buildings up to three habitable stories) and Nonresidential Appendix NA2.2.4.1.1 (for multifamily buildings four or more habitable stories) provide guidance for measurement of supply, exhaust, and balanced system types. These measurement procedures are applicable when there is a fixed airflow rate required for compliance, such as for systems that operate continuously at a specific airflow rate or systems that operate intermittently at a fixed speed (averaged over any three-hour period), according to a fixed programmed pattern that is verifiable by a HERS Rater on site. (Refer to ASHRAE Standard 62.2 Section 4.5.1 Short Term Average Ventilation.)

For exhaust-only systems, measurement of the whole-dwelling unit ventilation airflow should be done by measuring airflow of the exhaust fan(s). While this approach will over-represent the airflow from the outdoors, it is difficult to determine the fraction of the infiltration from the outdoors versus adjacent spaces in the building.

For whole-dwelling unit ventilation systems that use scheduled ventilation or real-time controls, the Energy Commission may consider the ventilation system for approval, if the manufacturer provides a method that can be used by a

HERS Rater or ATT to verify that an installed system is operating as designed. Figure 11-33 shows examples of an airflow rate measuring devices.

Figure 11-32: System Airflow Rate Measurement Using Flow Capture Equipment



Source: California Statewide CASE Team

11.4.2.9 Local Exhaust System

Local exhaust systems also require airflow measurement, similar to the whole-dwelling unit ventilation system. For local exhaust systems, there are two ways to demonstrate compliance with airflow requirements of §160.2(b)2Avie:

- Test the ventilation system using an airflow measuring device after completion of the installation to confirm that the delivered ventilation airflow meets the requirement using same process as airflow measurement of whole-dwelling unit ventilation system.
- Use a fan that has a certified airflow rating that meets or exceeds the required ventilation airflow, and ventilation ducts that meet either the fan manufacturer's published duct design specifications or the duct design requirements given in Table 11-25.

11.4.2.10 Dwelling Unit Air Filtration

Air filtration is used in forced air systems to protect the equipment from dust accumulation that could reduce the capacity or efficiency of the system. Preventing dust buildup may also prevent the system from becoming a host to biological contaminants such as mold, especially if dust is deposited on cooling coils that become wet from water condensation during comfort cooling operation. Air filter efficiencies of Minimum Efficiency Reporting Value (MERV) 6 remove approximately half of PM10 (Particulate Matter 10 microns or smaller), which includes these large airborne dust particles.

Air filter efficiencies of at least MERV 13 are needed to protect occupants from exposure to the smaller airborne particles that are known to adversely affect health. These smaller particles are often referred to as PM 2.5 which refers to particulate matter of 2.5 microns or smaller. PM2.5 can travel into the lungs and bloodstream, causing respiratory and cardiovascular impacts. PM2.5 is produced from several sources including combustion from cooking and exhaust from motor vehicles that enters a dwelling through ventilation openings and infiltration.

§160.2(b)1 requires that all recirculated air or outdoor air supplied to the occupiable space is filtered with MERV 13 filtration prior to being supplied to the occupiable space. The requirement applies to all ventilation systems with supply-side ventilation, including supply-only systems, ERVs, HRVs, and the supply side of other balanced systems with ductwork greater than 10 feet. This requirement does not apply to exhaust-only ventilation systems since those systems do not have dedicated supply air. However, since §160.2(b)1 applies to both recirculated and outdoor air, a dwelling unit with an exhaust-only ventilation system and forced air furnace will still need MERV 13 filtration in the furnace air handling unit with ductwork greater than 10 feet in length.

§160.2(b)1 also imposes air filtration requirements to address pressure drop and ensure minimum delivered airflow. These are detailed in Section 11.6.4.10.

Any gaps around an air filter allows air to bypass the filter. The Energy Code requires that filter racks and grilles use gaskets, sealing, or other means to close gaps around inserted filters and prevent air from bypassing the filter. Filter racks and grilles include any device that houses the air filter used to satisfy the air filtration requirements.

11.4.2.11 Dwelling Unit Compartmentalization, Adjacent Spaces and Transfer Air

Compartmentalization (i.e., sealing of the dwelling unit air barrier) is important for maintaining the indoor air quality of multifamily dwelling units because it limits transfer air. Transfer air is the airflow between adjacent dwelling units or between a dwelling unit and other nearby spaces (e.g., garage or crawlspace) in a multifamily building, that can be a major contributor to poor IAQ in the dwelling units. Transfer airflow is caused by differences in pressure between adjacent spaces that force air to flow through leaks in the dwelling unit enclosure. The pressure differences may be due to stack effects (hot air rising in taller buildings when outside air temperature is low, leading to air pressing upward and exiting the building through upper floors) and wind effects, but unbalanced mechanical ventilation is also a contributor. Compartmentalization minimizes leaks in all the dwelling enclosures in the building to prevent pollutants such as tobacco smoke, pollution generated from food preparation in the kitchen, odors, and other pollutants from being transferred to adjacent dwellings in the building. Drawing ventilation air from the garage could introduce carbon monoxide or volatile organic compounds into the indoor air. Drawing ventilation air from an unconditioned crawlspace could cause elevated allergen concentrations in the dwelling. In addition to maintaining good IAQ, compartmentalization provides energy benefits, by reducing leakage of conditioned air to the exterior.

The Energy Code in §160.2(b)2Aiv provide two compliance paths for mandatory mechanical ventilation which improve indoor air quality in multifamily buildings:

- Install a balanced ventilation system for all dwelling units.
- Compartmentalize each dwelling unit by sealing each dwelling unit envelope and verify that the dwelling unit leakage is not greater than 0.3 CFM per sq. ft of dwelling unit enclosure area using the procedures in RA3.8 (blower door test for multifamily buildings with up to three habitable stories) or NA2.3 (blower door test for multifamily buildings with four or more habitable stories) as applicable.[3] Sampling is allowed for the blower door testing, according to RA2.6 and NA1.6. If the sampled dwelling units in the multifamily building pass this blower door test, use of continuously operating supply-only ventilation systems, or continuously operating exhaust-only ventilation systems is allowed.

If the balanced ventilation path (#1) is used, air sealing to 0.3 CFM per sq. ft and blower door testing is not required. Both balanced ventilation and compartmentalization provide IAQ benefits. Balanced ventilation ensures that outdoor air is provided at the required rates, and compartmentalization reduces pollutant transfer between dwelling units. If compartmentalization (#2) is used, air sealing and blower door testing must be conducted. Note the Energy Code deviates from ASHRAE Standard 62.2, which requires compartmentalization in multifamily dwelling units, but does not require balanced ventilation as a mandatory requirement.

To compartmentalize the unit, project teams should seal areas that include, but are not limited to the following:

- Vent and pipe penetrations, including those from water piping, drain waste and vent piping
- HVAC piping and sprinkler heads

[3] While multifamily buildings up to three habitable stories follow the procedures in the Residential Appendix and multifamily buildings four or more habitable stories follow the procedures in the nonresidential appendix, for the blower door test, RA3.8 and NA2.3 provide the same protocol. In other words, this test is the same regardless of the number of stories.

- Electrical penetrations, including those for receptacles, lighting, communications wiring, and smoke alarms
- HVAC penetrations, including those for fans and for exhaust, supply, transfer, and return air ducts

In addition, project teams should seal leaks and gaps in the dwelling-unit air barrier, including but not limited to the intersections of baseboard trim and floor, the intersections of walls and ceilings, around window trim and dwelling-unit doors, and the termination points of internal chases in attics, between floors, and crawlspaces.

11.4.2.12 Dwelling Unit Prescriptive Requirements

A. Balanced Ventilation

§170.2(c)3

If a balanced system is used to satisfy mandatory requirements, the prescriptive requirements of §170.2(c)3Biv requires multifamily units to install HRVs or ERVs in Climate Zones 1, 2, and 11-16. Multifamily units that do not trigger this requirement may still choose to use an HRV or ERV.

For multifamily buildings up to three stories in Climate Zones 4-10, balanced ventilation systems without heat or energy recovery are required by §170.2(c)3 to have a fan efficacy of 0.4 W/CFM or less. For example, if the balanced ventilation system includes a bathroom exhaust fan and an in-line supply fan, the total rated fan efficacy must be less than 0.4 W/CFM. The total fan efficiency for the ventilation system is calculated using the parameters in the following equation.

$$\text{Total fan efficiency} = \frac{Total\ rated\ power\ of\ exhaust\ and\ supply\ fan\ at\ ventilation\ flow\ rate\ (W)}{\text{Outdoor air ventilation flow rate }(cfm)}$$

Compliance with the fan efficiency requirements for ventilation can be verified by reviewing product certification data from the HVI database or the AHAM Certified Range Hood Directory. Linear interpolation of rated performance parameters may be used when calculating the fan efficacy at the required outdoor airflow rate as described in Reference Residential Appendix RA3.7.4.4. The HVI database can be found at the following link: www.hvi.org/hvi-certified-products-directory. The AHAM Directory can be found at the following link: https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification.

B. CFI Ventilation Systems Fan Watt Draw

§170.2(c)3Biii

When using the prescriptive approach, the fan efficacy of CFI systems must be verified by a HERS Rater (for multifamily dwelling units in buildings up to three habitable stories) or an ATT (for multifamily dwelling units in buildings four or more habitable stories) using the same methods as required for furnaces and air handlers. (See

Reference Residential Appendix RA3.3.) For verification, the central system air handler must be operating in ventilation mode with the outdoor air damper open and with outdoor ventilation air flowing into the return plenum from the supply duct. Furthermore, the airflow that must be measured is the total airflow through the air handler (system airflow), which is the sum of the return airflow, and the outside air ducted to the return plenum (ventilation airflow).

The watt draw must be less than or equal to 0.45 W/CFM for furnaces, 0.58 W/CFM for air handlers that are not gas furnaces, and 0.62 W/CFM for small duct, high-velocity systems. If not, the performance approach must be used.

C. ERV/HRV Fan Efficacy and Heat Recovery

§170.2(c)3Biv,
§170.2(c)4A

For Climate Zones 1, 2, and 11-16, in addition to requiring heat recovery for ventilation, the prescriptive requirements require that HRVs and ERVs serving a single dwelling unit must have a fan efficacy of 0.6 W/CFM or less per §170.2(c)3Biv.

Central ERVs or HRVs (serving multiple dwelling units) must meet fan efficacy requirements per §170.2(c)4A using the fan power allowance formula below. For ERVs and HRVs, the fan power allowance must be separately calculated for the supply and return airflows, and then summed.

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} \times FPA_{comp}$$

Where:

- FPA_{adj} = The corrected fan power allowance for component in W/CFM
- Q_{comp} = The airflow through component in CFM
- Q_{sys} = The system airflow
- FPA_{comp} = The fan power allowance of the component from Table 170.2-B or Table 170.2-C.

ERVs and HRVs meeting the §170.2(c)3Biv prescriptive requirements must also meet a minimum sensible recovery efficiency or effectiveness of 67%, rated at 32°F.

Compliance with the requirements for unitary equipment can be verified by reviewing product certification data from the HVI database at the URL below. See Reference Residential Appendix RA3.7.4.4 for more information on verification of unitary equipment performance parameters.

https://www.hvi.org/hvi-certified-products-directory

Central equipment must have a bypass function for free cooling, in which the incoming outdoor air bypasses the heat exchanger when the outdoor air temperature is below the cooling set point. This allows the ventilation system to operate in economizing mode taking advantage of cool outdoor temperatures. The bypass mode is an important feature, particularly in mild climates where heat recovery without bypass can increase cooling loads. The controls must meet the air economizer high limit shut off control requirements in Table 170.2-G.

For ERVs or HRVs that are not meeting the prescriptive requirements, including in Climate Zones 3-10, the fan efficacy need only meet the mandatory requirement of 1.0 W/CFM or less.

11.4.2.13 Dwelling Unit Performance Approach

B. Ventilation Systems without Heat Recovery

The performance approach allows the option of default minimum dwelling unit ventilation airflow rate and a watt draw value of 0.25 W/CFM, which is typical of continuous exhaust fans that meet the 1 sone requirement. If the installed fan has a different airflow and fan efficacy, the actual airflow rate and fan watt draw of the fan must be used.

Values for airflow and fan W/CFM information may be available from the HVI directory at the following link: www.hvi.org/hvi-certified-products-directory/.

If HVI does not list fan energy for the installed model, use information from the manufacturer's published documentation. Note that fan energy may sometimes be listed as CFM/W rather than W/CFM, so must be converted to the Energy Code’ fan efficacy units of W/CFM. Installation of a dwelling unit ventilation system with a fan watt draw greater than 1.2 W/CFM of ventilation airflow will increase the proposed design energy. Values less than 1.2 W/CFM are compliance-neutral (standard design = proposed design).

11.4.2.14 ERV/HRV Fan Efficacy and Heat Recovery

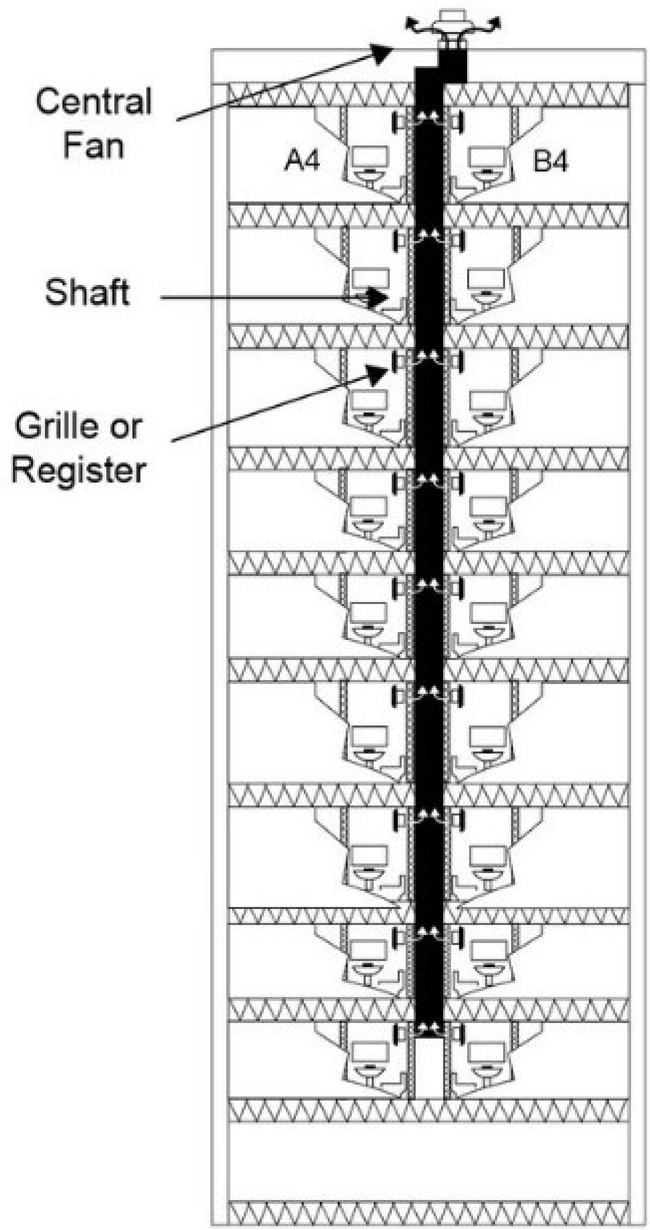
For the performance approach, the proposed equipment recovery efficiency, fan efficacy, and bypass condition are used in the compliance software. The compliance software assumes values for the standard design that align with the prescriptive requirements for ERVs/HRVs.

11.4.3 Central Ventilation Duct Systems Serving Dwelling Units

Central ventilation systems serving multiple dwelling units are often used, particularly in tall buildings, to provide supply air (such as in a DOAS system), exhaust, or balanced ventilation (such as a central ERV or HRV). These systems reduce the number of fans that must be maintained and the number of envelope penetrations for supply intakes or exhaust discharges.

The central ventilation system is typically comprised of a central fan (often located at the rooftop), a central ventilation duct (shaft) that runs between floors, horizontal branches to connect the dwelling units to the shaft, and in-unit connection points such as grilles to deliver (for supply) or remove (for exhaust) air from each dwelling unit. Figure 11-33 illustrates an example with no horizontal branches.

Figure 11-33: Diagram of Central Exhaust Ventilation Duct System Components



Source: Center for Energy and Environment 2016

11.4.3.1 Central Ventilation Mandatory Requirements

When a supply or exhaust system provides dwelling unit ventilation to more than one dwelling unit, the airflows in each dwelling unit must be equal to or greater than the specified ventilation rate, and the airflows for each dwelling unit must also be balanced to be no more than 20% greater than the specified rate, per §160.2(b)2Av. The specified rate for the systems that share a common fan/shaft may be the minimum rate required for compliance, in which case each of the dwellings receiving airflow from a common fan/shaft must have ventilation airflow no more than 20% greater than the minimum dwelling unit ventilation airflow required. If the lowest airflow provided to any of the dwellings served by the common fan/shaft is a specific percent value greater than the minimum required for compliance, then each of the dwellings receiving airflow from that common fan/shaft must have ventilation airflow no more than 20% greater than that lowest dwelling unit ventilation airflow. For example, if the lowest ventilation airflow among all dwellings served by the common fan/shaft is 2% greater than the minimum required for compliance, then all dwellings served by the common fan/shaft must be balanced to have ventilation airflow that is no more than 22% greater than the minimum ventilation airflow required for compliance

These systems must use balancing devices to ensure the dwelling-unit airflows can be adjusted to meet this balancing requirement. These system balancing devices may include, but are not limited to, constant air-regulation devices (often referred to as "CAR dampers"), orifice plates, and variable-speed central fans.

In addition, for multifamily buildings with four or more habitable stories, the Energy Code include a mandatory sealing and leakage testing requirement for central ventilation systems providing continuous airflow or an airflow to meet the balanced ventilation path in §160.2(b)2Aiv. An ATT must conduct a fan pressurization test to show that central shaft leakage is no greater than 6% compared to a nominal airflow rate of the central fan at 0.2 inches water column (inch w.c.) (50 Pa) for ducts serving more than six dwelling units. For ducts serving six or fewer dwelling units, the maximum leakage is the same, but the test must be conducted at 0.1 inches w.c. (25 Pa), since these systems typically have a lower operating pressure. As described in the NA1.6 procedures, sampling may be used for this duct testing requirement, and the ATT may conduct the leakage test at rough-in. Central ventilation systems providing intermittent flows, such as demand-controlled exhaust from kitchens, bathrooms, or driers, are exempt from this testing requirement, although careful sealing is still recommended.

The airflow, sealing, and leakage testing requirements work in tandem to provide better control of airflow to each unit so that units are not overventilated (which would waste energy) or under-ventilated (which would degrade IAQ).

11.4.4 Air-Moving Equipment - Mandatory Requirements (Section 7 of ASHRAE Standard 62.2)

From ASHRAE Standard 62.2, Section 7.1, Selection and Installation.

Ventilation devices and equipment serving individual dwelling units must be tested in accordance with ANSI/ASHRAE Standard 51/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating, and ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans, and rated in accordance with the airflow and sound rating procedures of the HVI (HVI 915, Loudness Testing and Rating Procedure; HVI 916, Air Flow Test Procedure; and HVI

920, Product Performance Certification Procedure Including Verification and Challenge). Installations of systems or equipment must be carried out in accordance with manufacturers' design requirements and installation instructions.

Equipment used to meet the dwelling unit ventilation requirements or the local exhaust ventilation requirements must have been tested and rated by manufacturers to ensure that the equipment meets the requirements of this section.

11.4.4.1 Fan Selection and Installation

The Energy Code require that equipment used to comply with the standard be selected based on tested and certified ratings of performance for airflow and sound. The HVI and AHAM products directories list certified ratings of performance for airflow and sound. The directories can be used to verify compliance with Energy Code requirements. The *HVI-Certified Products Directory* can be viewed at the following link: www.hvi.org/hvi-certified-products-directory.

The AHAM-Certified Products Directory can be viewed at the following link: www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification.

In addition, the Energy Code require that the fans be installed in accordance with the manufacturer's instructions.

11.4.4.2 Fan Sound Ratings

From ASHRAE Standard 62.2, Section 7.2, Sound Ratings for Fans.

Ventilation fans must be rated for sound at no less than the minimum airflow rate required by this standard as noted below. These sound ratings must be at a minimum of 0.1 in. w.c. (25 Pa) static pressure in accordance with the HVI procedures referenced in Section 7.1.

Exception: HVAC air handlers and remote mounted fans need not meet sound requirements. To be considered for this exception, a remote mounted fan must be mounted outside the habitable spaces, bathrooms, toilets, and hallways, and there must be at least 4 ft (1 m) of ductwork between the fan and the intake grille.

7.2.1 Dwelling-Unit Ventilation or Continuous Local Exhaust Fans. These fans must be rated for sound at a maximum of 1.0 sone.

7.2.2 Demand-Controlled Local Exhaust Fans. Bathroom exhaust fans used to comply with Section 5.2 must be rated for sound at a maximum of 3 sones. Kitchen exhaust fans used to comply with Section 5.2 must be rated for sound at a maximum of 3 sones at one or more airflow settings greater than or equal to 100 CFM (47 L/s).

Exception: Fans with a minimum airflow setting exceeding 400 CFM (189 L/s) need not comply.

Dwelling unit occupants may choose not to operate ventilation equipment, particularly local exhaust fans, due to the noise the fans may create. To address this, the Energy Code require that certain fans be rated for sound, and installed fans must have ratings below specified limits.

§160.2(b)2Avif requires kitchen range hoods to be rated for sound in accordance with Section 7.2 of ASHRAE Standard 62.2, and it provides an exception to allow kitchen range hoods to be rated for sound at a static pressure determined at working speed as specified in HVI 916 Section 7.2. The static pressure at working speed may be lower than 0.1 inch w.c.

Because of the variables in length and type of duct and grille, there is no clearly repeatable way to specify a sound level for ventilation devices that are not mounted in the ceiling or wall surface. Consequently, air handlers and remote fans are exempted from the sound rating requirements that apply to surface-mounted fans. However, to reduce the amount of fan and/or motor noise that could come down the duct to the grille, the Energy Code sets a minimum of four ft. of ductwork between the grille and the ventilation device. This may still produce an undesirable amount of noise for the occupant, especially if hard metal duct is used. A sound attenuator will reduce the transmitted sound into the space.

C. *Continuous Ventilation Fans (Surface-Mounted Fans)*

Continuously operated fans must be rated at 1 sone or less. This 1 sone requirement applies to continuous dwelling unit ventilation fans and to continuous local exhaust ventilation fans.

D. *Intermittent/Variable or Demand Controlled Fans (Surface-Mounted Fans)*

Intermittently/variably operated dwelling unit ventilation fans must be rated at 1 sone or less. Demand-controlled local exhaust fans must be rated at a maximum of 3 sones unless the minimum rated airflow is greater than 400 CFM.

The Energy Code extend the fan sound requirements to include range hoods and bath exhaust fans. Dwelling unit ventilation fans or systems that operate continuously must be rated 1 sone or less. Demand-controlled local exhaust fans, including demand-controlled bathroom fans, must be 3 sones or less. Range hood exhaust fans must also be rated at 3 sones or less at a minimum required speed of 100 CFM.

The 3 sone requirement is measured at a minimum required speed of 100 CFM that is different from the minimum airflow requirements of the Energy Code for kitchen range hoods. The Energy Code require range hoods to have a minimum airflow between 110 CFM and 280 CFM when using airflow rating for compliance, dependent on the size of the dwelling unit and kitchen fuel used. The requirements for the minimum airflow for a sound rating and the minimum airflow for an airflow rating are different to allow sound ratings of previously tested range hoods to be used. The Energy Code previously permitted testing at "working speed".

11.4.4.3 Duct Sizing

For local exhaust systems, there are two ways to demonstrate compliance with airflow requirements of §160.2(b)2Avie:

- Test the ventilation system using an airflow measuring device after completion of the installation to confirm that the delivered ventilation airflow meets the requirement discussed in Section 11.4.2.1.
- Use a fan that has a certified airflow rating that meets or exceeds the required ventilation airflow and ventilation ducts that meet the duct design requirements given in Table 11-25 (Table 160.2-H). This option is limited to ventilation systems with a total duct length less than or equal to 25 ft (8m), with no more than three elbows, and has exterior termination fitting with a hydraulic diameter greater than

or equal to the minimum duct diameter and not less than the hydraulic diameter of the fan outlet.

When using the duct sizing table or manufacturer's design criteria for compliance, the certified airflow rating of the fan must be based on tested performance at the 0.25 inches water column (w.c.) static pressure. The airflow rating of a fan is available from the HVI Certified Products Directory at the HVI website (www.hvi.org/hvi-certified-products-directory).

If the manufacturer's duct system design specifications are used for compliance, the enforcement agency may require that the manufacturer's published system design documentation be provided for use for inspection of the installation(s).

The duct design criteria provided in Table 11-25 identifies the minimum exhaust duct diameter based on airflow. The higher the airflow, the larger the required diameter. Smooth rigid duct can be used to reduce pressure losses for longer duct runs. Interpolation and extrapolation of Table 11-25 are not allowed. To use the table for kitchen exhaust, first determine the required airflow based on unit floor area and range type (gas or electric) using Table 11-22 (from Table 160.2-G in the Standards). Then select the column that lists an airflow equal to or greater than the required airflow and use the duct size listed for rigid duct. If the duct is rectangular, calculate the equivalent diameter using footnote a.

Table 11-25: Prescriptive Ventilation System Duct Sizing (from Table 160.2-H in the Energy Code)

Fan Airflow Rating, cfm at minimum static pressure[f] 0.25 in. water (L/s at minimum 62.5 Pa)	≤50 (25)	≤80 (40)	≤100 (50)	≤125 (60)	≤150 (70)	≤175 (85)	≤200 (95)	≤250 (120)	≤350 (165)	≤400 (190)	≤450 (210)	≤700 (330)	≤800 (380)
Minimum Duct Diameter, in. (mm) [a,b] For Rigid duct	4 [e] (100)	5 (125)	5 (125)	6 (150)	6 (150)	7 (180)	7 (180)	8 (205)	9 (230)	10 (255)	10 (255)	12 (305)	12 [d] (305)
Minimum Duct Diameter, in. (mm) [a,b] For Flex duct [c]	4 (100)	5 (125)	6 (150)	6 (150)	7 (150)	7 (180)	8 (205)	8 (205)	9 (230)	10 (255)	NP	NP	NP

Source: California Energy Commission

Relevant footnotes to table:

a. For noncircular ducts, calculate the diameter as four times the cross-sectional area divided by the perimeter.

f. When a vented range hood utilizes a capture efficiency rating to demonstrate compliance with 160.2(b)2Avic2, a static pressure greater than or equal to 0.25 in. of water at the rating point must not be required, and the airflow listed in the approved directory corresponding to the compliant capture efficiency rating point must be applied to Table 160.2-G for determining compliance.

Example 11-21: Duct Sizing

Question

I need to provide 40 CFM of continuous ventilation, which I plan to do using an exhaust fan. I plan to connect the fan to a roof vent termination using flex duct. The duct will be about 8 ft. long with no real elbows but some slight bends in the duct. What size duct do I need to use?

Answer

From Table 11-25, using the ≤50 CFM column, the size of the flex duct must be 4 inches.

Example 11-22

Question

For the situation in Example 11-21, again providing 40 CFM, what size duct would I need if rigid metal duct were used?

Answer

Using the ≤50 CFM column of Table 11-25, the diameter of rigid duct must also be 4 inches.

Example 11-23

Question

I am installing a gas range in a 1,200 sq. ft dwelling unit, so will need a 250 CFM range hood. What size duct do I need to use?

Answer

Looking at Table 11-25, in the ≤250 CFM column, an 8” duct will be needed. However, this table can only be used if the maximum duct length is 25 ft. and there are fewer than four elbows. As required by §504.3 of the California Mechanical Code, the duct must be rigid metal. Another alternative would be to install a hood with a certified airflow of 250 CFM or greater and install a duct that is the same size or larger as the duct connection to the hood and verify the airflow by testing. If an electric range is installed the airflow (from Table 160.2-G in the Standards) can be reduced to only 110 CFM, which would require a 6” duct.

Example 11-24: Ducting Kitchen Exhaust to the Outdoors

Question

How do I know what kind and what size of duct I need to use for a 900 sq. ft unit with an electric range? I’ve been using recirculating hoods my entire career, now I need to vent to the outdoors. How do I do it?

Answer

A kitchen range hood or downdraft duct must be a smooth metal duct. If capture efficiency is used for compliance, then airflow must be measured and verified to be equal to or greater than the airflow that corresponds to the listed capture efficiency or the airflow required by Table 160.2-G (Table 1 in this document). The listed airflow is based on whatever duct size is used for the capture efficiency tests, typically the same size as the duct connection to the range hood.

If airflow, instead of capture efficiency, is used for compliance, then the duct size can also be the same size as the connection to the range hood. If the connection to the hood is rectangular (for example 3.25” x 10”) and is adapted to round duct, it would be wise to install a 7 inch or larger diameter round duct to achieve compliance with airflow requirements.

An alternative approach that only requires visual inspection can be used if the total duct length is 25 ft or shorter, there are less than four elbows, and the termination fitting is properly sized. In this case the duct size can be selected using Table 160.2-H (ASHRAE Standard 62.2 Table 5-3 or Table 11-24

in this document). The terminal device must have a hydraulic diameter greater than or equal to that of the range hood connection. To calculate the hydraulic diameter, multiply the cross-sectional area of the fan outlet by four and divide by the perimeter.

In your case, from Table 11-22 above you will need a range hood with a capture efficiency of 55% or an airflow of 130 CFM or greater. If you want to comply using visual inspection and can keep the duct under 25 ft. with less than four elbows, then from Table 11-23 you will need a 6-inch duct. If the duct connection to the hood is 4.25” x 10”, then the termination fitting must have a hydraulic diameter of at least:

D_h = (4 x 3.25 x 10) / (2 x 3.24 + 2 x 10) = 4.9 square inches

11.4.4.4 Exhaust Ducts

From ASHRAE Standard 62.2, Section 7.3, Exhaust Ducts.

7.3.1 Multiple Exhaust Fans Using One Duct. Exhaust fans in separate dwelling units must not share a common exhaust duct. If more than one of the exhaust fans in a single dwelling unit shares a common exhaust duct, each fan must be equipped with a backdraft damper to prevent the recirculation of exhaust air from one room to another through the exhaust ducting system.

7.3.2 Single Exhaust Fan Ducted to Multiple Inlets. Where exhaust inlets are commonly ducted across multiple dwelling units, one or more exhaust fans located downstream of the exhaust inlets must be designed and intended to run continuously, or a system of one or more backdraft dampers must be installed to isolate each dwelling unit from the common duct when the fan is not running.

The Energy Code contains restrictions on situations where multiple exhausts are connected through a combined duct system. These restrictions are intended to prevent air from moving between spaces through the exhaust ducts.

The first restriction is that if more than one exhaust fan in the same dwelling unit shares a common duct, then each fan must be equipped with a backdraft damper, so air exhausted by one fan is not allowed to go into another space.

The other restriction applies to remote fans serving more than one dwelling unit. Sometimes a single remote fan or HRV/ERV will exhaust air from several dwelling units in a multifamily building. The Energy Code require that either the shared exhaust fan operate continuously, or each unit be equipped with a backdraft damper so that air cannot flow from unit to unit when the fan is off. Note these requirements are also in the California Mechanical Code §504.1.1.

Additionally, §160.2(b)2Ci requires central ventilation system ducts serving multiple dwelling, providing continuous airflows, or part of a balanced ventilation system to be balanced and sealed according to the California Mechanical Code §603.10 and tested in accordance with procedures in Reference Appendix NA7.18.3.

11.4.4.5 Supply Ducts

From ASHRAE Standard 62.2, Section 7.4, Supply Ducts.

Where supply outlets are commonly ducted across multiple dwelling units, one or more supply fans located upstream of all the supply outlets must be designed and intended to run continuously, or a system of one or more backdraft dampers must be installed to isolate each dwelling unit from the common duct when the fan is not running.

Supply outlets to more than one dwelling unit may be served by a single fan upstream of all the supply outlets if the fan is designed to run continuously or if each supply outlet is equipped with a backdraft damper to prevent cross-contamination when the fan is not running.

11.4.5 Other Mandatory Requirements (Section 6 of ASHRAE Standard 62.2 and California Mechanical Code)

All dwelling units must meet the requirements of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Residential Buildings subject to §160.2(b)2A ventilation requirements. These additional requirements are described below.

The following sections of ASHRAE Standard 62.2 are not required for compliance: Section 4.1.1, Section 4.1.2, Section 4.1.4, Section 4.3, Section 4.6, Section 5, Section 6.1.1, Section 6.5.2, and Normative Appendix A.

11.4.5.1 Instructions and Labeling

From ASHRAE Standard 62.2*, Section 6.2, Instructions and Labeling.*

Information on the ventilation design and/or ventilation systems installed, instructions on their proper operation to meet the requirements of this standard, and instructions detailing any required maintenance (similar to that provided for HVAC systems) must be provided to the owner and the occupant of the dwelling unit. Controls must be labeled as to their function (unless that function is obvious, such as toilet exhaust fan switches).

From Standards §160.2(b)2Aix:

Compliance with ASHRAE Standard 62.2 Section 4.4 (Control and Operation) must require manual ON-OFF control switches associated with dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: "This switch controls the indoor air quality ventilation for the home. Leave switch in the "on" position at all times unless the outdoor air quality is very poor."

Building on the requirements for labeling in ASHRAE Standard 62.2, the Energy Code Section §10-103(b)4 requires the builder to leave in the building for the building owner at occupancy:

- A description of the quantities of outdoor air that the whole-dwelling unit ventilation system(s) are designed to provide and instructions for proper operation and maintenance of the ventilation system.
- Instructions for proper operation and maintenance of local exhaust systems, including instructions for conditions for any occupant-controlled systems such as kitchen range hoods and bathroom exhaust fans that should be used.

For systems in buildings or dwelling unit spaces that are not individually owned by the dwelling unit occupants, the building's owner or their representative should provide:

- A copy of the ventilation system information to dwelling occupants at the beginning of their occupancy.

For systems in buildings or dwelling unit spaces that are centrally operated, the builder should provide:

- All applicable ventilation system information to the person(s) responsible for operating and maintaining the feature, material, component, or mechanical ventilation device installed in the building. This information must be in paper or electronic format.

The Energy Code require that ventilation system controls be labeled as to their function. An acceptable option is to affix a label to the electrical panel that provides some basic system operation information.

11.4.5.2 Clothes Dryers

From ASHRAE Standard 62.2, Section 6.3, Clothes Dryers.

Clothes dryers must be exhausted directly to the outdoors. Exception: Condensing dryers plumbed to a drain.

All dryers in dwelling units must be ducted to the outdoors, with the exception of condensing dryers. Devices that allow the exhaust air to be diverted into the indoor space to provide extra heating are not permitted.

In multifamily buildings, multiple dryer exhaust ducts can be connected to a common exhaust only when dampers are provided to prevent recirculation of exhaust air from one dwelling unit to another.

11.4.5.3 Combustion and Solid-Fuel Burning Appliances

From ASHRAE Standard 62.2, Section 6.4, Combustion and Solid-Fuel Burning Appliances

6.4.1 Combustion and solid-fuel burning appliances must be provided with adequate combustion and ventilation air and installed in accordance with manufacturers' installation instructions; NFPA 54/ANSI Z223.1, National Fuel Gas Code5; NFPA 31, Standard for the Installation of Oil-Burning Equipment6; or NFPA 211, Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances,7, or other equivalent code acceptable to the building official.

6.4.2 Where atmospherically vented combustion appliances or solid-fuel burning appliances are located inside the pressure boundary, the total net exhaust flow of the two largest exhaust fans (not including a summer cooling fan intended to be operated only when windows or other air inlets are open) must not exceed 15 CFM per 100 ft2 (75 L/s per 100 m2) of occupiable space when in operation at full capacity. If the designed total net flow exceeds this limit, the net exhaust flow must be reduced by reducing the exhaust flow or providing compensating outdoor air. Gravity or barometric dampers in nonpowered exhaust makeup air systems must not be used to provide compensating outdoor air. Atmospherically vented combustion appliances do not include direct-vent appliances. Combustion appliances that pass safety testing performed according to ANSI/BPI-1200, Standard Practice for Basic Analysis of Buildings, must be deemed as complying with Section 6.4.2.

The Energy Code require that the ventilation system for combustion appliances including furnaces and gas water heaters to be properly installed, as specified by the instructions from the appliance manufacturer and by the California Building Code. Compliance with the venting requirements involves determining the type of vent material to be used, the sizing of the vent system, and vent routing requirements.

The Energy Code require compensating outdoor air (makeup air) when atmospherically vented appliances are installed inside the pressure boundary if the two largest exhaust fans have a combined capacity that exceeds 15 CFM/100 sq. ft of floor area. Use of atmospherically vented appliances in new multifamily buildings is rare or nonexistent, but observation of this ASHRAE requirement will improve combustion even if atmospherically vented appliances are not installed.

The two largest exhaust fans are normally the kitchen range hood and the clothes dryer. In many cases, the range hood airflow/capture efficiency requirements result in the range hood alone exceeding the 15 CFM/100 sq. ft limit. Thus, many units with atmospherically vented appliances will require makeup air fan. Example 4-13 discusses an example of a multifamily unit using an atmospherically vented water heater.

A supply fan can be used to balance the exhaust airflow, but from an equipment, operating cost, maintenance cost, comfort, and safety standpoint, atmospherically-vented appliances are not recommended inside dwelling units, as illustrated in the example below.

Example 11-25: Gas Water Heater

Question

We are designing a multifamily building with unit sizes ranging from 750 sq. ft with one bedroom to 1200 sq. ft with three bedrooms. Half of the floor area will be open space (living areas and kitchen). Ceiling heights are nine ft. The building will have a community laundry, and each unit will have a 36,000 Btuh naturally vented gas water heater in an interior closet off the kitchen and will use continuously operating bathroom fans to meet whole unit ventilation requirements. How many CFM of compensating air must be provided? What are the alternatives to providing compensating fans?

Answer

The California Mechanical Code allows atmospherically vented appliances to use indoor air for combustion if the space has 50 ft^3 of interior volume for every 1000 Btuh of gas input, provided there are no interior doors isolating the space used to provide air to the appliance. Per the Mechanical Code the volume needed is 36,000 / 1000 x 50 = 1800 ft^3 so a 200 sq. ft space with 9 ft. ceilings would be sufficient. The smallest unit has 750 x 50% = 375 sq. ft of open area and will meet this requirement.

Per Table 160.2-G, the 750 sq. ft unit will need a range hood with a capacity of 280 CFM and the 1200 sq. ft unit will need 250 CFM. To maintain indoor air quality, the 750 sq. ft unit will need 38 CFM of mechanical ventilation and the 1200 sq. ft unit will need 66 CFM (from Equation 160.2-B).

So, the maximum exhaust rate will be 280 + 38 = 318 CFM for the small unit and 250 + 66 = 316 CFM for the large unit. The Energy Code limit for exhaust ventilation without compensation is 15 / 100 x 750 = 113 CFM for the small unit and 15 / 100 x 1200 = 180 CFM for the large unit. That leaves a deficit of 318 – 113 = 305 CFM for the small unit and 316 – 180 = 136 CFM for the large unit, which are the minimum sizes of the compensating (makeup air) fans required.

Although installing atmospherically vented water heaters inside the units can be made to be code compliant, it is highly undesirable due to the cost of the compensating fans, which must be controlled in parallel with the kitchen range hoods, the energy and comfort impact of delivering high volumes of unconditioned air to the units, and filter maintenance costs. Direct vented tankless water heaters or heat pump water heaters would be a far better alternative.

11.4.5.4 Ventilation Opening Area

From ASHRAE Standard 62.2, Section 6.6 Ventilation Opening Area.

Spaces must have ventilation openings as listed in the following subsections. Such openings must meet the requirements of Section 6.8.

Exception: Attached dwelling units and spaces that meet the local ventilation requirements set for bathrooms in Section 5.

6.6.1 Habitable Spaces. Each habitable space must be provided with ventilation openings with an openable area not less than 4% of the floor area or less than 5 ft2 (0.5 m2).

6.6.2 Toilets and Utility Rooms. Toilets and utility rooms must be provided with ventilation openings with an openable area not less than 4% of the room floor area or less than 1.5 ft2 (0.15 m2).

Exceptions:

1. Utility rooms with a dryer exhaust duct.

2. Toilet compartments in bathrooms.

While this section of ASHRAE Standard 62.2 requires that single-family homes have ventilation openings (typically operable windows) for all habitable spaces, multifamily dwelling units are exempt from this requirement. There are no requirements for ventilation openings areas for multifamily units in the Energy Code. It is best practice to design multifamily units to meet this design practice, if possible, to provide adequate ventilation during circumstances where high levels of contaminants are released into the space. Operable windows are the most likely means of providing additional ventilation. Additional ventilation can also be provided by operable skylights; through-the-wall vents; or similar devices that are readily accessible to the occupant. An operable skylight should have some means of being operated while standing on the floor: a push rod, a long crank handle, or an electric motor.

Ventilation openings should have openable area equal to at least 4% of the space floor area (but not less than five sq. ft).

Example 11-26: Ventilation Openings

Question

I have a dwelling unit with a 14 ft. by 12 ft. bedroom. What size window should I install?

Answer

Multifamily dwelling units are exempted from requiring windows. However, as a best practice, window sizes should follow the single-family design requirements. The openable area of the window, not the window unit, should be 4% of the floor area, or 14 ft x 12 ft x 0.04 = 6.7 sq. ft or greater. The recommendation for this example can be met using two double-hung windows, each with a fully opened area of 3.35 sq. ft. Any combination of windows whose opened areas add up to at least 6.7 sq. ft will meet the recommendation.

11.4.5.5 Air Inlets

From ASHRAE 62.2, Section 6.8, Air Inlets.

Air inlets that are part of the ventilation design must be located a minimum of 10 ft (3 m) from known sources of contamination such as a stack, vent, exhaust hood, or vehicle exhaust. The intake must be placed so that entering air is not obstructed by snow, plantings, or other material. Forced air inlets must be provided with rodent/insect screens (mesh not larger than 1/2 in. [13 mm]).

Exceptions:

1. Ventilation openings in the wall may be as close as a stretched-string distance of 3 ft (1 m) from sources of contamination exiting through the roof or dryer exhausts.

2. No minimum separation distance must be required between windows and local exhaust outlets in kitchens and bathrooms.

3. Vent terminations covered by and meeting the requirements of the National Fuel Gas Code (NFPA 54/ANSI Z223.1)7 or equivalent.

4. Where a combined exhaust/intake termination is used to separate intake air from exhaust air originating in a living space other than kitchens, no minimum separation distance between these two openings is required. For these combined terminations, the exhaust air concentration within the intake airflow must not exceed 10%, as established by the manufacturer.

6.8.1 Ventilation Openings.

Operable windows, skylights, through-the-wall inlets, window air inlets, or similar devices must be readily accessible to occupants. Where openings are covered with louvers or otherwise obstructed, openable area must be based on the free, unobstructed area through the opening.

When the ventilation system is designed with outdoor air inlets, the inlets must be located away from locations that can be expected to be sources of contamination. The minimum separation is 10 ft. Inlets include not only inlets to ducts, but windows that are needed to achieve the minimal opening area.

For residential buildings, typical sources of outdoor air contaminants include:

1. Vents from combustion appliances
2. Fireplace chimneys.

3. Exhaust fan outlets.
4. Barbeque grills.
5. Driveways or any location where vehicles may be idling.
6. Any other locations where outdoor air contaminants are generated.

The Energy Code also requires that air intakes be placed so that they will not become obstructed by snow, plants, or other material. Forced air inlets must also be equipped with insect/rodent screens with mesh is no larger than 1/2 inch.

11.4.6 Common Use Area Ventilation Requirements

This section provides an overview of the Energy Code requirements for ventilation and ventilation systems serving common use areas of the building, such as community rooms, corridors, fitness areas, common laundry rooms, and parking garages. This section also discusses whether the Energy Code or California Mechanical Code (CMC, or Title 24 Part 4) takes precedent, for areas where both standards provide requirements.

Since there are similar requirements for ventilation systems serving common use area and systems serving nonresidential occupancies, more detailed discussion of the applicable requirements can be found in Chapter 4.3 for the applicable requirements.

Requirements for systems serving nonresidential occupancies in mixed occupancy buildings are in Section 120, 130, 140 and 141 of the Energy Code.

11.4.6.1 Common Use Area Ventilation Prescriptive Requirements

Applicable Prescriptive requirements for common use area ventilation system include:

- Common Use Area Space Conditioning Systems, which includes requirements for space conditioning as well as ventilation - §170.2(c)4

11.4.6.2 Performance Approach

Applicable Performance approach requirements for common use area ventilation systems include:

11.4.6.3 Common Use Area Ventilation Performance Approach

§170.1 specifies the performance approach for common use area ventilation.

11.4.7 Additions and Alterations

§180.1(a)2, §180.1(b)3, and §180.2(b)5

This section describes dwelling unit and common use area ventilation requirements for additions and alterations, including the scopes that trigger these requirements.

For both additions and alterations, when HERS field verification is required, buildings with up to three habitable stories should use the applicable procedures in the Residential Appendices. All HERS forms must be registered online with a HERS Provider. (See Section 2.5 and Appendix A.) Buildings with four or more habitable stories should use the applicable procedures in Nonresidential Appendices NA1 and NA2.

11.4.7.1 Additions

11.4.7.2 Dwelling Unit

For additions to existing buildings, local mechanical exhaust should comply with all applicable requirements specified in §160.2(b)2Avi (Local Mechanical Exhaust) and §160.2(b)2B (Dwelling Unit HERS Field Verification and Diagnostic Testing).

For whole-dwelling unit mechanical ventilation, the following requirements apply:

- For additions to an existing dwelling unit that increase conditioned floor area by more than 1,000 sq. ft, the mechanical ventilation airflow must be in accordance with §160.2(b)2Aiv (Whole-Dwelling unit Mechanical Ventilation) or §160.2(b)2Av (Central Ventilation System Airflow Rate Tolerance), as applicable. The mechanical ventilation airflow rate should be based on the conditioned floor area of the entire dwelling unit including the existing and additional conditioned floor area.
- For new dwelling units that are additions to an existing building, mechanical ventilation must meet §160.2(b)2Aiv or §160.2(b)2Av, as applicable. The mechanical ventilation airflow rate should be based on the conditioned floor area of the new dwelling unit.
- Dwelling units do not have to meet the whole-dwelling unit ventilation airflow requirements of §160.2(b)2Aiv or §160.2(b)2Av if the addition increases the existing dwelling unit conditioned floor area by less than or equal to 1000 sq. ft.

11.4.7.3 Common Use Area

Additions to the common use area should follow the nonresidential building requirements. Any newly installed space conditioning system must meet the ventilation requirements in §120.1 (Requirements for Ventilation and Indoor Air Quality) for both the prescriptive and performance approaches.

11.4.7.4 Alterations

11.4.7.5 Dwelling Unit

If the ventilation system is entirely new or a complete replacement, the ventilation system should comply with all applicable requirements in §160.2(b)2 (Ventilation and Indoor Air Quality Requirements for Attached Dwelling Units). An entirely new ventilation system includes a new ventilation fan component and an entirely new duct system, where an entirely new duct system should be at least 75% new duct material. Up to 25% of the duct system may be made up of reused parts of the existing duct system.

For altered ventilation system components or newly installed ventilation equipment serving the alteration, requirements are dependent on the component and requirements under the previous building permit.

For whole-dwelling unit mechanical ventilation:

- For an altered or replaced whole-dwelling ventilation system, if a previous building permit required compliance with whole-dwelling unit airflow requirements in §160.2(b)2, the whole-dwelling unit mechanical ventilation airflow must meet or exceed requirements specified in §160.2(b)2Aiv or §160.2(b)2Av. Otherwise, compliance is not required.
- Whole-dwelling unit replacement ventilation fans should be rated for airflow and sound in accordance with requirements in ASHRAE Standard 62.2 Section 7.1 and 7.2. If a specified airflow is required for compliance, the fan should be rated at an airflow no less than airflow rate required for compliance.
- For an altered or replaced air filtration device, if a previous building permit required air filtration requirements in §160.2(b)1, the altered or replacement filtration device must comply with air filtration requirements in §160.2(b)1. Otherwise, compliance is not required.

For local mechanical exhaust systems:

- Altered bathroom local mechanical exhaust systems should comply with applicable requirements specified in §160.2(b)2Avi.
- For a kitchen local ventilation fan that is altered or replaced, if a previous building permit required compliance with local exhaust requirements in §160.2(b)2Avi, the applicable airflow and capture efficiency must meet or exceed requirements in §160.2(b)2Avi. If a previous building permit required installation of a vented kitchen range hood or other kitchen exhaust fan, the replacement fan must have an airflow that meets or exceed requirements of the previous building permit, or 100 CFM, whichever is greater. Otherwise, compliance is not required.
- New or replacement local mechanical exhaust fans should be rated for airflow and sound in accordance with requirements of ASHRAE Standard 62.2 Section 7.1 and §160.2(b)2Avif. If a specified exhaust airflow is required for compliance, the fan should be rated at not less than the required airflow.

For alterations to space conditioning systems in existing buildings that have all or portions of the forced air ducts, plenums or air-handling units in the garage, there are leakage requirements discussed in "Duct System Sealing and Leakage Testing" in Section 11.6.4 of the Building Space Conditioning Systems section. Note that for the central ventilation system duct sealing test, the sampling group consists of no more than three central ventilation duct systems.

11.4.7.6 Common Use Area

Alterations to the common use area should follow the nonresidential building requirements. Any altered components of space conditioning systems or newly installed space conditioning systems must meet the ventilation requirements in §120.1 (Requirements for Ventilation and Indoor Air Quality) for both the prescriptive and performance approaches.

11.4.8 Compliance and Enforcement

Compliance with the Standard requirements must be verified by the enforcement agency, except for the requirements listed in Table 11-10Table , which must be verified by a HERS Rater or ATT. As a summary, HERS raters:

- Conduct dwelling unit air leakage testing (compartmentalization / blower door test).
- Verify ERV/HRV listing in the HVI directory, nominal airflow, and (in dwelling units in buildings up to three habitable stories) sensible recovery efficiency and fan efficacy.
- Verify kitchen exhaust range hood listing in the HVI or AHAM directory, compliance based on nominal airflow or capture efficiency, and sound rating.

ATTs:

- Verify ERV/HRV sensible recovery effectiveness and fan power allowance in dwelling units in buildings four or more habitable stories.
- Conduct functional bypass testing for central ERVs /HRVs.
- Conduct an air leakage testing measurement in central ventilation ducts.

11.4.8.1 Design-Phase Documentation Requirements

This subsection describes design-phase documents for multifamily buildings.

The performance approach allows compliance credit for special additional features to be quantified. The certificate of compliance lists features for which special compliance credit was taken using the performance approach. They require additional visual verification by the enforcement agency to ensure proper installation. Some require field verification and diagnostic testing by a HERS Rater or ATT. These will be listed in a separate section.

The mechanical ventilation rate (Qfan) must be manually calculated using the applicable equations in §160.2(b)2Aiv. The value for Qfan is required to be reported on the certificate of compliance. The performance certificate of compliance will report the:

- Minimum mechanical ventilation airflow rate (calculated value) that must be delivered by the system.
- Type of ventilation system (exhaust, supply, balanced, CFI).
- Fan efficacy (W/CFM) for the selected system.
- Recovery efficiency (%) (applicable to HRV/ERV system types only)
- For CFI systems--HERS verification of air handler fan efficacy is required.

The installed dwelling unit ventilation system must conform to the performance requirements on the certificate of compliance.

The enforcement agency may require additional information/documentation describing the ventilation systems be submitted along with the certificate of compliance at plan check.

11.4.8.2 Construction-Phase Documentation

This subsection describes construction-phase documents for multifamily buildings up to three stories. For multifamily buildings with four or more stories, the equivalent processes must be followed using nonresidential forms.

During construction, the general contractor or specialty subcontractors must complete all applicable certificate of installation documents for the building design special features specified on the certificate of compliance. The builder/installer must complete certificates of installation for the dwelling.

Like the certificate of compliance, registration of the certificate of installation is required, except for multifamily buildings with four stories and more. For all other buildings, the licensed contractor responsible for the installation must submit the certificate of installation information that applies to the installation to a HERS Provider Data registry using procedures described in §10-103 and Section RA2 of the Reference Residential Appendix. Certificate of installation documents corresponding to the list of special features requiring HERS Rater or ATT verification are required. For buildings with four or more stories, the licensed contractor responsible for the installation must complete and submit the certificate of installation to the building department or jurisdiction having authority.

E. Certificate of Installation

The following information must be provided on the certificate of installation to identify each ventilation system/fan in the dwelling that will require HERS verification.

For dwelling unit ventilation systems:

- Ventilation system name or identification
- Ventilation system location
- Ventilation system control type (i.e., continuous, variable)

- Ventilation system type (i.e., exhaust, supply, balanced).
- Ventilation system target airflow rate (may be less than Q_{fan} if using multiple systems/fans to comply)
- Ventilation system manufacturer name
- Ventilation system model number
- Control system manufacturer (if applicable)
- Control system model number (if applicable)
- Energy Commission certification number for variable system/control (if applicable)
- ERV or HRV manufacturer name (if applicable)
- ERV or HRV model number (if applicable)
- ERV or HRV location (if applicable)
- ERV or HRV type (i.e., unitary or central, if applicable)
- Presence of bypass recovery bypass or free cooling function (if applicable)
- Duct system name or identification
- Dust system description of area served
- Supply duct location
- Return duct location
- Sealing materials used for duct system (if applicable)

For kitchen exhaust ventilation systems:

- Kitchen exhaust control type (i.e., demand-controlled, continuous)
- Kitchen exhaust system type (i.e., range hood, over-the-range microwave, downdraft, local exhaust, other)
- Kitchen exhaust system required airflow rate or capture efficiency for demand-controlled or downdraft, and minimum kitchen air exchange rate (ACH50) for continuous systems
- Kitchen exhaust system manufacturer name
- Kitchen exhaust system model number

The following additional information must be provided on the certificate of installation to document compliance with §160.2 and 170.2(c)3B. Refer also to the procedures in RA 3.7.4 for dwelling units in buildings up to three habitable stories, and sections including NA 1.1 for dwelling units in buildings four or more habitable stories.

For dwelling unit ventilation systems:

- Measured airflow rate of the installed dwelling unit ventilation system. For balanced systems, exhaust and supply airflows must be measured and recorded.
- Installed ERV or HRVs' nominal sensible recovery efficiency and fan efficacy, if applicable.
- Installed exhaust or supply dwelling unit ventilation efficacy, if applicable.
- Installed dwelling unit ventilation system fan sone rating for fans that are not remotely mounted.
- Confirmation installed ERV or HRV has a sensible recovery efficiency and fan efficacy greater than those specified in standards.
- If a central ERV or HRV is installed, confirmation that the installed ERV or HRV includes a bypass or free cooling function.

For kitchen exhaust ventilation systems:

- Confirmation the installed system is rated by HVI or AHAM to meet the required airflow or capture efficiency and sound requirements
- The rated airflow value or rated capture efficiency listed in the HVI or AHAM directory
- The sound rating listed in the HVI or AHAM directory
- Confirmation the value for the rated airflow or capture efficiency given in the HVI directory is greater than or equal to those specified in the standards, and the value for the sone rating given in the directory is less than or equal to the sone rating requirements in specified standards.

For central ventilation systems that provide dwelling unit ventilation or operates continuously:

- Confirmation an ATT has performed a duct leakage field verification
- Documentation of duct leakage field verification showing flow rate measurement that meets requirements of specified standards

For all ventilation systems:

- Confirmation that the other applicable requirements given in Sections 6 and 7 of ASHRAE Standard 62.2 as amended in 160.2 have been met (see Sections 11.4.4 and 11.4.5)

11.4.8.3 Field Verification and Diagnostic Testing

This subsection describes field verification and diagnostic testing for multifamily buildings.

Table 11-10 lists special features requiring HERS Rater or ATT field verification or diagnostic testing for multifamily buildings. For buildings for which the certificate of compliance requires HERS or ATT field verification for compliance with the Energy Code, a HERS Rater or ATT must visit the site to perform field verification and diagnostic testing to complete the applicable heating and cooling system certificates of field verification and diagnostic testing. Certificate of verification documents corresponding to the list of special features requiring HERS Rater or ATT verification are required.

Field verification for nonmandatory features is necessary only when performance credit is taken for the feature. Some field verifications are for mandatory requirements and will occur in all multifamily buildings unless they are exempt from the requirement.

Like the certificate of compliance and certificate of installation, registration of the certificate of verification is required. The HERS Rater must submit the field verification and diagnostic testing information to the HERS Provider Data Registry as described in RA2 of the Residential Appendix and NA2 of the Nonresidential Appendix. For features requiring ATT verification, the ATT must follow the procedures described in NA1.9.

For multifamily buildings up to three habitable stories: verification, testing, and sampling procedures should follow the Residential Appendix requirements for these features, which are primarily located in RA 2.6 (sampling) and RA3.7 (Field Verification and Diagnostic Testing of Mechanical Ventilation Systems). For multifamily buildings four or more habitable stories: verification, testing, and sampling procedures should follow the Nonresidential Appendix requirements for these features, which are primarily found in sections NA1.6 (sampling), NA 2.2 (Field Verification and Diagnostic Testing of Mechanical Ventilation Systems), and NA 7.18 (Multifamily Building Acceptance Tests). The central ventilation duct sealing test has unique sampling requirements, in that the ATT's sampling group may consist of no more than three central ventilation duct systems in the building.

11.5 Building Space Conditioning System Requirements

This section addresses the requirements for space conditioning systems in multifamily buildings. Requirements related to ventilation and indoor air quality are discussed in Chapter 11.4.

Requirements for a space conditioning system that serves one or more dwelling units are described in Chapters 11.6.3 and 11.6.4. Requirements for a space conditioning system that serves common use areas of the building—including community rooms, corridors, fitness areas, common laundry rooms, and parking garages—are described in Chapter 11.6.5. Space conditioning systems that serve both dwelling units and common use areas must meet both sets of requirements.

Systems serving nonresidential occupancies in a mixed occupancy building must comply with nonresidential requirements in §120.0 through §141.1. See Chapter 4 for information on those systems.

Chapter 11.6.7 covers the heating and cooling requirements for additions to existing dwellings and for alterations to existing heating and cooling systems.

Table 11-26: Overview of Space Conditioning System Requirements in the Energy Code and Compliance Manual Organization

Space Conditioning System Application	Mandatory Requirements	Prescriptive Requirements	Performance Approach Requirements	Manual Chapter
Dwelling Units	§110.2, §110.5, §160.2(b)1, §160.3(a)(b)(d)	§170.2(c)3	§170.1	11.6.3 11.6.4 11.6.6
Common Use Areas	§110.2, §110.5, §110.9, §110.12, §160.2(c)1, §160.3(a)(c)(d)	§170.2(c)1,2,4	§170.1	11.6.5
Additions and Alterations	§110.2, §110.5, §110.9, §160.2(c), §160.3, §180.1	§180.1(a)	§180.1(b)	11.6.7

Source: California Energy Commission

11.5.1 What's New for the 2022 Energy Code

The following is an overview of the new HVAC requirements for the *2022 Building Energy Efficiency Standards* (Energy Code).

- The mandatory testing requirements that applied to multifamily buildings up to three habitable stories under the 2019 Energy Code (duct leakage, airflow rate, and fan efficacy) now apply to all multifamily buildings with HVAC systems serving individual dwelling units with some exceptions. The HERS Rater field verification and HERS Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings with four or more habitable stories. In these cases, the installer must certify on the Certificate of Installation that diagnostic testing was performed in accordance with the applicable procedures.
- For dwelling units in multifamily buildings with up to three habitable stories, the prescriptive approach requires the space conditioning system to be a heat pump in Climate Zones 1-15. For Climate Zone 16, the space conditioning system must be an air conditioner with a gas-fired furnace. In addition, in Climate Zones 4-10, if the ventilation system is a balanced system without heat or energy recovery, the fan efficacy must be 0.4 W/CFM or less.

- For dwelling units in multifamily buildings with four or more habitable stories prescriptive approach requires the space conditioning system to be a heat pump in Climate Zones 2-15. For Climate Zones 1 and 16, the space conditioning system should be a dual-fuel heat pump.
- The prescriptive refrigerant charge testing requirements that applied to multifamily buildings up to three habitable stories the 2019 Energy Code now apply to all multifamily buildings with HVAC systems serving individual dwelling units. The HERS Rater field verification and HERS Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings with four or more habitable stories. In these cases, the installer must certify on the certificate of installation that diagnostic testing was performed in accordance with the applicable procedures.
- Ducts in conditioned space can be uninsulated if specific conditions are met, as explained in Chapter 11.6.4
- New requirements for space conditioning system that serve common use areas of the building are described in Chapter 4.1.
- Filter racks or grilles must use a gasket, sealing or other means to prevent air from bypassing the filter
- Variable Capacity Heat Pump Compliance Option that was approved in November 2019 is incorporated into the Energy Code

  For alterations and additions, the following changes are included:

- For altered duct systems the prescriptive duct insulation R-Value is R-8 in Climate Zones 1-2, 4, and 8 through 16.
- The 40-foot trigger for prescriptive duct sealing and insulation has been reduced to 25 ft. for altered systems. The minimum length requirement for additions has been eliminated, and duct sealing is required whenever an existing duct system is extended to serve an addition.

A new prescriptive requirement for insulation and sealing in vented attics was added, which is triggered by the installation of an entirely new or complete replacement duct system is in a vented attic. Requirements apply in all climate zones, except 5 and 7, and various exceptions are allowed. See Chapter 11.6.7.2 of the compliance manual for additional details.

11.5.2 California Appliance Standards and Equipment Certification

§110.0 and §110.1

Most heating and cooling equipment installed in California multifamily buildings is regulated by the National Appliance Efficiency Conservation Act (NAECA) and/or the California *Appliance Efficiency Regulations (Title 20)*. Both the federal and state appliance standards apply to the manufacturing and sale of new equipment, whether for installation or replacement in newly constructed buildings, additions, or alterations. The *Appliance Efficiency Regulations* are enforced at the point of sale (except central split-system air conditioners and central single package air conditioners, see Table 11-27), while the Energy Code explained in this compliance manual is enforced by local enforcement agencies.

The equipment listed below is covered by the *Appliance Efficiency Regulations*. The manufacturer must certify that the equipment complies with the current *Appliance Efficiency Regulations* at the time of manufacture. The energy efficiency of other equipment, usually larger equipment, is regulated by the Energy Code §110.2(a).

Appliances covered by the *Appliance Efficiency Regulations* include:

- Room air-conditioners
- Room air-conditioning heat pumps
- Central air conditioners with a cooling capacity of less than 135,000 British thermal units per hour (Btu/hr.)
- Central air conditioning heat pumps
- Gas-fired central furnaces
- Gas-fired boilers
- Gas-fired furnaces
- Gas-fired floor furnaces
- Gas-fired room heaters
- Gas-fired duct furnaces
- Gas-fired unit heaters

The *Appliance Efficiency Regulations* do not require certification for:

- Electric resistance space heaters.
- Oil-fired wall furnaces, floor furnaces, and room heaters. (Some are voluntarily listed with certified gas-fired furnaces.)

Equipment that does not meet the federal appliance efficiency standards may not be sold in California. Any equipment covered by the *Appliance Efficiency Regulations* and sold in California must have the date of manufacture permanently displayed in an accessible place on that equipment. This date is frequently included as part of the serial number.

Generally, equipment manufactured before the effective date of a new standard may be sold and installed in California indefinitely as long as the performance approach demonstrates energy compliance of the building using the lower efficiency of the relevant appliances. An exception is central split-system air conditioners and central single package air conditioners installed in California. The U.S. Department of Energy (DOE) requires compliance with the minimum efficiencies specified in Table 11-27 at the time of installation.

The compliance and enforcement processes should ensure that all installed HVAC equipment regulated by the *Appliance Efficiency Regulations* is certified by the California Energy Commission.

11.5.3 Dwelling Unit Space Conditioning Equipment Requirements

Dwelling unit space conditioning systems must meet the following mandatory Energy Code requirements:

- Space Conditioning Equipment Certification and Equipment Efficiency: §110.1, §110.2
- Restrictions on Pilot Lights for Natural Gas Appliances and Equipment: §110.5
- Space Conditioning System Controls: §160.3(a) 1. Dwelling Unit Thermostats
- Dwelling Unit Space Conditioning and Air Distribution Systems: §160.3 (b)
- Fluid Distribution Systems – Pipe Insulation: §160.3(b)6, §160.3 (c)1.

Prescriptive requirements include:

Prescriptive requirements for Space Conditioning Systems are in §170.2(c)3.

The requirements for the performance approach are in §170.1.

11.5.3.1 Mandatory Requirements

This section addresses the mandatory requirements for heating and cooling equipment, including furnaces, boilers, heat pumps, air conditioners, and electric resistance equipment, serving multifamily dwelling units. Residential equipment used in common use areas must meet these mandatory requirements. Commercial equipment used in common use areas must meet the mandatory requirements described in Chapter 11.6.5.1.

11.5.3.2 Equipment Efficiency

§110.1 and §110.2(a)

The efficiency of most dwelling unit heating and cooling equipment is regulated by the National Appliance Energy Conservation Act of 1987 (NAECA, the federal appliance standard) and California's *Appliance Efficiency Regulations*. These regulations are not contained in the Energy Code but are published separately. These regulations are referenced in §110.1. The energy efficiency of larger equipment is regulated by §110.2(a). The *Appliance Efficiency Regulations* include definitions for all types of equipment and are regularly updated.

Note: The *Appliance Efficiency Regulations* that are in effect when the building permit is applied for will determine the minimum efficiency of the appliances identified in the compliance documentation.

L. Central, Single-Phase Air Conditioners and Air Source Heat Pumps

Central, single-phase air conditioners and air source heat pumps commonly installed in multifamily dwelling units have a capacity less than 65,000 Btu/hr.

Air conditioner efficiencies are determined according to federal test procedures. The efficiencies are reported in terms of SEER and EER. The *Appliance Efficiency Regulations* for this equipment require minimum SEER. The SEER of all new central, single-phase air conditioners and air source heat pumps with an output less than 65,000 Btu/h must be certified to the Energy Commission to have values no less than the values listed in Table 11-27.

Table 11-27: Minimum Cooling Efficiencies for Central Air Conditioners and Heat Pumps

(Cooling Capacity Less Than 65,000 Btu/h)

(NR = No Requirement) Appliance	Type	SEER	EER
Central Air Conditioners[1]	Split-System <45,000 Btu/h	14	12.2
Central Air Conditioners[1]	Split-System 45,000 Btu/h	14	11.7
Central Air Conditioners[1]	Single-Package	14	11.0
Central Air Source Heat Pumps	Split-System	14	NR
Central Air Source Heat Pumps	Single-Package	14	NR
Space-Constrained Air Conditioner	Split-System	12	NR
Space-Constrained Air Conditioner	Single-Package	12	NR
Space-Constrained Heat Pump	Split-System	12	NR
Space-Constrained Heat Pump	Single-Package	12	NR
Small-Duct, High-Velocity Air Conditioner	All	12	NR
Small-Duct, High-Velocity Heat Pump	All	12	NR

1. *See 10 CFR section 430.32(c) for less stringent federal standards applicable to these units that are manufactured on or after January 1, 2015, and installed in states other than Arizona, California, Nevada, or New Mexico.*

Source: California Appliance Efficiency Regulations, Title 20, Table C-3, and Federal Appliance Standards (NAECA)

M. Heat Pumps and Electric Heating

Efficiency requirements for package terminal air conditioners, package terminal heat pumps, single-package vertical air conditioners, and single-package vertical heat pumps are listed in Table 110.2-E of the Energy Code.

Heat pumps must be certified to have a HSPF or coefficient of performance (COP) equal to or better than those listed in Table 11-28.

There are no minimum appliance efficiency standards for electric-resistance or electric-radiant heating systems.

Table 11-28: Minimum Heating Efficiency for Heat Pumps

Equipment Type	Reference	Configuration/Size	Minimum Heating Efficiency
Single-phase air source heat pumps (NAECA)	Table C-3	< 65,000 Btu/h cooling	Packaged 8.0 HSPF Split 8.2 HSPF
Single-phase air source heat pumps (NAECA)	Table C-3	Space constrained < 65,000 Btu/h cooling capacity	7.4 HSPF
Single-phase air source heat pumps (NAECA)	Table C-3	Small duct, high velocity < 65,000 Btu/h cooling capacity	7.2 HSPF
Three-phase air source heat pumps	Table C-4	< 65,000 Btu/h	Packaged 8.0 HSPF Split 8.2 HSPF
Three-phase air source heat pumps	Table C-4	≥ 65,000 and <135,000	3.3 COP (Equipment manufactured starting January 1, 2018) 3.4 COP (Equipment manufactured starting on January 1, 2023)
Three-phase air source heat pumps	Table C-4	≥ 135,000 and <240,000	Electric resistance heating: 3.2 COP (Equipment manufactured starting January 1, 2018) 3.3 COP (Equipment manufactured starting on January 1, 2023) All other: 3.3 COP (Equipment manufactured starting January 1, 2018) 3.4 COP (Equipment manufactured starting on January 1, 2023)
Three-phase air source heat pumps	Table C-4	≥ 240,000 and <760,000	3.2 COP
Water-source heat pumps	Table C-5	<17,000 Btu/h	4.3 COP
Water-source heat pumps	Table C-5	≥ 17,000 Btu/h, < 135,000 Btu/h	4.3 COP
Single package vertical heat pumps	Table C-6	< 65,000 single-phase	3.3 COP (Equipment manufactured starting on September 23, 2019)
Single package vertical heat pumps	Table C-6	< 65,000 3-Phase	3.3 COP (Equipment manufactured starting on September 23, 2019)

Source: California Appliance Efficiency Regulation Title 20

N. Other Air Conditioners and Heat Pumps

Appliance Efficiency Regulations

The *Appliance Efficiency Regulations* contain minimum efficiency requirements for three-phase models, larger-capacity central air conditioners and heat pumps, and all room air conditioners and room air conditioner heat pumps. The efficiency for these types of equipment must be certified to the Energy Commission by the manufacturer. Table 11-29 and Table 11-30 include efficiency requirements for equipment with a cooling capacity less than 65,000 Btu/hour. Efficiency requirements for larger equipment requirements are covered in Chapter 4.

Table 11-29: Minimum Cooling Efficiency for Three-Phase Models and Central Air Conditioners and Heat Pumps

Equipment Type	Size Category	SEER or EER
Central Air-Conditioners	< 65,000 Split-System*	13.0 SEER
Central Air-Conditioners	< 65,000 Single-Packaged*	13.0 SEER
Central Air-Source Heat Pumps	< 65,000 Split-System*	13.0 SEER
Central Air-Source Heat Pumps	< 65,000 Single-Packaged*	13.0 SEER
Central Water-Source Heat Pumps	< 17,000 Btu/h	11.2 EER
Central Water-Source Heat Pumps	≥ 17,000 Btu/h and < 65,000 Btu/h	12.0 EER
Water-Cooled Air Conditioners	< 17,000 Btu/h	12.1 EER
Water-Cooled Air Conditioners	≥ 17,000 < 65,000 Btu/h	12.1 EER

* Three-phase models only

1 Applies to equipment that has electric resistance heat or no heating.

2 Applies to equipment with all other heating-system types that are integrated into the unitary equipment.

3. Deduct 0.2 from the required EER for units with heating sections other than electric resistance heat.

Source : California Appliance Efficiency Regulations Table C-4, C-5

Table 11-30: Minimum Cooling Efficiency for Noncentral Space-Cooling Equipment

Equipment Type	**Size Category (Input)**	**Minimum Efficiency**
Room Air Conditioners, With Louvered Sides	< 6,000 Btu/h	11.0 EER
Room Air Conditioners, With Louvered Sides	≥ 6,000 Btu/h and - 7,999 Btu/h	11.0 EER
Room Air Conditioners, With Louvered Sides	≥ 8,000 Btu/h and - 13,999 Btu/h	10.9 EER
Room Air Conditioners, With Louvered Sides	≥ 14,000 Btu/h and - 19,999 Btu/h	10.7 EER
Room Air Conditioners, With Louvered Sides	≥ 20,000 Btu/h and 27,999 Btu/h	9.4 EER
Room Air Conditioners, With Louvered Sides	≥ 28,000 Btu/h	9.0 EER
Room Air Conditioners, Without Louvered Sides	< 6,000 Btu/h	10.0 EER
Room Air Conditioners, Without Louvered Sides	≥ 6,000 Btu/h and - 7,999 Btu/h	10.0 EER
Room Air Conditioners, Without Louvered Sides	≥ 8,000 Btu/h and - 10,999 Btu/h	9.6 EER
Room Air Conditioners, Without Louvered Sides	≥ 11,000 Btu/h and - 13,999 Btu/h	9.5 EER
Room Air Conditioners,	≥ 14,000 Btu/h and - 19,999 Btu/h	9.3 EER

Equipment Type	Size Category (Input)	Minimum Efficiency
Without Louvered Sides		
Room Air Conditioners, Without Louvered Sides	≥ 20,000 Btu/h	9.4 EER
Room Air Conditioner Heat Pumps With Louvered Sides	< 20,000 Btu/h	9.8 EER
Room Air Conditioner Heat Pumps With Louvered Sides	≥ 20,000 Btu/h	9.3 EER
Room Air Conditioner Heat Pumps Without Louvered Sides	< 14,000 Btu/h	9.3 EER
Room Air Conditioner Heat Pumps Without Louvered Sides	≥ 14,000 Btu/h	8.7 EER
Casement-Only Room Air Conditioner	All Capacities	9.5 EER
Casement-Slider Room Air Conditioner	All Capacities	10.4 EER

Cap. = Cooling Capacity (Btu/hr)

Note: Including room air conditioners and room air conditioner heat pumps,

Source: California Appliance Efficiency Regulations Title 20, Table B-3, the Energy Code Table 110.2-E

O. Gas and Oil-Fired Furnaces

The *Appliance Efficiency Regulations* require gas- and oil-fired central furnaces with outputs less than 225,000 Btu/hr to be rated according to the associated annual fuel utilization efficiency (AFUE). Gas- and oil-fired central furnaces with outputs greater than or equal to 225,000 Btu/hr are rated according to the respective thermal (or steady-state) efficiency.

Equipment with outputs less than 225,000 Btu/hr is listed in Table E-6 of the *Appliance Efficiency Regulations* and incorporated in Table 11-31. Efficiency for equipment with outputs greater than or equal to 225,000 Btu/hr is listed in Table E-6 of the *Appliance Efficiency Regulations* and included in Appendix B.

Table 11-31: Minimum Efficiency for Gas- and Oil-Fired Central Furnaces

Appliance	Rated Input (Btu/h)	AFUE
Weatherized gas central furnaces with single phase electrical supply	< 225,000	81
Non-weatherized gas central furnaces with single phase electrical supply	< 225,000	80
Weatherized oil central furnaces with single phase electrical supply	< 225,000	78
Non-weatherized oil central furnaces with single phase electrical supply	< 225,000	83

Source: California Appliance Efficiency Regulations Title-20 - Table E-6

Noncentral gas furnaces and space heaters must be certified to have AFUE values greater than or equal to those listed in Table 11-32.

Table 11-32: Minimum Heating Efficiency for Nonducted, Noncentral, Gas-Fired Heating Equipment

Type	Capacity	AFUE
Wall Furnace (fan type)	≤ 42,000 Btu/h	75%
Wall Furnace (fan type)	> 42,000 Btu/h	76%
Wall Furnace (gravity type)	≤ 27,000 Btu/h	65%
Wall Furnace	> 27,000 to ≤ 46,000 Btu/h	66%

Type	Capacity	AFUE
(gravity type)		
Wall Furnace (gravity type)	> 46,000 Btu/h	67%
Floor Furnace	≤ 37,000 Btu/h	57%
Floor Furnace	> 37,000 Btu/h	58%
Room Heater	≤ 20,000 Btu/h	61%
Room Heater	> 20,000 to ≤ 27,000 Btu/h	66%
Room Heater	> 27,000 to ≤ 46,000 Btu/h	67%
Room Heater	> 46,000 Btu/h	68%

Source: California Appliance Efficiency Regulations Title 20 - Table E-2

P. Gas- and Oil-Fired Central Boilers and Electric Boilers

Gas- and oil-fired central boilers must be certified to have and AFUE or combustion efficiency equal to or better than those listed in the Energy Code Table 110.2-J.

11.5.3.3 Dwelling Unit Controls

§110.2 (b) & (c), §160.3(a)1

The Energy Code includes a mandatory requirement for thermostat controls. Unless controlled by a central energy management control system the thermostat must have setback capabilities. An exception is allowed only if the system is one of the following non-central types:

- Non-central electric heaters such as mini-split heat pumps
- Room air conditioners
- Room air conditioner heat pumps
- Gravity gas wall heaters
- Gravity floor heaters
- Gravity room heaters
- Wood stoves
- Fireplace or decorative gas appliances

When it is required, the setback thermostat must have a clock or other mechanism that allows the resident to schedule the heating and/or cooling set points for at least four periods over 24 hours.

If more than one piece of heating or cooling equipment is installed in a dwelling unit, the setback requirement may be met by controlling all heating or cooling units by one thermostat or by controlling each unit with a separate thermostat. Separate heating or cooling units may be provided with a separate on/off control capable of overriding the thermostat.

Thermostats for heat pumps equipped with supplementary electric resistance heat must be thermostats that minimize the use of supplementary electric resistance heating during startup and recovery from setback, as discussed in Heat Pump System Controls.

Example 11-27

Question

Am I exempt from the requirement for a thermostat if I have a packaged terminal air conditioner or heat pump or any of the equipment types listed in the exception to §110.2(c)?

Answer

Yes.

11.5.3.4 Heat Pump System Controls

§160.3(a)2C, §110.2(b), Exceptions to §110.2(b), §110.2(c), Exception to §110.2(c)

Heat pump systems must be controlled by a central energy management control system (EMCS) or by a setback thermostat as described under Dwelling Units Controls. Any heat pump with supplementary electric resistance heating requires controls with capabilities to limit the electric resistance heating. The first required capability is to set the cut-on and cut-off temperatures for the heat pump and supplementary electric resistance heating at different levels.

For example, if the heat pump begins heating when the inside temperature reaches 68°F, the electric resistance heating may be set to come on if the temperature goes below 65°F if the heat pump alone could not maintain the set point of 68°F. Also, there must be an OFF mode that automatically shuts off the electric resistance when the inside temperature reaches 68°F.

The second control capability must prevent the supplementary electric resistance heater from operating if the heat pump alone can meet the heating load, except during defrost. There is a limited exception to this second function for “smart thermostats” that provide intelligent recovery, staging, ramping, or another control mechanism that prevents the unnecessary operation of supplementary electric resistance heating when the heat pump alone can meet the heating load.

To meet the thermostat requirements, a thermostat for a heat pump with supplementary electric resistance heating must be a thermostat that minimizes the use of supplementary heating during startup and recovery from setbacks.

Note: Room air conditioner heat pumps are not required to comply with the thermostat requirements.

11.5.3.5 Equipment Sizing

§160.3 (b)1 and 2

The Energy Code does not set limits on the sizing of heating and cooling equipment, but does require that heating and cooling loads be calculated for new HVAC systems. Oversized equipment typically operates less efficiently and can create comfort problems due to excessive cycling and improper airflow. Ducts must be sized correctly, otherwise the system airflow rate may be restricted, adversely affecting the efficiency of the system and preventing the system from meeting the mandatory minimum airflow rate requirements.

Acceptable load calculation procedures include methods described in the following publications:

- The ASHRAE Handbook – Equipment
- The ASHRAE Handbook – Applications
- The ASHRAE Handbook – Fundamentals
- The SMACNA Residential Comfort System Installation Standards Manual
- ACCA Manual J

The Energy Code requires that the outdoor design conditions for heating load calculations be selected from JA2 and that the indoor design temperature for heating load calculations be 68°F. The outdoor design temperature must be no lower than the "heating winter median of extremes," as listed in JA2. The outdoor design conditions for cooling load calculations must be selected from JA2, Table 2-3, using values no greater than the "1.0 percent cooling dry bulb" and "mean coincident wet bulb" values listed. The indoor design temperature for cooling load calculations must be 75°F.

If the actual city location for a project is not included in JA2, or if the data given for a particular city do not match the conditions at the actual site as well as that given for another nearby city, consult the local building department for guidance.

The load calculations must be submitted with the compliance documentation when requested by the building department.

The load calculations may be prepared by 1) a mechanical engineer, 2) the mechanical contractor who is installing the equipment or 3) someone who is qualified to do so in the State of California according to Division 3 of the Business and Professions Code.

The Business and Professions Code does not prohibit an unlicensed person from preparing plans, drawings, or specifications for certain buildings containing no more than four dwelling units of wood-frame construction and not more than two stories and basement in height.

11.5.3.6 Standby Losses and Pilot Lights

§110.5 and §110.2(d)

Fan-type central furnaces may not have a continuously burning pilot light. This requirement does not apply to wall furnaces, floor furnaces, or any gravity-type furnace. Household cooking appliances also must not have a continuously burning pilot light, except for those without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/h.

Larger gas-fired and oil-fired forced air furnaces with input ratings equal to or greater than 225,000 Btu/h (which is bigger than a typical residential furnace) must also have an intermittent ignition device and either power venting or a flue damper.

A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings equal to or greater than 225,000 Btu/h, including electric furnaces, that are not within the conditioned space must have jacket losses not exceeding 0.75 percent of the input rating.

11.5.3.7 Pipe Insulation

§160.3(b)6, §160.3(c)1

Specific insulation requirements for heating and cooling system piping in dwelling units are the same as requirements in common use areas. These requirements are detailed in Chapter 11.1.18.1, Chapter 4.5, and Tables 4-15a through 4.15f.

For air conditioners and heat pumps, two refrigerant lines connect the indoor and outdoor units of split-system air conditioners and heat pumps: the liquid line (the smaller diameter line) and the suction line (the larger diameter line). If the liquid line is at an elevated temperature relative to outdoor and indoor temperatures, it should not be insulated. In those areas, heat escaping from it is helpful.

The suction line carries refrigerant vapor that is cooler than ambient in the summer and (with heat pumps) warmer than ambient in the winter. This line must be insulated to the required thickness (in inches).

Insulation used for refrigerant suction lines located outside of conditioned space must include a Class I or Class II vapor retarder. The vapor retarder and insulation must be protected from physical damage, UV deterioration, and moisture with a covering that can be removed for equipment maintenance without destroying the insulation. Insulation is typically protected by aluminum, sheet metal jacket, painted canvas, or plastic cover. Adhesive tape should not be used as insulation protection because removal of the tape will damage the integrity of the original insulation during preventive maintenance. See Figure 11-34 for example of refrigerant line insulation.

Figure 11-34: Refrigerant Line Insulation

Source: Airex Manufacturing Inc.

11.5.3.8 Outdoor Condensing Units

§160.3 (b)3.

Any obstruction of the airflow through the outdoor unit of an air conditioner or heat pump lowers efficiency. Dryer vents are prime sources for substances that clog outdoor coils and sometimes discharge substances that can cause corrosion. Therefore, condensing units must not be placed within five ft. of a dryer vent. This requirement is applicable to new installations and to replacements. Regardless of location, condenser coils should be cleaned regularly. The manufacturer installation instructions may include requirements for minimum horizontal and vertical distance to surrounding objects that should be met if greater than the minimum distance required by the Energy Code. Figure 11-35 shows an example when a condensing unit installed location does not meet the clearance requirement.

Figure 11-35: Noncompliant Condensing Unit Clearance from Dryer Vents

Source: California Energy Commission

Liquid line filter driers are components of split system air-conditioners and split system heat pumps that are installed in the refrigerant line to remove moisture and particles from the refrigerant stream. These contaminants may be introduced in the refrigerant as a result of improper flushing, evacuation, and charging procedures, causing the efficiency and capacity of the air conditioner to be impaired or damaging components. If required by manufacturer's instructions, liquid line filter dryers must be installed. Sometimes, liquid line filter dryers are preinstalled by manufacturers within condensing units. Some manufacturers install liquid line filter dryers outside condensers, so they can be easily serviced by technicians and more easily verified by HERS Raters.

The quality of the filter dryer installation impacts the effectiveness of the liquid line filter dryer, as some liquid line filter dryers can be installed without regard to the direction of refrigerant flow. Heat pumps, for example, allow refrigerant flow in both directions. However, in other air conditioners where refrigerant flow occurs in only one direction, correct orientation of the liquid line filter dryer is important.

11.5.3.9 Dwelling Unit Prescriptive Requirements

§170.2(c)3

Prescriptive compliance requires the installation of a heat pump for dwelling units in buildings up to three habitable stories in Climate Zones 1-15. For Climate Zone 16, the installation of an air conditioner with gas-fired furnace is prescriptively required. For buildings with four or more habitable stories, prescriptive compliance requires installation of a heat pump for Climate Zones 2-15. For Climate Zone 1 and 16, prescriptive compliance requires the installation of a dual-fuel heat pump that uses gas as supplemental heat.

In addition, for buildings with three habitable stories in Climate Zones 4-10, see Chapter 11.4.2.2 for ventilation fan power requirements.

When using the prescriptive compliance approach, the installed heat pump or gas heating system gets no additional credit for higher efficiency equipment.

Prescriptive requirements for air-cooled air conditioners and air-source heat pumps installed in Climate Zones 2 and 8 through 15 necessitate the installation of a measurement access hole (MAH), refrigerant charge verification (RCV), and minimum system airflow verification. The minimum system airflow installation and RCV must be performed by the installer and/or HERS Rater or ATT. The MAH provides a nonintrusive means of measuring return air temperature, which is an important parameter to the RCV process. The alternative to RCV by a HERS Rater is the installation of a refrigerant FID. When installing an FID, the installer must still perform RCV.

11.5.3.10 Dual-fuel Heat Pump System

For Climate Zones 1 and 16, the prescriptive requirement includes the use of a dual-fuel heat pump for buildings four habitable stores or greater. This system pairs an electric heat pump with a gas-fired furnace and alternates between the two fuel sources for heating. Heat pumps face a challenge in colder climates where their capacity for providing heat and the efficiency of the equipment reduces as the outdoor temperature drops. This is especially true for the type of minimal efficiency heat pumps that are the basis for the federal appliance standards for heat pumps. To address these challenges, gas-fired furnace can be used for space heating when outdoor air temperature is below a certain threshold, normally between 35-45°F.

The dual-fuel heat pump system can be controlled similarly to a heat pump with electric resistance required by §110.2(b). The control should have the capability to set the cut-on and cut-off temperatures for the heat pump and supplementary gas-fired heating at different levels. For example, if the heat pump begins heating when the inside temperature reaches 68°F, the gas-fired furnace heating may be set to come on if the temperature goes below 65°F, if the heat pump alone could not maintain the set point of 68°F. Also, there must be an OFF mode that automatically shuts off the gas-fired heating when the inside temperature reaches 68°F. The system may also have a control capability that prevents the supplemental gas-fired furnace from operating if the outdoor air temperature is above a pre-set threshold.

11.5.3.11 Supplemental Heating System

Supplemental heating systems are allowed prescriptively, and the designer may elect to provide supplemental heating to a space such as a bathroom. In this instance, the supplemental heating system must be installed in a space that is served by the primary heating system and must have a thermal capacity of less than 2 kilowatts (kW) or 7,000 Btu/h while being controlled by a time-limiting device not exceeding 30 minutes. Electric resistance and electric radiant heating installation are not allowed as the primary heating system when using the prescriptive compliance method.

Example 11-28: Compliance Using the Prescriptive Approach

Question

We are designing a 3-story multifamily building in Climate Zone 4, and we want to comply with Title 24 prescriptively, can we use air conditioners for dwelling unit space cooling and gas-fired furnace for space heating? What if we have a project in Climate Zone 16?

Answer

No for Climate Zone 4. To comply with Title 24 prescriptively, the dwelling unit space heating and cooling must be provided by heat pump systems. In addition, if balanced ventilation without heat or energy recovery, the combine supply and exhaust fan rated efficacy must be 0.4W/CFM or less.

Yes, for Climate Zone 16. To comply prescriptively, air conditioner and gas-fired furnace must be used for dwelling unit space cooling and heating.

Example 11-29

Question

We are designing a 4-story multifamily building in Climate Zone 1. Can we use air conditioners for dwelling unit space cooling and gas-fired furnace for space heating?

Answer

No. To comply with Title 24 prescriptively, the dwelling unit space heating and cooling must be provided by dual-fuel heat pump systems.

11.5.3.12 Measurement Access Hole

The MAH provides a nonintrusive means for refrigerant charge verification by HERS Raters or ATT and other third-party inspectors. They eliminate the need for raters/inspectors to drill holes into the installed air conditioning equipment enclosures to place the temperature sensors that are required by the refrigerant charge verification test procedures described in the Reference Residential Appendix RA3.2.

Installation of MAH must be performed by the installer of the air conditioner or heat pump equipment according to the specifications given in Reference Residential Appendix RA3.2.

The MAH feature consists of one 5/8-inch (16 millimeters [mm]) diameter hole in the return plenum, upstream from the evaporator coil. (See Figure RA3.2-1 in Reference Residential Appendix RA3.2.)

11.5.3.13 Refrigerant Charge Verification

The prescriptive standards for Climate Zones 2 and 8-15 require all cooling systems— including ducted air-cooled air conditioners, ducted air-source heat pumps, small-duct high-velocity systems, and mini-split systems — to have the correct refrigerant charge verified. Verification of refrigerant charge must be conducted by a HERS Rater for multifamily buildings with up to three habitable stories. For multifamily buildings with four or more stories, testing only needs to be conducted and certified by the installing contractor, and neither a HERS Rater nor registration with a HERS Provider is required. The RCV procedures are documented in Reference Residential Appendix RA1.2, RA2.4.4, and RA3.2.

Refrigerant charge refers to the actual amount of refrigerant present in the system. Excessive refrigerant charge (overcharge) reduces system efficiency and can lead to premature compressor failure. Insufficient refrigerant charge (undercharge) also reduces system efficiency and can cause compressors to overheat. Ensuring correct refrigerant charge can significantly improve the performance of air-conditioning equipment. Refrigerants are the working fluids in air-conditioning and heat-pump systems that absorb heat energy from one area (through the evaporator), transfer, and reject it to another (through the condenser).

Verification of proper refrigerant charge must occur after the HVAC contractor has installed and charged the system in accordance with the manufacturer's specifications. The procedure requires properly calibrated digital refrigerant gauges, thermocouples, and digital thermometers. When multiple systems in the same dwelling unit require testing, test each system.

In a typical cooling system, there are two important performance criteria that are relatively easy to verify that there is neither too much nor too little refrigerant in the system. In systems with a fixed-orifice device in the evaporator coil, the number to check is called the *superheat*. In a system with a variable-metering device, the number to check is called the *subcooling*.

Superheat refers to the number of degrees the refrigerant is raised after it evaporates into a gas. This occurs inside the evaporator coil (or *indoor coil*). The correct superheat for a system will vary depending on certain operating conditions. The target superheat for a system must be obtained from a table provided in the RA3.2 protocols or the manufacturer's superheat table. There is an allowed range of several degrees between the measured superheat and the target superheat for a system to pass.

Subcooling refers to the number of degrees the refrigerant is lowered after it condenses into a liquid. This occurs inside the condenser coil (or *outdoor coil*). The manufacturer specifies the correct subcooling for a system. It may vary depending on operating conditions. Like superheat, there is an allowed range of several degrees between the measured subcooling and the target subcooling for a system to pass.

The temperature at which a refrigerant condenses or evaporates is called the *saturation temperature*. Above the saturation temperature, a refrigerant is always a gas. Below the saturation temperature, a refrigerant is always a liquid.

Saturation is when a refrigerant exists as both a liquid and a gas. It always occurs at the same temperature, depending on what the pressure of the refrigerant happens to be. At higher pressures, the saturation temperature goes up and vice versa. This convenient property is what makes refrigeration work.

The saturation temperature can be determined by simply measuring the pressure of a refrigerant and referring to a table, known as a *pressure-temperature* (PT) *table*, for that specific refrigerant. Saturation temperatures are well-documented for all common refrigerants.

Because variable refrigerant metering devices are prone to failure and even more so to improper installation, it is important that the operation of these devices be checked. A metering device maintains a relatively constant superheat over a wide range of operating conditions; therefore, checking the superheat, in addition to the other tests performed, will indicate if the metering device is operating correctly.

Unfortunately, checking superheat and subcooling can be done only under certain indoor and outdoor conditions. This verification procedure, called the Standard Charge Verification Method, is very weather-dependent.

There is another way to verify proper refrigerant charge that is not weather–dependent, and that is by weighing the refrigerant. Called the Weigh-in Charge Verification Method, this approach can be performed only by the installer. It can be verified by the HERS Rater either by simultaneous observation or by using the standard method when conditions permit.

11.5.3.14 Minimum System Airflow Verification for Refrigerant Charge Verification

To have a valid charge test, the system airflow must be verified to be at least 300 CFM/ton for altered systems and 350 CFM/ton for new systems. The procedures for measuring total system airflow are found in RA3.3. They include plenum pressure matching using a fan flow meter, a flow grid, a powered flow hood, and the traditional (nonpowered) flow hood. The airflow verification procedures for refrigerant charge verification no longer include the temperature split method.

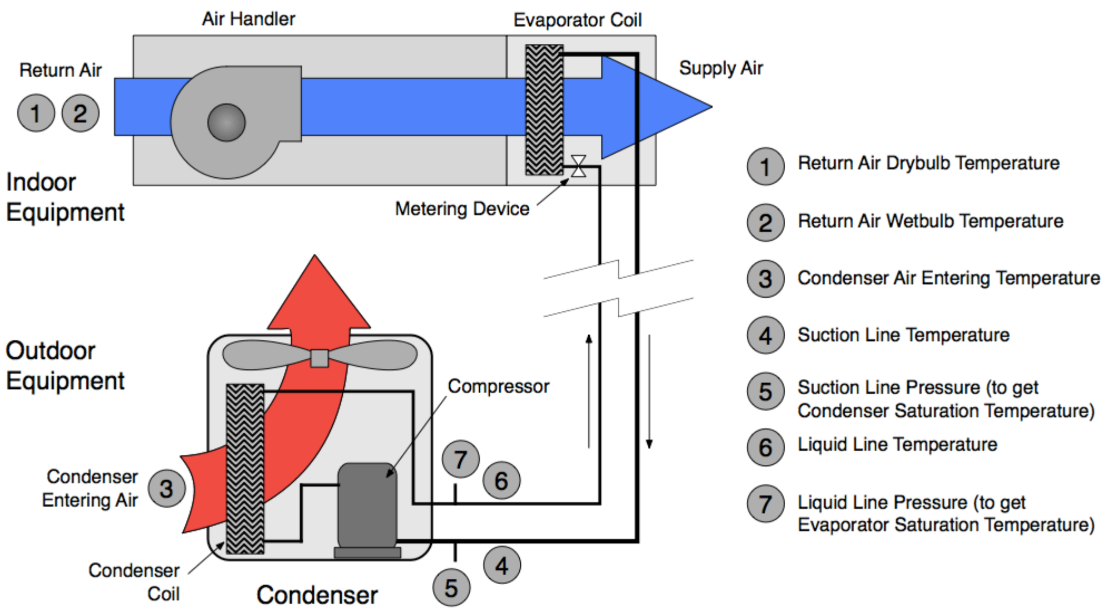
If an altered system does not meet the minimum airflow requirements, remedial steps are required to increase system airflow. More airflow is generally better for systems with air conditioning. Not only does this allow proper refrigerant charge to be verified, but it improves the overall performance of the system. When able to be performed on a system, regardless of the refrigerant charge verification procedure, minimum system airflow must always be verified.

In some alterations, improving airflow may be cost-prohibitive, and there is a process for documenting this (RA3.3.3.1.5). When this option is used, verification by sample groups is not allowed. Minimum airflow is critical to proper air-conditioner operation. Reducing airflow reduces cooling capacity and efficiency. Many systems in California have oversized equipment and undersized ducts. In newly installed duct systems, the minimum airflow requirement is higher because the opportunity exists to design and install a better system. In altered systems, the installer may be required to modify the ducts system to meet the minimum airflow. The minimums of 300 and 350 CFM/ton are lower than the desired airflow for most systems, which is usually 400 CFM/ton and higher.

11.5.3.15 Standard Charge Verification Procedure (RA3.2.2)

The first step is to turn on the air-conditioning system and let it run for at least 15 minutes to stabilize temperatures and pressures. While the system is stabilizing, the HERS Rater or the installer may attach the instruments needed to take the measurements.

Figure 11-39: Measurements for Refrigerant Charge and Airflow Tests



Source: California Energy Commission

The following measurements must be taken by the technician or HERS Rater, when applicable.

1. The return air wet bulb and dry bulb temperatures are measured in the return plenum before the blower at the location labeled "Title 24 – Return Plenum Measurement Access Hole." This hole must be provided by the installer, not the rater (See Points 1 and 2 in Figure 11-39). See Figure RA 3.2-1 for more information on the placement of the measurement access hole (MAH).
2. Moreover, the outdoor air dry bulb temperature is measured at the point where the air enters the outdoor condensing coil. (See Point 3 in Figure 11-39). It is important that this outdoor temperature sensor be shaded from direct sun during the verification procedure.

In addition to the air temperature measurements, four refrigerant properties need to be measured. Two of these measurements are taken near the suction line service valve before the line enters the outdoor unit and are used to check the superheat.

1. The first measurement is the temperature of the refrigerant in the suction line, which is taken by a clamp-on thermocouple or other suitable device insulated from the outdoor air. (See Point 4 in Figure 11-39.)
2. The second measurement determines the saturation temperature of the refrigerant in the evaporator coil. (See Point 5 in Figure 11-39.) The saturation temperature can be determined from the low-side (suction line) pressure and a saturation temperature table for the applicable refrigerant.

To check the subcooling, two more refrigerant properties are required and may be measured near the liquid line service valve at the point where the line exits the outdoor unit.:

1. The liquid refrigerant temperature in the liquid line is measured by a clamp-on thermocouple insulated from the outdoor air. (See Point 6 in Figure 11-39.)
2. The condenser saturation temperature can be determined from the liquid line pressure and a saturation temperature table for the applicable refrigerant. (See Point 7 in Figure 11-39.)

Determination of the condenser saturation temperature and the liquid line temperature is used only for the subcooling verification method on systems with TXV or EXV metering devices.

11.5.3.16 Superheat Charge Verification Method (RA3.2.2.6.1)

The *Superheat Charge Verification Method* is used on units with a fixed-orifice refrigerant metering device (not a TXV or EXV).

Airflow verification must be confirmed before starting the Superheat Verification Method.

The *Superheat Verification Method* compares the actual (measured) superheat temperature to a target value from a table. The actual superheat temperature is the measured suction line temperature ($T_{Suction,\ db}$) minus the evaporator saturation temperature ($T_{Evaporator,\ Saturation}$). The target superheat value is read from a table (Table RA3.2-2 or the manufacturer’s superheat table).

Only an EPA-certified technician may add or remove refrigerant. Under no circumstances may HERS Raters add or remove refrigerant on systems that they are verifying.

11.5.3.17 Subcooling Verification Method (RA3.2.2.6.2)

The *Subcooling Verification Method* is used on units with a variable refrigerant metering device (a TXV or EXV).

Airflow verification must be confirmed before starting the Subcooling Verification Method.

The *Subcooling Verification Method* compares the actual subcooling temperature to the target value supplied by the manufacturer. The actual subcooling is the condenser saturation temperature ($T_{Condenser,\ Saturation}$) minus the liquid line temperature (T_{Liquid}).

11.5.3.18 Weigh-In Charging Procedure (RA3.2.3)

The weigh-in charging procedure charges the system by determining the appropriate weight of refrigerant based on the size of the equipment and refrigerant lines rather than by measuring steady-state performance of the system. Systems using the weigh-in procedure to meet the refrigerant charge verification requirement may not use group sampling procedures for HERS verification compliance.

The weigh-in procedure does not relieve the installer of the responsibility to comply with the required minimum system airflow.

There are two installer options for completing the weigh-in procedure. One involves adjusting the amount of refrigerant supplied by the manufacturer in a new system, as specified by the manufacturer (weigh-in charge adjustment). The other involves evacuating the entire system and recharging it with the correct total amount of refrigerant, by weight (weigh-in total charge).

The weigh-in charge adjustment procedure may be used only when a new factory-charged outdoor unit is being installed and the manufacturer provides adjustment specifications based on evaporator coil size and refrigerant line size and length.

The weigh-in total charge may be used for any weigh-in procedure but still requires manufacturer's adjustment specifications. Only the installer/technician may perform any kind of weigh-in procedure.

11.5.3.19 Equipment Limitations

The Energy Code specifically requires verification of refrigerant charge only for air-cooled air conditioners and air-source heat pumps. All other types of systems are not expressly exempt from the refrigerant charge requirements. Certain portions of the requirements may still apply, such as the minimum system airflow requirement. The installer would have to confirm with the manufacturer and the CEC. The installer must adhere strictly to the manufacturer's specifications.

Variable refrigerant flow systems and systems such as some mini-split systems that cannot be verified using the standard charge verification procedure in RA3.2.2 must demonstrate compliance using the weigh-in method. Verification by the HERS Rater can be accomplished only by simultaneous observation of the installer's weigh-in as specified by RA3.2.3.2, and only if use of HERS Rater observation procedure is specified by the Energy Code.

11.5.3.20 HERS Verification Procedures

When required by the CF1R, HERS Raters must perform field verification and diagnostic testing of the refrigerant charge, including verification of minimum system airflow and verification of installation of the measurement access hole.

The verification procedures are essentially identical for the rater and the installer except that the tolerances for passing the superheat and subcooling tests are less stringent for the rater's test. This is to allow for some variations in measurements due to instrumentation or test conditions (for example, weather).

The following conditions prohibit verification using sample groups:

1. When the weigh-in method is used

2. When the minimum airflow cannot be met despite reasonable remediation attempts. (See RA3.3.3.1.5).

As always, to be eligible for sampling, the installer must first verify and pass the system. If sampling is not being used, the rater will perform the verification only after the installer has charged the system according to manufacturer's specifications.

11.5.3.21 Winter Setup Procedures

Reference Appendix RA1 provides for the approval of special case refrigerant charge verification procedures. These protocols may be used only if the manufacturer has approved use of the procedure for their equipment.

One such procedure is found in RA1.2 Winter Setup for the standard charge verification procedure (winter charge setup). It provides for a modification to the standard charge procedure when temperature conditions do not allow use of the RA3.2.2 standard charge verification procedure.

The winter charge setup allows both installers and HERS Raters to verify the charge when outdoor temperatures are below the manufacturer's allowed temperature, or the outdoor temperature is less than 55°F. The Weigh-in Charging Procedure specified in RA3.2.3 may also be used when the outdoor temperatures are below the manufacturer's allowed temperature or below 55°F but may be used only by the installer.

The winter charge setup procedure allows the system to operate in the same range of pressure differences between the low-side pressure and the high-side pressure as occurs during warm outdoor temperatures, by restricting the airflow at the condenser fan outlet. The winter charge setup is used only for units equipped with variable metering devices, which include thermostatic expansion valves (TXV) and electronic expansion valves (EXV) for which the manufacturer specifies subcooling as the means for determining the proper charge for the unit, including units equipped with microchannel heat exchangers. Once this pressure differential is achieved, the variable metering device calculations are conducted in the same way as the variable metering device procedures described in RA3.2.2.6.2. All other applicable requirements in RA3.2.2 remain the same and must be completed when using the winter charge setup.

Though not specifically mentioned in the FID protocols in Residential Appendix RA3.4.2, the RA 1.2 winter setup method may be used if applicable. Thus, for FID verification, the winter setup method may be used in place of the subcooling method.

11.5.3.22 Using Weigh-In Charging Procedure at Low Outdoor Temperatures

When a new HVAC system is installed, the HVAC installer must check the refrigerant charge, and a HERS Rater must verify the correct charge; however, an exception to §150.1(c)7A provides for an alternative third-party HERS verification if the weigh-in method is used when the outdoor temperature is less than 55 degrees F.

Typically, when the weigh-in method is used by the installing contractor, a HERS Rater must perform a charge verification in accordance with the RA3.2. standard charge procedure. However, because the RA3.2.2 procedures cannot be used when the outdoor temperatures are less than 55 degrees, the Energy Code provides the installer with two choices:

1. Use the RA3.2.3.1 Installer Weigh-In Charging Procedure to demonstrate compliance and install an occupant-controlled smart thermostat (OCST)**.**
2. Wait for warmer temperatures then perform the standard charge verification procedure. In this case, the installer must agree to return to correct refrigerant charge if a HERS Rater determines later, when the outside temperature is 55 degrees F or above, that correction is necessary as described in Residential Appendix RA2.4.4. The installer must also provide written notice to the owner and enforcement agency that the charge has not yet been verified. An example owner's notification is shown in Figure 11-40.

Figure 11-40: Example of Notification to Owners of Delayed Charged Verification

<u>Note to Owner: We're not done yet!</u>

Congratulations on your new Air-Conditioning System! Your new system is more efficient than older systems and it has been installed to industry guidelines, ensuring many years of comfort and efficient service.

One thing you to know, however, is that the installation process is not complete! Because your unit was installed when the outside air temperature too low to fine tune the air conditioner, the unit must be serviced and verified when the weather is warmer.

This requires your cooperation. You need to allow access to the unit for your Installer and/or HERS Rater (verifier) to verify that the airflow is set correctly. Your project is not considered finished until this verification takes place. If it is not done, **your unit may cost more to operate, may not heat and cool as effectively and may not last as long.**

You will be contacted within the next few months to schedule this service. If you do not hear something after a few months of warmer weather, please contact your Installer. Enjoy your new system!

Source: California Energy Commission

11.5.3.23 Minimum System Airflow

Ducted forced-air cooling systems must comply with the minimum system airflow rate of greater than or equal to 350 CFM/ton, or 250 CFM/ton for small duct, high velocity systems, when performing the refrigerant charge verification. The airflow is important when performing the refrigerant charge verification to validate the measured values for pressure and temperature. The correct airflow will also improve the performance of the air-conditioning equipment.

The airflow verification procedure is documented in Reference Residential Appendix RA3.3.

11.5.3.24 Fault Indicator Display (FID)

The installation of an FID may be used as an alternative to the prescriptive requirement for HERS diagnostic testing of the refrigerant charge in air conditioners and heat pumps. The installation of an FID does not preclude the HVAC installer from having to properly charge the system with refrigerant. The FID provides real-time information to the building occupant or operator about the status of the system refrigerant charge, metering device, and system airflow. The FID will monitor and determine the operating performance of air conditioners and heat pumps and provide visual indication to the system owner or operator if the refrigerant charge, airflow, or metering device performance of the system does not conform to approved target parameters for minimally efficient operation. Thus, if the FID signals the owner/occupant that the system requires service or repair, the occupant or operator can immediately call for a service technician to make the necessary adjustments or repairs. An FID can provide significant benefit by alerting the owner/occupant to the presence of inefficient operation that could result in excessive energy use/costs over an extended period. An FID can also indicate system performance faults that could result in system component damage or failure if not corrected, thus helping the owner/occupant avoid unnecessary repair costs.

Fault indicator display technologies are expected to be installed at the factory; otherwise, they may be installed in the field according to manufacturer's specifications. Reference Joint Appendix JA6 contains more information about FID technologies.

The presence of an FID on a system must be field-verified by a HERS Rater or ATT. See Reference Residential Appendix RA3.4.2 for the HERS verification procedure, which consists of a visual verification of the presence of the installed FID technology. The Rater must inspect to see that the visual indication display component of the installed FID technology is mounted adjacent to the thermostat of the split system. When the outdoor temperature is greater than 55°F, the Rater must also observe that the system reports no system faults when the system is operated continuously for at least 15 minutes when the indoor air temperature returning to the air conditioner is at or above 70°F. When the outdoor temperature is below 55°F, the Rater must observe that the FID performs a self-diagnosis and indicates that the sensors and internal processes are operating properly.

11.5.3.25 Dwelling Unit Performance Approach

§170.1(d)

There are several options for compliance credit related to the dwelling unit heating and cooling system through the performance approach.

11.5.3.26 High-Efficiency Heating

Heating system efficiencies are explained in Chapter 11.6.3.1 0. The minimum efficiency is required for prescriptive compliance. When the performance approach is used, additional compliance credit may be available from higher efficiency heating equipment.

When a heat pump is providing space heating, if the efficiency used for compliance is higher than the minimum required HSPF, the system efficiency must be verified by a HERS Rater. Moreover, because the capacity of the heat pump affects the amount of back-up electric resistance heating required to attain and maintain comfort conditions, if the capacity proposed for compliance is different than the default capacity used in the compliance software, the Air Conditioning, Heating, and Refrigeration Institute (AHRI) ratings for heating capacity of the installed heat pump must be verified by a HERS Rater to confirm the heating capacities at 47°F and 17°F are equal or greater than the heating capacities given on the certificate of compliance. See RA3.4.4.2 for more information about this HERS verification

11.5.3.27 High-Efficiency Air Conditioner

Savings can be achieved by choosing an air conditioner that exceeds the minimum efficiency, SEER and (or) EER, requirements.

The EER is the full-load efficiency at specific operating conditions. It is possible that two units with the same SEER can have different EERs. In cooling climate zones of California, for two units with a given SEER, the unit with the higher EER is more effective in saving energy. Using the performance approach, credit is available for specifying an air conditioner with an EER greater than the minimums identified in Chapter 11.5.3. When credit is taken for a high EER and/or SEER, field verification by a HERS Rater or ATT is required. (See Reference Residential Appendix RA3.4.4).

11.5.3.28 Central Fan Ventilation Cooling

Central fan ventilation cooling performs a function similar to a WHF using the central space-conditioning ducts to distribute outside air. There is no performance credit for central fan ventilation cooling because the compliance software does not include it as an option.

11.5.3.29 Zonal Control

A credit is provided for zoned heating systems, which save energy by providing selective conditioning for only the occupied areas of a dwelling unit. A dwelling unit having at least two zones (living and sleeping) may qualify for this compliance credit. The equipment may consist of one heating system for the living areas and another system for sleeping areas or a single system with zoning capabilities, set to turn off the sleeping areas in the daytime and the living area unit at night. This compliance credit is not commonly applied in multifamily buildings.

There are unique eligibility and installation requirements for zonal control to qualify under the Energy Code. The following steps must be taken for the building to show compliance with the Energy Code under this exceptional method:

1. **Temperature Sensors**. Each thermal zone, including a living zone and a sleeping zone, must have air temperature sensors that provide accurate temperature readings of the typical condition in that zone.
2. **Habitable Rooms**. For systems using central forced-air or hydronic heating, each habitable room in each zone must have a source of space heating, such as forced-air supply registers, radiant tubing, or a radiator. For systems using a combination of a central system and a gas-vented fireplace or other conditioning units, the zone served by the individual conditioning unit can be limited to a single room. Bathrooms, laundry, halls and/or dressing rooms are not habitable rooms.
3. **Noncloseable Openings**. The total noncloseable opening area (W) between adjacent living and sleeping thermal zones (such as halls, stairwells, and other openings) must be less than or equal to 40 ft^2. All remaining zonal boundary areas must be separated by permanent floor-to-ceiling walls and/or fully solid, operable doors capable of restricting free air movement when closed.
4. **Thermostats**. Each zone must be controlled by a central automatic dual-setback thermostat that can control the conditioning equipment and maintain preset temperatures for varying periods in each zone independent of the other. Thermostats controlling vented gas fireplace heaters that are not permanently mounted to a wall are acceptable as long as they have the dual-setback capabilities.

Other requirements specific to forced-air-ducted systems include the following:

1. Each zone must be served by a return air register located entirely within the zone. Return air dampers are not required.
2. Supply air dampers must be manufactured and installed so that when they are closed, there is no measurable airflow at the registers.
3. The system must be designed to operate within the equipment manufacturer's specifications.
4. Air is to positively flow into, though, and out of a zone only when the zone is being conditioned. No measurable amount of supply air is to be discharged into unconditioned or unoccupied space to maintain proper airflow in the system.

Although multiple thermally distinct living and/or sleeping zones may exist in a residence, the correct way to model zonal control for credit requires only two zones: a living zone and a sleeping zone. All separate living zone components must be modeled as one living zone; the same must be done for sleeping zones.

11.5.3.30 Alternative Systems

Alternative system types can comply through the performance approach. Chapter 11.6.6 describes some common alternative systems used in dwelling units and the associated code requirements.

11.5.4 Dwelling Unit Air Distribution System Ducts, Plenums, Fans, and Filters

Air distribution system performance impacts overall HVAC system efficiency. Therefore, air distribution systems are required to meet several mandatory and prescriptive requirements as discussed below.

The Energy Code requires that air distribution ducts to be sealed and tested in all climate zones. There are also several compliance credits available related to duct system design.

Duct efficiency is affected by the following parameters:

- Duct location (attic, crawlspace, basement, inside conditioned space, or other)
- Specific conditions in the unconditioned space, for example, presence of a radiant barrier
- Duct insulation characteristics
- Duct surface area
- Air leakage of the duct system

In performance calculations, duct efficiency can be calculated in one of two ways:

- Default input assumptions
- Diagnostic measurement values

The compliance software uses default assumptions for the proposed design when the user does not include improvements in duct efficiency.

11.5.4.1 Dwelling Unit Mandatory Requirements

Unless otherwise noted, the enforcement of these minimum standards is normally the responsibility of the building official. HERS Raters or ATTs may also verify compliance with these requirements in conjunction with mandatory testing.

11.5.4.2 Duct Installation Standards

§160.3(b)5A

Duct construction must comply with the California Mechanical Code Sections 601, 602, 603, 604, 605, and the applicable requirements of the Energy Code. Some highlights of these requirements are listed in this section, along with some guidance for recommended quality construction practice.

Q. Minimum Insulation

§160.3(b)5Aii

Portions of supply-air and return-air ducts and plenums that are not installed entirely in conditioned space must have an R-value of R-6. Ducts installed in conditioned space do not require insulation if the following conditions are met and verified by visual inspection by the building department:

- The non-insulated portion of the duct system is located entirely inside conditioned space within the building's thermal envelope.
- At all locations where non-insulated portions of the duct system penetrate unconditioned space, the penetration must be draft stopped compliant with California Fire Code (CFC) sections 703.1 and 704.1 and air-sealed with materials complaint with CMC section E502.4.2. All connections in unconditioned space must be insulated to at least R-6.0.

CFC Sections 703.1 and 704.1 require that materials and firestop systems used through penetrations in fire-resistance-rated construction, construction installed to resist the passage of smoke, and materials and systems used to protect joints and voids in the following locations must be maintained.

- Joints in or between fire-resistance-rated walls, floors or floor/ceiling assemblies and roof or roof/ceiling assemblies.
- Joints in smoke barriers.
- Voids at the intersection of a horizontal floor assembly and an exterior curtain wall.
- Voids at the intersection of a horizontal smoke barrier and an exterior curtain wall.
- Voids at the intersection of a nonfire-resistance-rated floor assembly and an exterior curtain wall.
- Voids at the intersection of a vertical fire barrier and an exterior curtain wall.
- Voids at the intersection of a vertical fire barrier and a nonfire-resistance-rated roof assembly.

The materials and systems must be securely attached to or bonded to the construction being penetrated or the adjacent construction, with no openings visible through or into the cavity of the construction.

CMC E502.4.2 requires that all joints, seams, and penetrations of must be made airtight by means of mastics, gasketing, or other means.

Alternatively, ducts may be uninsulated if the entire duct system is verified to be entirely in conditioned space as defined in §100.1 by visual inspection and by using the protocols of RA3.1.4.3.8. For buildings with four or more habitable stories, testing may be conducted by the installing contractor and verified by the enforcement agency field inspector. For buildings with up to three habitable stories, the testing and visual inspection must be conducted by a HERS Rater.

RA3.1.4.3.8 describes the duct leakage to outside test that determines whether the ducts are within the pressure boundary of the space being served by the duct system. A basic visual inspection of the ducts ensures that no portion of the duct system is obviously outside the apparent pressure/thermal boundary.

Leakage to outside means conditioned air leaking from the ducts to anywhere outside the pressure boundary of the dwelling unit conditioned space served by the duct system, which includes leakage to outside the building and leakage to adjacent dwelling units or other interior building spaces.

Exception to §160.3(b)5A: Ducts and fans integral to a wood heater or fireplace are exempt from §160.3(b)5A.

§160.3(b)5E

For determining the installed R-value of duct insulation based on thickness, when not an integral part of a manufacturer-labeled, insulated duct product such as vinyl flex duct, the following must be used:

- For duct wrap, the installed thickness of insulation must be assumed to be 75 percent of the nominal thickness due to compression.
- For duct board, duct liner, and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness must be used.

Example 11-30

Question

I have a five-story multifamily building with individual ducted heat pumps serving the dwelling unit. The ducts and equipment are located in a dropped soffit within conditioned space. Do I need to insulate the ducts?

Answer

No, if the duct system is entirely in the conditioned space there is no insulation requirement.

Question

What if I have the same scenario in a three-story multifamily building?

Answer

The duct system does not need to be insulated. There is a performance credit available if the ducts are tested by a HERS Rater to meet no greater than 25 CFM leakage to outside per RA3.1.4.3.8.

R. Joints

§160.3(b)5

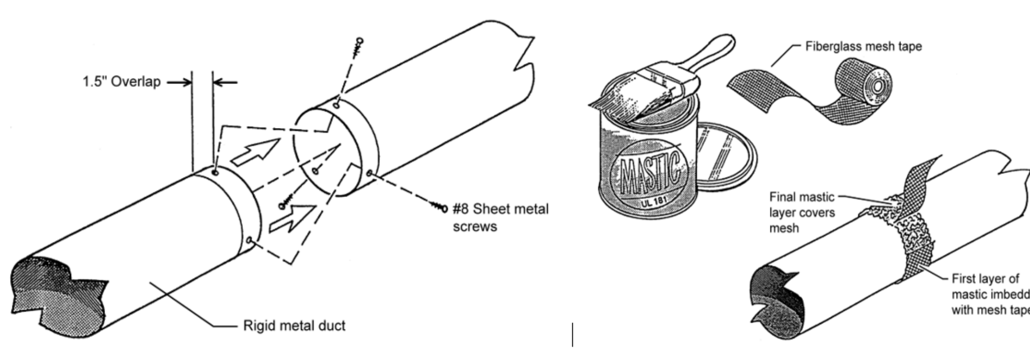
All joints must be sealed to be airtight with either mastic, tape, aerosol sealant, or other duct-closure system that meets the applicable requirements of UL 181, UL 181A, UL 181B, or UL 723. Duct systems must not use cloth-backed, rubber-adhesive duct tape regardless of UL designation, unless it is installed in combination with mastic and clamps. The CEC has approved three cloth-backed duct tapes with special butyl synthetic adhesives rather than rubber adhesive to seal flex duct to fittings. These tapes are:

1. Polyken 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
2. Nashua 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
3. Shurtape PC 858CA, manufactured by Shurtape Technologies, Inc.

These tapes passed Lawrence Berkeley Laboratory tests comparable to those that cloth-backed, rubber-adhesive duct tapes failed. (The LBNL test procedure has been adopted by the American Society of Testing and Materials as ASTM E2342.) These tapes are allowed to be used to seal flex duct to fittings without being in combination with mastic. These tapes cannot be used to seal other duct system joints, such as the attachment of fittings to plenums and junction boxes. These tapes have on the backing a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition) to illustrate where they are not allowed to be used, installation instructions in the packing boxes that explain how to install them on duct core to fittings, and a statement that the tapes cannot be used to seal fitting to plenum and junction box joints.

Mastic and mesh should be used where round or oval ducts join flat or round plenums. (See Figure 11-36.)

Figure 11-36: Sealing Metallic Ducts with Mastic and Mesh

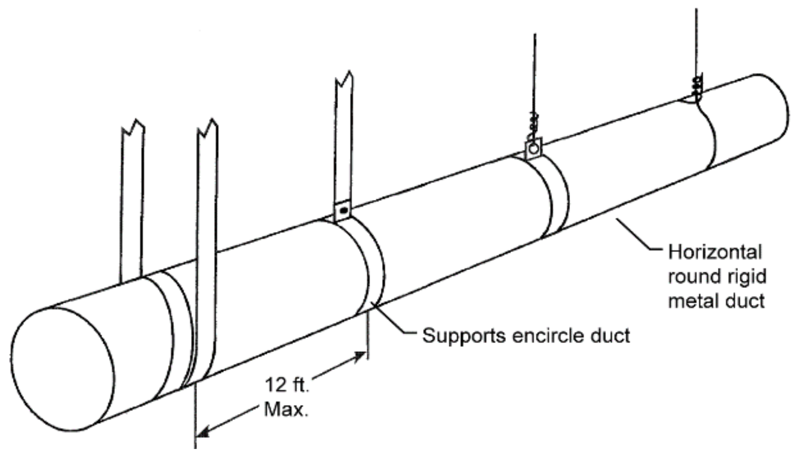


Source: Richard Heath & Associates/Pacific Gas and Electric Company

All ducts must be adequately supported. Rigid ducts and flex ducts may be supported on rigid building materials between ceiling joists or on ceiling joists.

For rigid round metal ducts that are suspended from above, hangers must occur 12 ft. apart or less (See Figure 11-37).

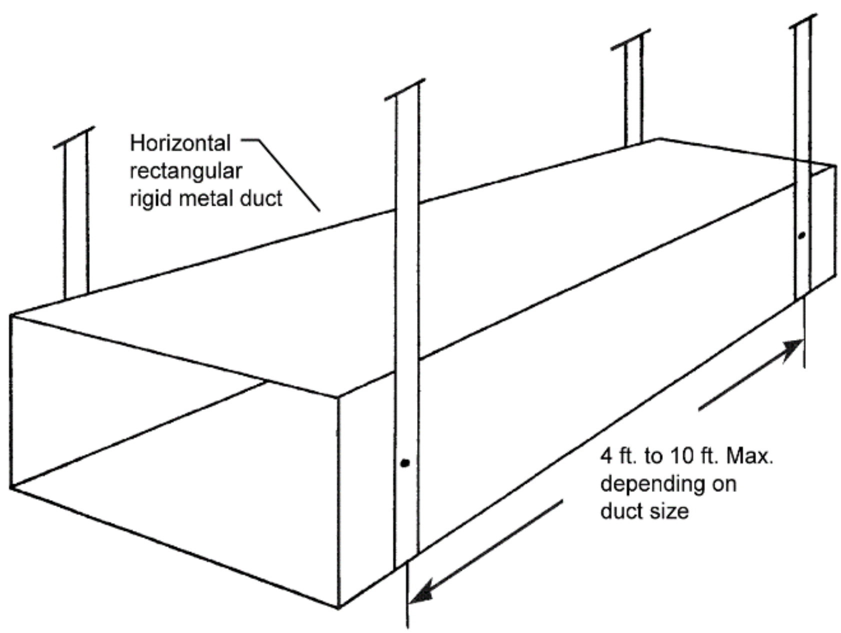
Figure 11-37: Options for Suspending Rigid Round Metal Ducts



Source: Richard Heath & Associates/Pacific Gas and Electric Company

For rectangular metal ducts that are suspended from above, hangers must occur at a minimum of 4 ft. to 10 ft., depending on the size of the ducts (refer to Figure 11-38).

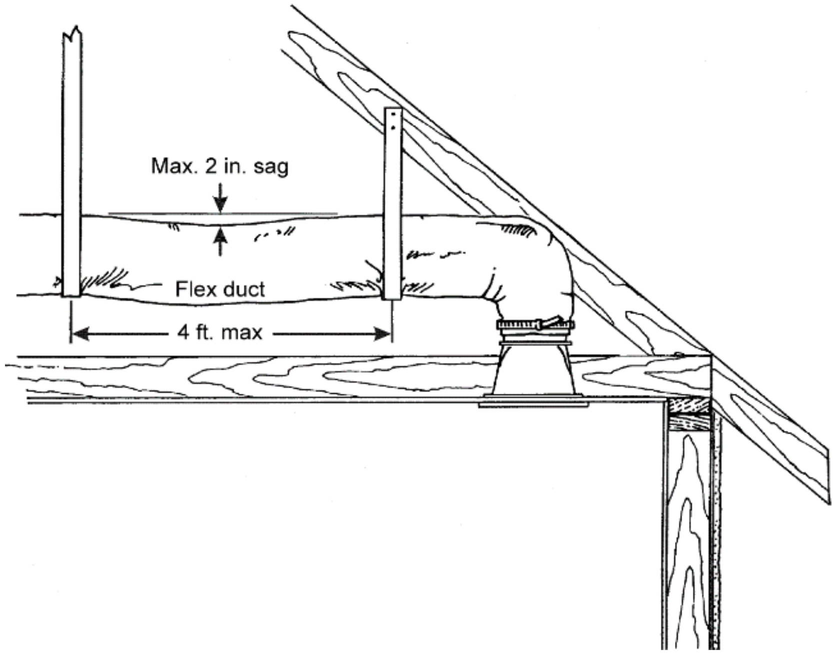
Figure 11-38: Options for Suspending Rectangular Metal Ducts



Source: Richard Heath & Associates/Pacific Gas and Electric Company

For flex ducts that are suspended from above, hangers must occur at 4 ft. apart or less, and all fittings and accessories must be supported separately by hangers (See Figure 11-39).

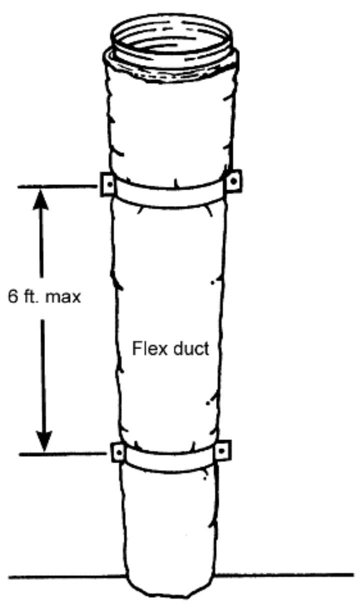
Figure 11-39: Minimum Spacing for Suspended Flex Ducts



Source: Richard Heath & Associates/Pacific Gas and Electric Company

For vertical runs of flex duct, support must occur at 6 ft. intervals or less (See Figure 11-40).

Figure 11-40: Minimum Spacing for Supporting Vertical Flex Ducts

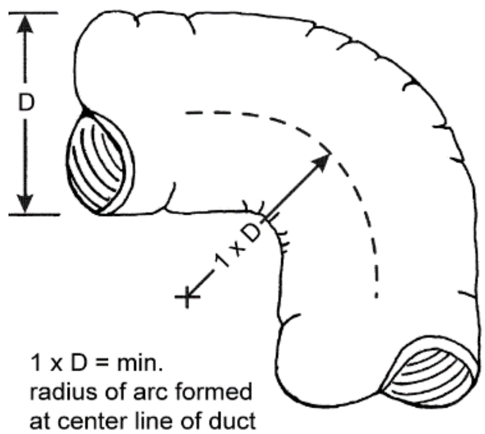


Source: Richard Heath & Associates/Pacific Gas and Electric Company

The routing and length of all duct systems can have significant effects on system performance, due to possible increased airflow resistance. The CEC recommends using the minimum length of duct to make connections and the minimum possible number of turns.

For flexible ducts, the CEC recommends fully extending the duct by pulling the duct tightly, cutting off any excess duct, avoiding bending ducts across sharp corners or compressing them to fit between framing members (See Figure 11-41) and avoiding incidental contact with metal fixtures, pipes, or conduits or installation of the duct near hot equipment such as furnaces, boilers, or steam pipes that are above the recommended flexible duct use temperature.

Figure 11-41: Minimizing Radius for Flex Duct Bends



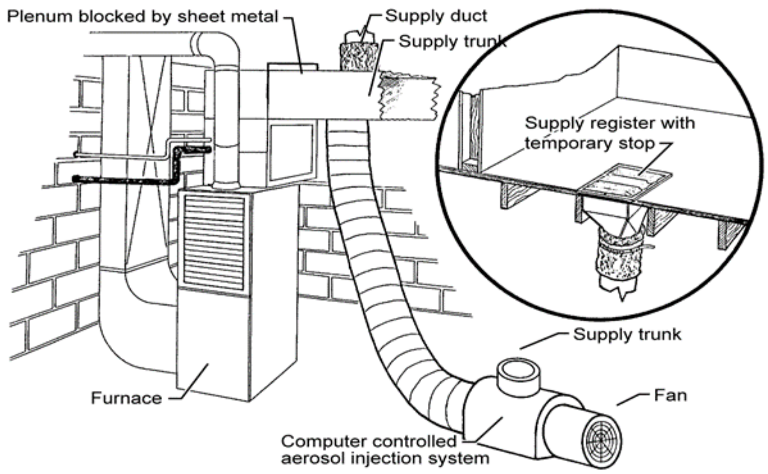
Source: Richard Heath & Associates/Pacific Gas and Electric Company

All joints between two sections of duct must be mechanically fastened and substantially airtight. For a flex duct, this must consist of a metal sleeve no less than four inches between the two sections of flex duct.

All joints must be properly insulated. For flex ducts, installers must pull the insulation and jacket back over the joint and use a clamp or two wraps of tape. Aerosol sealant injection systems are an alternative that typically combines duct testing and duct sealing in one process.

Figure 11-42 shows the computer-controlled injection fan temporarily connected to the supply duct. The plenum is blocked off by sheet metal to prevent the sealant from entering the furnace. Supply air registers are also blocked temporarily to keep the sealant out of the house. Ducts must still be mechanically fastened even if an aerosol sealant system is used.

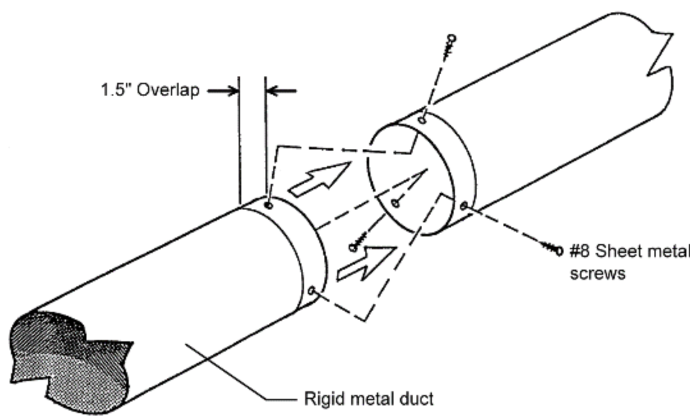
Figure 11-42: Computer-Controlled Aerosol Injection System



Source: Richard Heath & Associates/Pacific Gas and Electric Company

All joints must be mechanically fastened. For residential round metal ducts, installers must overlap the joint by at least 1½ inches and use three sheet metal screws equally spaced around the joint (See Figure 11-43).

Figure 11-43: Connecting Round Metallic Ducts

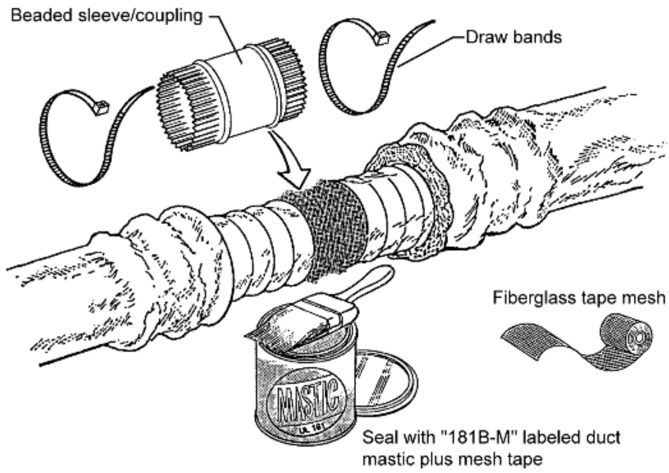


Source: Richard Heath & Associates/Pacific Gas and Electric Company

For round, nonmetallic flex ducts, installers must insert the core over the metal collar or fitting by at least one inch. This connection may be completed with either mesh, mastic and a clamp, or two wraps of tape and a clamp.

For a mesh and mastic connection, the installer must first tighten the clamp over the overlapping section of the core, apply a coat of mastic covering both the metal collar and the core by at least one inch, and then firmly press the fiber mesh into the mastic and cover with a second coat of mastic over the fiber mesh (See Figure 11-44).

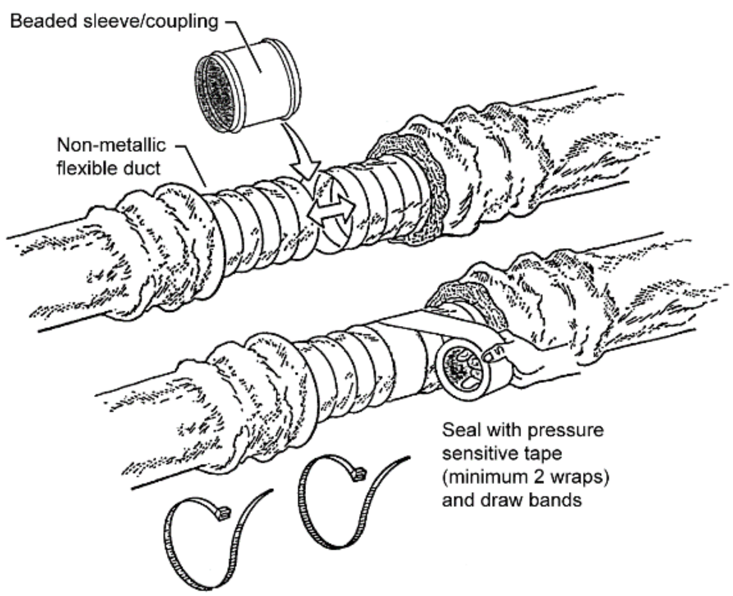
Figure 11-44: Connecting Flex Ducts Using Mastic and Mesh



Source: Richard Heath & Associates/Pacific Gas and Electric Company

For the tape connection, first apply at least two wraps of approved tape covering both the core and the metal collar by at least one inch, then tighten the clamp over the overlapping section of the core (See Figure 11-45).

Figure 11-45: Connecting Flex Ducts Using Tape and Clamps



Source: Richard Heath & Associates/Pacific Gas and Electric Company

S. Factory-Fabricated Duct Systems

§160.3(b)5B

Factory-fabricated duct systems must comply with the following requirements:

- All factory-fabricated duct systems must comply with UL 181 for ducts and closure systems, including collars, connections, and splices, and be labeled as complying with UL 181.

- All pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts must comply with UL 181 and UL 181A.
- All pressure-sensitive tapes and mastics used with flexible ducts must comply with UL 181 and UL 181B.
- Joints and seams of duct systems and related components cannot be sealed with cloth-backed rubber adhesive duct tapes unless such tape is used in combination with mastic and draw bands.
- The tape has on the backing the phrase "CEC approved," a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition), and a statement that it cannot be used to seal fittings to plenums and junction box joints.

T. Field-Fabricated Duct Systems

§160.3(b)5C

Field-fabricated duct systems must comply with the following requirements:

- Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems must comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants, or other closure systems used for installing field-fabricated duct systems must meet the applicable requirements of UL 181, UL 181A, and UL 181B.
- Mastic sealants and mesh:
  - Sealants must comply with the applicable requirements of UL 181, UL 181A, and/or UL 181B and be nontoxic and water-resistant.
  - Sealants for interior applications must be tested in accordance with ASTM C731 and D2202.
  - Sealants for exterior applications must be tested in accordance with ASTM C731, C732, and D 2202.
  - Sealants and meshes must be rated for exterior use.
- Pressure-sensitive tapes must comply with the applicable requirements of UL 181, UL 181A, and UL 181B.
- Joints and seams of duct systems and their components must not be sealed with cloth-backed rubber adhesive duct tapes unless such tape is used in combination with mastic and draw bands.
- The tape has on the backing the phrase "CEC approved," a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition), and a statement that it cannot be used to seal fittings to plenums or junction box joints.

U. Flexible Duct Draw Bands

- Draw bands must be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.
- Draw bands must have a minimum tensile strength rating of 150 pounds.
- Draw bands must be tightened as recommended by the manufacturer with an adjustable tensioning tool.

V. Aerosol-Sealant Closures

- Aerosol sealants must meet the requirements of UL 723 and be applied according to manufacturer specifications.
- Tapes or mastics used in combination with aerosol sealing must meet the requirements of this section.

If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape must be used.

Building spaces such as cavities between walls, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board, or flexible duct must not be used for conveying conditioned air, including return air and supply air. Using drywall materials as the interior surface of a return plenum is not allowed. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms must not be compressed to cause reductions in the cross-sectional area of the ducts. Although a HERS Rater or acceptance test technician may examine this as a part of his or her responsibilities when involved in a project, the enforcement of these minimum standards for ducts is the responsibility of the building official.

W. Product Markings

§160.3(b)5Bi, §160.3(b)5F

All factory-fabricated duct systems must meet UL 181 for ducts and closure systems and be labeled as complying with UL 181. Collars, connections, and splices are factory-fabricated duct systems and must meet the same requirement.

Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of three ft., showing the R-value for the duct insulation (excluding air films, vapor barriers, or other duct components), based on the tests and thickness specified in §160.3(b)5D and §160.3(b)5Eiii.

X. Dampers to Prevent Air Leakage

§160.3(b)5G

Fan systems that exhaust air from the building to the outside must be provided with back draft or automatic dampers.

§160.3(b)5H

Gravity ventilating systems must have an automatic or readily accessible, manually operated damper in all openings to the outside, except combustion inlet, outlet air openings, and elevator shaft vents. This includes clothes dryer exhaust vents when installed in conditioned space.

Y. Protection of Insulation

§160.3(b)5I

Insulation must be protected from damage, including damage from sunlight, moisture, equipment maintenance, and wind, but not limited to the following:

- Insulation exposed to weather must be suitable for outdoor service, for example, protected by aluminum, sheet metal, painted canvas, or plastic cover.
- Cellular foam insulation must be protected as above or painted with a coating that is water-retardant and shields from solar radiation that can degrade the material.

Z. Porous Inner Core Flex Duct

§160.3(b)5J

Over time, the outer vapor barrier of flex duct can degrade and be easily damaged. Therefore, porous inner core flex duct must have a non-porous layer or air barrier between the inner core and the outer vapor barrier.

11.5.4.3 Duct System Sealing and Leakage Testing

§160.3(b)5K

Duct system sealing and leakage testing is mandatory in all climate zones. Duct systems in newly constructed multifamily dwellings are required to comply with the requirements regardless of the duct system location, except for buildings with four or more habitable stories in Climate Zone 1, 3, 5, and 7, which are exempt from the testing requirements. When the air-handling unit is installed and the ducts connected directly to the air handler, the total leakage of the duct system must not exceed 12% of the nominal system air handler airflow or the duct system leakage to outside must not exceed 6% of the nominal system air handler airflow.

The duct system leakage must be determined according to the applicable procedures outlined in RA3.1.4.3. Verification of duct leakage must be conducted by a HERS Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings in Climate Zones 2, 4, 6, and 8-16, testing only needs to be conducted and certified by the installing contractor and neither a HERS Rater nor registration with a HERS Provider is required. Entirely new or complete replacement duct systems as part of an addition or alteration in all climate zones are required to comply with these mandatory maximum leakage criteria. A duct system in an existing building is considered entirely new when:

- At least 75% of the duct material is new.
- All remaining components from the previous system are accessible and can be sealed.

11.5.4.4 Air Filtration

§160.2(b)1

Air filtration is used in forced air systems to protect the equipment from dust accumulation that could reduce the capacity or efficiency of the system. Preventing dust buildup may also prevent the system from becoming a host to biological contaminants such as mold, especially if dust is deposited on cooling coils that become wet from water condensation during comfort cooling operation. Air filter efficiencies of Minimum Efficiency Reporting Value (MERV) 6 to MERV 8 are sufficient for protection from these large airborne dust particles. Air filter efficiencies of at least MERV 13 are needed to protect occupants from exposure to the smaller airborne particles that are known to adversely affect respiratory health. These smaller particles are often referred to as PM 2.5, which refers to particulate matter of 2.5 microns or smaller. PM2.5 is produced from several sources including combustion from cooking and from exhaust from motor vehicles that enters a dwelling through ventilation openings and infiltration.

AA. Air Filter Pressure Drop

Standards §160.2(b)1D requires all systems to be designed to accommodate the clean-filter pressure drop imposed by the system air filter device(s). This applies to space-conditioning systems and to the ventilation system types described in the *Air Filter Particle Removal Efficiency Requirements – MERV 13* section. The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter device must be determined and posted on a sticker or label by the installer inside the filter grille or near the filter rack, according to *Air Filter Particle Removal Efficiency Requirements – MERV 13* section below.

Designers of space-conditioning systems must determine the total system external static pressure losses from filters, coils, ducts, and grilles, such that the sum is not greater than the available static pressure of the air handling unit at the design airflow rate. Therefore, air filters should be sized to minimize static pressure drop across the filter during system operation. The air filter pressure drop can be reduced by increasing the amount of air filter media surface area available to the system airflow. Increased media surface area can be accomplished by adjusting one, two, or all three of the following factors:

- **Adjust the number of pleats of media per inch inside the air filter frame.** The number of pleats per inch inside the filter frame is determined by the manufacturer's filter model design and is held constant for all filter sizes of the same manufacturer's model. For example, all 3M Filtrete 1900 filters will have the same media type, the same MERV rating, and the same number of pleats of media per inch inside the filter frame regardless of whether the nominal filter size is 20" X 30" or 24" X 24", and so forth. Generally, as the number of pleats per inch is increased, the pressure drop is reduced if all other factors remain constant. The pressure drop characteristics of air filters vary widely between air filter manufacturers and between air filter models, largely because of the number of pleats per inch in the manufacturer's air filter model design. System designers and system owners cannot change the manufacturer's filter model characteristics, but they can select a superior air filter model from a manufacturer that provides greater airflow at a lower pressure drop by comparing the filter pressure drop performance shown on the air filter manufacturer's product label (see example label in Table 11).

- **Adjust the face area of the air filter and filter grille.** Face area is the nominal cross-sectional area of the air filter, perpendicular to the direction of the airflow through the filter. Face area is also the area of the filter grille opening in the ceiling or wall. The face area is determined by multiplying the length times width of the filter face (or filter grille opening). The nominal face area for a filter corresponds to the nominal face area of the filter grille in which the filter is installed. For example, a nominal 20" X 30" filter has a face area of 600 in^2 and would be installed in a nominal 20" X 30" filter grille. Generally, as the total system air filter face area increases, the pressure drop is reduced if all other factors remain constant. Total system air filter face area can be increased by specifying a larger area filter/grille or by using additional/multiple return filters/grilles, summing the face areas. The filter face area is specified by the system designer or installer.
- **Adjust the depth of the filter and filter grille.** Air filter depth is the nominal filter dimension parallel to the direction of the airflow through the filter. Nominal filter depths readily available for purchase include one, two, four, and six inches. Generally, as the system air filter depth increases, the pressure drop is reduced if all other factors remain constant. For example, increasing filter depth from one inch to two inch nominally doubles the filter media surface area without increasing the filter face area. The filter depth is specified by the system designer or installer.

BB. Air Filter Particle Removal Efficiency Requirements – MERV 13

An air filter with a particle removal efficiency equal to or greater than MERV 13 or a particle size efficiency rating equal to or greater than 50 percent in the

0.30-1.0 μm range, and it is and equal to or greater than 85 percent in the 1.0-3.0 μm range is required for the following systems:

- Mechanical space conditioning (heating or cooling) systems with a total of more than 10 ft. of duct. The total is determined by summing the lengths of all the supply and return ducts for the forced-air system.
- Mechanical supply-only ventilation systems that provide outside air to an occupiable space.
- The supply side of mechanical balanced ventilation systems, including heat recovery ventilation systems and energy recovery ventilation systems that provide outside air to an occupiable space.

Evaporative coolers are exempt from the air filtration requirements.

CC.Air Filter Requirements for Space-Conditioning Systems:

- Space conditioning systems may use any of the three following compliance approaches:
- Install a filter grille or accessible filter rack that accommodates a minimum 2-inch depth filter and install the appropriate filter.
- Install a filter grille or accessible filter rack that accommodates a minimum 1″ depth filter and install the appropriate filter. The filter/grille must be sized for a velocity of ≤ 150 ft per minute. The installed filter must be labeled to indicate the pressure drop across the filter at the design airflow rate for that return is ≤ 0.1 inch water column (w.c. [25 PA]).

Use the following method to calculate the 1" depth filter face area required. Divide the design airflow rate (ft^3/min) for the filter grille/rack by the maximum allowed face velocity 150 ft/min. This yields a value for the face area in ft^2. Since air filters are sold using nominal sizes in terms of inches, convert the face area to in^2 by multiplying the face area (ft^2) by a conversion factor of 144 in^2/ft^2. Summarizing:

Filter Nominal Face Area (in^2) = airflow (CFM) ÷ 150 x 144

- Comply with Standards Tables 160.3-A and B, which prescribe the minimum total system nominal filter face area and return duct size(s). The installed filter must be labeled to indicate the pressure drop across the filter at the design airflow rate for that return is ≤ 0.1 inch w.c. (25 PA). This option is an alternative to the §160.3(b)5L requirement for HERS-verified fan efficacy and airflow rate, but it requires instead a HERS verification of the return duct design.

DD. Air Filter Requirements for Ventilation Systems

- Filters with a depth of 1″ or greater are allowed.

- The design airflow rate, and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter device, must be determined by the system designer or installer and that information must be posted on a sticker by the installer inside or near the filter grille/rack according to Chapter 11.6.4.10FF.
- Ventilation systems must deliver the volume of air specified by §160.2(b)2 with filters in place.

EE. Filter Access and Filter Grille Sticker: Design Airflow and Pressure Drop

All filters used in all system types must be accessible to facilitate replacement.

- **Air filter grille sticker**. The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter grille/rack must be determined by the designer/installer and posted on a sticker placed by the installer inside or near the filter grille/rack. The design airflow and initial resistance posted on this sticker should correspond to the conditions used in the system design calculations. This requirement applies to space conditioning systems and also to the ventilation system types described in *Air Filter Particle Removal Efficiency Requirements – MERV 13* section above.

An example of an air filter grille sticker showing the design airflow and pressure drop for the filter grille/rack is shown in Table 11-33.

- **Air filter manufacturer label.** Space-conditioning system filters are required to be labeled by the manufacturer to indicate the pressure drop across the filter at several airflow rates. For the system to comply, and to ensure adequate airflow for efficient heating and cooling equipment operation, the manufacturer's air filter label must display information that indicates the filter can meet the design airflow rate for that return grille/rack at a pressure drop ≤ the value shown on the installer's filter grille sticker. This requirement does not apply to the ventilation system types described in *Air Filter Particle Removal Efficiency Requirements – MERV 13* section above.

Table 11-33: Example of Installer's Filter Grille Sticker

Air Filter Performance Requirement	Air Filter Performance Requirement	Maintenance Instructions
Airflow Rate (CFM) Must be greater than or equal to the value shown	Initial Resistance (IWC) Must be less than or equal to the value shown	Use only replacement filters that are rated to simultaneously meet both of the performance requirements specified on this sticker:

Air Filter Performance Requirement	Air Filter Performance Requirement	Maintenance Instructions
750	0.1	Left Blank

Source: California Energy Commission

Figure 11-46: Example Manufacturer's Filter Label

MERV	(µm)	0.30-1.0	1.0-3.0	3.0-10	Airflow Rate (CFM)	615	925	1230	1540	2085*	*Max Rated Airflow
13	PSE (%)	62	87	95	Initial Resistance (IWC)	0.07	0.13	0.18	0.25	0.38	

Source: California Energy Commission

FF. Air Filter Selection

For a filter to meet the system specifications for airflow and pressure drop, it must be rated by the manufacturer to provide more than the specified airflow at less than the specified pressure drop. It is unlikely that a filter will be available that is rated to have the exact airflow and pressure drop ratings specified, so filters should be selected that are rated to have less than the specified pressure drop at the specified airflow rate. Otherwise, select filters that are rated to have greater than the specified airflow rate at the specified pressure drop. See Table 11-34 for an example of an installer's filter grille sticker that provides an air filter rating specification for minimum airflow of 750 CFM at maximum pressure drop 0.1 inch w.c.

Manufacturers of air filters may make supplementary product information available to consumers that will assist with selecting the proper replacement filters. This product information may provide more detailed information about the filter model airflow and pressure drop performance – details such as airflow and pressure drop values that are intermediate values that lie between the values shown on their product label. The information may be published in tables, graphs, or presented in software applications available on the internet or at the point of sale.

Figure 11-47 below shows a graphical representation of the initial resistance (pressure drop) and airflow rate ordered pairs given on the example air filter manufacturer's label shown in Figure 11-49 above. The graph in Figure 11-47 makes it possible to visually determine the airflow at 0.1 inch w.c. pressure drop for which the values are not shown on the manufacturer's filter label.

If there is no supplementary manufacturer information available, and it is necessary to determine the performance of a filter model at an airflow rate or pressure drop between two values shown on a manufacturer's label, linear interpolation may be used. Linear interpolation apps are readily available on the internet, and formulas for linear interpolation are shown below.

The linear interpolation method may be used to determine an unknown pressure drop corresponding to a known airflow rate by use of Equation 11-2a, or it may also be used to determine an unknown airflow rate corresponding to a known pressure drop by use of Equation 11-2b.

$p = p_1 + [(f-f_1) \div (f_2-f_1)] \times (p_2 - p_1)$ Equation 11-2a

where:

f = a known flow value between f_1 and f_2

p = the unknown pressure drop value corresponding to f.

p_1 and p_2 = known values that are less than and greater than p respectively.

f_1 and f_2 are the known values corresponding to p_1 and p_2.

$f = f_1 + [(p-p_1) \div (p_2-p_1)] \times (f_2 - f_1)$ Equation 11-2b

where:

p = a known pressure drop value between p_1 and p_2

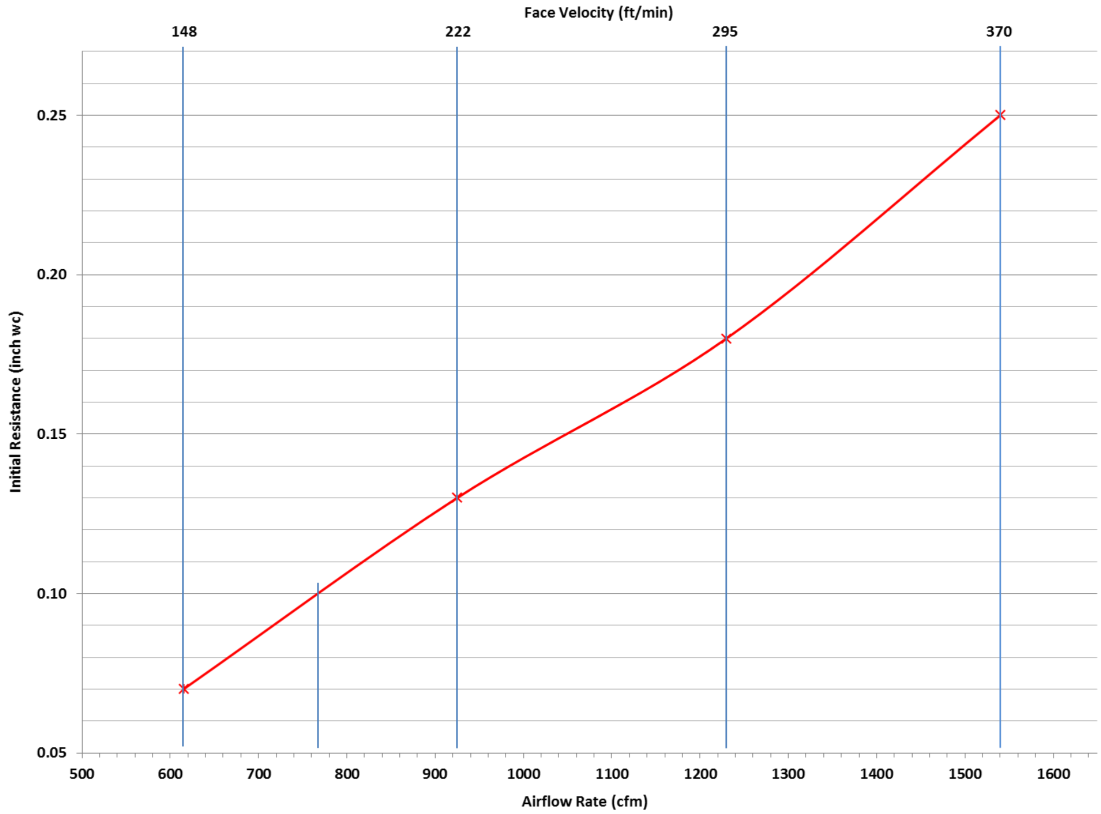
f = the unknown flow value corresponding to p.

f_1 and f_2 = known values that are less than and greater than f respectively.

p_1 and p_2 are the known values corresponding to f_1 and f_2.

See Example 11-31 for sample calculations that determine the rated airflow of the filter corresponding to a known pressure drop specification (0.1 inch w.c.).

Figure 11-47: Plot of Pressure drop vs. Airflow for a 20" X 30" X 1" Depth Air Filter



From Manufacturer Label Information

H. Preventing Bypass

Any gaps around an air filter allows air to bypass the filter. The Energy Code requires that filter racks and grilles use gaskets, sealing, or other means to close gaps around inserted filters and prevent air from bypassing the filter. Filter racks and grilles include any device that houses the air filter used to satisfy the air filtration requirements.

Example 11-31: Filter Selection Using Linear Interpolation

Question

Does the air filter label in Figure 11-49 indicate the filter would meet the airflow (750 CFM) and pressure drop (0.1 inch w.c.) requirements shown on the installer filter grille sticker in Table 11? How can I determine the filter's airflow rate at 0.1 inch w.c. for the manufacturer's filter label shown in Figure 11-49?

Answer

The filter must be rated to provide greater than 750 CFM at the specified 0.1 inch w.c. pressure drop, or equivalently: the filter must be rated to provide a pressure drop less than 0.1 inch w.c. at the specified 750 CFM.

Referring to Equation 11-2b, we calculate the unknown value "f" in CFM that corresponds to the known value "p" of 0.1 inch w.c.

Referring to Figure 4-5: p1=0.07, p2=0.13, f1=615, f2=925, and applying Equation 11-2b:

615 + [(0.1-0.07) ÷ (0.13-0.07)] x (925-615) yields 770 CFM

Therefore, since the filter is rated for greater than 750 CFM at 0.1 inch w.c., the filter complies.

Example 11-32: Filter Sizing

Question

I am installing a 1,200 CFM furnace in a new house. It has a 20" x 20" x 1” inch filter rack furnished with a 1" depth filter installed in the unit. Is this filter in compliance?

Answer

The nominal face area of the filter rack is 20" x 20" = 400 in^2, and since it is a 1” filter, the face area may not be less than 1,200 (CFM)/150x144 (in^2 / ft^2) = 1,152 in^2. Therefore, this filter installation does not comply.

Example 11-33

Question

For the same 1,200 CFM furnace, what other options do I have?

Answer

Option 1: The filter will be in compliance if it has a depth of 2 inches or more and is properly sized by the system designer such that the duct system as a whole will be capable of meeting the HERS verification for fan efficacy specified in §160.3(b)5L.

Otherwise, the required total system filter face area of 1,152 in^2 must be met using multiple remote wall or ceiling filter grilles for which the sum of the face areas is equal to or greater than 1152 in^2, and the filters must be rated for pressure drop of 0.1 inch w.c. or less at the design airflow rates of each filter grille.

Option 2: Table 160.3-A may be used for compliance. If the air conditioner is rated at 3 tons and two return ducts sized at 16” and 14” or larger are provided, the total filter/grille nominal area may be reduced to 900 in^2, or 450 in^2 per filter grille. However, the filters still must have a pressure drop of 0.1 inch or less at 600 CFM (based on filter manufacturer label data).

For any filter, the pressure drop, efficiency, and length of time the filter can remain in operation without becoming fully loaded with dust, can all be improved by using filters that are deeper than 1". As the depth of the filter is increased, the pressure drop across the filter at the same face area will be greatly reduced.

Example 11-34

Question

I am installing a ductless split system in a space that is being added on to the house. Must I use the designated MERV 13 filter?

Answer

No. The filtration requirements do not apply unless there is at least 10 ft. of duct attached to the unit.

Example 11-35

Question

My customer has allergies and wants a MERV 16 or better filter. Is this in compliance?

Answer

Yes. MERV rated filtration greater than MERV 13 meets (exceeds) the minimum particle removal efficiency requirement; thus, it may be used provided all other applicable requirements in Section 160.0(m)12 are complied with.

11.5.4.5 Forced-Air System Duct Sizing, Airflow Rate, and Fan Efficacy

§160.3(b)5L

Adequate airflow is critical for cooling equipment efficiency. Further, it is important to maintain adequate airflow without expending excessive fan power. §160.3(b)5L establishes mandatory requirements that are intended to ensure adequate cooling airflow through properly sized ducts and efficient fan motors.

There are two options allowed to ensure adequate air flow. The first option is to design and install the systems using standard design criteria and then have the airflow and fan efficacy of the system tested in the field. The second option is to size the return ducts according to Table 11-34 and Table 11-35 (as specified by EXCEPTION 1 to §160.3(b)5Lii and iv).

Both options require verification. Verification must be conducted by a HERS Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings in Climate Zones 2-16, verification only needs to be conducted and certified by the installing contractor and neither a HERS Rater nor registration with a HERS Provider is required. Buildings with four or more habitable stories in Climate Zone 1 are exempt from these mandatory requirements.

A. Airflow and Watt Draw Measurement and Determination of Fan Efficacy

When using the airflow (CFM/ton) and fan efficacy (watt/CFM) method, the following criteria must be met:

- Provide airflow through the return grilles that is equal to or greater than:

  - 350 CFM per ton of nominal cooling capacity for systems that are not small-duct high-velocity systems.
  - 250 CFM per ton for small duct for high velocity systems.

Nominal cooling capacity: To determine the required airflow for compliance in CFM/ton, the nominal cooling capacity of the system in tons must be known. The nominal cooling capacity system may be obtained from the manufacturer's product literature or from listings of certified product ratings from organizations such as AHRI, but the nominal capacity is usually shown in the unit model number on the manufacturers nameplate attached to the outdoor condensing unit. A two- or three-digit section of the manufacturer's model number typically indicates the nominal capacity in thousands of BTU/hour. Given that there are 12,000 BTU/hour per ton of cooling capacity, the nameplate will display something similar to one of the following number groupings: "018" which represents 1.5 tons; "024," which represents 2 tons; "030," which represents 2.5 tons; "036," which represents 3 tons; "042," which represents 3.5 tons; "048," which represents 4 tons; or "060," which represents 5 tons.

- At the same time, the fan watt draw must be less than or equal to
  - 0.45 watts per CFM for gas furnaces, or
  - 0.58 watts per CFM for air handling units that are not gas furnaces.
  - 0.62 watts per CFM for small duct, high velocity systems.

See Table 11-36 for a summary of the requirements.

The methods for measuring the air-handling unit watt draw are described in Reference Residential Appendix RA3.3. Three acceptable apparatuses are:

- A portable watt meter.
- An analog utility revenue meter.
- A digital utility revenue meter.

Note that when measuring fan watt draw in package air conditioners or heat pumps, it is recommended to use a portable true power clamp-on meter to provide flexibility for isolating the correct fan wires. These meters may need to be high-voltage-capable.

Ducted mini-split heat pumps and air conditioners are typically exempt from the requirement to measure fan watt draw because of the difficulties with isolating the fan power and accurately measuring it. They are not exempt from the airflow measurement requirement.

There are three acceptable methods for determining compliance with the system airflow requirement. They are described in Reference Residential Appendix RA3.3 and use one of the following:

- An active or passive flow capture hood to measure the total airflow through the return grill(s)
- Flow grid device(s) at the return grill(s) or other location where all the central fan airflow passes through the flow grid
- Fan flow meter device (also known as a duct blaster) to perform the plenum pressure matching procedure

The flow grid and the fan flow meter methods both require access to static pressure measurements of the airflow exiting the cooling coil, which require use of a HSPP or PSPP (RA3.3.1.1).

The contractor must install either a hole for the placement of a static pressure probe (HSPP) or provide a permanently installed static pressure probe (PSPP) stated in Reference Residential Appendix RA3.3.

The HSPP or PSPP simplifies cooling coil airflow measurement when using devices or procedures that depend on supply plenum pressure measurements.

The California Green Code (CALGreen or Title 24, Part 11) and the California Mechanical Code require that residential duct systems be designed according to ACCA Manual D, or equivalent. If reasonable care and judgment are used while designing the duct system (both return and supply ducts), and the system is designed to reasonable parameters for airflow per ton, static pressure across the fan, and friction rate, these systems should have no problem passing the diagnostic tests.

The following design guidelines will increase the chances of the system passing the airflow and fan efficacy testing:

- Right-size the HVAC system. If a two-ton unit is enough to satisfy the cooling load, do not install a three-ton unit just to be safe. Oversizing equipment can cause comfort problems in addition to excessive energy use.
- The HVAC designer must coordinate closely with the architect and structural engineer to make sure that the ducts will fit into the dwelling unit as designed.
- Prepare a detailed mechanical plan that can be followed in the field. If deviations must occur in the field, make sure that they are coordinated with the designer and that the design is adjusted as needed.
- Follow Manual D for duct sizing:
    - Make sure that the correct duct type is used (vinyl flex, sheet metal, rigid fiberglass, or other).
    - Make sure that all equivalent lengths and pressure drops are correctly accounted for (bends, plenum start collars, t-wyes, filters, grilles, registers, and so forth.

  - Select an air handler that will provide at least 400 CFM/ton at the desired static pressure of 125 to 150 Pa (0.5 to 0.6 inches w.c.).
  - Design the duct system to a static pressure across the fan of no more than 150 Pa (0.6 inches w.c.).
  - Consider upsizing the evaporator coil relative to the condenser to reduce the static pressure drop. This upsizing results in better airflow and slightly better capacity and efficiency. Manufacturers commonly provide performance data for such condenser coil combinations.
  - Consider specifying an air handler with a high efficiency (brushless permanent magnet) fan motor.
- Install a large grill area and use a proper filter for the system.
- Locate registers and equipment to make duct runs as short as possible.
- Make all short-radius 90° bends out of rigid ducting.
- Install flex duct properly by stretching all flex duct tight and cutting off excess ducting. Ensure the duct is not kinked or compressed and is properly supported every four ft. or less using one inch strapping. Flex duct should have less than two inches of sag between supports.
- Consider using better quality supply and filter grilles. Bar-type registers have considerably better airflow performance than standard stamped-face registers. Refer to the manufacturer's specifications and select accordingly.

B. Return Duct System Design Method

This method allows the designer to specify, and the contractor to install, a system that does not have to be tested for airflow and fan efficacy. This method can be used for systems with either one or two return grilles. Each return must not exceed 30 ft. as measured from the return plenum to the filter grille. When bends are needed, sheet metal elbows are desirable. Each return can have up to 180 degrees of bend, and flex duct can have no more than 90° of bend. To use this method, the designer and installer must provide return system sizing that meets the appropriate criteria in Energy Code Table 160.3-A and B, also shown in Table 11-34 or Table 11-35 below.

Energy Code Tables 160.3-A and B (Table 11-34 or Table 11-35) allow for only one or two returns. There may be times where three returns are necessary on a single system. Furthermore, Table 160.3-B does not allow for deviation from the two sizes specified. For example, the table requires two 14-inch return ducts for a 2.5-ton system, but specific airflow requirements and architectural constraints may dictate an 18-inch and a 12-inch. In this situation, airflow and fan efficacy diagnostic testing are required.

Historically, duct systems have been sized to fit into the dwelling unit at the expense of proper airflow. The performance of these systems, in terms of efficiency and capacity, has suffered greatly because of this practice. The dwelling unit should be designed to accommodate properly sized ducts. This requires improved coordination among the architect, structural engineer, and mechanical designer early in the process.

Tables 160.3-A and B require the use of return grilles that are sized to achieve an optimal face velocity and static pressure drop. Tables 160.3-A and B also require the return grille devices to be labeled in accordance with the requirements in §160.2(b)1A to disclose the design airflow rate of the grille and the maximum allowable clean-filter pressure drop for the air filter media, as determined by the system design or applicable standards requirements. The nominal size of the air filter grille or air filter media should be used to calculate the return filter grille gross area for determining compliance with Tables 160.3-A and B. The nominal size of the filter grille is expected to be the same as the nominal size of the air filter media that is used in the grille and is most often the information used to identify these items for purchases. For example, a nominal 20-inch x 30-inch filter grille will use nominal 20-inch x 30-inch air filter media.

Table 11-34: Return Duct Sizing for Single Return Duct Systems

System Nominal Cooling Capacity (Ton)	Minimum Return Duct Diameter (inch)	Minimum Total Return Filter Grille Gross Area (Inch^2)
1.5	16	500
2.0	18	600
2.5	20	800

Source: From Table 160.3-A of the Energy Code

Table 11-35: Return Duct Sizing for Multiple Return Duct Systems

System Nominal Cooling Capacity (Ton)	Return Duct 1 Minimum Diameter (inch)	Return Duct 2 Minimum Diameter (inch)	Minimum Total Return Filter Grille Gross Area (inch^2.)
1.5	12	10	500
2.0	14	12	600
2.5	14	14	800
3.0	16	14	900
3.5	16	16	1000
4.0	18	18	1200

5.0	20	20	1500

Source: From Table 160.3-B of the Energy Code

C. Zonally Controlled Central Forced-Air Cooling Systems

§160.3(b)5Liii

The primary purpose of zoning ducted air conditioners, heat pumps, and furnaces is to improve comfort. Increased comfort is attained by having the capacity of the HVAC system (cooling or heating delivered) follow the shift in load as it changes across the dwelling unit.

Since the most common dwelling unit is single-zoned and has only one thermostat placed near the center of the unit, temperatures in the rooms distant from that thermostat will vary, sometimes significantly. If zoning is added, the more distant rooms may be conditioned to a more comfortable temperature. This increased conditioning requires more energy. When designed correctly, zoning allows only the zones that need conditioning to be conditioned, thus potentially saving energy.

It is common for single-speed zonally controlled central forced-air cooling systems to produce lower total system airflow through the returns when fewer than all zones are calling for conditioning. The reduced airflow lowers the sensible efficiency of single-stage heating or cooling equipment. Two primary causes of lower airflow in multiple zone dampered systems are:

1. Restriction of some system supply ducts by closing zoning dampers in zones that do not need additional cooling, while other zones do need cooling.
2. Recirculation of already-cooled air from the supply plenum directly back to the return plenum without first delivering the cooled air to the conditioned space by use of a bypass duct.

To prevent the lower efficiency that results from reduced system airflow or from recirculated bypass duct airflow, single-speed compressor zonally controlled central cooling systems must demonstrate they simultaneously meet mandatory fan efficacy and airflow requirements in all zonal control modes, which is possible with a duct system design that does not restrict the system total airflow when fewer than all zones are calling for conditioning and does not use a bypass duct. §170.2(c)3v prohibits use of bypass ducts prescriptively, but bypass ducts may be used if the efficiency penalty due to the reduced airflow through the return grille is modeled as described later in this section.

Zonally controlled cooling systems with or without bypass dampers (multiple zones served by a single air handler with motorized zone dampers) usually do not meet the airflow and fan efficacy requirements when fewer than all zones are calling. The energy penalty that results from this is greater than the benefit of having zonal control; therefore, zonal control is not always a better-than-minimum condition.

Zonal control accomplished by using multiple single-zone systems is not subject to the requirements specified in §160.3(b)5Liii.

Two-speed and variable-speed compressors are considered multi-speed. Multispeed compressors allow the system capacity to vary to match reduced cooling loads more closely when fewer than all zones call for cooling. Therefore, an exception to §160.3(b)5Liii gives multispeed compressor systems special consideration when used in zoned systems, and these systems are not required to verify performance in all zonal control modes. Instead, the airflow and fan efficacy testing are required to be performed only at the highest speed when all zones call for cooling.

An exception to §160.3(b)5Liii allows single-speed compressor systems to comply with the mandatory airflow and fan efficacy requirements only at the highest fan speed and when all zones call for cooling, rather than in every zonal control mode. This is allowed if:

- The performance approach is used.
- Airflow is tested in all zonal control modes when fewer than all zones call for cooling to be no less than that specified by the software user and reported on the compliance report.
- Fan efficacy is tested in all zonal control modes to be no greater than that specified by the software user and reported on the compliance report.

In the compliance software, if the system is modeled as a zoned system with a single-speed compressor, the minimum allowable airflow drops to 150 CFM/ton. The compliance software calculates a penalty for the reduced airflow (specified by the user) during operation when fewer than all zones call for cooling. Other energy features for the building must offset this penalty. A value between 150 CMF/ton and 350 CFM/ton can lessen the penalty resulting from the minimum allowed value of 150 CFM/ton.

The energy consultant should model airflow and fan efficacy values that are reasonable and can be verified. If not, the compliance calculations will have to be revised to match the actual verified value. Energy consultants should coordinate with the HVAC designer before registering the certificate of compliance.

See Table 11-36 for a summary of the requirements.

Bypass dampers may be installed only if the certificate of compliance specifically states that the system was modeled as having a bypass damper.

Table 11-36: Central Forced-Air Cooling Systems Airflow & Fan Efficacy Requirements

Compressor & Zone Type	Mandatory Requirements for Airflow[1]	Mandatory Requirements for Fan Efficacy[1]	Performance Approach Proposed Design System Defaults	Performance Approach Standard Design System Assumptions
Single Zone Single-Speed or Multispeed (tested on highest speed only)	• ≥ 350 CFM/ton • ≥ 250 CFM/ton if a small duct high velocity (SDHV) type	• ≤ 0.45 W/CFM for gas furnaces (GF) • ≤ 0.58 W/CFM for all other air handlers • ≤ 0.62 W/CFM for SDHV type	Same as mandatory	Same as mandatory
Zonally Controlled Single Speed (tested at all zonal control modes)[2]	• ≥ 350 CFM/ton • ≥ 250 CFM/ton if a small duct high velocity (SDHV) type	• ≤ 0.45 W/CFM for gas furnaces (GF) • ≤ 0.58 W/CFM for all other air handlers • ≤ 0.62 W/CFM for SDHV type	150 CFM/ton	Same as mandatory
Zonally Controlled Multispeed (tested at all zonal control modes)	• ≥ 350 CFM/ton • ≥ 250 CFM/ton if a small duct high velocity (SDHV) type	• ≤ 0.45 W/CFM for gas furnaces (GF) • ≤ 0.58 W/CFM for all other air handlers • ≤ 0.62 W/CFM for SDHV type	350 CFM/ton	Same as mandatory

[1]Exception: Airflow and fan efficacy testing not required if return system meets Tables 160.3-A or B. However, verification that return duct installation meets Tables 160.3-A or B is required

[2] For the prescriptive approach use of a bypass duct is not allowed. For the performance approach use of a bypass duct may be specified in the compliance software input for the zoned system type.

D. Hole for Static Pressure Probe (HSPP) or Permanently Installed Static Pressure Probe (PSPP)

§160.3(b)5Li

Space-conditioning systems that use forced air ducts to cool occupiable space must have a HSPP or PSPP installed downstream from the evaporator coil. The HSPP or PSPP must be installed in the required location, in accordance with the specifications detailed in Reference Residential Appendix RA3.3. The HSPP or PSPP are required to promote system airflow measurement when using devices/procedures that depend on supply plenum pressure measurements. The HSPP or PSPP allows HERS Raters to perform the required diagnostic airflow testing in a nonintrusive manner by eliminating the necessity for the raters to drill holes in the supply plenum for placement of pressure measurement probes.

The size and placement of the HSPP/PSPP must be in accordance with RA3.3.1.1 and must be verified by a HERS Rater. If the HSPP/PSPP cannot be installed as shown in Figure RA3.3-1 because of the configuration of the system or that the location is not accessible, an alternative location may be provided that can accurately measure the average static pressure in the supply plenum. If an alternative location cannot be provided, then the HSPP/PSPP is not required to be installed. The HERS Rater will verify this for multifamily buildings up to three stories. Not installing an HSPP/PSPP will limit the airflow measurement method to either a powered flow hood or passive (traditional) flow hood.

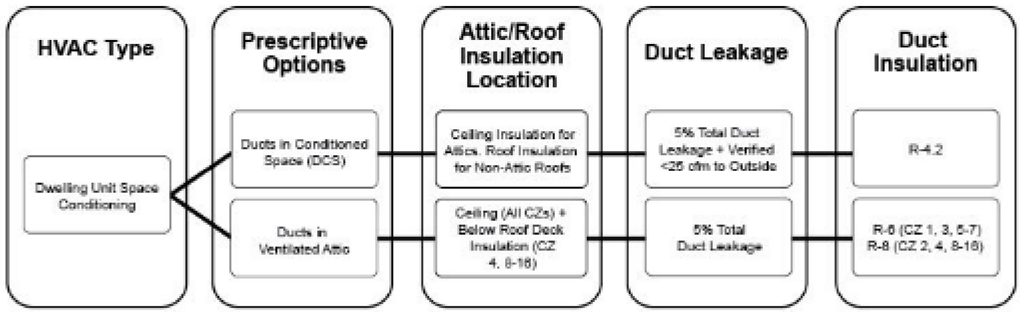
The HSPP/PSPP requirement also applies when the plenum pressure matching method or the flow grid method of airflow measurement is used by either the installer or the rater to verify airflow in an altered system. The HSPP/PSPP must be installed by the installer, not the rater.

See Chapter 11.6.4 for discussion regarding mandatory sizing/airflow requirements for ducted systems with cooling.

11.5.4.6 Dwelling Unit Prescriptive Requirements

The Energy Code is designed to offer flexibility to multifamily newly constructed building designers and builders to achieve code compliance as shown in Figure 11-48.

Figure 11-48: Duct Prescriptive Compliance Choices



Source: California Energy Commission

11.5.4.7 Duct Location

§170.2(c)3Bii

Standard multifamily construction practice in California is to place ducts and associated air handling equipment in conditioned space. Ducts are typically in a dropped soffit or in-between floors, and equipment may also be in the ceiling or an interior mechanical closet. When meeting the prescriptive requirements for the Energy Code, there are two options for where ducts and equipment can be located:

- Ducts in conditioned space (DCS) with the duct system and air handler(s) within the thermal envelope and air barrier of the building. This DCS option requires field verification to meet the prescriptive requirement. This option applies to both attic roofs and non-attic roofs.
- For buildings with attic roofs, ducts may be installed in a vented attic if Option B in Table 170.2-A is met. Option B requires a high-performance attic (HPA) design in climate zones 4 and 8-16. A HPA implements requirements that minimize temperature differences between the attic space and the conditioned air being transported through ductwork in the attic. The package consists of insulation below the roof in addition to insulation at the ceiling. These requirements and approaches to meet the requirements are explained in Chapter **Error! Reference source not found.** of this manual.

For the DCS prescriptive approach, additional requirements apply:

- Air handlers containing a combustion component should be direct-vent (sealed combustion chambers) and must not use air from any conditioned or unconditioned space as combustion air. Other types of combustion heating systems are possible if the system installer adheres to the combustion air requirements found in Chapter 7 of the California Mechanical Code.
- Duct location needs to be verified through a visual inspection per Reference Residential Appendix RA3.1.4.1.3. This must be conducted by a HERS Rater for

multifamily buildings up to three habitable stories. Otherwise, the installing contractor can certify the results.

- Duct leakage to outside needs to be confirmed by field verification and diagnostic testing in accordance with Reference Residential Appendix RA3.1.4.3.8. This must be conducted by a HERS Rater for multifamily buildings up to three habitable stories. Otherwise, the installing contractor can certify the results.

For the vented attic with HPA prescriptive approach, additional requirements apply. Refer to Chapter 3.5 of the Single-Family Compliance Manual for more information on this option.

- Ducts are insulated to a level required in Table 170.2-K.
- Ceiling and below roof deck insulation must meet the levels required in Table 170.2-A Option B. Roof deck insulation must be installed with an air space present between the roofing and the roof deck, such as is typical with standard installation of concrete or clay tile.
- Roofing products must meet the reflectance and emittance values in Table 170.2-A Option B.
- A radiant barrier is required is Climate Zones 2, 3, and 5-7 per Table 170.2-A Option B.

If a building is not able to meet all the requirements listed above, it must use the performance approach. The prescriptive options apply to dwelling units individually. Multifamily buildings with vented attics may have ductwork in the attic above the top floor units with lower floor unit ductwork in conditioned space. To comply prescriptively, the top floor units need to meet the requirement for ducts in a vented attic, which may include HPA depending on climate zone. The lower floor units need to meet all the requirements for DCS.

There are several methods of achieving the goal of DCS. For additional information, the basic information of the strategies, related benefits, challenges, and potential solutions to those challenges are described in the Single-Family Compliance Manual Chapter 4.4.2.

11.5.4.8 Duct Insulation

§170.2(c)3B

Projects meeting the prescriptive requirements for DCS need to only meet the mandatory insulation requirements of R-6. All ducts in a ventilated attic space must be insulated to a minimum installed level as specified by Table 170.2-K, which requires either R-6 or R-8 depending on the climate zone. Prescriptively, the attic must also meet the insulation requirements per Table 170.2-A Option B. Since R-6 is the mandatory minimum for ducts in unconditioned space, where R-8 is prescriptively required, this can be traded off against other features using the performance approach.

11.5.4.9 Central Fan-Integrated (CFI) Ventilation

CFI ventilation uses a central forced air heating and/or cooling system that operates regularly to pull outside air into the air distribution system and distribute air around the dwelling unit. There is a prescriptive requirement that CFI systems meet the same mandatory fan efficacy requirements for other forced air cooling systems. This requires no greater than 0.45 W/CFM for gas furnaces and 0.58 W/CFM for all other air handler including heat pumps. This can be traded-off using the performance approach. Verification must be conducted by a HERS Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings, verification only needs to be conducted and certified by the installing contractor, and neither a HERS Rater nor registration with a HERS Provider is required.

11.5.4.10 Dwelling Unit Performance Approach

The Energy Code provide credit for several compliance options related to duct design and construction.

11.5.4.11 System Airflow and Fan Efficacy

Performance compliance credits are available for demonstrating the installation of a high-efficiency system with a lower fan wattage and/or higher airflow than the mandatory requirements. Compliance with these credits can be achieved by installing a well-designed duct system and can be assisted by a high-efficiency fan. There are two possible performance compliance credits:

- The performance approach allows the user’s proposed fan efficacy to be entered and credit earned if it is lower than the default mandatory values. To obtain this credit for a system with cooling, the system airflow must meet the mandatory requirement of at least 350 CFM/ton of nominal cooling capacity.
- The performance approach allows the user’s proposed system airflow to be entered and credit earned if it is higher than the default of 350 CFM/ton of nominal cooling capacity. To obtain this credit, the fan efficacy must meet the mandatory requirements listed above.

The performance approach allows the user’s proposed airflow and fan efficacy to be entered into the program, and credit will be earned if the airflow is greater than the minimum required, and fan efficacy is lower than the default. After installation, the contractor must test the actual airflow and fan efficacy of each system using the procedure in *Reference Residential Appendix* RA3.3 and show that it is equal or less than what was proposed in the compliance software analysis.

For multifamily buildings up to three habitable stories the fan efficacy and airflow must be verified by a HERS Rater.

11.5.4.12 Duct Location

For multifamily buildings up to three habitable stories, there are three ways to achieve credit for favorable duct location when using the performance approach and the building has an attic.

- Credit is available if no more than 12 linear ft. of duct are outside the conditioned space. This total must include the air handler and plenum lengths. This credit results in a reduction of duct surface area in the computer software. This option requires certification by the installer and field verification by a HERS Rater.
- The second alternative applies when 100% of the ducts are in conditioned space. This credit results in eliminating the conduction losses associated with the return and supply ducts; however, leakage rates still apply. This option requires field verification of the duct system by means of a visual inspection by a HERS Rater.
- Additional credit is available when ducts are in conditioned space and a HERS Rater verifies that duct leakage to outside does not exceed 25 CFM.

There may also be compliance credit for the distribution system for choosing a ductless heating or cooling system. However, many of these systems do not perform as well as the baseline system, which can result in an overall penalty.

For buildings with no attic, the standard design assumes ducts inside the conditioned space with duct leakage verified to not exceed 25 CFM. No additional credit is available within the software for duct location.

There is no duct location compliance credit for multifamily buildings four or more habitable stories, because the software does not evaluate distribution systems.

11.5.4.13 Duct Insulation

For multifamily buildings up to three habitable stories, performance credit is available for ducts in unconditioned space if all the ducts are insulated to a level higher than required by the prescriptive package. If ducts with multiple R-values are installed, the lowest duct R-value must be used for the entire duct system. However, the air handler, plenum, connectors, and boots must be insulated to the mandatory minimum R-value.

As an alternative when there is a mix of duct insulation R-values, credit is available through the method described in the next section.

There is no duct insulation compliance credit for multifamily buildings four or more stories, because the software does not evaluate distribution systems.

11.5.4.14 Verified Duct Design: Duct Location, Surface Area, and R-value

For multifamily buildings up to three habitable stories when all or a portion of ducts are in unconditioned space, this compliance option allows the designer to take credit for a high-efficiency duct design that incorporates duct system features that may not meet the criteria for the duct location and/or insulation compliance options described above. This method requires that the designer enter the design characteristics of all ducts that are not within the conditioned space. The information required for the input to the compliance software includes the length, diameter, insulation R-value, and location of all ducts. This method will result in a credit if the proposed duct system is better than the standard design.

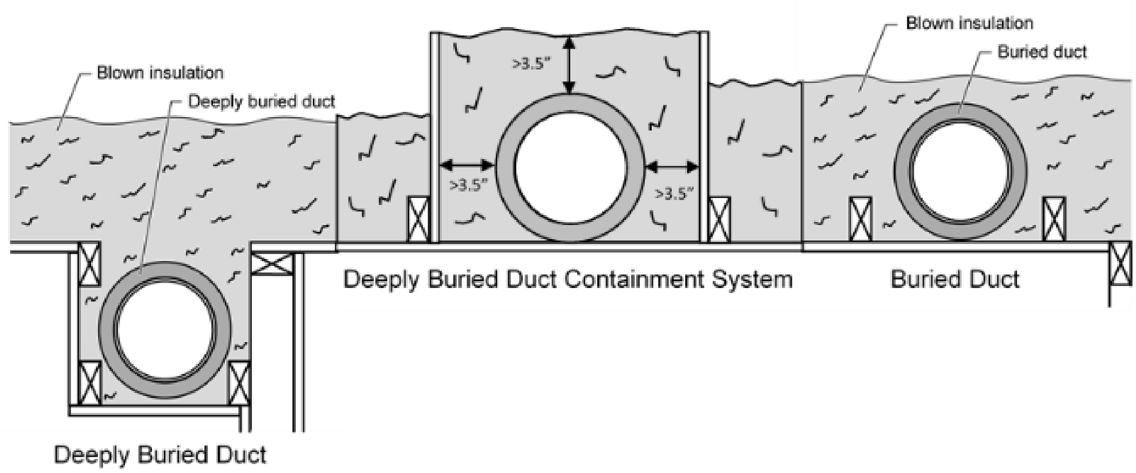
To claim this credit, the duct system design must be documented on plans that are submitted to the enforcement agency and posted at the construction site for use by the installers, the enforcement agency field inspector, and the HERS Rater. The duct system must be installed in accordance with the approved duct system plans, and the duct system installation must be certified by the installer on the certificate of installation form and verified by a HERS Rater on the certificate of verification form. Details of this compliance option are described in the Nonr*esidential ACM Reference Manual*, and verification procedures are described in RA3.1 of the Reference Residential Appendix.

11.5.4.15 Buried and Deeply Buried Ducts

For multifamily buildings up to three habitable stories, this compliance option allows credit for the special case of ducts that are buried by blown attic insulation. For ducts that are within 3.5 inches of the ceiling, the effective R-value is calculated based on the duct size and R-value, depth of ceiling insulation, and type of blown insulation (fiberglass or cellulose) as shown in Tables 16, 17, and 18 in the Residential ACM Reference Manual. The user-entered duct system can be any combination of unburied, buried, and deeply buried duct runs. The software will determine the overall duct system effective R-value by weight averaging the user entered duct system.

Ducts must have a minimum insulation level prior to burial, R-6 for new ducts and R-4.2 for existing. Deeply buried ducts meet the requirements for buried ducts on the Ceiling and ducts are completely covered by at least 3.5 inches of attic insulation. Deeply buried ducts must be enclosed in a lowered portion of the ceiling or buried by use of a durable containment system (e.g., gypsum board, plywood, etc.), or buried under a uniform level of insulation that achieves the 3.5-inch burial level.

Figure 11-49: Buried Ducts on Ceiling and Deeply Buried Ducts



Source: California Energy Commission

Deeply buried containment systems must be installed such that the walls of the system are at least 7 inches wider than the duct diameter (3.5-inch clearance on each side of duct) extend at least 3.5 inches above the duct outer jacket, and the containment area surrounding the duct must be completely filled with blown insulation.

In addition to the above requirements, the attic area containing the buried or deeply buried ducts must have insulation with uniform depth (not mounded over the duct), level ceiling, and at least six inches of space between the duct outer jacket and the roof sheathing. Insulation raised by a containment system is an exception to the uniform depth requirement.

To take credit for buried ducts, the system must meet the verified duct system design criteria described above and meet the requirements for QII described in Reference Appendices RA3.5.

11.5.5 Common Use Area Space Conditioning Systems Requirements

This section provides an overview of the Energy Code requirements for space conditioning systems serving common use areas of the building, such as community rooms, corridors, fitness areas, and common laundry rooms. Since there are similar requirements for space conditioning systems serving common use area and systems serving nonresidential occupancies, more detailed discussion of the applicable requirements can be found in Chapter 4.

Requirements for systems serving nonresidential occupancies in mixed occupancy buildings are in §120, §130, §140 and §141 of the Energy Code.

11.5.5.1 Common Use Area Mandatory Requirements

§110.1, §110.2, §110.5, §160.2(c)1, §160.3(a)2, §160.3(c)1, §160.3(c)2 A through §160.3(c)2.H, §160.3(d)1 and §160.3(d)3

Applicable mandatory requirements for common use area space conditioning systems, as described in Chapter 4 include:

- Space conditioning equipment certification and equipment efficiency
- Restrictions on pilot lights for natural gas appliances and equipment
- Space conditioning system air filtration
- Space conditioning system controls
- Fluid distribution system: Pipe insulation
- Fluid distribution systems - Requirements for Air Distribution System, Ducts, and Plenum
- Mechanical acceptance testing

Residential equipment used in common use areas needs to meet requirements outlined in Chapter 11.6.3.1.

11.5.5.2 Common Use Area Prescriptive Requirements

§170.2(c) 1, §170.2(c) 2, and §170.2(c) 4

Applicable Prescriptive requirements for common use area space conditioning systems are covered in Chapter 4 and include:

- Space conditioning system sizing and equipment selection
- Space conditioning system calculations
- Space conditioning system requirement

11.5.5.3 Common Use Area Performance Approach

§170.1

Refer to Chapter 4.9 for applicable performance approach requirements for common use area space conditioning systems.

11.5.6 Alternative Systems

Alternative system types can comply through the performance approach. This section describes some common alternative systems used in dwelling units and the associated code requirements. See Chapter 4 for more about systems serving common use areas and central systems.

11.5.6.1 Variable Capacity Heat Pumps

Several manufacturers offer mini-split or multi-split heat pump equipment that may or may not use air distribution ducts to heat or cool spaces. These systems provide advanced controls and multispeed compressors for optimizing performance through a wide range of conditioning loads.

These systems are generally required to be modeled as minimally efficient systems. A variable capacity heat pump (VCHP) compliance option is available to provide credit for systems meeting the eligibility requirements published in the Residential Appendices RA3.4.4.3. The credit can be applied through a CEC-approved modeling software by selecting the VCHP compliance option for the HVAC system type. The certificate of compliance will indicate when a space conditioning system requires verification of the VCHP compliance option eligibility requirements. A system that does not meet the eligibility requirements upon verification will not be eligible to claim the VCHP performance compliance credit for the specified space conditioning system.

Compliance with the mandatory duct system sealing and leakage and fan airflow rate and fan efficacy testing are not required for systems that use this VCHP performance compliance option. However, there are requirements to verify that VCHP system indoor unit ducts are located entirely in conditioned space that are specified as eligibility requirements for this compliance option. There are also requirements for verification of minimum airflow rates for VCHP system indoor units that are specified as eligibility requirements for this compliance option.

Additional verification requirements apply depending on the system type and credit taken, including:

- Low-static certification for ducted systems
- Non-continuous indoor unit fan operation
- Refrigerant charge verification
- Ducts located entirely in conditioned space
- Indoor units located entirely in conditioned space
- Supply to all habitable spaces
- Wall-mounted thermostat
- Space-conditioning system airflow
- Air filter sizing
- Air filter pressure drop rating

11.5.6.2 Hydronic Heating Systems

Hydronic heating is the use of hot water to distribute heat. A hydronic heating system consists of a heat source, which may be a gas boiler, gas or heat pump water heater, and a distribution system. There are three main types of hydronic distribution systems, and they may be used individually or in combination: baseboard convectors or radiators, air handlers, and radiant panel systems. Radiant panel surfaces can include floors, walls, and/or ceilings. Air handlers and radiant panels may be used for heating and cooling. Hot water air handlers may also be equipped with DX coils for cooling. The three distribution options are illustrated in Figure 11-50. Ducting is used only with air handlers.

If the hydronic system serves both dwelling units and common use areas or nonresidential spaces, applicable requirements for nonresidential space conditioning system must be met too.

11.5.6.3 Hydronic Heating Systems Mandatory Requirements

For hydronic heating systems without ducts, the mandatory requirements cover pipe insulation, tank insulation, and boiler efficiency. For fan coils with ducted air distribution, the mandatory air distribution requirements also apply. For combined hydronic systems, as described below, mandatory water heating requirements also apply to the water heating portion of the system.

E. Pipe and Tank Insulation

§160.3(b)6 and 160.3(c)1 Pipe Insulation

The typical residential hydronic heating system operating between 105° and 140° F must have at least 1 inch (25 mm) of insulation on pipes less than 1 inch in diameter and 1.5 inch (38 mm) of insulation on pipes 1 inch or more in diameter. Systems operating between 141° and 200° F must have at least 1.5 inches of insulation on pipes less than 1.5 inches in diameter. For other temperatures and pipe insulation characteristics, see **Error! Reference source not found.**.

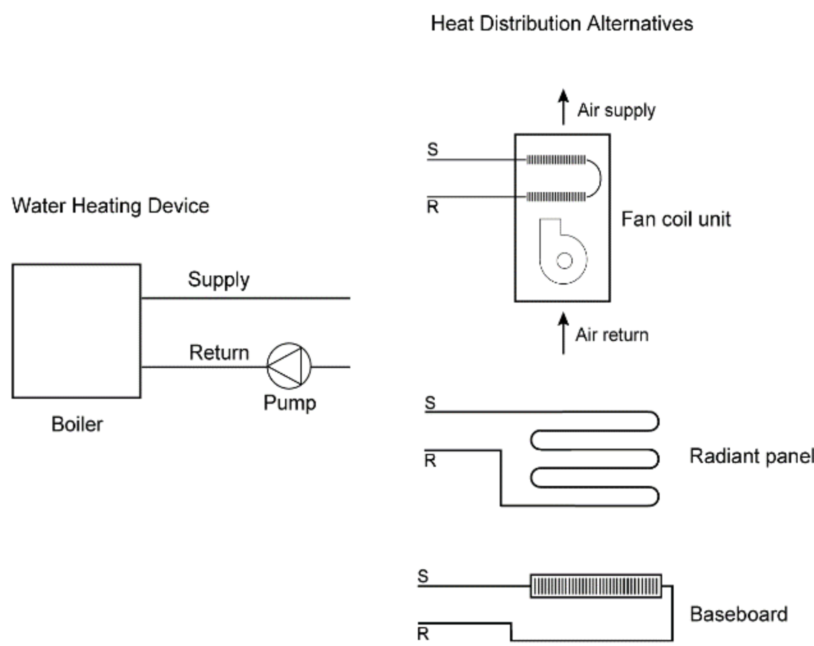
There are a few exceptions where insulation is not required:

- Sections of pipes where they penetrate framing members
- Pipes that provide the heat exchange surface for radiant heating and/or cooling
- Piping in the attic that is covered by at least 4 inches (100 mm) of blown insulation on top
- Piping installed within walls if all the requirements for QII are met (see Chapter 3 Building Envelope Requirements).

If the system includes an unfired hot water storage tank, then the tank must be either wrapped with R-12 insulation or insulated internally to at least R-16.

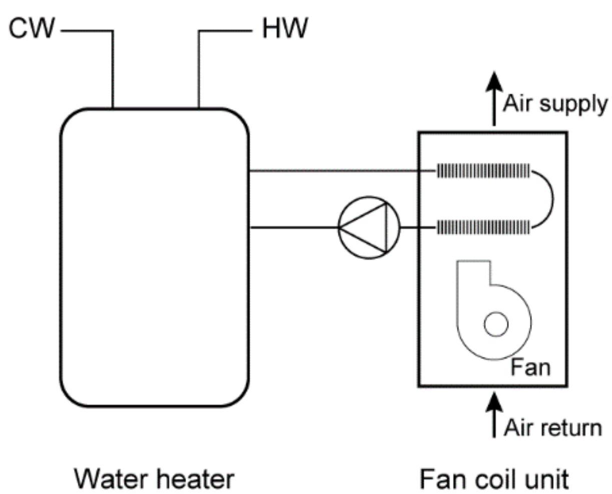
Piping used to deliver chilled water to panels or air handlers should be continuously insulated with closed-cell foam to prevent condensation damage.

Figure 11-50: Hydronic Heating System Components



Source: Richard Heath & Associates/Pacific Gas and Electric Company

Figure 11-51: Combined Hydronic System with Water Heater as Heat Source



Source: Richard Heath & Associates/Pacific Gas and Electric Company

For pipes in hydronic heating systems that operate at pressure greater than 15 psi, the requirements of §160.3(c)1apply. These are the same requirements that apply to nonresidential piping systems per §120.3.

F. Equipment Efficiency

Equipment for residential space heating must meet the minimum efficiency set by the Energy Code. Electric resistance water heaters are not allowed for use in dedicated space heating systems. Therefore, some water heaters may be used for space heating only if used as part of a combined hydronic system, as described below. In that case, the mandatory water heater requirements apply.

There are no minimum efficiency requirements for heat pumps that produce hot or chilled water, but compliance calculations must use ratings listed in the CEC's Title 20 appliance database under the category "Central Heat Pumps" and appliance type "Heat Pump Water Heating Packages."

https:/cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

Thermostat requirements also apply to hydronic systems, as described in Chapter 4.5.1.

F. Hydronic Heating Systems Prescriptive Requirements

There are no specific prescriptive requirements that apply to hydronic systems. However, if the system has a fan coil with ducted air distribution, the relevant prescriptive requirements apply, including duct insulation and duct sealing.

G. Hydronic Heating Systems Performance Approach

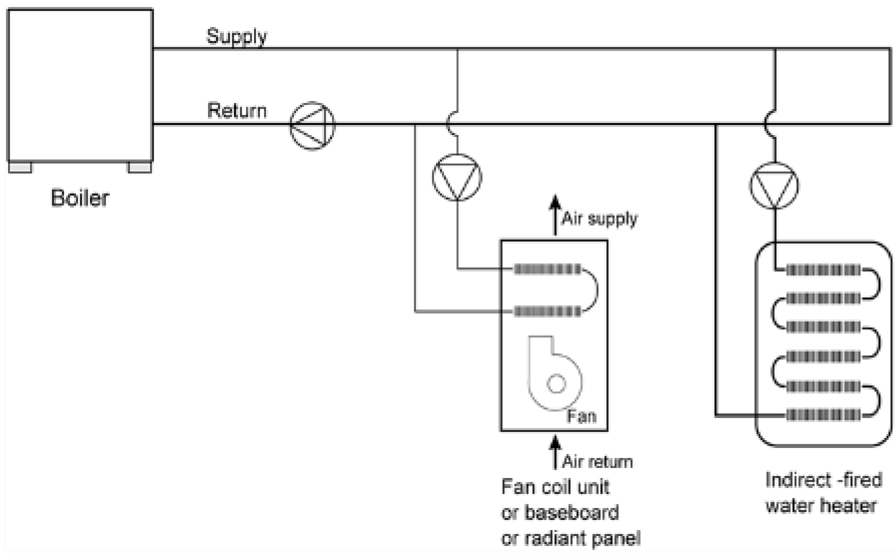
Credit for choosing a hydronic heating system is possible using the performance approach. The standard design is assumed to use air distribution system. Therefore, hydronic systems without ducts can take credit for avoiding duct leakage penalties. In addition, minimizing the amount of pipe outside conditioned space will provide some savings. Hydronic heating and cooling compliance calculations are described in the Residential ACM Manual.

If the proposed hydronic system includes ducted air distribution, then the associated compliance options described earlier in this chapter may apply, such as improved airflow (if there is air conditioning) and supply duct location.

A combined hydronic system is a compliance option using the performance method. Combined hydronic heating refers to the use of a single water heating device as the heat source for space and domestic hot water heating.

Combined hydronic systems may use either a boiler (as in the figure below) or a water heater as a heat source. The boiler heats domestic water by circulating hot water through a heat exchanger in an indirect-fired water heater. The water heater provides domestic hot water as usual.

Figure 11-52: Combined Hydronic System with Boiler and Indirect Fired Water Heater



Source: Richard Heath & Associates/Pacific Gas and Electric Company

Space heating is accomplished by circulating water from the boiler or water heater through the space heating delivery system. Sometimes a heat exchanger is used to isolate potable water from the water circulated through the delivery system. Some water heaters have built-in heat exchangers for this purpose.

For compliance calculations, the water heating function of a combined hydronic system is analyzed for water heating performance as if the space heating function were separate. For the space heating function, an effective AFUE or HSPF rating is calculated. These calculations are performed automatically by the compliance software.

11.5.6.4 Air-to-Water Heat Pumps

Air-to-water heat pumps (AWHPs) provide space heating and cooling by conditioning water at the outdoor unit and circulating it to indoor delivery systems (e.g., fan coils, radiant floors, radiant ceiling panels). Some AWHPs can also provide domestic water heating capability. Title 20 requires AWHPs to be listed, but there are currently no minimum efficiency requirements. The compliance software treats fixed compressor speed AWHPs as equivalent to the prescriptive standard air source heat pump and provides a 2% heating and 8% cooling energy reduction for variable speed AWHPs, relative to the prescriptive standard air source heat pump. Current Title 20 listings for AWHPs can be found at the following link with Category "Central Heat Pumps" and Appliance "Heat Pump Water Heating Packages" selected.

www.cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx

11.5.6.5 Radiant System

§110.8(g) and Table 110.8-A

Radiant slab-on-grade floor systems, using either hydronic tubing or electric cable, must meet mandatory insulation requirements. Radiant floors may take one of several forms. Tubing or electric elements for radiant floor systems may be:

- Embedded in a concrete floor slab.
- Installed over the top of a wood subfloor and covered with a concrete topping.
- Installed over the top of a wood subfloor in between wood furring strips.
- Installed on the underside surface of a wood subfloor

In the latter two types of installations, aluminum fins are typically installed to spread the heat evenly over the floor surface and reduce the temperature of the water as required. All hydronic systems use one or more pumps to circulate hot water. Pumps are controlled directly or indirectly by thermostats or by special outdoor reset controls.

When concrete slab-on-grade is heated by radiant tubing or cables, one of the insulation methods listed in the Energy Code Table 110.8-A must be complied with to prevent excessive heat loss from the slab edge. Chapter 3.2.8.1 provides more details about the heated slab floor insulation requirements.

Example 11-36

Question

My client wants a dedicated hydronic-heating system (space heating only), but a few things are unclear: (1) What piping insulation is required? (2) Can I use any compliance approach? (3) Do I have to insulate the slab with slab edge insulation? (4) What special documentation must be submitted for this system type?

Answer

(1) The supply lines not installed within a concrete radiant floor must be insulated in accordance with §160.3(c)1D— Systems operating between 105° and 140° F must have at least 1 inch of insulation on pipes less than 1 inch in diameter, and 1.5 inches of insulation on pipes between 1 inch and less than 1.5 inches in diameter. Systems operating between 141° and 200° F must have at least 1.5 inches of insulation on pipes less than 1.5 inches in diameter.

(2) You can use any compliance approach, but the boiler must meet the mandatory efficiency 80 percent AFUE.

(3) The slab edge insulation shown in ***Error! Reference source not found.*** is required only when the distribution system is a slab-on-grade radiant floor system (pipes in the slab). When this is the case, the insulation values shown are mandatory requirements (no modeling or credit).

(4) No special documentation is required.

11.5.6.6 Evaporatively Cooled Condensers

Evaporatively cooled condenser air conditioners are a type of air-conditioning system that can provide significant space-cooling savings, especially in hot, dry climates. The equipment minimal efficiencies are determined according to federal test procedures. The efficiencies of these air conditioners are reported in terms of energy efficiency rating (EER).

If credit is taken for a high EER, field verification by a HERS Rater is required. Other HERS verifications are also required, including duct sealing, airflow, fan efficacy, and refrigerant charge or FID.

Besides the HERS verification, there are additional special requirements for evaporatively cooled condensing air conditioners. These include that the manufacturer provide certification that water use is limited to no more than 0.15 gallon per minute per ton of capacity and that the supply line be no larger than ¼-inch in diameter. For a listing of all the requirements for evaporatively cooled condensing air conditioners, see the certificate of installation form.

11.5.7 Additions and Alterations

§180.2,

New or altered mechanical systems serving alterations or additions for dwelling units or common use areas must meet all applicable mandatory requirements and comply with either the prescriptive or performance approach. If a building does not meet all applicable prescriptive requirements, then the performance method using an approved compliance software is the alternative.

All HVAC systems serving additions generally are required to meet the newly constructed building prescriptive requirements, with few exceptions. Table 11-37 summarizes the requirements.

Table 11-37: HVAC Requirements for Prescriptive Additions

Component	Additions
New or replaced space conditioning system(s)	All prescriptive requirements per §170.2 except the system may be a heat pump or gas heating system
Use existing space conditioning system(s)	No requirements for the heating/cooling equipment except that heating system must have adequate capacity
New duct system(s)	All prescriptive requirements per §170.2
Extend existing duct system(s)	Duct sealing and duct insulation per §180.2(b)2Aii

Source: California Energy Commission

If the heating and cooling system is unchanged as part of an addition or alteration, compliance for the HVAC system is not necessary. However, changing, altering, or replacing any component of a system triggers prescriptive requirements for that component. If the extended ducts are serving dwelling units, the combined new and existing duct system must meet the requirement to seal the ducts and verify that duct leakage is no greater than 15% of system airflow. If 15% leakage or lower cannot be attained, there are alternatives, including sealing all accessible leaks and confirming by a visual inspection.

When the HVAC system is entirely new or a complete replacement, then additional mandatory and prescriptive requirements apply.

The Energy Code make a distinction between two HVAC changeout situations:

- Entirely new or complete replacement space conditioning systems.
- Altered space conditioning systems.

11.5.7.1 Entirely New or Complete Replacement Space Conditioning Systems Serving Dwelling Units

§180.2(b)2Ai and Table 180.2-C

An entirely new or complete replacement must meet all applicable mandatory and prescriptive requirements as described below.

- §160.2(b)1: Air filtration requirements.
- §160.3(a)1: Setback thermostats or controlled by EMCS.
- §160.3(b)1-2: Cooling and heating load calculations.
- §160.3(b)3: Outdoor condensing unit requirements.
- §160.3(b)4: Heating furnace temperature rise requirements.
- §160.3(b)5A-J: Duct insulation, labeling, & damper requirements.
- §160.3(b)5L: Static pressure probe, airflow, and fan efficacy requirements (or alternative return duct sizing as per Table 160.3-A and B). Multifamily buildings in Climate Zone 1 with four or more habitable stories are exempt from this requirement.
- §160.3(b)6: Pipe insulation.
- §170.2(c)3A: Prescriptive heating system type: the new or complete replacement space-conditioning system may be a heat pump or gas heating system.
- §170.2(c)3Bi: Prescriptive refrigerant charge verification.
- §170.2(c)3Biii: Prescriptive central fan integrated ventilation system airflow and fan efficacy.
- Table 180.2-C: Prescriptive duct insulation.

A system installed in an existing dwelling unit as part of an alteration must be considered entirely new when both of the following conditions are met:

- The air handler and all the system heating/cooling equipment (e.g., outdoor condensing unit and indoor cooling or heating coil for split systems; or complete replacement of a package unit), are new.
- The duct system is entirely new (including systems with less than 40 ft. in length).

  An entirely new duct system may be part of an entirely new space conditioning system, or it may be connected to an existing space conditioning system. Duct systems are classified as entirely new when:

- At least 75% of the duct material is new. Up to 25% may be composed of reused parts from the existing duct system.
- All remaining components from the previous system are accessible and can be sealed.

  Completely new or replacement duct systems in dwelling units must meet the 12% (total leakage protocol) or 6% (leakage to outside protocol) criteria used for newly constructed systems. A new duct system may be connected to an existing air handler, which typically leaks substantially more than new equipment. If the 12% leakage rate criteria cannot be met, a smoke test should be performed to verify that excess leakage is not from other accessible portions of the duct system. The protocol for the smoke test for accessible-duct sealing is given in RA3.1.4.3.7.

  Verification of duct leakage must be conducted by a HERS Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor and neither a HERS Rater nor registration with a HERS Provider is required.

  In addition, entirely new ducts systems must meet the following mandatory requirements:

- §160.2(b)1: Air filtration requirements.
- §160.3(b)5L: Static pressure probe, airflow, and fan efficacy requirements (or alternative return duct sizing as per Table 160.3-A and B). Multifamily buildings in Climate Zone 1 with four or more habitable stories are exempt from this requirement.

  When an entirely new duct system and the furnace or air handler it is connected to are in a vented attic the following prescriptive requirements also must be met.

- §180.2(b)1Bi: Attic insulation and air sealing requirements.

  Altered duct systems that are not entirely new or complete replacements are treated as an extension of an existing system.

11.5.7.2 Altered Space Conditioning Systems Serving Dwelling Units

11.5.7.3 New and Altered Duct System – Insulation

When more than 25 linear ft. of new ducts are installed in an unconditioned space, the new ducts must be insulated to a minimum R-value as described in Table 11-38. When

25 ft. or less of ducts are installed in an unconditioned space, they must be insulated to the minimum mandatory insulation level of R-6 in all climate zones.

Table 11-38: Duct Minimum R-Value

Climate Zone	3, 5-7	1-2, 4, 8-10, 12-13
Duct R-value	R-6	R-8

Source: California Energy Commission

When new ducts are installed in conditioned space, the ducts must be insulated to the minimum mandatory insulation level of R-6 unless an exception or alternative mandatory minimum applies. For multifamily buildings four habitable or more stories, this can be confirmed by visual verification of the enforcement agency. For multifamily buildings up to three habitable stories, the entire duct system must be tested and confirmed to be in conditioned space by a HERS Rater per RA3.1.4.3.8.

H. Altered System Duct Sealing

In all climate zones altered existing duct systems must be sealed and tested. An existing duct system is considered altered under any of the following conditions:

- An outdoor condensing unit of a split system air conditioner or heat pump is installed or replaced.
- A packaged system is completely replaced.
- A cooling or heating coil is installed or replaced.
- An air handler is installed or replaced.
- More than 25 ft. of new or replacement ducts are installed.
- The ducts are extended to serve an addition, regardless of the length of duct.

If a dwelling unit has more than one duct system, only the altered ducts or ducts connected to the altered equipment need to be sealed and verified.

There are three options for showing compliance for altered existing duct systems listed below. Compliance must at least be attempted with one of the first two options (15% total leakage or 10% leakage to outside); then the third option (sealing all accessible leaks) any of the other options can be used.

- Total leakage is less than 15% of nominal system fan airflow (RA3.1.4.3.1).
- Leakage to the outside is less than 10% of system fan airflow (RA3.1.4.3.4).
- If the first two option leakage targets cannot be met, then compliance can be achieved by sealing all accessible leaks and conducting a smoke test (RA3.1.4.3.7).

For multifamily buildings with up to three habitable stories, HERS verification is required for all options listed above. For Options 1, and 2, verification can be accomplished through sampling. For Option 3, sampling is not allowed; a certified HERS Rater must do the visual inspection and the smoke test on every house. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor, and neither a HERS Rater nor registration with a HERS Provider is required.

Some judgment is required in determining if ducts are accessible. The local code enforcement agency will have the final say when it is not immediately obvious.

There are a few cases where duct sealing and duct leakage verification are not required. These exceptions include:

- Ducts that have already been sealed, tested, and certified by a HERS Rater. This does not apply if the sealing requirements are triggered by the installation or new or replacement ducts (duct extension).
- Duct systems with less than 40 ft. of duct. This does not apply if the sealing requirements are triggered by the installation or new or replacement ducts (duct extension).
- Duct systems that are insulated or sealed with asbestos.

11.5.7.4 Altered System Refrigerant Charge Verification and Airflow

In Climate Zones 2 and 8 through 15, when a refrigerant-containing component of an air conditioner or heat pump is replaced or installed in an existing building, any system that does not have an FID installed must have refrigerant charge field tested in accordance with all applicable procedures specified in RA3.2.2 or RA1.

When refrigerant charge verification is required for compliance, the system must also comply with the minimum airflow of 300 CFM/ton according to the procedures specified in RA3.3.

Entirely new or complete replacement space-conditioning systems must meet the minimum 350 CFM/ton airflow rate compliance criterion or the duct design alternative along with the other prescriptive and mandatory requirements described above.

Verification of refrigerant charge and airflow must be conducted by a HERS Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor and neither a HERS Rater nor registration with a HERS Provider is required.

G. Thermostats

When an existing system has a refrigerant containing component added or replaced, the thermostat must be upgraded to a setback type that meets §110.2(c)

11.5.7.5 Heating System Replacements

Prescriptive compliance requires new heating systems be limited to a heat pump or a gas or propane system. Altered systems must not use electric resistance as the primary heat source unless the existing space heating system is electric resistance and one of the following conditions are met:

- Non-ducted electric resistance systems.
- Ducted electric resistance systems only when a ducted space cooling system is not being replaced or installed as part of the alteration.
- Any electric resistance systems in Climate Zones 6, 7, 8 or 15.

11.5.7.6 Entirely New or Complete Replacement Space Conditioning Systems Serving Common Use Area

§180.2(b)2Bi and Table 180.2-D

An entirely new or complete replacement must meet all applicable mandatory and prescriptive requirements as described below.

- §170.2(c)1: Space conditioning system sizing and equipment selection
- §170.2(c)2: Space conditioning system calculations
- §170.2(c)4: Space conditioning system requirement

Each new or replacement fan system must meet the fan power budget requirement specified in Table 180.2-D.

11.5.7.7 Altered Air Duct Systems Serving Common Use Area

§180.2(b)2Bii

Since there are similar requirements for altered air distribution systems serving common use area and systems serving nonresidential occupancies, more detailed discussion of the applicable requirements can be found in Chapter 4.9.1.1.1.10.

11.5.7.8 Altered Space Conditioning Systems Serving Common Use Area

§180.2(b)2Biii

Since there are similar requirements for altered space conditioning systems serving common use area and systems serving nonresidential occupancies, more detailed discussion of the applicable requirements can be found in Chapter 4.9.1.1.1.11.

11.5.8 Compliance and Enforcement

This section describes compliance documentation and field verification requirements related to heating and cooling systems.

11.5.8.1 Design-Phase Documentation

The following are heating and cooling system features that will be listed on the certificate of compliance if they exist in the proposed design:

- Information summarizing requirements for field verification and diagnostic testing is presented in Table RA2-1 of the Reference Residential Appendix RA2. The field verification and diagnostic testing protocols that must be followed to qualify for compliance credit are described in RA3 of the Reference Residential Appendix.

- Registration of the certificate of compliance with an approved HERS Provider is required for buildings up to three stories. The building owner or the person responsible for the design must submit the Certificate of Compliance to the HERS Provider Data Registry for retention according to the procedures described in §10-103 and Reference Residential Appendix RA2. Registration ensures that the project follows the appropriate verification process, provides tracking, and provides electronic access to the documentation.

11.5.8.2 Construction-Phase Documentation

During construction, the general contractor or specialty subcontractors must complete all applicable certificate of installation documents for the building design special features specified on the certificate of compliance.

Like the certificate of compliance, registration of the certificate of installation is required except for multifamily buildings four or more stories. For all other buildings, the licensed contractor responsible for the installation must submit the certificate of installation information that applies to the installation to a HERS Provider Data registry using procedures described in §10-103 and Reference Residential Appendix RA2. Certificate of installation documents corresponding to the list of special features requiring HERS Rater verification in Chapter above are required. For buildings four or more stories, the licensed contractor responsible for the installation must complete and submit the certificate of installation to the building department or authority having jurisdiction.

11.5.8.3 Field Verification and Diagnostic Testing

For buildings for which the certificate of compliance requires HERS or ATT field verification for compliance with the Energy Code, a HERS Rater or ATT must visit the site to perform field verification and diagnostic testing to complete the applicable heating and cooling system certificates of verification. Certificate of verification documents corresponding to the list of special features requiring HERS Rater or ATT verification in Chapter above are required.

Field verification for nonmandatory features is necessary only when performance credit is taken for the feature. Some field verifications are mandatory requirements and will occur in all dwelling units unless they are exempt from the requirement.

Like the certificate of compliance and certificate of installation, registration of the certificate of verification is required. The HERS Rater or ATT must submit the field verification and diagnostic testing information to the HERS Provider Data Registry as described in Chapter 2. For additional details describing HERS verification and the registration procedure, refer to Reference Residential Appendix RA2.

A. Requirements for HERS Field Verification and Diagnostic Testing

Special features requiring HERS Rater verification for multifamily buildings with up to three habitable stories:

- Duct sealing
- Verified duct design: for reduced duct surface area or buried ducts
- Low-leakage ducts in conditioned space
- Low-leakage air handlers
- Verification of return duct design
- Verification of bypass duct prohibition
- Refrigerant charge verification
- Installation of an FID
- Verified system airflow
- Air handler fan watt draw
- High energy efficiency ratio
- High SEER
- High heating seasonal performance factor
- Heat pump - rated heating capacity

The requirements in Table 11-39: require additional verification. For all multifamily buildings, testing must be conducted and certified by the installing contractor. For multifamily buildings up to three habitable stories, the contractor results must be verified by a HERS Rater and all applicable certificates of compliance, installation, and verification must be registered with an approved HERS Provider. For multifamily buildings four or more habitable stories neither a HERS Rater nor registration with a HERS Provider is required. Verification, testing, and sampling procedures should follow Chapter 2.2.

Table 11-39: Air Distribution System Verification Requirements

Feature	Mandatory	Prescriptive	Performance Credit
Duct sealing	X		X
Duct location in conditioned space	X	X (If complying with §170.2(c)Biib)	X
Low-leakage ducts in conditioned space	X	X (If complying with §170.2(c)Biib)	X
Cooling coil airflow	X		X
Air handler fan watt draw	X		X
Return duct system design	X		
Verification of bypass duct prohibition		X	
Verified duct design (reduced duct surface area / buried ducts)			X
Low-leakage air handlers			X

Source: California Energy Commission

11.5.9 Code in Practice

11.5.9.1 Garden Style Multifamily Case Study

The Garden Style Multifamily Case Study considers a new two-story garden style multifamily building in Burbank, California (Climate Zone [CZ] 9). This is a sample project created for training purposes, and it consists of 7,216 ft² of conditioned floor area with eight dwelling units and no common use areas. The case study tables in this chapter compare the proposed building mechanical system features to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Figure 53: Garden Style Multifamily Case Study: North (Rear) Elevation Showing Outdoor Condensers

Table 11-40: Garden Style Multifamily Mechanical Schedule

Split DX heat pumps: One heat pump per dwelling unit	**Cooling Efficiency**: 14 SEER **Cooling Output:** 1-1/2 ton, 17,700 Btuh total, 12,390 Btuh sensible **Heating Efficiency:** 8.2 HSPF **Heating Output:** 1-1/2 ton, 17,200 Btuh total	**Supply Fan:** 450 CFM 0.25 BHP MERV 13 2" filter	**Air Handler Location:** 1st Floor: Exterior closets 2nd Floor: Interior closets	**Distribution:** 1st Floor: R-8 Ducts between floors 2nd Floor: R-8 Ducts in attic
Bathroom exhaust fans: Continuous operation for whole dwelling unit IAQ ventilation	**EF-1** (1-bedroom units): 40 CFM each, 0.083 horsepower **EF-2** (2-bedroom units): 60 CFM each, 0.125 horsepower			
HVAC Controls	Programmable setback thermostats			

Source: California Energy Commission

Table 11-41: Garden Style Multifamily Case Study Compared to Mandatory and Prescriptive Mechanical System Requirements (Climate Zone 9)

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Multifamily Building	New two-story garden style multifamily building, eight dwelling units, no common use areas, Burbank, CA	§110.0, §110.1, §110.2, §160.2, §160.3 Title 20 Section 1605.1 Table C-3	§170.2(c), Table 170.2-K New multifamily building ≤ three stories, Climate Zone (CZ) 9	Case study Mandatory and Prescriptive compliance rated for each feature below as "Yes" (complies), "No" (does not comply) or "N/A" (not applicable). If "No", see compliance options provided.
Total Conditioned Floor Area (CFA)	7,216 ft²	7,216 ft²	7,216 ft²	
Fuel Type	Space Heating: Electricity Space Cooling: Electricity	No Mandatory fuel type requirements	Space Heating: Electricity Space Cooling: Electricity	Mandatory: NR Prescriptive: Yes
Equipment Type	Split DX heat pumps with air handlers in closets (1st floor exterior, 2nd floor interior) and condensers on pads outside, one 1.5 ton heat pump per dwelling unit	Meet or exceed Mandatory requirements for proposed HVAC system type	CZ 9: Electric heat pumps required for dwelling units in multifamily buildings ≤ three stories, HERS-verified refrigerant charge	
Heating Efficiency	8.2 HSPF	Meet or exceed current Federal minimum: HSPF ≥ 8.2	Meet or exceed current Federal minimum: HSPF ≥ 8.2	Mandatory: Yes Prescriptive: Yes
Cooling Efficiency	14.0 SEER	Meet or exceed current Federal minimum: SEER ≥14.0	Meet or exceed current Federal minimum: SEER ≥14.0	Mandatory: Yes Prescriptive: Yes

Table 11-42: Distribution, Ventilation and Verifications

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Distribution and Air Handler Location	1st Floor: R-8 ducts between floors, Air handler in unconditioned closet 2nd Floor: R-8 ducts in vented attic with R-30 ceiling insulation, Air handler in indirectly conditioned closet	Mandatory minimum R-6 for ducts in unconditioned space, HERS-verified duct leakage testing	HERS-verified ducts and air handler in conditioned space, OR Minimum R-8 ducts in Option B high performance vented attic and air handler in any location	Mandatory: Yes Prescriptive: No Compliance Options: 1. For 2nd floor ducts in attic: Upgrade to high performance attic (R-38 ceiling, R-19 roof, roofing type with air space) For 1st floor: Move ducts and air handler to conditioned space, and HERS verify. 2. Move all ducts and air handing units to conditioned space to meet Option C, and HERS verify 3. Performance Approach
Ventilation	Continuous bathroom exhaust fans for whole unit IAQ (triggers blower door envelope air-leakage testing): 1-Bedroom units: 40 CFM, 0.083 bhp 2-Bedroom units: 60 CFM, 0.125 bhp; AHAM/HVI certified kitchen hood over electric stovetop	Minimum whole dwelling unit ventilation per Equation 160.2-B: 1-Bedroom units: ≥ 38 CFM 2-Bedroom units: ≥ 55 CFM Mandatory HERS-verified: AHAM/HVI certified kitchen hood, IAQ ventilation, and enclosure air leakage	N/A	Mandatory: Yes Prescriptive: N/A
Verifications	Proposed building will have all required Mandatory and Prescriptive HERS verifications	Mandatory Kitchen hood Mandatory Duct testing Mandatory Fan efficacy/airflow rate Mandatory Heat Pump Rated Heating Capacity Mandatory IAQ Mandatory Enclosure Air Leakage	Prescriptive Refrigerant charge	Mandatory: Yes Prescriptive: Yes

Source: California Energy Commission

The proposed mechanical system meets all applicable mandatory requirements plus some of the relevant prescriptive requirements.

The split heat pump space heating and cooling equipment complies with the prescriptive heat pump requirement and meets the Federal mandatory minimum SEER and HSPF efficiency requirements. Note that the applicable heat pump heating and cooling efficiency requirements are listed in Title 20 Section 1605.1 Table C-3 for heat pumps under 65,000 Btuh, rather than in Table 110.2-B in Title 24, Part 6 which covers larger capacity heat pumps. Mandatory minimum whole dwelling unit ventilation for indoor air quality is calculated per Energy Code equation 160.2-B:

$Q_{tot} = (0.03 \times A_{floor}) + (7.5 \times (N_{br} + 1))$

Q_{tot} = Total required ventilation rate in CFM
A_{floor} = Dwelling unit floor area in ft²
N_{br} = Number of bedrooms (must be one or more)

1-bedroom units: (0.03 CFM/ft² x 750 ft²) + (7.5 CFM x (1 + 1)= 37.5 CFM

2-bedroom units: (0.03 CFM/ft² x 1080 ft²) + (7.5 CFM x (2 +1) = 54.9 CFM

HERS-verified continuous exhaust fan ventilation combined with HERS-verified limits to building envelope leakage, plus HERS-verified kitchen range hoods meet Mandatory ventilation requirements. Note that the kitchen hoods must be AHAM/HVI certified as meeting airflow rate or capture efficiency, and sound rating.

By contrast, the duct locations for the proposed systems as shown do not comply prescriptively. The building plans show the heat pump air handling units in the mechanical closets for each dwelling. On the first level the closets only open to the outside, so they are unconditioned space. R-8 ducts run from the air handlers up through the ceiling framing between levels to serve the conditioned spaces below. On the second level, the mechanical closets only open into the conditioned space of the dwelling units, so they are indirectly conditioned spaces. R-8 ducts run up from the air handlers into the vented attic which only has ceiling insulation but no roof insulation. These designs meet all mandatory requirements, but the Prescriptive path only allows two duct location options:

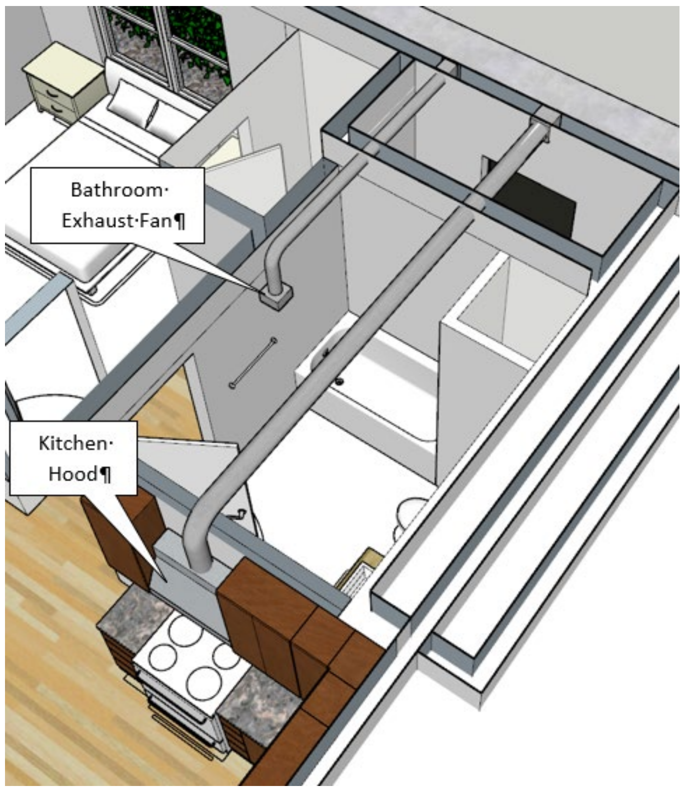
1. Ducts and air handling units both in conditioned space
2. R-8 ducts in a high performance attic designed to Prescriptive Option B with both ceiling and roof insulation

The Prescriptive Approach requires that a building meets all Prescriptive requirements. Unless the design team and owner are willing to change this particular building envelope to accommodate ducts and air handlers in conditioned space for the first floor, and either ducts in conditioned space or in a high performance attic for the second floor, the building will need to show compliance using the Performance Approach.

The Performance method allows trade-offs between different building features to offset components that do not comply prescriptively. There are also HVAC Performance compliance credit options available, such as:

- Higher efficiency equipment
- Variable capacity heat pump (VCHP)
- Low leakage air-handling unit (AHU)
- Pre-cooling
- ERV/HRV
- Whole house fan
- Central fan ventilation cooling system

Figure 54: Garden Style Multifamily: Bathroom Exhaust and Kitchen Hood Ducts



11.5.9.2 Mid-Rise Multifamily Case Study

The Mid-Rise Multifamily Case Study covers a new five-story multifamily building in Sacramento, California (Climate Zone [CZ] 12). This is a sample project created for training purposes, and it includes 112,044 ft² of conditioned floor area with 88 dwelling units, shared residential corridors, laundry rooms, fitness center and lounge, plus ground floor retail. The case study tables in this chapter compare the proposed building mechanical system features to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Figure 55: Mid-Rise Multifamily Case Study: Mechanical and Central DHW Roof Plan

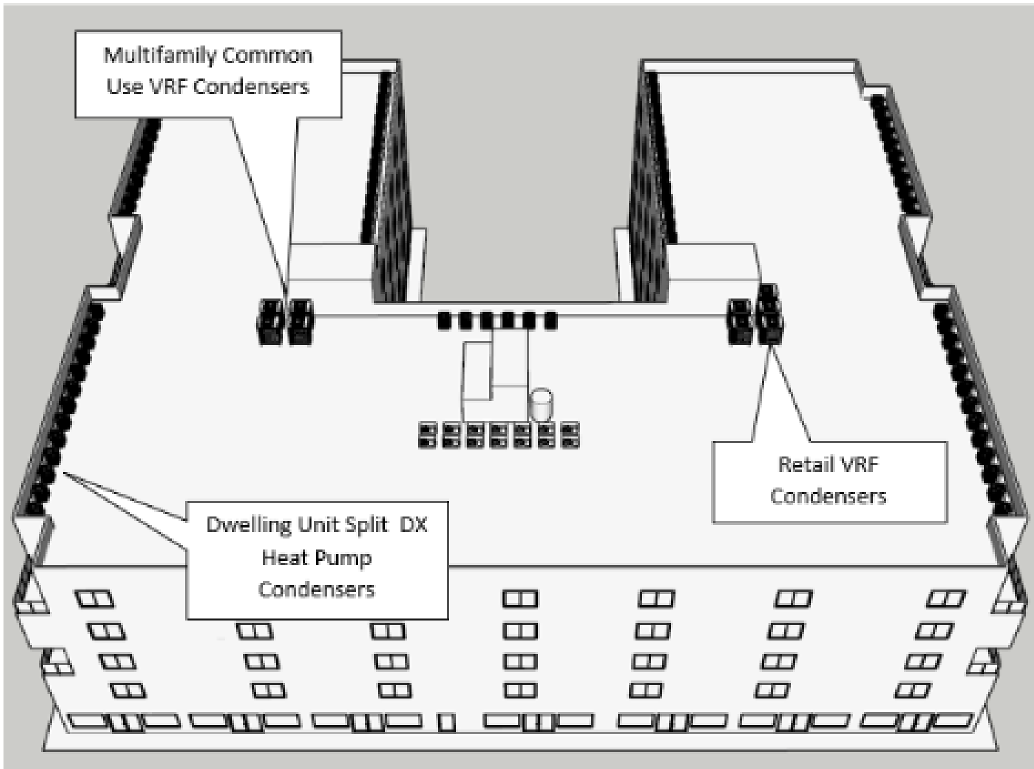


Figure 56: Mid-Rise Multifamily Case Study: 5th Floor Apartment Air Handler and Condenser

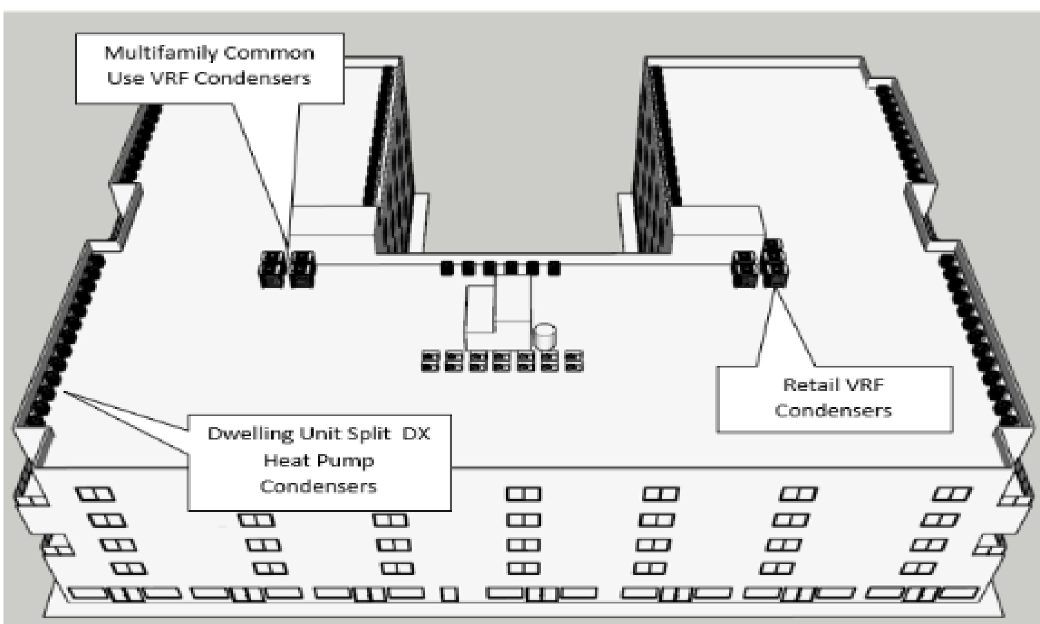


Table 11-43: Mid-Rise Multifamily Case Study Compared to Mandatory and Prescriptive Mechanical System Requirements (Climate Zone 12)

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Mid-Rise Multifamily Building	New five-story mid-rise multifamily building, 88 dwelling units, common use areas, ground floor retail, Sacramento, CA	§110.0, §110.1, §110.2, §120.1, §120.2, §120.3, §160.2, §160.3 Title 20 Section 1605.1 Table C-3	§170.2(c), Table 170.2-K Section 140.4 New mixed occupancy multifamily plus nonresidential building ≥ four stories, Climate Zone (CZ) 12	Case study Mandatory and Prescriptive compliance rated for each feature below as “Yes” (complies), “No” (does not comply) or “N/A” (not applicable). If “No”, see compliance options provided.
Conditioned Floor Area (CFA)	Dwelling Units: 78,384 ft²	78,384 ft²	§170.2(c)3	
	Common Use Multifamily: 17,487 ft²	17,487 ft² 160.3(b)	§170.2(c)1-2	
	Nonresidential: 16,173 ft²	16,173 ft²	§140.4	
	Total: 112,044 ft²	112,044 ft²		
Total Percent Multifamily in Mixed Occupancy Building	(78,384 + 17,487)/ 112,044 = 85.6%	Mandatory requirements for each occupancy type	Because multifamily is ≥ 80% of total CFA, the whole building has the option of complying with multifamily Prescriptive, or could comply by separate occupancies	

Source: California Energy Commission

Figure 57: Section 100.0(f) Exception 1 for Mixed Occupancy

Mixed Occupancy. When a building is designed and constructed for more than one type of occupancy (residential and nonresidential), the space for each occupancy shall meet the provisions of Part 6 applicable to that occupancy.

EXCEPTION 1 to Section 100.0(f): If one occupancy constitutes at least 80 percent of the conditioned floor area of the building, the entire building envelope, HVAC, and water heating may be designed to comply with the provisions of Part 6 applicable to that occupancy, provided that the applicable lighting requirements in Sections 140.6 through 140.8, ~~or~~ 150.0(k), or 160.5 and 170.2(e) are met for each occupancy and space, and mandatory measures in Sections 110.0 through 130.5, ~~and~~ 150.0, and 160.0 through 160.9 are met for each occupancy and space.

Table 11-44: Fuel Type, Equipment Type and Efficiency

Case Study Equipment Types and Locations
1st Floor: Mixed Occupancy: Retail (Nonresidential) and 1st -5th Floors: Multifamily Common Use (MF CU): Variable refrigerant flow (VRF) multi-split air source heat pumps, condensers on the roof, VRF heat pump fan coil units installed for each zone, economizers for FCUs with cooling capacity > 33,000 Btuh, Retail: No ducts, MF CU: Ducts in conditioned space 2nd-5th Floors: Multifamily Dwelling Units (MF DU): Split DX heat pumps with air handlers in interior closets and condensers on roof, ducts in conditioned space, one 1.5 ton heat pump for each studio, 1-bedroom and 2-bedroom dwelling unit, one 2 ton heat pump for each 3-bedroom dwelling unit
Fuel Type, Equipment Type and Efficiency

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Fuel Type: Space Heating	MF DU: Electricity	No requirement	Electric heat pump	Mandatory: NR Prescriptive: Yes
	MF CU: Electricity	No requirement	No requirement	Mandatory: NR Prescriptive: NR
	Retail: Electricity	No requirement	No requirement	Mandatory: NR Prescriptive: NR
Fuel Type: Space Cooling	MF DU: Electricity	No requirement	Electric heat pump	Mandatory: NR Prescriptive: Yes
	MF CU: Electricity	No requirement	No requirement	Mandatory: NR Prescriptive: NR

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
	Retail: Electricity	No requirement	No requirement	Mandatory: NR Prescriptive: NR
Equipment Type Note: Proposed systems are designed to meet all applicable Mandatory requirement	MF DU: Split DX heat pumps (HP)	Meet or exceed all applicable Mandatory requirements	CZ 12: Electric heat pumps with verified refrigerant charge required	MF DU: Mandatory: Yes Prescriptive: Yes
	MF CU: VRF HP ≥ 240 kBtuh cooling, sized to meet design loads	VRF heating rating condition: 47°F DB and 43°F WB outdoor air	Sized to meet design heating and cooling loads per 170.2(c)1-2	MF CU: Mandatory: Yes Prescriptive: Yes
	Retail: VRF HP ≥ 240 kBtuh cooling, sized to meet design loads	VRF heating rating condition: 47°F DB and 43°F WB outdoor air	Sized to meet design heating and cooling loads per 140.4(a)1	Retail: Mandatory: Yes Prescriptive: Yes
Heating Efficiency: Meet or exceed Federal minimums	MF DU: Split HP: 8.2 HSPF	HSPF ≥ 8.2	HSPF ≥ 8.2	Mandatory: Yes Prescriptive: Yes
	MF CU: VRF HP: 3.2 COP	COP ≥ 3.2	COP ≥ 3.2	Mandatory: Yes Prescriptive: Yes
	Retail: VRF HP: 3.2 COP	COP ≥ 3.2	COP ≥ 3.2	Mandatory: Yes Prescriptive: Yes
Cooling Efficiency: Meet or exceed Federal minimums	MF DU: Split HP: 14.0 SEER	SEER ≥ 14.0	SEER ≥ 14.0	Mandatory: Yes Prescriptive: Yes
	MF CU: VRF HP: 9.5 EER	EER ≥ 9.5	EER ≥ 9.5	Mandatory: Yes Prescriptive: Yes
	Retail: VRF HP: 9.5 EER	EER ≥ 9.5	EER ≥ 9.5	Mandatory: Yes Prescriptive: Yes

Source: California Energy Commission

Table 11-45: Distribution, Air Handlers and Fan Systems

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Distribution and Air Handlers	MF DU: Verified uninsulated ducts in conditioned space, air handlers in indirectly conditioned closets, refrigerant line pipe insulation	Mandatory verification of uninsulated ducts in conditioned space, Pipe insulation for refrigerant distribution systems per 160.3(c)1	No requirement for ducts in conditioned space	Mandatory: Yes Prescriptive: Yes
	MF CU: R-4.2 ducts in indirectly conditioned space, fan coil units (FCUs) in indirectly conditioned space, economizers for FCUs with > 33,000 Btuh cooling, refrigerant line pipe insulation	Pipe insulation for refrigerant distribution systems per 160.3(c)1 Minimum R-4.2 duct insulation or ducts in directly conditioned space	Economizers required for air handlers with > 33,000 Btuh cooling	Mandatory: Yes Prescriptive: Yes
	Retail: Ductless, FCUs in indirectly conditioned space, economizers for FCUs with > 33,000 Btuh cooling, refrigerant line pipe insulation	Pipe insulation for refrigerant distribution systems per 120.3	Economizers required for air handlers with > 33,000 Btuh cooling	Mandatory: Yes Prescriptive: Yes
Fan Systems	MF DU: See ventilation section below	See Ventilation section below	See Ventilation section below	Mandatory: N/A Prescriptive: N/A
	MF CU: All proposed fan systems, including VRF HP FCUs and DOAS ERV, with any fan or fan array ≥ 1 kW will be designed so that Fan kWdesign system ≤ Fan kWbudget per 170.2(c)4Aia. Fan motors < 1 hp and ≥ 1/12 hp to meet 170.2(c)4iii		170.2(c)4Ai: Each fan system with any fan or fan array ≥ 1 kW: Fan kWdesign system ≤ Fan kWbudget per 170.2(c)4Aia 170.2(c)4Aiii: Efficiency requirements for fan motors < 1 hp and ≥ 1/12 hp	Mandatory: N/A Prescriptive: Yes
	Retail: Similar to MF CU, but for 140.4(c)1 and 3		Similar to MF CU, but for 140.4(c)1 and 3	Mandatory: N/A Prescriptive: Yes

Table 11-46: Ventilation and Verifications

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Ventilation	MF DU: Balanced Energy Recovery Ventilation (ERV): Sensible Recovery Efficiency = 0.67 Fan Efficacy = 0.60 W/CFM Studios and 1-Bedroom units: 40 CFM, 0.032 bhp 2-Bedroom units: 60 CFM, 0.048 bhp; 3-Bedroom units: 75 CFM, 0.060 bhp AHAM/HVI certified kitchen hood over electric stovetop	MF DU: Balanced ERV: Fan Efficacy ≤ 1 W/CFM Minimum whole dwelling unit ventilation per Equation 160.2-B: Studios: ≥ 32 CFM 1-Bedroom units: ≥ 38 CFM 2-Bedroom units: ≥ 55 CFM 3-Bedroom units: ≥ 73 CFM Mandatory HERS-verified: AHAM/HVI certified kitchen hood, IAQ ventilation	MF DU: ERV: Sensible Recovery Efficiency ≥ 0.67 Fan Efficacy ≤ 0.60 W/CFM	Mandatory: Yes Prescriptive: Yes
	MF CU: DOAS ERV: 3,100 CFM Working with separate VRF HP system, meets 170.2(c)4O; Demand Control Ventilation (DCV)	Minimum total MF CU ventilation per Equation 160.2-G: ≥ 3,033 CFM	170.2(c)4N: DOAS with separate space conditioning to meet 170.2(c)4O Exhaust Air Heat Recovery. If airflow > 1,000 CFM require DCV	Mandatory: Yes Prescriptive: Yes
	Retail: DOAS ERV: 4,100 CFM (Other features same as MF CU)	Minimum total retail ventilation per Equation 120.1-F: ≥ 4,043 CFM	Same as MF CU	Mandatory: Yes Prescriptive: Yes
Verifications	Proposed building will have all required Mandatory and Prescriptive verifications	MF DU (Installing Contractor) Mandatory Duct testing Mandatory Ducts in conditioned space Mandatory Fan efficacy/airflow rate Mandatory Heat Pump Rated Heating Capacity Mandatory ERV/HRV fan efficacy (when present) MF DU (HERS) Mandatory Kitchen hood	Prescriptive Refrigerant charge Balanced Ventilation Systems (if present) ERV/HRV recovery efficiency (if present) ERV/HRV recovery efficiency above mandatory min. (if present) ERV/HRV recovery bypass (if present)	Mandatory: Yes Prescriptive: Yes

		Mandatory IAQ MF CU and Retail (ATT) Mandatory Airflow Mandatory Demand Shed Controls Mandatory EMCS Occupancy Sensor Zone Controls (corridors)		

Source: California Energy Commission

Table 11-47: Mid-Rise Multifamily Mechanical Schedule: Dwelling Units

Split DX heat pumps: One heat pump per dwelling unit: **1.5 tons** for studios, 1-bedroom and 2-bedroom units **2 tons** for 3-bedroom units	**Cooling Efficiency**: 14 SEER **Heating Efficiency:** 8.2 HSPF **Cooling Output:** **1.5 ton units:** 17,700 Btuh total, 12,390 Btuh sensible **2 ton units:** 22,200 Btuh total, 15,540 Btuh sensible **Heating Output:** **1.5 ton units:** 17,200 Btuh total **2 ton units:** 22,000 Btuh total	**Supply Fan:** **1.5 ton:** 525 CFM 0.40 BHP **2 ton:** 700 CFM 0.50 BHP **All:** MERV 13 2" filter	Air Handler Location: Interior closets	**Distribution:** Uninsulated ducts in conditioned space verified by installer

Notes on System:

- ERV Systems: Providing dwelling unit ventilation
- Balanced Energy Recovery Ventilation (ERV): Studios and 1-Bedroom units: 40 CFM, 0.032 bhp. 2-Bedroom units: 60 CFM, 0.048 bhp; 3-Bedroom units: 75 CFM, 0.060 bhp
- Kitchen hood: Installed over induction electric cooktops in each dwelling unit
- Bathroom exhaust fans: 70 CFM each, 0.055 bhp
- HVAC Controls: Programmable setback thermostats

Source: California Energy Commission

Table 11-48: Mid-Rise Multifamily Mechanical Schedule: Multifamily Common Use and Retail

Area Served	QTY	Equipment	Distribution
All 1st Floor Retail Total Outside Air ≥ 4,043 CFM	1	VRF Condenser: Cooling Output: 364,000 Btuh	
Retail Zones Total Outside Air ≥ 4,043 CFM	11	(1) VRF Heat pump FCU per zone: Cooling Output: 36,100 Btuh Heating Output: 48,100 Btuh Economizer	Ductless
All Multifamily Common Use Total Outside Air ≥ 3,033 CFM	1	VRF Condenser: Cooling Output: 246,000 Btuh	
MF CU Zones:		(1) VRF Heat pump FCU per zone:	

Area Served	QTY	Equipment	Distribution
1st Floor: Leasing Outside Air ≥ 216 CFM	1	Cooling Output: 26,800 Btuh Heating Output: 36,200 Btuh	R-4.2 Ducts in ind. conditioned
1st Floor: Lounge/Rec Outside Air ≥ 585 CFM	1	Cooling Output: 36,100 Btuh Heating Output: 48,100 Btuh Economizer	R-4.2 Ducts in indirectly conditioned
1st Floor: Fitness Center Outside Air ≥ 135 CFM	1	Cooling Output: 18,000 Btuh Heating Output: 19,100 Btuh	R-4.2 Ducts in ind. conditioned
1st Floor: Business Center Outside Air ≥ 54 CFM	1	Cooling Output: 9,300 Btuh Heating Output: 9,600 Btuh	R-4.2 Ducts in ind. conditioned
1st - 4h: Corridor/Stairs/Support 1st : Outside Air ≥ 387 CFM 2nd 4th: Outside Air per Zone ≥ 414 CFM	4	Cooling Output: 30,800 Btuh Heating Output: 36,200 Btuh	R-4.2 Ducts in indirectly conditioned
5th: Corridor/Stairs/Support Outside Air ≥ 414 CFM	1	Cooling Output: 33,600 Btuh Heating Output: 42,000 Btuh Economizer	R-4.2 Ducts in indirectly conditioned

Source: California Energy Commission

VRF systems: Separate multi-split VRF heat pump systems serving retail and multifamily common use areas

Dedicated Outdoor Air Systems (DOAS): MERV 13 Filters, Demand Control Ventilation

Retail ERV: Outdoor Air Volume: 4,100 CFM, Supply Fan: 2 hp, Exhaust Air Volume: 4,100 CFM, Exhaust Fan: 2 hp

HVAC Controls: Programmable setback thermostats for each zone, occupant sensor shut-off controls in corridors and stairwells with partial OFF lighting controls, automatic time switch shut-off controls in other zones

MF CU ERV: Outdoor Air Volume: 3,100 CFM, Supply Fan: 1.5 hp, Exhaust Air Volume: 3,100 CFM, Exhaust Fan: 1.5 hp

This mid-rise multifamily case study has different types of mechanical systems for the dwelling units versus the multifamily common use areas and retail zones.

The dwelling unit split heat pump space heating and cooling equipment complies with the Prescriptive heat pump requirement and meets the Federal Mandatory minimum SEER and HSPF efficiency requirements. Note that the applicable heat pump heating and cooling efficiency requirements are listed in Title 20 Section 1605.1 Table C-3 for heat pumps under 65,000 Btuh. Each system consists of a heat pump air handler located in a dwelling unit and a separate condenser located on the roof. Since there are 88 total dwelling units with split heat pumps, there are 88 condensers located on the roof. In this case study, those condensers are placed around the roof perimeter next to the parapets to leave room for the required solar photovoltaic (PV) panels.

The multifamily common use areas and the retail spaces are served by VRF heat pump equipment with central condensing units on the roof and VRF heat pump fan coil units in each zone. The selected equipment meets the Federal Mandatory minimum heating and cooling efficiency requirements found in Energy Code Table

110.2-H for VRF air cooled systems. There are different cooling efficiency requirements for VRF systems with different cooling capacities ranging from less than 65,000 Btuh to greater than or equal to 240,000 Btuh. There are also different heating efficiency requirements based on cooling, not heating, capacities ranging from less than 65,000 Btuh to 135,000 Btuh or more. Note that while the VRF fan coil units all have cooling capacities less than 65,000 Btuh, the two different VRF condensers for retail and common use areas are both over 240,000 Btuh. The efficiencies in Table 110.2-H are based on the condenser cooling capacity, not that for the fan coil units. Knowing that, Table 110.2-H shows that these particular VRF systems must meet or exceed a cooling efficiency of 9.5 EER and a heating efficiency of 3.2 COP.

Supplying mandatory ventilation outside air is handled differently for the residences compared to the common use areas and retail zones. The dwelling unit ventilation system includes three main components within each residence:

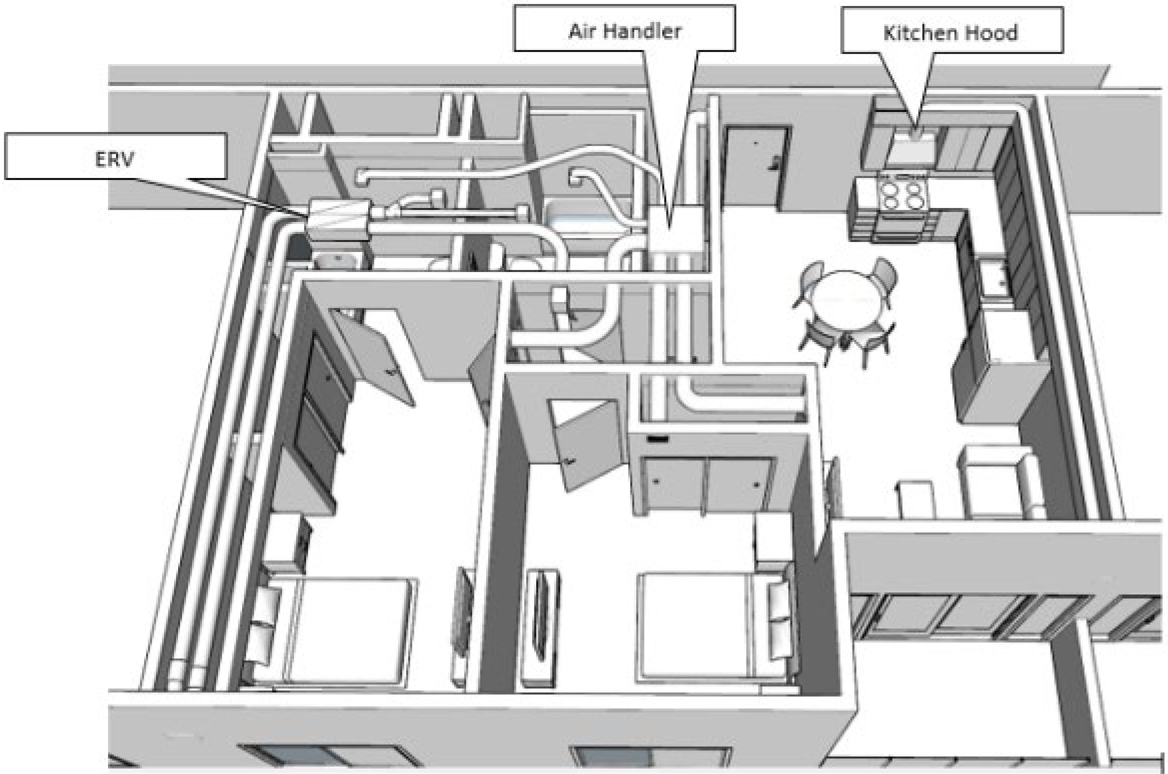
- The primary air handler in each unit connected to ducts in conditioned space that deliver heated and cooled air throughout the residence
- A balanced energy recovery ventilator or ERV that supplies outdoor air and exhausts indoor air
- The kitchen hood installed over the electric induction cooktop that exhausts cooking fumes directly to the outside

By contrast, the multifamily common use areas and retail spaces have the following ventilation components:

- Central ERV dedicated outside air systems (DOAS) – one that delivers outside air to all the retail spaces and another that delivers outside air to all the multifamily common use areas. Since these systems are ERVs, they also exhaust the same amount of indoor air from the zones they serve.
- VRF heat pump fan coil units in each zone that deliver heated and cooled air within the space. The retail fan coil units are ductless, so they deliver conditioned air from one central location within each store. The common use fan coil units deliver air through ducting throughout each space.

Overall, the proposed mechanical systems meet all applicable mandatory requirements and prescriptive requirements, so the proposed systems comply prescriptively as designed.

Figure 58: Mid-Rise Multifamily: 5th Floor Apartment HVAC Supply, ERV and Kitchen Hood Layout with Ducts



11.6 Water Heating Requirements

Chapter 11.7.5 describes the compliance requirements for domestic water heating for newly constructed multifamily dwellings. This chapter describes common water heater types, and hot water distribution system designs. For service hot water systems serving common use area and nonresidential spaces within a multifamily building, see Chapter 4.8.

Table 11-49 provides an overview of the location of the water heating requirements in the Energy Code by system building type and where descriptions reside in this document.

Table 11-49: Overview of Multifamily Water Heating Requirements

Types	Mandatory Requirements Standards Section	Mandatory Requirements Manual Section	Prescriptive Requirements Standards Section	Prescriptive Requirements Manual Section	Performance Requirements Standards Section	Performance Requirements Manual Section
System serving individual dwelling units only; Systems serving common use areas without a recirculation loop	§110.3. §160.4	11.7.5; 11.7.6.10;	§170.2(d) 1	11.7.6.10; 11.7.6.20	§170.1	11.7.6.10: 11.7.6.20;
Systems serving multiple dwelling units; Systems serving common use areas with a recirculation loop	§110.3. §160.4 except (a)	11.7.5; 11.7.6.10; 11.7.7.20	§170.2(d). §170.2(d) 2 through 4	11.7.7.10; 11.7.7.20	§170.1	11.7.7.10; 11.7.7.20

Source: California Energy Commission

11.6.1 What's New for the 2022 Energy Code

This section summarizes changes to the requirements for multifamily water heating for the *2022 Energy Code*. Water heating requirements are organized by and based on whether a water heating system services individual versus multiple dwelling units.

11.6.1.1 Mandatory Requirements

For systems serving individual dwelling units:

For systems serving multiple dwelling units:

- Increase in pipe insulation requirements for hot water pipes two inches and larger.

For system serving common use area:

11.6.1.2 Prescriptive Requirements

For water heating systems serving individual dwelling units:

- 240 volt heat pump water heaters were added as a prescriptive path, with additional efficiency features required for select climate zones. A NEEA Advanced Water Heater Specification Tier 3 or higher heat pump water heater can be used also.

- Gas storage water heater is removed as a prescriptive path. Instantaneous gas water heaters are allowed prescriptively.

  For central water heating systems serving dwelling units:

- A prescriptive pathway for central heat pump water heating systems serving multiple dwelling units. The prescriptive pathway includes basic plumbing configuration and control requirements to ensure system performance. It also includes design documentation requirements that are part of JA 14.
- Updates to central gas or propane storage system call for minimum ninety percent thermal efficiency for system at or larger than one MMBtu/h for Climate Zones 1 through 9. A solar thermal system with minimum solar savings fraction is required in conjunction.

11.6.1.3 Performance Approach

- The central water heating system energy budget for the performance approach now has a gas or electric baseline based on the proposed water heater type. For gas-fueled water heaters, the energy budget is based on the performance of a gas storage water heater system. For electric water heaters (both electric resistance and heat pump heaters), the energy budget is based on the performance of a central HPWH system. The gas and electric water heaters used in the baseline must meet the minimum requirements in California's Title 20 Appliance Efficiency Regulations Section 1605.1(f) for federally regulated appliances.
- For central HPWH systems to comply using the performance method, central HPWH products to be certified to the Energy Commission and specifies design documentation requirements per JA 14 qualification requirements.

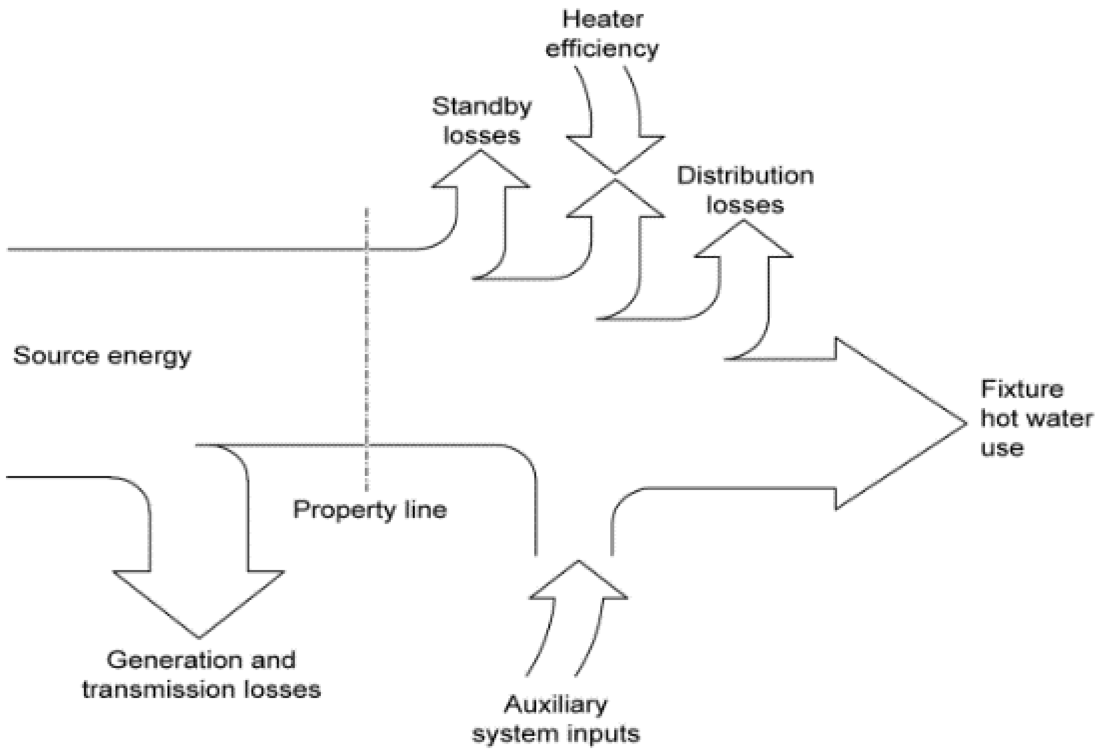
11.6.2 Water Heating Energy

Total energy use associated with water heating consists of fixture hot water use, heater inefficiencies, standby losses, and distribution system losses. Figure 11-59 below shows the energy flows that constitute water heating energy usage. Hot water draws at the end use points (for example, faucets, showers, etc.) represent the useful energy consumed. In most cases, hot water usage represents the largest fraction of water heating energy consumption, although in situations when there are very few hot water draws, standby losses from a standard gas storage water heater and the hot water distribution system can exceed the quantity of useful energy consumed at the end point.

Energy impacts associated with the hot water distribution system vary widely based on the type of system, quality of insulation and installation, building and plumbing design, and hot water use patterns. Distribution losses in a typical water heating system serving individual dwelling units may be as much as 30% of the total energy used for water heating. This figure drops to lower than 10% of total water heating energy use for dwelling units with compact hot water distribution. In a typical multifamily building where a centralized system is installed, distribution losses can account for more than 30% of total water heating energy use.

In this compliance manual, the hot water load at the end use points is defined as the *Primary Water Heating Load,* and the hot water load due to heat loss in the distribution loop is defined as *Temperature Maintenance Load*. For central water heating systems with large recirculation loop, designers must consider both types of load for equipment sizing and plumbing configuration.

Figure 11-59: Water Heating Energy Flow Representation



11.6.3 Multifamily Water Heating Equipment

This section describes various water heating systems and equipment types for multifamily buildings. Descriptions of applicable code requirements begin in Section 11.7.5 and on.

There are several types of water heaters for multifamily buildings, as described below. The most common water heaters serving individual dwelling units are consumer gas storage, instantaneous gas water heaters, and heat pump water heaters. For systems serving multiple dwelling units and common use area, two options are commonly used: 1) a central domestic hot water (DHW) system with one or more commercial storage water heaters or 2) one or more boilers coupled with a storage tank to serve the entire building.

To comply with the Energy Code using either the prescriptive or performance approach, the water heater must meet the federal and/or the California Appliance Efficiency Regulations (Title 20).

11.6.3.1 Dwelling Unit Instantaneous Water Heaters

Instantaneous water heaters, commonly referred to as *tankless* or *on-demand*, heat water using natural gas, electricity, or propane. These units do not have a tank for storing heated water, but instead use a sensor that detects the flow of water over the heat exchanger that initiates the heating element (typical volumes around 0.5 gallons). Instantaneous units can deliver water at a controlled temperature of less than 180ºF. The input rating for gas instantaneous water heaters ranges between 50,000 and 200,000 BTU per hour (at least 4,000 BTU per hour per gallon of stored water) with a storage capacity of less than two gallons.

Instantaneous water heaters require an electrical connection for controls and the combustion air blower, a direct or power venting system. Instantaneous gas water heaters require a larger gas line (typical input ratings of 140,000 to 200,000 BTU/hr) than storage gas water heaters.

Electric instantaneous water heaters are not generally designed for use with solar water heating systems or as heat sources for indirect-fired water heaters. They are also typically inappropriate for use with recirculation systems. Electric instantaneous water heaters are not allowed through the prescriptive approach but can be modeled in the performance approach, although it is difficult to show compliance without significant upgrades to other building components.

To comply prescriptively with the *Energy Code*, a user can choose to install a gas or propane instantaneous water heater that meets the minimum efficiency requirements of California's *Title 20 Appliance Efficiency Regulations*. The equipment is limited to an input of 200,000 BTU per hour and no storage tank.

11.6.3.2 Storage Water Heater

11.6.3.3 Consumer Storage Water Heaters

Storage water heaters use gas (natural gas or propane), electricity, or oil to heat and store water at a thermostatically controlled temperature (less than 180º F) for delivery on demand. Federal appliance efficiency standards differentiate storage water heaters based on whether the rated storage volume is greater than 55 gallons or less than or equal to 55 gallons.

The U.S. Department of Energy (DOE) classifies consumer gas water heaters as having an input of 75,000 BTU per hour or less and has a storage capacity ranging between 20 and 100 gallons. A basic gas storage water heater is composed of a standing pilot ignition system, a burner, a combustion chamber, a flue baffle, a flue, an insulated water tank, a cold water inlet and hot water outlet, a sacrificial anode, a gas valve, a temperature and pressure relief valve, a thermostat, heat traps, and an outer case.

The DOE classifies consumer electric storage water heaters as having an input of 12 kilowatt (kW) or less and have a storage capacity ranging between 20 and 120 gallons. A basic electric storage water heater differs from gas water heaters by using an electric resistance heating element. As noted in this chapter, electric storage water heaters are not allowed through the prescriptive approach but can be installed using the performance approach.

In 2015, the DOE added a new category of water heaters called *grid-enabled water heaters* defined as an electric resistance water heater that has a rated storage tank volume of more than 75 gallons and is manufactured on or after April 16, 2015. The water heater must have an activation lock at the point of manufacture and is intended for use only as part of an electric thermal storage or demand response (DR) program.

11.6.3.4 Residential-Duty Commercial Water Heater

Residential-duty commercial water heater is essentially a commercial water heater that can be legally installed in a residential dwelling unit. It is defined in the Federal Code of Regulations (10 CFR 431.102) as any gas-fired, electric, or oil storage or instantaneous commercial water heater that meets the following conditions:

1. Uses a single-phase external power supply for models that require electricity.
2. Is not designed to provide outlet hot water at temperatures greater than 180°F.
3. Is not excluded by the specified limitations regarding rated input and storage capacity as described in Table 11-50 below. In other words, a residential-duty commercial water heater must have rated input and rated storage volume below the value listed in Table 11-50.

Table 11-50: Capacity Limitations for Defining Commercial Water Heaters – Heaters with Specifications below These Thresholds are "Residential-Duty"

Water Heater Type	Indicator of Nonresidential Application
Gas-Fired Storage	Rated input >105 kBTU/h; Rated storage volume >120 gallons.
Oil-Fired Storage	Rated input >140 kBTU/h; Rated storage volume >120 gallons.
Electric Instantaneous	Rated input >58.6 kW; Rated storage volume >2 gallons.

Source: U.S. Department of Energy (2014). "Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Residential and Commercial Water Heaters; Final Rule." http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-TP-0042-0082

Residential-duty commercial water heaters are rated in uniform energy factor (UEF) and are allowed through the prescriptive approach. They can also be installed using the performance approach serving either individual or multiple dwelling units, though use with multiple dwelling units trigger solar water heating requirements and potentially recirculation requirements if serving more than eight dwelling units.

11.6.3.5 Hot Water Supply Boiler

A *hot water supply boiler* is water heating equipment with a heat input rate from 300 to 12,500 kBTU per hour and at least 4,000 BTU per hour per gallon of stored water. A hot water boiler should have either the temperature or pressure control necessary for heating potable water for purposes other than space heating, or the boiler manufacturer's literature should indicate that the intended uses of the boiler include heating potable water for purposes other than space heating. A hot water boiler could be fueled by oil or gas, and it must adhere to the minimum thermal efficiency and maximum standby loss as described in California's *Title 20 Appliance Efficiency Regulations*.

Boilers are typically used for both central space heating and water heating in multifamily buildings and require one or more unfired storage tanks as part of the system. Careful attention should be given to the layout of these systems, due to the potential for high energy losses between the boiler and storage tanks.

11.6.3.6 Heat Pump Water Heaters

This section describes heat pump water heater equipment for multifamily buildings. Descriptions of applicable code requirements begin in Section 11.7.5 and on.

An HPWH is an electric water heater that works like an air condition cycle in reverse. It uses a compressor to transfer heat from the surrounding air to the water tank. It includes all necessary auxiliary equipment such as fans, storage tanks, pumps, or controls. Typically, HPWHs include backup electric resistance elements to ensure hot water delivery when the air temperature is too cold, or the hot water demand is too high. A few models use larger compressors to avoid the need for resistance elements.

The performance of HPWHs depends heavily on air temperature because they rely on extracting heat from the air. Climate conditions and different installation locations, such as a garage or a vented outdoor closet, have an impact on performance. HPWHs are most efficient in warmer climates. In addition to air temperature sensitivity, HPWH performance is affected by cold water inlet temperatures, as introduction and mixing of inlet water during larger draws may trigger second stage electric resistance heating in the tank.

There are two basic configurations of a HPWH system's storage tank and heat pump.

- Unitary heat pump with integrated storage (commonly used for individual systems)
- Split heat pump with separate storage tank(s)

A simple and readily available is unitary heat pump with integrated storage. These units are single package, and they physically resemble the size and form of traditional residential tank-type gas water heaters. Most integrated heat pumps are sized for individual or multiple dwelling unit applications. Multiple heat pumps can be combined to create a larger system without recirculation, referred to as a clustered design.

Split heat pumps with separate storage tanks are larger capacity products suitable for multifamily central HPWH applications. These heat pumps range in heating capacity from 15,000 Btu/hr to 250,000 Btu/hr. Central system designs often bundle modular compressors for combined capacities of over 2,000,000 Btu/hr.

For split systems, the designer needs to separately size and specify the heat pump, storage tanks, and other associated components. Without turnkey packaged central HPWH solutions, manufacturers typically work closely with the design engineers for customized matching of their various product components to the design condition.

The Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification[4] (Spec) was developed to address critical performance and comfort issues of individual HPWH in colder climates. The NEEA Spec incorporates tiers of various product performance and configuration. A NEEA Tier 3 or higher HPWH can be used to meet the prescriptive requirements.

HPWHs use a range of refrigerant types, each with different thermodynamic properties, which impact their operation pressure, temperature requirements, and efficiency to move heat. This consequently impacts design and installation approaches such as the plumbing configuration, equipment location, and ventilation air quantity. The refrigerant can also dictate whether electric resistance backup, integrated or otherwise, is needed. A given refrigerant can achieve a certain heat transfer rate at an achievable pressure. If the heat transfer rate is insufficient under low outdoor temperatures or during certain draw periods (e.g., high total hot water usage), then electric resistance backup heating becomes necessary. The refrigerant likewise may be able to operate more efficiently at a higher pressure, negating the need for back up electric resistance; however, that pressure may not be achievable in the equipment's system. Therefore, the properties of the refrigerant play a big role in system design and capability.

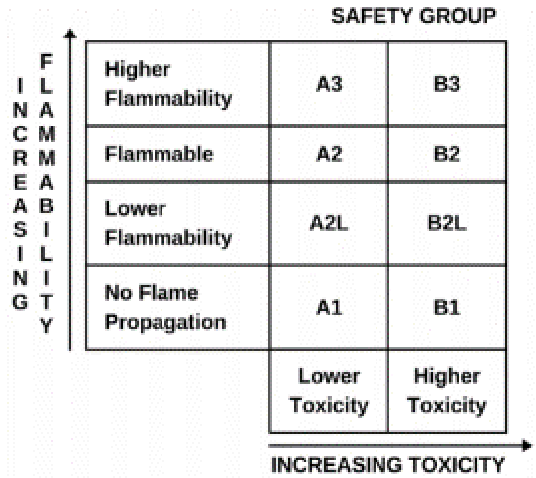
The global warming potential (GWP) metric differentiates refrigerants based on their environmental destructiveness. The California Air Resources Board (CARB) regulations prohibit or are phasing out the use of high GWP refrigerants in a range of equipment types and end uses. CARB's regulations will drive technological development of low GWP refrigerant systems and impact HPWH product availability, design considerations, and efficiency performance.

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) classifies refrigerant safety in terms of toxicity and flammability levels in ASHRAE Standard 34 (2019) as shown in Figure 11-60. Lower toxicity refrigerants displace oxygen if not properly managed, and ASHRAE develop a refrigerant

[4] https://neea.org/img/documents/qualified-products-list.pdf

concentration limit (RCL) to ensure the equipment and the space that houses the equipment address these risks. Mitigation strategies include locating the equipment outside or providing adequate circulation or ventilation to ensure the concentration does not exceed the RCL (which has a safety margin built in).

Figure 11-60: ASHRAE Safety Classification of Refrigerants



11.6.3.7 Design Capacity and Storage Sizing

HPWH functions are fundamentally different than gas water heaters in terms of thermal performance characteristics, operating conditions, and recovery capacity. A gas water heater can heat water quickly with a high instantaneous heating capacity. A design approach with large heating capacity, but small storage volume, will improve system efficiency by reducing the heat loss associated with water storage. The incremental costs for large capacity gas water heaters are minimal such that this traditional sizing approach often results in a cost-effective solution. Gas water heaters typically fire for short durations, on a scale of minutes, intermittently. HPWHs, on the other hand, heat water at a much slower rate and perform best with steady operation over long blocks of time, on a scale of hours. Unlike gas systems, a HPWH is unable to quickly recover storage tank heat after a prolonged hot-water draw. Recovery is sometime accomplished through electric resistance back up. A more efficient method to manage prolonged hot-water draw is to install additional hot water storage capacity. The heat pump can then slowly recover over several hours following the hot water draw.

HPWH systems with large storage capacity leads to additional benefits:

- Typically, lower first cost, because tanks are less expensive than heat pumps. A smaller heat pump capacity also reduces electrical service and infrastructure requirements for a building, further reducing first-cost impacts.
- Slightly larger tanks and heat pumps could enable grid flexibility by providing enough storage to disable the heat pumps during periods of peak

electric pricing. The slightly larger heat pumps could recharge the tanks more quickly during off-peak periods.

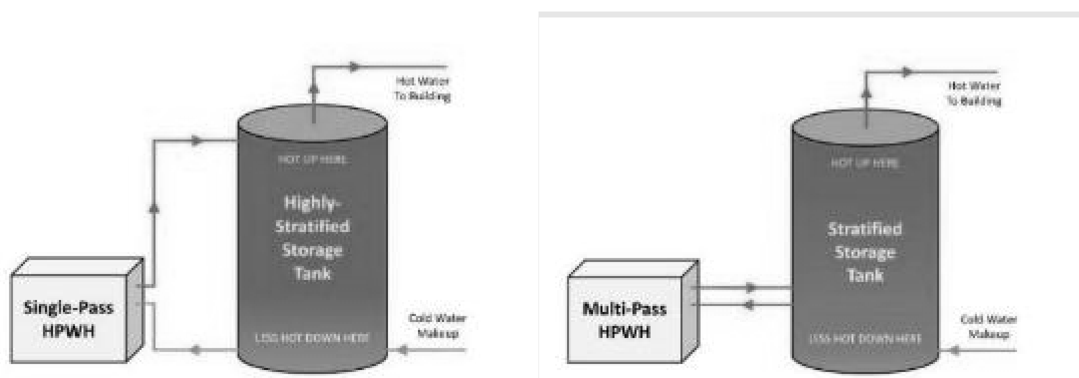
11.6.3.8 Single-Pass vs. Multi-Pass

A key design feature of a central HPWH system is whether it has a single-pass or multi-pass piping configuration. In a single-pass HPWH system, the cold water passes through the heat pump(s) once and is heated to the intended storage temperature. In this type of system, the heat pump draws cold water from the bottom of the storage tank and delivers hot water to the top of the storage tank, resulting in a highly stratified tank. HPWH equipment that use R744 require single-pass configuration, since R744 requires a large (20°F+) water temperature increase through the heat pump. Some R134 and R410A systems can have single-pass configurations.

In a multi-pass HPWH system, the cold water passes through the heat pump(s) multiple times, each time gaining a 7-10°F temperature increase, until the tank reaches the intended storage temperature. In a multi-pass system, the heat pumps draw cold water from the bottom third of the storage tank and deliver hot water to just above where it is drawn. This piping configuration can still produce a stratified tank, but less so than in a single-pass configuration. HPWH equipment that uses R410A, R134a, and refrigerants other than R744 can have multi-pass configuration, since they can handle a small water temperature lift through the heat pump. Some R134a and R410A systems can have either single-pass or multi-pass configuration.

Figure 11-61 shows schematic depictions of a single- vs. multi-pass systems side by side. Traditional gas water heaters are multi-pass systems.

Figure 11-61: Schematics of Single-Pass (left) vs. Multi-pass (right) HPWH Systems



Source: Ecotope

Some key differences between single-pass and multipass models are:

- Single-pass models have higher reported coefficient of performance (COP) values than multi-pass models.
- Most single-pass heat pumps do not operate well with warm incoming water temperatures (above approximately 110°F), while multi-pass systems performance does not degrade as much with warm incoming water

temperature. This is a critical feature that impacts DHW system configuration. DHW systems typically supply water at 120-125°F and return water at 105-115°F.

- For single-pass heat pumps, integration with recirculation systems is more complex and costly due to HPWH sensitivity to inlet water temperature. In contrast, multi-pass models integrated with the recirculation system resemble standard gas water heaters, which make multi-pass models more familiar albeit with a lower COP values.

Depending on the type of HPWH selected, designers must configure and control the plumbing system to ensure the HPWH operation stays in a favorable operation range. Section 11.7.3.40 describes current plumbing solutions, and most of them focus on single-pass HPWHs.

11.6.3.9 Spatial and Surrounding Air Temperature Considerations

Gas water heaters require nominal access to make-up air to support combustion. A small mechanical room or closet can suffice with no impact on performance. In situations with tight spatial limitations, makeup air can be vented directly to the gas unit through a small duct. In contrast, HPWHs pull thermal energy from the surrounding air and require constant ventilation and air circulation around the compressor unit. The heat pump cools the surrounding air, which must be replaced to avoid reducing system efficiency. Locating a heat pump indoors requires sufficient ventilation. With a split-heat pump configuration, the heat pump compressor units are commonly housed outdoors. These systems must be designed to operate at a range of ambient air temperatures and may not be suitable for colder climates. The ambient air temperature impacts system efficiency and capacity as it interacts with the refrigerant. Cold air temperatures can drastically reduce both efficiency and capacity, but high temperatures may also reduce performance. Section 11.7.3.40 describes suggested equipment locations for HPWH.

11.6.3.10 Inlet Water Temperature Impacts

Inlet water temperature from a municipal supply will fluctuate during the year. The coldest inlet temperatures occur during the winter. Cold inlet temperatures reduce performance for both gas boilers and heat pump water heaters, as it takes more heat to raise the inlet water to the designated storage temperature. However, the impact is more pronounced for HPWHs as interaction with the refrigerant can play a key role. Additionally, for HPWHs high inlet water temperatures can reduce efficiency depending on the refrigerant and heat exchanger configuration. Traditional plumbing configurations for gas water heater may significantly degrade HPWH performance.

11.6.3.11 Grid Flexibility and DR Capabilities

Unitary and central HPWH equipment with DR capabilities has the potential to meet a building’s water heating needs while also supporting electric grid needs. Grid flexibility refers to the ability of a device or equipment to control when and how it draws power from the grid based on building/occupant preferences, price signals, weather conditions, grid conditions, and other inputs. HPWHs convert electricity to thermal energy and can store this energy in system's storage tanks. This allows the system, with the right signals and controls, to respond to grid signals or utility programs.

11.6.3.12 Central HPWH Best Practices

This section provides best practices for central heat pump water heating system design. The best practices are intended to help with system design to meet code requirements and ensure optimal performance. Descriptions of applicable code requirements begin in Section 0.

11.6.3.13 HPWH Equipment and Storage Sizing and Equipment Selection

Hot water system sizing includes both the heating capacity and hot water storage volume needed to meet design day peak hot water demand. This is usually the day with coldest water inlet temperature in the winter. The American Society of Plumbing Engineers (ASPE) and ASHRAE developed existing common water heater sizing methodologies for central water heating equipment around gas water heater characteristics as these systems favor quick recovery capacity over large storage volume. The ASPE and ASHRAE sizing approaches can deliver reliable and cost-effective gas water heating systems, but sizing central HPWH systems with these sizing approaches may result in oversized HPWH equipment.

Unlike gas water heaters, which have linear and steady input and output performance, HPWH performance, operational characteristics, and design considerations vary largely depending on the refrigerant that the model uses and the heat exchanger configuration (i.e., single-pass vs. multi -pass). Designers must select equipment carefully to meet project needs.

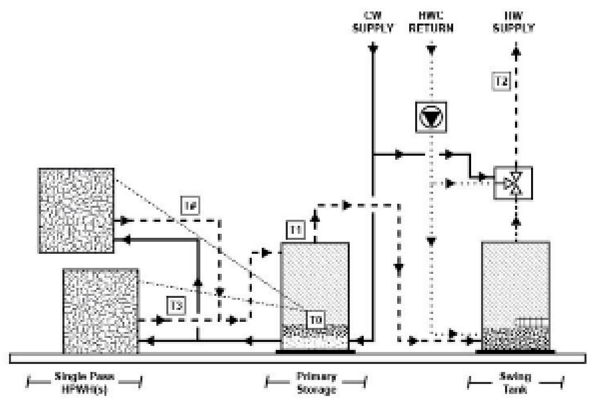
In general, sizing for central HPWHs should use large storage volumes to provide for peak hot water demand periods and smaller output capacity. This results in long, slow recovery periods with compressors operating up to 16-20 hours per day. These systems are likely more cost effective and efficient, and they have fewer maintenance issues compared to gas DHW systems.

11.6.3.14 System Plumbing and Configurations

For HPWHs, most single-pass heat pumps do not operate well with warm incoming water temperatures (above approximately 110°F). A critical design feature of CHPWH systems with hot water circulation systems is to separate the two distinct building DHW loads: 1) primary water heating and 2) temperature maintenance of recirculating hot water due to heat loss in the distribution loop. The HPWH(s) in the primary loop is referred as the primary HPWH. In separating the loads, the DHW system design can prioritize delivering cool water to the primary HPWHs for peak performance while maintaining thermal stratification in the primary tanks. Separating primary heating load and temperature maintenance load can improve equipment efficiency, lessen heating equipment cycling, and yield better system reliability.

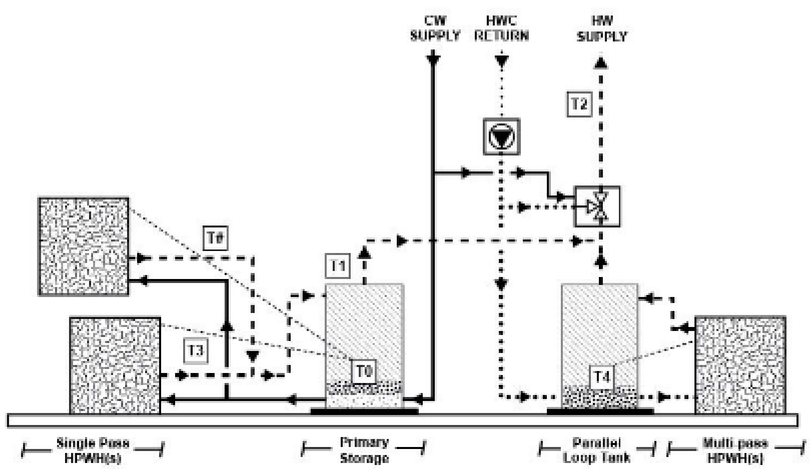
To separate the two loads, a key design practice is to use a temperature maintenance system separated from the thermally stratified primary storage volume. A temperature maintenance system consists of a recirculation pump, a storage tank (the loop tank), and a temperature maintenance heat source. A manufacturer developed two different types of temperature maintenance systems: 1) a swing tank design which uses a loop tank piped in series with the primary storage, illustrated in Figure 11-62, and 2) a parallel loop tank design which uses a loop tank piped in parallel with the primary storage, illustrated in Figure 11-63.

Figure 11-62: Single-Pass HPWH (s) with Swing Tank



Source: Ecotope

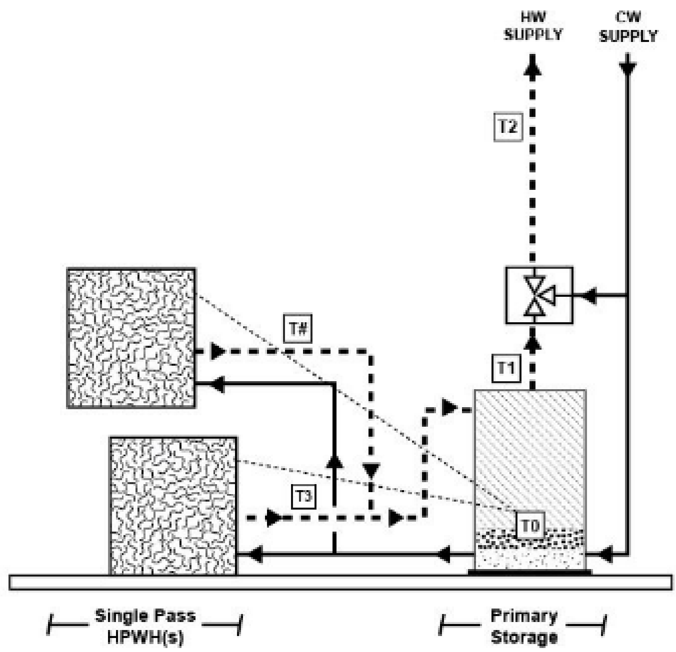
Figure 11-63: Single-Pass HPWH (s) with Parallel Loop Tank



Source: Ecotope

For a clustered design, the hot water heater(s) must be located close to each hot water usage such that a recirculation loop is not needed. This strategy is most easily applicable to buildings with up to three stories where the designer can locate the system on the roof and feed hot water to the dwelling units below with straight hot water piping, as shown in Figure 11-64.

Figure 11-64: Single-Pass HPWH(s) without Hot Water Recirculation (For Clustered Design)



Source: Ecotope

Central HPWH retrofits present more challenges than newly constructed buildings. Retrofit system designs may be limited by the design decision to re-use existing equipment such as the hot water storage tank or designating existing boiler or electric resistance heaters as back up. In comparison to newly constructed buildings, retrofit designs are often subject to tighter space constraints that negatively impact adequate equipment clearance and ventilation requirements.

11.6.3.15 Equipment Location

HPWHs need access to outdoor air or to a high volume of ventilation air as a heat source. Many existing gas-fired boilers are in small rooms in tight corners of buildings and vented as necessary to meet code. Tight spaces without adequate outdoor air and airflow may not provide adequate space for central and clustered HPWH equipment.

There are three typical locations for central HPWH equipment:

11.6.3.16 Outside

The most straightforward location for central HPWH equipment is outside, either on the roof or on the ground. All standalone HPWH units are rated for outdoor use. For ground-level installation, designers need to ensure the discharge air from the heat pump (which would be noticeably cold), is not directed at locations where people are likely to spend significant time, particularly in the winter. Equipment located outside or on a roof may present noise and/or vibration control concerns. As such, designers would need to consult manufacturer sound decibel ratings and implement appropriate noise/vibration control measures, particularly if equipment is located adjacent to living spaces.

- **Parking garage**: Ground floor or underground garages are another common location for central HPWH equipment. A covered, naturally ventilated garage is an ideal location for a HPWH, since it allows for adequate air circulation but remains protected from sun and rain. Fan-exhausted garages can also serve as locations for central HPWH; some designers have connected the heat pumps to the garage exhaust systems or use the heat pumps as the exhaust system. In colder climates, locating a HPWH in a garage, which will generally be slightly warmer than the outside air in the winter, can help raise the air temperature seen by the heat pump and improve system efficiency (Ecotope, 2009).
- **Inside with ducting**: In some circumstances, central HPWH equipment may need to be located inside or in areas with insufficient natural air circulation. These cases require ducted units. Manufacturers typically recommend ducting the (cold) exhaust air from the heat pumps out of the space and allowing makeup air into the room via passive louvers, though both air streams can generally be ducted if necessary. Designers must ensure louvers are large enough, and they must design the ducting to not exceed the static pressure limits of the heat pump fans.

11.6.3.17 Temperature Maintenance System

When a temperature maintenance system is used to separately handle the temperature maintenance load, designers must determine the recirculation loop heat loss to properly size the loop tank and determine whether a heater is needed. Managing temperature maintenance load is critical to reduce installed cost and improve operation efficiency. The most effective strategies to reduce heat loss of the distribution and recirculation piping are optimizing the piping design and insulating the piping.

When the temperature maintenance load is small, it can be handled using just a loop tank. Otherwise, a temperature maintenance heater maybe added. Designers should consider using a heater that can be configured to operate efficiently at higher incoming water temperature. Single-pass HPWH is not recommended due to poor performance when incoming water temperature is above 110°F.

11.6.3.18 Control

The primary HPWP(s) can be controlled to maintain a target output temperature between 120-140°F. Generating and storing the hot water at a higher temperature, normally above 135°F, can effectively increase the stored heating capacity of the plant, maximize load shifting capability and also to control possible legionella bacteria.

To prevent scalding, the high temperature hot water is tempered with recirculation water and/or incoming city water down to 120°F before delivery to the apartments.

When a loop tank is present, the high temperature hot water generated by the primary HPWH can be stored in the tank. The loop tank temperature setpoint must set to 120-125°F to only engage the less efficient loop tank heater when additional heat is needed.

Aquastats are temperature sensing devices used in water systems, synonymous to thermostats in non-hydronic systems. They have high- and low-temperature settings and control the ON/OFF status of the heating equipment (HPWHs in this case) as well as the circulator pump. Designers must carefully determine the aquastat location to avoid over cycling the HPWH. The general principal is to locate aquastat far enough away from incoming water to avoid triggering aquastat every time any water is used. If there are multiple primary storage tanks piped in series configuration, locating the aquastat in a second serial storage tank accomplishes this goal. The primary HPWHs can be set to switch ON when the aquastat in the middle storage tank drops below approximately 115°F, and to stay on until an aquastat in the first storage tank rises to approximately 100°F. Time delay built into HPWH operation can also help with avoiding turning on HPWH prematurely.

11.6.3.19 Electric Resistance as Backup and Supplemental Heat

Many storage-integrated heat pump units include both a heat pump and electric resistance backup for several reasons including:

- To reduce HPWH size and first cost when back up is only needed on the coldest days.
- To provide redundancy due to concern about HPWH reliability and long lead time for replacement parts.
- Some HPWH models cannot operate in low ambient temperature.

  Low-temperature operation of R410A and R134a HPWH units allow operation down to 15-20°F and R744 central HPWH equipment that can operate well below 0°F. Properly sized and selected heat pumps should be able to eliminate the need for electric resistance backup in nearly all central HPWH applications in California climates.

In some cases, especially for retrofits, designers may be asked to reuse the existing gas-boiler or incorporate a new one as a backup system to the primary HPWH equipment. The existing boiler equipment would serve a similar, supplemental function to the HPWH as an electric resistance backup heater and provide additional capacity to handle low ambient conditions, meet extremely high hot water demand, or to ensure service continuity during maintenance events.

11.6.3.20 Design Resources and Tools

Many manufacturers offer support resources and tools to help designers with project scoping and high-level design concepts. These tools reference various rules-of-thumb and guidelines. Manufacturers are actively developing new and updated tools in this quickly evolving market.

To support the optimal HPWH sizing strategy that accounts for recovery speed differences, Ecotope developed Ecosizer, a generic sizing tool for central HPWH systems in multifamily buildings. Ecosizer provides basic water heater and storage sizing information for any piece of equipment with a known heating output capacity[5]. Ecotope developed the sizing method based on monitored hot water demand data from multifamily buildings. The tool yields smaller system size recommendations than the ASHRAE method tailored for gas water heating system.

11.6.3.21 Combined Hydronic System

Combined hydronic space heating systems use a single heat source to provide space and water heating. The modeling of these system types treats water heating performance separately from the space-heating function.

11.6.3.22 Drain Water Heat Recovery

This section describes drain water heat recovery equipment. It can be installed for compliance credit, except in instances where it is a prescriptive requirement. descriptions of applicable code requirements are in Sections 11.7.6 and 0.

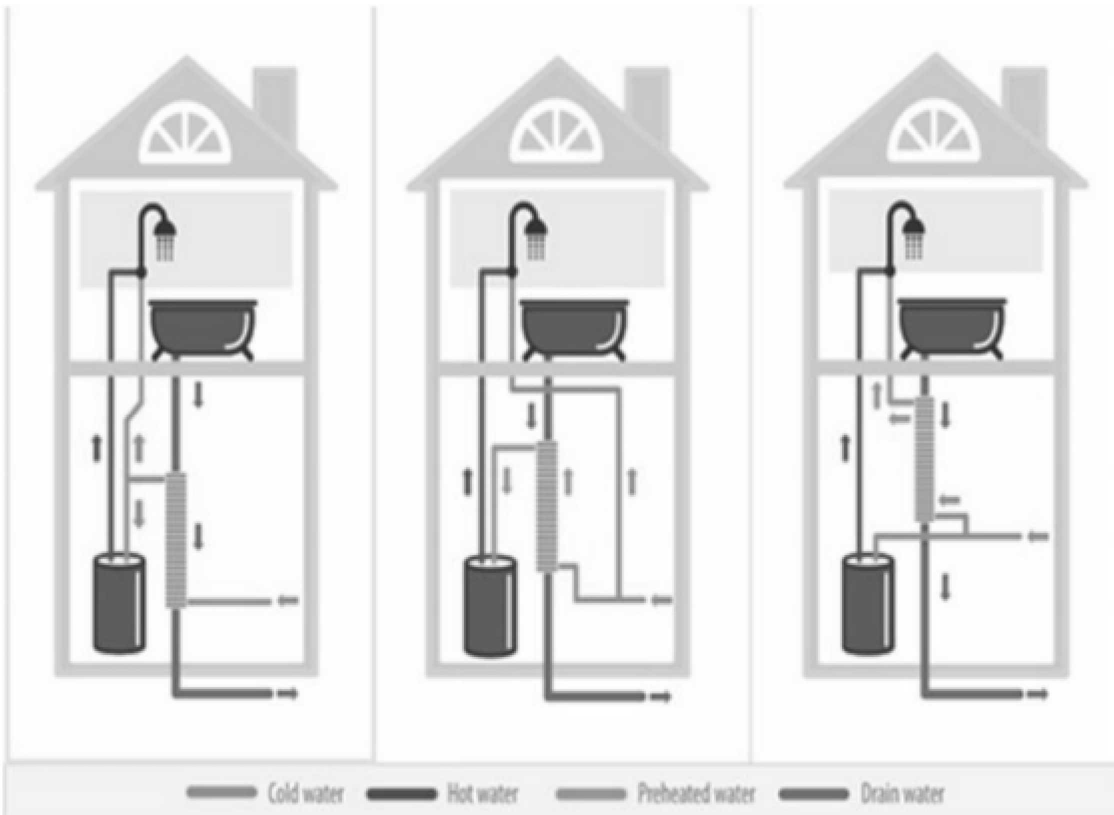
Drain water heat recovery (DWHR) is a technology that captures shower waste heat from the drain line. DWHR devices are counter flow heat exchangers, with cold water entering the building on one side of the device and hot drain water exiting the building on the other.

A DHWR device uses the reclaimed heat to preheat potable cold water that is then delivered either to the shower or the water heater. The device can be installed in either an *equal flow* configuration (with preheated water being routed to both the water heater and the shower) or an *unequal flow* configuration (preheated water directed to either the water heater or shower). Figure 11-65 schematically shows the three installation configurations. The energy harvested from a DWHR device is maximized in an equal flow configuration. They are available in both vertical design configurations, as shown in Figure 11-65, and in horizontal configurations. The two forms each have advantages and disadvantages, which should be evaluated for each potential installation.

To use these systems to comply with Energy Code, the design and installation must be HERS-verified and meet the Reference Appendix RA4.4.21 requirements for buildings with three stories or fewer and be field verified for buildings with four stories or more.

[5] https://ecosizer.ecotope.com/sizer/

Figure 11-65: The Three Plumbing Configurations of DWHR Installation (From left to right: Equal Flow, Unequal Flow - Water Heater, Unequal Flow - Fixture)



Source: Frontier Energy

11.6.3.23 DWHR Best Practices

DWHR are either distributed or central ganged systems based on the location of the DWHR devices and the number of drain water line(s) feeding into a DWHR device. DWHR devices on distributed designs are installed inline on shower drain stacks that are distributed throughout the building. Central banked designs have multiple DWHRs installed in parallel at a central location of the building and may be capable of recovering heat from all types of wastewater.

11.6.3.24 Distributed DWHR Design

Installation of DWHR devices in drain lines shared by multiple dwelling units is a common DWHR installation approach. This decentralized design creates a small loop, so the preheated cold water feeds either directly into the bath/shower cold water inlet (unequal flow to fixture) or to the main hot water plant (unequal flow to heater). Equal flow configurations are not common and could be cost prohibitive in multifamily applications, due to the distance between the DWHR device and the hot water plant.

One configuration is a heat recovery device at the base of each vertical plumbing stack to recover drain water waste heat from all dwelling units located on the second floor and above, as shown in Figure 11-66. This minimizes the impact on standard plumbing design and limits the length of additional piping that must be installed to accommodate a DWHR device.

For taller buildings where pressure zones are required every five to six stories, multiple DWHRs can be installed in one drain stack, one for each pressure zone such that the cold water preheated by a DWHR can be sent to each shower without needing a booster pump.

Figure 11-66: Distributed DWHR Installation with One DWHR Serving Two Dwelling Units (From Left to Right: Unequal Flow – Heater, Unequal Flow – Fixture)

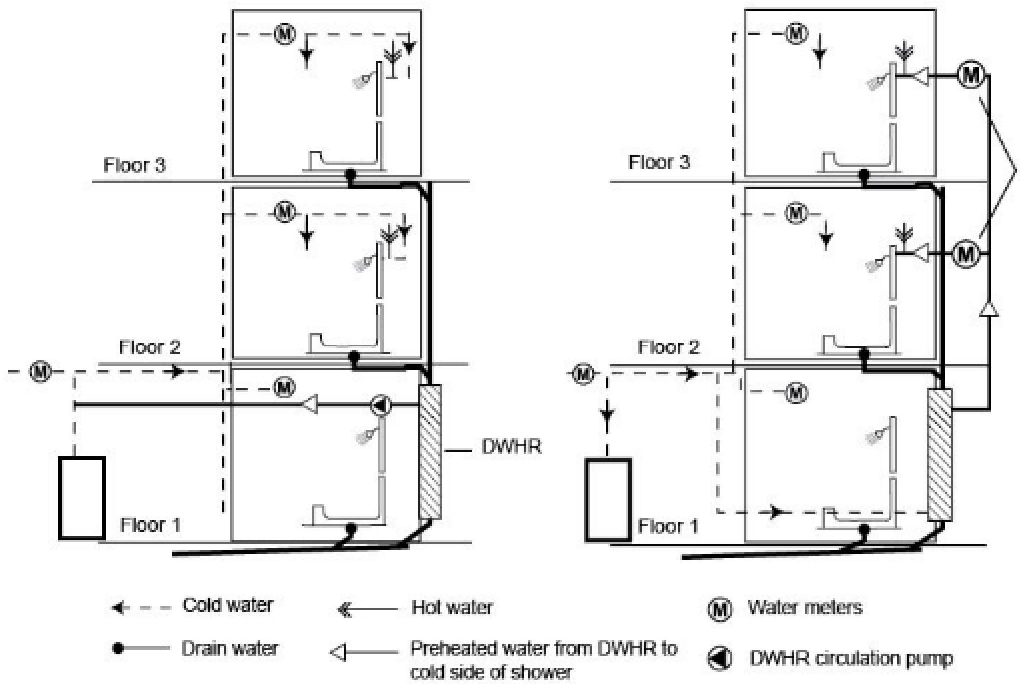


Figure 11-67: Single-Pass HPWH(s) without Hot Water Recirculation (For Clustered Design

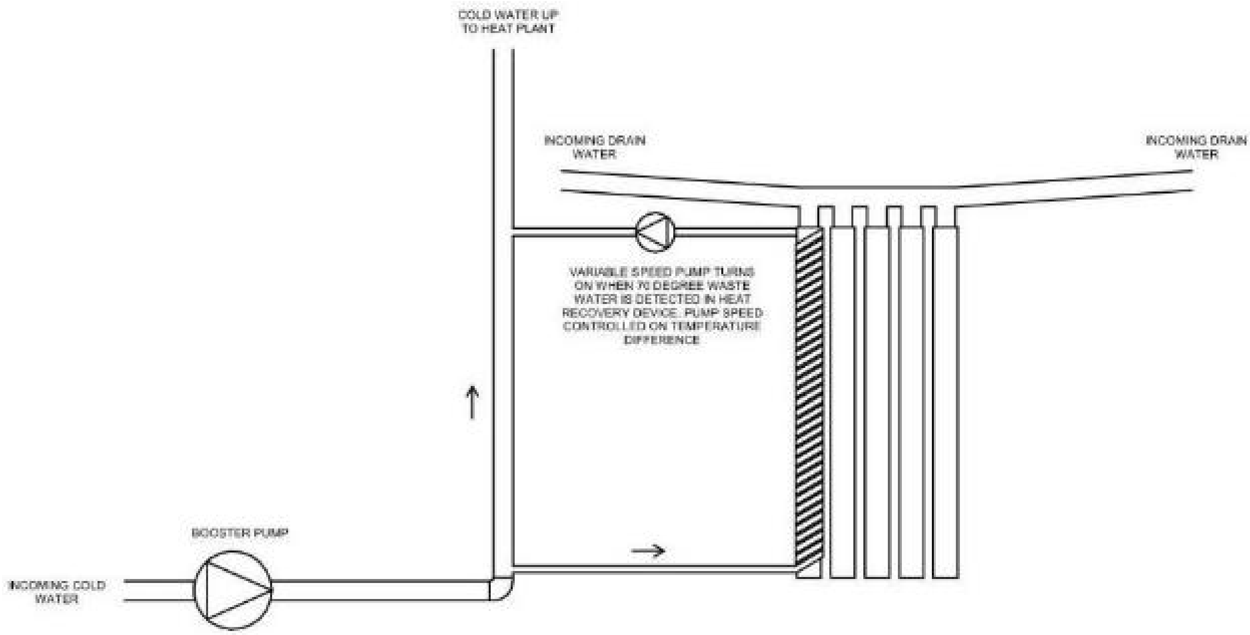
11.6.3.25 Central Ganged DWHR Design

Central ganged DWHR systems use multiple vertical drainage stacks to feed into a single large DWHR device (or manifold of multiple smaller devices) located in a ground floor mechanical room as illustrated in Figure 11-68. Individual drainage stacks are intentionally distributed throughout the building footprint; therefore, the routing between the base of the individual drain stack and the DWHR device is long.

The UPC Section 708.0 requires that horizontal drainage piping has a minimum slope of 0.25 inches per linear foot (IAPMO, 2019). In typical multifamily construction, there is 11 inches of vertical space between floor joists, which translates to an approximate maximum of 32 ft. of horizontal travel (assuming a two-inch pipe diameter and one inch of clearance for other construction considerations). In practice, the drainage stacks are not typically located close enough together such that all drain stacks could be gathered at a single central point to drain into a DWHR device. Therefore, a centralized DWHR system would require a detailed, custom plumbing design.

For central DWHR design, unequal flow to heater configuration is common as DWHRs are typically installed closer to the water heater and the long distance between the DWHRs and shower fixtures makes it impractical to send preheated water to shower.

Figure 11-68: Central DWHR Plant Schematic



Source: Ecotope

11.6.3.26 Impacts of Architectural Layout on DWHR Configurations

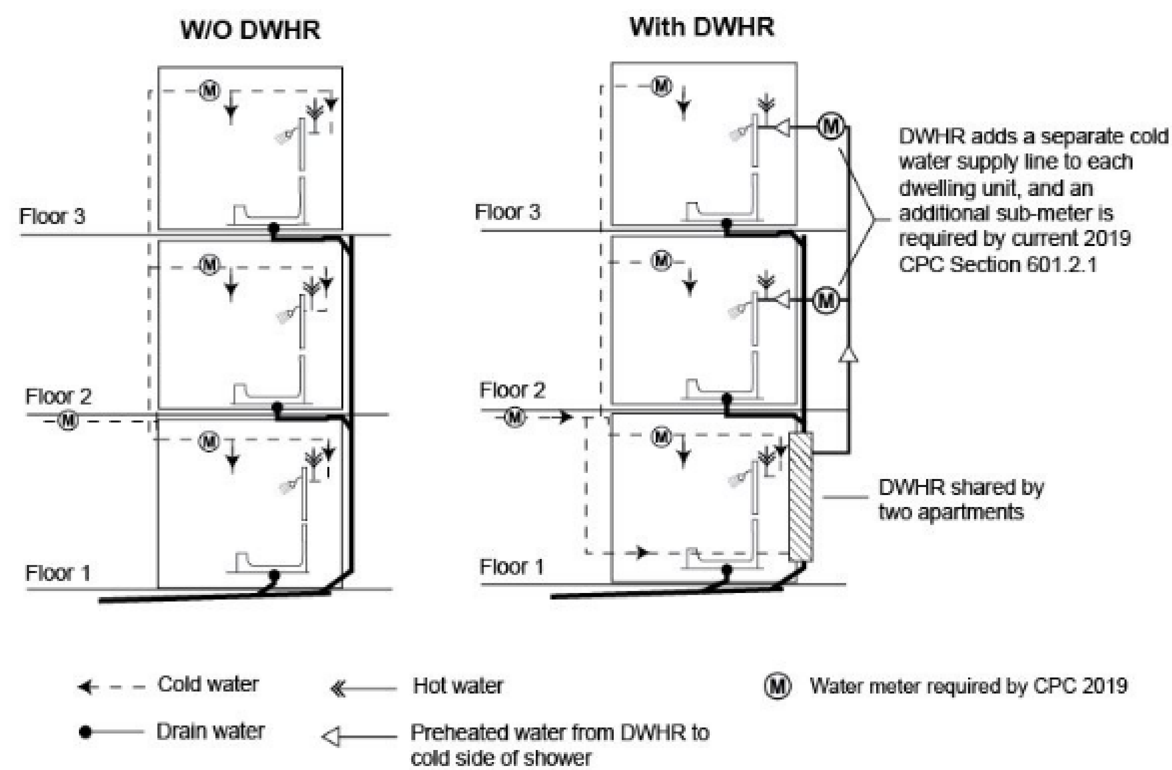
Due to sloping requirements in drain water piping and limited floor to floor height, drainpipes could have an approximate maximum of 32 ft. of horizontal travel. This means it is impractical to combine showers from the same floor if they are more than 32 ft. apart from each other. In typical multifamily design, the distance between two showers is usually more than 50 ft. If designers want to combine showers for one DWHR, they will need to locate showers closer to each other (e.g., using back-to-back showers). This is especially true for buildings with up to three stories where it is not possible to combine multiple showers located at different floor levels.

11.6.3.27 Impact of SB7 Water Meter Requirement on DWHR Configurations

Most current plumbing designs use dedicated cold and hot water risers for each fixture or washroom. SB7, which Governor Brown signed into law in 2016, directed the HCD to develop building codes that would require "the installation of water meters or water submeters in newly constructed multiunit residential structures and mixed-use residential and commercial facilities." HCD subsequently recommended code requirements for Section 601.2.1 of the CPC that the California Building Standards Commission approved for the 2019 CPC. The requirements in SB7 would require the submeters for market-rate dwelling units, but not for affordable housing.

To meet 2019 CPC Section 601.2.1 requirement, when a DWHR unit is installed in a drain line from multiple dwelling units to preheat cold water delivered to the shower or individual water heater, each dwelling unit would be required to have an additional dedicated water meter or submeter, as shown in Figure 11-69 below.

Figure 11-69: Water Metering Requirement with and Without DWHR



Source: Ecotope

11.6.3.28 Impacts of Drain Water Piping Design

Hot water is piped to most fixtures in multifamily buildings, including kitchen sinks, dishwashers, bathroom sinks (lavatories), bathtubs, showers, and clothes washing machines. Since DWHR is only effective when there are simultaneous hot water draws and drainage of that water, baths, and showers are typically the only fixtures where it makes sense to install DWHR. To concentrate the heat, a dedicated drain piping system is desirable, so only water from the bath/shower water is routed through the heat recovery device. This ensures that heat extraction occurs with the hottest drain water possible. Dedicated shower drain stack is consistent with current plumbing design practice.

Due to the potential long distance between the DWHR devices and shower fixtures, temperature loss in drainpipes may be an issue that impacts energy saving potential. There are two common drainpipe installation locations: 1) fur-out wall which has no insulation and 2) plumbing walls also serving as acoustic and fire separation wall, which are insulated. The second installation location has less temperature loss compared to the first location.

11.6.4 Multifamily Distribution Systems

This section describes various water heating distribution systems for multifamily buildings. Descriptions of applicable code requirements are in Section 11.7.6.2 and 11.7.7.2.

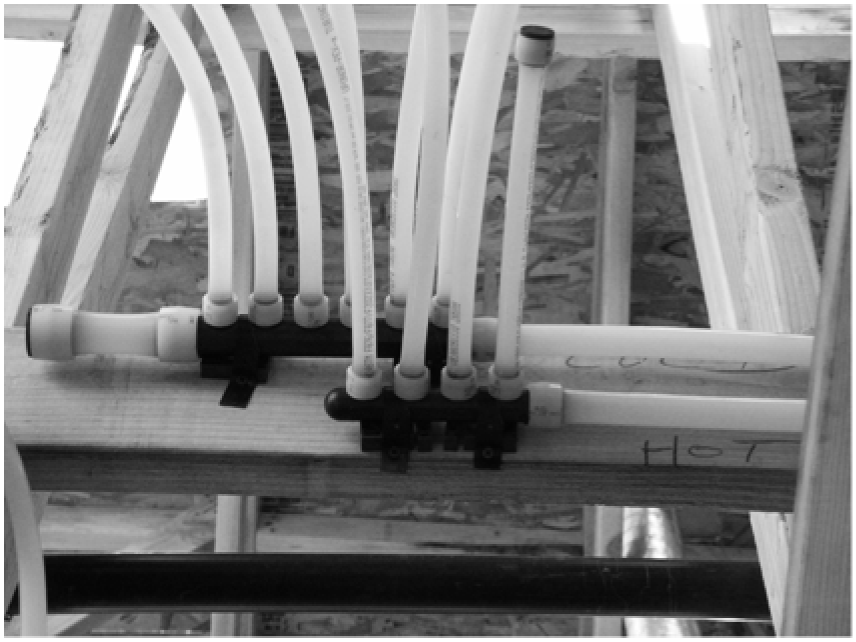
The water heating distribution system is the configuration of piping (and pumps and controls in the case of recirculating systems) that delivers hot water from the water heater to the end-use points within the building. By minimizing the length of distribution piping, energy use, water waste, wait time for hot water and construction costs can all be reduced. This section describes the types of distribution systems relevant to multifamily buildings, organized by system types applicable to hot water distribution *within* an individual dwelling unit and system types applicable to distribution network that serves multiple dwelling units.

11.6.4.1 Distribution System for an Individual Dwelling Unit

11.6.4.2 Trunk-and-Branch and Mini-manifold Configurations (Standard Distribution System)

The most basic plumbing layout assumed as the reference design in the performance approach, is represented by the conventional trunk-and-branch layout. This layout of a trunk-and-branch system may include one or more trunks, each serving a portion of the dwelling unit. The trunks are subdivided by branches that serve specific rooms, and they divide into twigs that serve a particular point of use. This distribution system type includes mini-manifold layouts, shown in Figure 11-70, which incorporate trunk lines that feed remote manifolds that then distribute water via twigs to the end-use points. A standard distribution system cannot incorporate a pump for hot water recirculation.

Figure 11-70: Mini-manifold Configuration



No pumps may be used to recirculate hot water with the standard distribution system. When designing a trunk-and-branch system, all segments should be as short and as small a diameter as possible. The requirements and guidelines for the installation of the standard distribution system are included in Reference Appendix RA3 - Residential Field Verification and Diagnostic Testing Protocols and RA4 - Eligibility Criteria for Energy Efficiency Measures.

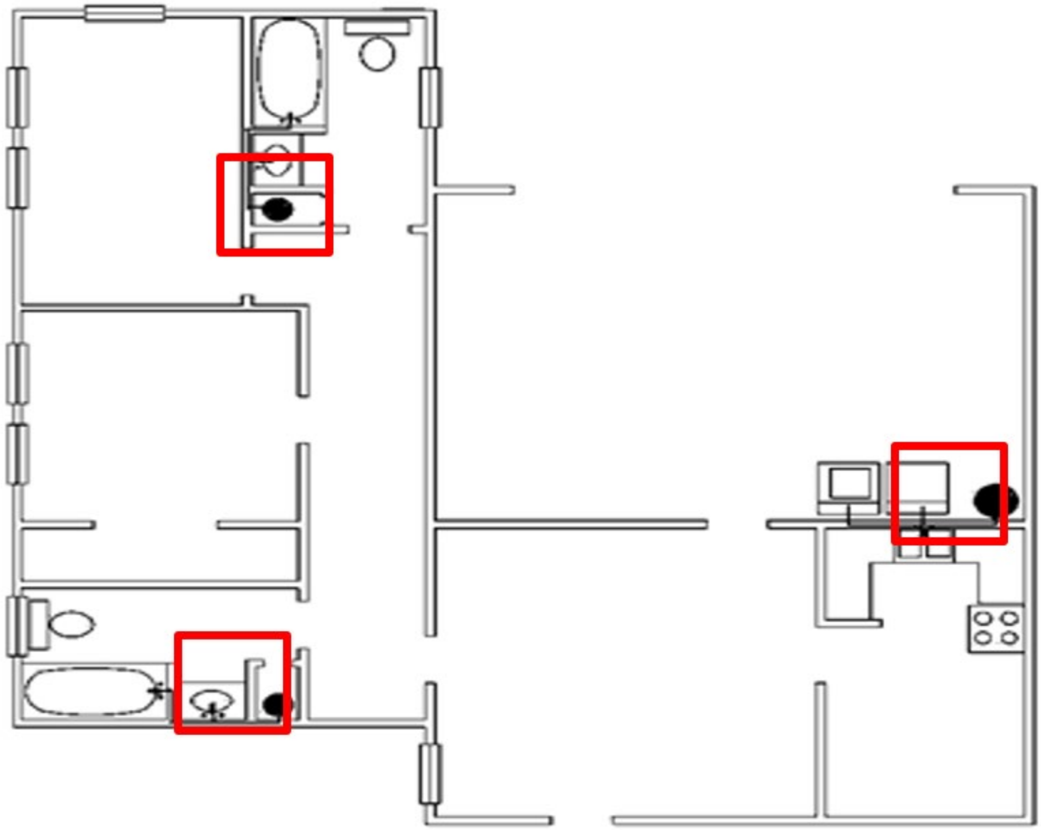
11.6.4.3 Central Parallel Piping System

The primary design concept in a central parallel piping system is an insulated main trunk line that runs from the water heater to one or more manifolds, which then feeds use points with ½" or smaller plastic piping. The traditional central system with a single manifold must have a maximum pipe run length of 15 ft. between the water heater and the manifold. Using mini-manifolds, the central parallel piping system can accommodate multiple mini-manifolds in lieu of the single central manifold, provided that 1) the sum of the piping length from the water heater to all the mini-manifolds is less than 15 ft. and 2) all piping downstream of the mini-manifolds is nominally ½ inch or smaller. The requirements for installation guidelines are included in RA3.

11.6.4.4 Point of Use

A *point-of-use distribution system design* significantly reduces the volume of water between the water heater and the hot water use points. Use of this type of system requires the water heater to be located adjacent to hot water use points, an indoor mechanical closet, or the use of multiple water heaters. Figure 11-71 provides an example of the latter approach where three water heaters are installed close to the use points.

Figure 11-71: Point-of-Use Distribution System



Source: 2019 CASE Report: Compact Hot Water Distribution

The distance between the water heater and any fixture using hot water cannot exceed the length specified in Table 11-51 below. The adopted requirements for installation guidelines are included in RA3 and RA4.

Table 11-51: Point-of-Use Distribution System

Size Nominal, Inch	Length of Pipe (ft.)
3/8″	15
1/2″	10
3/4″	5

11.6.4.5 Compact Hot Water Distribution System

The intent of a compact hot water distribution system design is to reduce the size of the plumbing layout by bringing the water heater closer to hot water use points than in typical trunk and branch systems. The Standards allow a basic credit and a HERS-verified compact hot water distribution system expanded credit.

Eligible compact hot water distribution designs can generate a compliance credit using the performance approach. There are two versions of the Compact Design credit. Basic Credit does not require HERS verification, while Expanded Credit requires field verification by a HERS Rater. Qualification for both credits is based on using a plan view, straight-line measurement to calculate a *Weighted Distance* to key hot water use points including the master bath, kitchen, and remaining furthest hot water fixture from the water heater (In some multifamily situations, there may not be another use point beyond the master bath and kitchen, resulting in the third term being ignored). If this resulting Weighted Distance is less than a Qualification Distance (dependent on floor area, number of stories in the dwelling unit, and number of water heaters), the plan is eligible for the Basic Credit. The Basic Credit does not require any further verification steps to secure the compliance credit. If the builder chooses to pursue an Expanded Credit, additional energy savings will be recognized under the performance method; however, there are several HERS-verification requirements that must be met.

H. *Weighted Distance Calculation Method*

Calculation of the Weighted Distance metric varies for a non-recirculating distribution system or a recirculation distribution system. The calculated Weighted Distance input cell would be activated in the compliance software if the user selected either the Basic CHWDS Credit or the Expanded Credit.

The basis of the calculation is a plan-view, straight-line measurement from the water heater to the center of the use point fixture in three rooms. It is calculated using the following equation.

Weighted Distance = x * d_MasterBath + y * d_Kitchen + z * d_FurthestThird

where,

x, y, and z = Weighted Distance coefficients (unitless), see Table 11-52.

d_MasterBath = The plan view, straight line distance from the water heater to the furthest fixture served by that water heater in the master bathroom (ft.).

d_Kitchen = The plan view, straight line distance from the water heater to the furthest fixture served by that water heater in the kitchen (ft.).

d_FurthestThird = The plan view, straight line distance from the water heater to the furthest fixture served by that water heater in the furthest room[6] (ft.).

Table 11-52 shows the values for the coefficients depending on the type of distribution system.

[6] Because the master bath and kitchen represent unique defined use points, the d_FurthestThird fixture must not be located in either of these rooms. The laundry room is excluded and should not be used as the furthest third room. In some multifamily cases, there may not be another qualifying use point, in which case the d_FurthestThird term equals zero.

Table 11-52: Weighted Distance Coefficients

Distribution System	x	y	z
Non-Recirculating	0.4	0.4	0.2
Recirculating	0.0	0.0	1.0

Note that the calculations are based on horizontal plan view distance measurements from the center of the water heater to the center of the use point in the designated location.

In dwelling units with multiple water heaters, the Weighted Distance "z term" calculation is performed for each water heater to arrive at a FurthestThird term averaged over each of the "n" water heaters installed. For a non-recirculating distribution system, the resulting Weighted Distance calculation would include the master bath, the kitchen, and an average of the FurthestThird term for each of the installed water heaters. (For recirculating systems, similarly the FurthestThird term would represent an average across the "n" water heaters.)

11.6.4.6 Recirculation System: Non-Demand Control Options

This type of distribution system encompasses all recirculation strategies that do not incorporate a demand control to minimize recirculating pump operation. Under this category, recirculation system types include uncontrolled continuous recirculation, timer control, temperature control, and time/temperature controls. Recirculation systems can save water, but the energy impact can be very high in a poorly designed and/or controlled system.

11.6.4.7 Recirculation System: Demand Control

A demand-control recirculation system uses brief pump operation in response to a hot water demand *signal* to circulate hot water through the recirculation loop. The system must have a temperature sensor, typically located at the most remote point of the recirculation loop. Some water heaters have temperature sensors located within the water heater. The sensor provides input to the controller to terminate pump operation when the sensed temperature rises. Typical control options include manual push button controls or occupancy sensor controls installed at key use areas (bathrooms and kitchen).

11.6.4.8 Distribution Systems Serving Multiple Dwelling Units

11.6.4.9 Central Demand Recirculation System (Standard Distribution System)

The standard distribution system for water heaters serving multiple dwelling units incorporates recirculation loops, which bring hot water to different parts of the building, and a demand control, which automatically shuts off the recirculation pump when the recirculation flow is not needed. Central recirculation systems include three components: recirculation loops, branch pipes, and pipes within dwelling units. Recirculation loops are used to bring hot water close to all dwelling units, but they are not expected to go through each dwelling unit. Branch pipes are used to connect pipes within dwelling units and the recirculation loops.

Demand controls for central recirculation systems are automatic control systems that control the recirculation pump operation based on measurement of hot water demand and hot water return temperatures.

11.6.4.10 Recirculation Temperature Modulation Control

A recirculation temperature modulation control must reduce the hot water supply temperature when hot water demand is determined to be low by the control system. The control system may use a fixed control schedule or a dynamic control schedule based on measurements of hot water demand. The daily hot water supply temperature reduction, which is defined as the sum of temperature reduction by the control in each hour within a 24-hour period, must be more than 50°F to qualify for the energy savings credit.

Recirculation systems must also meet the requirements of §110.3, covered in Section 11.7.5.

11.6.4.11 Recirculation Continuous Monitoring Systems

Systems that qualify as recirculation continuous monitoring systems for DHW systems serving multiple dwelling units must record no less frequently than hourly measurements of key system operation parameters, including hot water supply temperatures, hot water return temperatures, and status of gas valve relays for water-heating equipment. The continuous monitoring system must automatically alert building operators of abnormalities identified from monitoring results.

Recirculation systems must also meet the requirements of §110.3, covered in Section 11.7.5.

11.6.4.12 Non-recirculating Water Heater System

Multifamily buildings may use systems without a recirculation system if the dwelling units served are located so the branch pipes between the water-heating equipment and dwelling units are relatively short. This is the same as a *clustered design*.

11.6.5 Mandatory Requirements for Water Heating

This section describes code requirements applicable to all system types, and there are additional mandatory requirements specific to systems serving individual dwelling units described in Section 0.

11.6.5.1 Equipment Certification

§110.3(a)

Manufacturers must certify that their products comply with California's *Title 20 Appliance Efficiency Regulations*, Section 1605.1(f) at the time of manufacture.

Regulated equipment that applies to all the aforementioned system types in Section 5.2 must be listed in the California Energy Commission Appliance Efficiency Database.

For heat pump water heating systems serving multiple dwelling units…

11.6.5.2 Equipment Efficiency

§110.3(b), §110.1

Water heaters are regulated under California's *Title 20 Appliance Efficiency Regulations*, Section 1605.1(f). These regulations align with the federal efficiency standards for water heaters. Consumer water heaters and residential-duty commercial water heaters are both rated in Uniform Energy Factor (UEF). The draw pattern is based on the water heater's design first hour rating for storage water heater or gallons per minute (GPM) for instantaneous water heaters.

For commercial water heaters, unlike consumer water heaters, these water heaters are not rated in UEF. The required minimum energy efficiency for commercial water heaters is in terms of thermal efficiency and standby loss.

For heat pump water heaters used in central water heating system, there is no required minimum energy efficiency requirement. Manufacturers must certify their products to meet Joint Appendix 14 requirements.

11.6.5.3 Isolation Valves

§110.3(c)6

All newly installed instantaneous water heaters (minimum input of 6.8 kBTU/hr) must have isolation valves on both the incoming cold water supply and the hot water pipe leaving the water heater. Isolation valves assist in the flushing of the heat exchanger and help prolong the life of instantaneous water heaters. Instantaneous water heaters that have integrated drain ports for servicing are acceptable to meet the requirements of §110.3(c)6 and will not require additional isolation valves.

11.6.5.4 Pipe Insulation

§160.4(f)1

Table 11-53 summarizes the insulation requirements applicable to hot water piping in multifamily buildings. The insulation thickness requirements are specified in Table 160.4-A.

Table 11-53: Pipe Insulation Thickness Requirement*

Fluid Operating Temperature Range (°F)	Insulation Conductivity (in Btu·in/h·ft²·°F)	Insulation Conductivity Mean Rating Temperature (°F)	Units	< 1	1 to <1.5	1.5 to < 4	4 to < 8	8 and larger
Above 350	0.32-0.34	250	Inches**	4.5	5.0	5.0	5.0	5.0
Above 350	0.32-0.34	250	R-value***	R 37	R 41	R 37	R 27	R 23
251-350	0.29-0.32	200	Inches**	3.0	4.0	4.5	4.5	4.5
251-350	0.29-0.32	200	R-value***	R 24	R 34	R 35	R 26	R 22
201-250	0.27-0.30	150	Inches**	2.5	2.5	2.5	3.0	3.0
201-250	0.27-0.30	150	R-value***	R 21	R 20	R 17.5	R 17	R 14.5
141-200	0.25-0.29	125	Inches**	1.5	1.5	2.0	2.0	2.0
141-200	0.25-0.29	125	R-value***	R 11.5	R 11	R 14	R 11	R 10
105-140	0.22-0.28	100	Inches**	1.0	1.5	2.0	2.0	2.0
105-140	0.22-0.28	100	R-value***	R 7.7	R 12.5	R 16	R 12.5	R 11

Source: excerpt from Table 160.4-A of the Energy Code

* Space heating and Service Water Heating Systems (Steam, Steam Condensate, Refrigerant, Space Heating, Service Hot Water)

**Minimum Pipe Insulation Required (Thickness in inches or R-value)

*** Nominal Pipe Diameter (in inches)

Piping exempt from mandatory insulation Includes:

- Factory-installed piping within space conditioning equipment.
- Piping that penetrates framing members. This piping is not required to have insulation where it penetrates the framing. However, if the framing is metal, then some insulating material must prevent contact between the pipe and the metal framing.
- Piping located within exterior walls that are installed so that piping is placed inside wall insulation. Wall insulation may be an acceptable alternative insulation method for sections of pipes that would otherwise need pipe insulation, if the wall insulation in the walls where the pipes are located meets the requirements of QII and the pipes are roughly centered in the wall cavity (See Reference Appendix RA4.4.1).
- Piping that are surrounded with at least one inch of wall insulation, two inches of crawlspace insulation, or in the attic continuously buried by at least four inches of

blown-in ceiling insulation. Piping may not be placed directly in contact with sheetrock and then covered with insulation to meet this requirement.

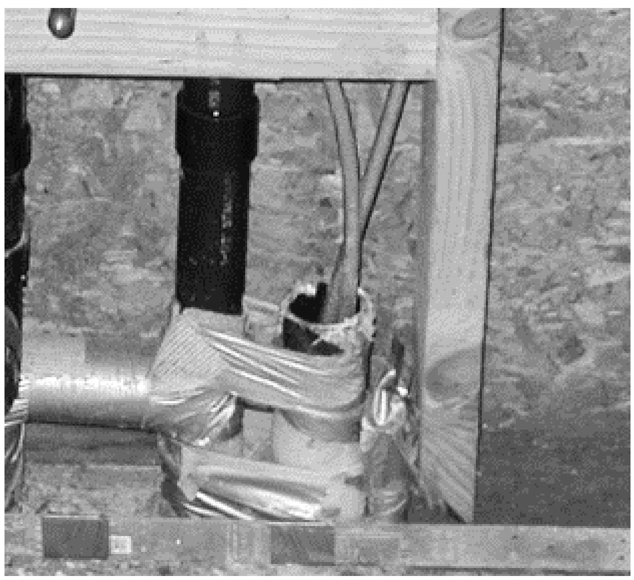
11.6.5.5 Insulation Protection

§160.4(f)2

If hot water piping insulation is exposed to weather, it must be protected from physical damage, ultraviolet light deterioration, and moisture. Insulation is typically protected by aluminum, sheet metal, painted canvas, plastic cover, or a water-retardant coating that shields from solar radiation. Adhesive tape should not be used as insulation cover because removal of the tape will damage the integrity of the original insulation during preventive maintenance.

All DHW pipes that are buried below grade must be installed in a waterproof and non-crushable casing or sleeve. The installation shown in Figure 11-72 below would not meet the installation requirements since it is not insulated. In addition, in Figure 11-72 the hot and cold water lines are not separated. Heat transfer will occur, resulting in energy loss and causing condensation on the cold water line.

Figure 11-72: Noncompliant Below-Grade Piping and Hot and Cold Water Lines Separation



11.6.6 Systems Serving Individual Dwelling Units

This section describes requirements applicable to water heating systems serving individual dwelling units and common use area without a recirculation loop. These requirements are in addition to requirements in Section 11.7.5.

11.6.6.1 Individual Dwelling Unit Water Heating Equipment

11.6.6.2 Mandatory Requirements

§160.4(a)

Electric readiness is required if a gas or propane water heater is installed. These requirements include installing a dedicated 125-volt (V) electrical receptable, reserving space for single pole circuit breaker and having a condense drain. Refer to Section 11.10.2 for detailed descriptions.

11.6.6.3 Prescriptive Requirements

§170.2(d)1

There are three options to comply with the prescriptive requirements for water heating systems serving individual dwelling units in newly constructed multifamily buildings:

- **Option 1:** Install a single, 240 volt heat pump water heater. In addition, the building must comply with both of the following as applicable:
  - For Climate Zones 1 and 16, a compact hot water distribution design meeting the requirements specified in the Reference Appendix RA 4.4.6.
  - For Climate Zone 16 only, a DWHR system meeting the requirement specified in the Reference Appendix RA 3.6.9.

  Option 2: Install a single HPWH that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher. In addition, for Climate Zone 16 only, a drain water heat recovery system meeting the requirement specified in the Reference Appendix RA 3.6.9. The list of qualified product list of NEEA HPWH can be found here:www.neea.org/img/documents/qualified-products-list.pdf
- **Option 3:** Install one or more natural gas or propane instantaneous water heater with an input rating of 200,000 BTU per hour or less and no storage tank.

11.6.6.4 Performance Approach

For individual water heating systems serving individual dwelling units, any type or number of water heaters supported by the software can be installed. The calculated energy use of the proposed design is compared to the standard design energy budget, based on either a single gas instantaneous water heater for gas water heaters with a standard distribution system or a HPWH with compact distribution system and DWHR, where applicable.

Joint Appendix (JA) 13 provides qualification requirements for HPWH demand management systems. Qualifying HPWHs have the capability to optimize operation to reduce normal water heater operation during on-peak periods by biasing operation prior to the peak period. Future opportunities include overheating the storage tank above setpoint prior to the peak period, further improving the electrical load profile of these systems. A credit exists for these HPWHs within the compliance software. JA13 certified HPWHs, which must have a mixing valve installed to prevent any scalding risks, are currently listed at this website:

www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/ja13

11.6.6.5 Individual Dwelling Unit Distribution System

This section describes requirements for distribution systems serving individually dwelling units. These requirements are distinct from requirements applicable to systems serving multiple dwelling units.

There are no additional mandatory requirements specific to equipment serving individual dwelling units other than those described in Section 11.7.5.

11.6.6.6 Prescriptive Requirements

§170.2(d)

Installation of a demand recirculation control to minimize pump operation and heat loss from pipes is a prescriptive requirement. This is applicable regardless of fuel source.

11.6.6.7 Performance Approach

The compliance software does not include a hot water recirculation pump for the standard distribution system serving a single dwelling unit and does not allow credit for any additional DHW design features.

Alternative distribution systems are compared to the standard design by using distribution system multipliers, which effectively rate alternative options. Table 11-54 lists all the recognized distribution systems that can be used in the performance approach with the assigned distribution multiplier. The standard distribution system has a multiplier of 1.0. Distribution systems with a multiplier less than 1.0 represent an energy credit, while distribution systems with a multiplier greater than 1.0 are an energy penalty. For example, pipe insulation with HERS inspection required (PIC-H) has a multiplier of 0.8. That means that it is modeled at 20% less distribution loss than the standard distribution system.

Table 11-54: Applicability of Distribution Systems Options Within a Dwelling Unit

Distribution System Types	Assigned Distribution System Multiplier	Systems Serving a Single Dwelling Unit
No HERS Inspection Required		
Trunk and Branch -Standard (STD)	1.0	Yes
Parallel Piping (PP)	1.1	Yes
Point of Use (POU)	0.3	Yes
Recirculation: Non-Demand Control Options (R-ND)	9.8	Yes
Recirculation with Manual Demand Control (R-Dmn)	1.75	Yes
Recirculation with Motion Sensor Demand Control (R-DAuto)	2.6	Yes
HERS Inspection Required		
Pipe Insulation (PIC-H)	0.85	Yes
Parallel Piping with 5' maximum length (PP-H)	1	Yes
Recirculation with Manual Demand Control (R-DRmc-H)	1.6	Yes
Recirculation with Sensor Demand Control (RDRsc-H)	2.4	Yes

Source: California Energy Commission

11.6.7 Systems Serving Multiple Dwelling Units

This section describes requirements applicable to water heating systems serving multiple dwelling units and common use areas with a recirculation loop. These requirements are in addition to requirements captured in Section 11.7.5.

11.6.7.1 Multiple Dwelling Unit Water Heating Equipment

There are no additional mandatory requirements specific to equipment serving multiple dwelling units other than those described in Section 11.7.5.

11.6.7.2 Prescriptive Requirements

§170.2(d)

There are three options for using the prescriptive approach for systems serving multiple dwelling units for newly constructed multifamily buildings:

1. A central HPWH system
2. A central gas or propane-fired water heater or boiler with minimal solar waving fraction based on the Climate Zone
3. A water-heating system determined by the Executive Director to use no more energy than the central HPWH and central gas or propane-fired systems

The water heater must have an efficiency that meets the requirements in §110.1 and §110.3. In addition, if a central recirculation system is installed, it must be installed with demand recirculation.

A. Central Heat Pump Water Heating Systems

§170.2(d)2

To use the prescriptive approach, the central HPWH system design must use a temperature maintenance system to meet the DHW temperature maintenance load. A temperature maintenance system consists of a recirculation pump, a *loop tank*, and a temperature maintenance heat source. The hot water return from the recirculation loop must connect to the loop tank and cannot connect directly to the primary storage tanks or the inlet of the primary HPWH equipment. This design approach can prioritize delivering cool water to the HPWHs for peak performance while maintaining thermal stratification in the primary tanks.

The prescriptive approach allows the use of either single-pass or multi-pass HPWH as the primary heat source. It does not allow the use of a HPWH configured as single-pass operation to handle temperature maintenance load. The temperature maintenance heater must use electricity as the fuel source. Multi-pass HPHW or electric resistance water heaters are both acceptable in the temperature maintenance system.

When there are multiple primary storage tanks included in the design, the primary storage tanks must be piped in series when the primary HPWH is configured as single-pass operation. This configuration can maximize hot water storage capacity, minimize disruption of stratification by cold city water, and allow the cool temperature water to connect to the HPWP inlet. In addition, piping the primary tanks in series allows the strategic placement of Aquastat for HPWH control to improve overall operation efficiency and avoid over cycling. On the other hand, when the primary HPWH is configured as a multi-pass system, the primary storge tanks mush be configured in parrel to ensure proper operation.

To effectively increase storage capacity and leverage the load shifting capability of hot water storage, the prescriptive approach requires the primary hot water storage temperature must be at least 135°F. In addition, the loop tank temperature setpoint must be controlled to be at least 10°F lower than the primary thermal storage tank setpoint. Since the loop tank heater, which could be an electric resistance heater or a multi-pass HPWH, operate less efficiently than the primary HPWH, lowered loop tank setpoint can ensure to only engage the loop heater when additional heat is needed for temperature maintenance purpose.

HPWH compressor must be able to operate to meet all control requirements stated above when the ambient air temperature is equal to or higher than 40°F.

In addition to the plumbing configuration and control requirements, the prescriptive approach requires presentation of specified information in the design documentation. JA 14. 4 specifies the following information must be included:

- Minimum and maximum ambient air temperature designed for the HPWH to operate. HPWH performance is impacted by the ambient air conditions. Designers must consider the climate conditions and where to locate the HPWHs for equipment selection.
- Minimum and maximum cold-water temperature.
- Minimum and maximum building demand at design draw and recovery conditions and duration. Designers must consider these parameters to properly size for HPWH and storage tank, regardless of if load shifting is considered.
- Recirculation loop heat loss: designers must determine the recirculation loop heat loss to properly size the loop tank and determine whether a heater is needed.

Recirculation system is not required for a central HPWH system serving eight or fewer dwelling units. When recirculation system is present, it must meet all applicable requirements in the Energy Standard.

B. Gas or Propane Water Heating Systems with Solar Savings Fraction

To use the prescriptive path with gas or propane central water heating system, water heaters with input capacity at or over 1 MMBtu/h must have a minimum thermal efficiency of 90%. Water heaters with lower capacity rate are exempt from the thermal efficiency requirement. Additional exemption is allowed when 25% or more of the annual water heating load is met by on-site solar PV system or site-recovered energy.

When a central gas or propane water heating system is installed, a solar water heating system with a minimum solar fraction is also required. The minimum solar savings fraction requirement is climate zone dependent; the minimum is 0.2 for Climate Zones 1 through 9 and 0.35 in Climate Zones 10 through 16. If a DWHR device meeting the requirements specified in the Reference Appendix RA 3.6.9 is installed, moderately lower solar savings fraction levels are required instead. The minimums become 0.15 for Climate Zones 1 through 9 and 0.30 for Climate Zones 10 through 16.

The water heating calculation method allows water heating credits for solar water heaters. Solar thermal systems save energy by using renewable resources to offset the use of conventional energy sources. For multifamily buildings, only systems with OG-100 collectors can be installed. For detailed instructions on installation of solar water heaters, refer to Reference Appendix RA4.4.20.

The database of SRCC-certified equipment is on the SRCC website at the following link:

www.secure.solar-rating.org//Certification/Ratings/RatingsSummaryPage.aspx?type=1

The database of IAPMO R&T-certified equipment is on the IAPMO R&T website at the following link:

www.iapmort.org/Pages/SolarCertification.aspx

11.6.7.3 Performance Approach

C. Central Heat Pump Water Heating System

Joint Appendix 14 Qualification Requirements for Central Heat Pump Water Heater Systems sets the requirements for central HPWH system using the performance approach. The requirements are applicable to systems to be installed in multifamily buildings and nonresidential buildings.

JA 14.3 requires that central HPWH equipment to be certified to the Energy Commission, which includes submitting required performance data to the Commission. The process of data submission can be found in the link below:

www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment-8

Each basic model that is claimed on the performance certificate of compliance must be certified. Manufacturers must determine performance data for each basic model, which means all units of a given type of product manufactured by one manufacturer; have the same primary energy sources; and have essentially identical electrical, physical, and functional (hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency.

JA 14.3 further details the acceptable methods to determine performance data and the data reporting requirement:

- When simulation is used, an alternative efficiency determination methods (AEDM) as described in 10 CFR part 429.70(a)-(c) must be used to generate performance data required in JA 14.3.2

- When lab testing is used, testing must be conducted as described in Appendix E to Subpart G of 10 CFR Part 431 for each of the test conditions described in JA14.3.3.

JA 14.4 Design Condition Documentation Requirements are applicable for central HPWH designs using prescriptive and performance approach.

When the proposed DHW system is a central DHW system that uses electricity as the primary fuel source, the standard design is a central HPWH system that is based on the prescriptive requirement of a central HPWH in Section 170.2(d)2The standard design central HPWH system has a recirculation system with single pass compressors, with separate primary storage tank and recirculation loop storage tank.

(Place holder to describe standard Central HPWH design)

JA 13 provides qualification requirements for HPWH demand management systems. Qualifying HPWHs have the capability to optimize operation to reduce normal water heater operation during on-peak periods by biasing operation prior to the peak period. Future opportunities include overheating the storage tank above setpoint prior to the peak period, further improving the electrical load profile of these systems. A credit exists for these HPWHs within the compliance software. JA13 certified HPWHs, which must have a mixing valve installed to prevent any scalding risks, are currently listed at this website:

www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/ja13

D. Solar Water Heating

Solar water heating systems with a solar fraction higher than the specified prescriptive minimum can be used as a tradeoff under the performance approach. Users now input collector and system component specifications to calculate a corresponding solar fraction for the proposed system.

11.6.7.4 Distribution Systems Serving Multiple Dwelling Units

This section describes requirements for distribution systems serving multiple dwelling units. These requirements are distinct from requirements applicable to systems serving individual dwelling units.

11.6.7.5 Mandatory Requirements

§110.3(c)4

Multifamily buildings recirculation loop consists of a supply portion of larger diameter pipe connected to smaller diameter branches that serve multiple dwelling units, guest rooms, or common use area fixtures and a return portion that completes the loop back to the water heating equipment. The large volume of water that is recirculated during periods of high use creates situations that require the installation of certain controls and servicing mechanisms to optimize performance and allow for lower cost of maintenance. This section covers the mandatory requirements for system serving multiple dwelling units and with recirculation loops.

E. Air Release Valves

§110.3(c)4A

The constant supply of new water in combination with the continuous operation of pumps creates the possibility of the pump cavitation due to the presence of air in the water. *Cavitation* is the formation of bubbles in the low-pressure liquid on the suction side of the pump. The cavities or bubbles will collapse when they pass into the higher regions of pressure, causing noise and vibration that may lead to damage to many of the components. In addition, there is a loss in capacity, and the pump can no longer build the same head (pressure). This ultimately affects the efficiency and life expectancy of the pump.

Cavitation must be minimized either by installing an air release valve or mounting the pump vertically. The air release valve must be located no more than four ft. from the inlet of the pump. The air release valve must also be mounted on a vertical riser with a length of at least 12 inches.

F. Backflow Prevention

§110.3(c)4B

Temperature and pressure differences in the water throughout a recirculation system can create backflows. This can result in cooler water from the bottom of the water heater tank and water near the end of the recirculation loop flowing backward toward the hot water load and reducing the delivered water temperature.

To prevent this from occurring, the Energy Code require that a check valve or similar device be located between the recirculation pump and the water heating equipment.

G. Equipment for Pump Priming/Pump Isolation Valves

§110.3(c)4C&D

Repair labor costs can be reduced significantly by planning and designing for pump replacement when the pump fails. Provision for pump priming and pump isolation valves helps reduce maintenance costs.

To meet the pump priming equipment requirement, a hose bib must be installed between the pump and the water heater. In addition, an isolation valve must be installed between the hose bib and the water heating equipment. This configuration will allow the flow from the water heater to be shut off, allowing the hose bib to be used for bleeding air out of the pump after pump replacement.

The requirement for the pump isolation valves will allow replacement of the pump without draining a large portion of the system. The isolation valves must be installed on both sides of the pump. These valves may be part of the flange that attaches the pump to the pipe. One of the isolation valves may be the same isolation valve as for pump priming.

H. Connection of Recirculation Lines

§110.3(c)4E

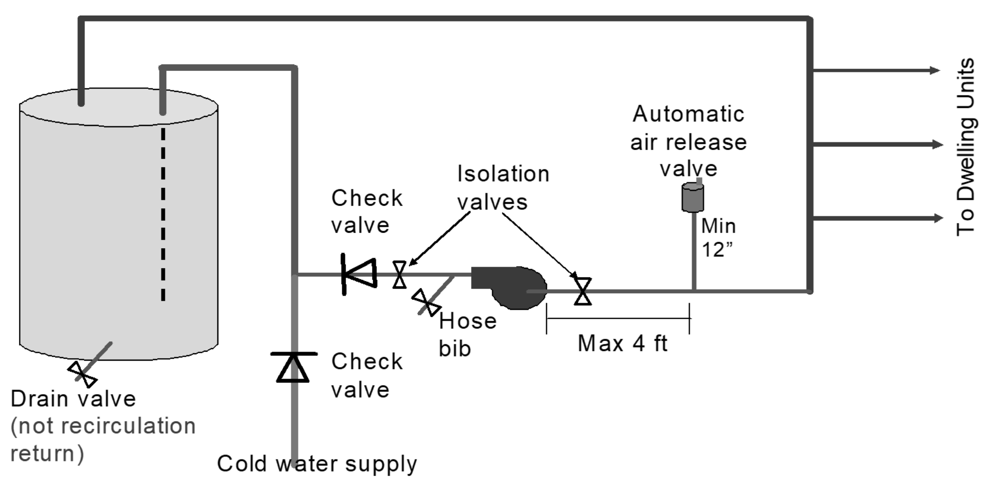
Manufacturer's specifications should always be followed to assure optimal performance of the system. The cold water piping and the recirculation loop piping should never be connected to the hot water storage tank drain port.

I. Backflow Prevention in Cold Water Supply

§110.3(c)4F

The dynamic between the water in the heater and the cold water supply are similar to those in the recirculation loop. Thermosyphoning can occur on this side of this loop, just as it does on the recirculation side of the system. To prevent this, the Energy Code require a check valve to be installed on the cold water supply line. The valve should be located between the hot water system and the next closest tee on the cold water supply line. The system must comply with the expansion tank requirements as described in the California Plumbing Code.

Figure 11-73: Mandatory Central Recirculation System Installation Requirements



Source: California Energy Commission

11.6.7.6 Prescriptive Requirements

§170.2(d)

Installation of an automatic recirculation control based on sensing hot water demand and recirculation return temperatures is a prescriptive requirement. This is applicable regardless of system type or fuel source.

11.6.7.7 Performance Approach

For systems serving multiple dwelling units with a recirculating pump, the standard distribution system design is based on a central recirculation system automatically controlled by sensing of hot water demand and recirculation return temperatures. Systems designed with other options are allowed, and some of them are subject to HERS field verification.

Buildings with uncontrolled recirculation systems will need to install other efficiency features to offset the resulting compliance penalty. Table 11-55 lists all the recognized distribution systems that can be used in the performance approach with the assigned distribution multiplier.

Table 11-55: Applicability of Distribution Systems Options Serving Multiple Dwelling Units

Distribution System Types	Assigned Distribution System Multiplier	Central Recirculation Systems Serving Multiple Dwelling Units
No HERS Inspection Required		
Trunk and Branch -Standard (STD)	1.0	Yes
HERS Inspection Required		
Pipe Insulation (PIC-H)	0.85	Yes

J. Dual-Loop Recirculation System

Dual-loop recirculation systems are a performance option. In a dual loop recirculation system, each recirculation branch loop serves roughly half of the dwelling units. Pipe diameters can be downsized in a dual loop system compared to a single-loop system serving all dwelling units while still following California Plumbing Code requirements. The total pipe surface area is effectively reduced with smaller distribution pipe diameters, even though total pipe length remains similar to than that of a single-loop system.

For example, for simple building footprints, locating the water heating equipment at the center of the building footprint rather than at one end of the building helps minimize the pipe length. If a water heating system serves several building sections, the water heating equipment would preferably nest between these sections.

11.6.8 Mandatory Requirements for Residential Swimming Pool and Spa Heating

The Energy Code include several mandatory requirements for residential swimming pool filtration equipment, which affect pump selection and flow rate, piping and fittings, and filter selection. These standards are designed to reduce the energy used to filter and maintain the clarity and sanitation of pool water. Refer to Section 4.7 on Pool and Spa Heating Systems for details.

11.6.9 Additions and Alterations

§180.0

Additions and alterations to existing individual water heating systems are subject to mandatory requirements and select prescriptive requirements. These requirements apply to systems serving multiple dwelling units. Examples of instances that trigger requirements include:

- Increasing the number of water heaters serving individual dwelling units (as part of an addition).
- Replacing the existing water heating or adding water heaters and/or adding hot water piping.
- Replacing a heating element in a water heat but not replacing the entire water heater.

11.6.9.1 Mandatory and Prescriptive

§180.1(a)3, §180.2(b)3, §160.4(f)Water heater systems that serve one or more dwelling units as part of an addition will meet the prescriptive requirements specified in §170.2(d) on both water heater and distribution system.

Altered or replaced water heating systems or components serving dwelling units must meet mandatory pipe insulation and insulation protection requirements. Reference Section 11.7.5 for more details.

For a replacement water heater, there are separate requirements for the distribution system and the water heater. The requirements for pipe insulation are mandatory and cannot be traded off. For the distribution system and the water heater, if the prescriptive requirements cannot be met, then the performance approach can be used to comply.

To meet the prescriptive requirements, the replacement water heater must be one of the following:

- A natural gas or propane water heater.
- If the existing water heater is an electric resistance water heater, a replacement electric water heater may be installed.
- A single HPWH meeting NEEA Tier 3 or higher specifications.

- A single heat pump water heater, 1) located in an unconditioned space like the garage or in conditioned space, 2) placed on an incompressible (rigid) surface that is insulated to a minimum R-10, and 3) installed with a communication interface (demand control device) meeting §110.12(a) or an ANSI/CTA-2045-B communication port.
- A water-heating system determined by the California Energy Commission's Executive Director to use no more energy than those specified above.

If a recirculation system is installed, then it must be a demand recirculation system with a manual on/off control to meet the prescriptive requirements.

11.6.9.2 Performance Approach

§180.1(b), 180.2(c)

Modeling an addition alone requires meeting the same requirements as newly constructed buildings. The prescriptive requirements apply only to the space that is added, not the entire building

For altered or replaced water heating systems, the calculated energy use of the proposed design is compared to the standard design energy budget. For system serving individual dwelling units, the standard design is based on either a single gas instantaneous water heater for gas water heaters or a HPWH system with a standard distribution system. For systems serving multiple dwelling units, the standard design is based on the existing efficiency level.

11.6.10 Compliance and Enforcement

Chapter 2 of this compliance manual addresses the compliance and enforcement process, and it discusses the roles and responsibilities of each of the major parties, the compliance forms, and the process for field verification and/or diagnostic testing. This section highlights compliance enforcement issues for water heating systems.

11.6.10.1 Design Review

The design review verifies that the certificate of compliance matches the plans and specifications for the proposed building. The certificate of compliance has a section where special features are listed. The following are water heating features that should be listed in this section of the certificate of compliance:

- Any system type other than one water heater per dwelling unit
- Non-NAECA large water heater performance
- Indirect water heater performance
- Instantaneous gas water heater performance
- Distribution system type and controls
- Solar system

- Combined hydronic system
- Central HPWH system

Information provided on the certificate of compliance must be included on the plan set. Highlighting key concerns or adding notes will allow field inspectors to quickly catch any features that should be installed that made a significant difference in compliance.

When a central heat pump water heating system is installed, design documentation should include additional information required in JA 14.4, including equipment design air and outlet temperature ranges, building demand, and recirculation loop heat loss.

11.6.10.2 Field Inspection

During construction, the contractor (or the specialty contractors or both) completes the necessary sections of the Certificate of Installation. There is one section of the Certificate of Installation where information about the installed water heating system is entered if complying prescriptively with a gas instantaneous, select gas storage above 55 gallons, or a NEEA Tier-3 rated heat pump water heating equipment. Additional documents are needed to comply prescriptively for all other options. (See Appendix A.)

Inspectors should check that the number and types of water heating systems indicated on the installation certificates match the approved certificate of compliance. For a central heat pump water heater, inspectors should check that plumbing configurations between the water heater, storage tanks, and recirculation loop correspond to plan specifications.

11.6.10.3 HERS Field Verification and/or Diagnostic Testing

11.6.10.4 Individual Dwelling Unit Water Heaters

HERS verification is required for all hot water distribution types that include options for field verification. The first type is alternative designs to conventional distribution systems that include parallel piping, demand recirculation, and automatic and manual on-demand recirculation. The second type is for compact distribution systems earning the expanded credit, which can be used only when verified by field verification. Where HERS verification is required, the HERS Rater must verify that the eligibility requirements in RA3.6 for the specific system are met.

In addition, HERS-verified DWHR is a prescriptive compliance option and a performance compliance credit.

11.6.10.5 Multifamily With Central Water Heating Systems

The HERS verification for central water heating recirculation systems includes verification of multiple distribution lines for central recirculation systems and the verification of DWHR systems.

11.6.11 Code in Practice

11.6.11.1 Garden Style Multifamily Case Study

The Garden Style Multifamily Case Study considers a new two-story garden style multifamily building in Burbank, California (Climate Zone (CZ) 9). This is a sample project created for training purposes, and it consists of 7,216 ft² of conditioned floor area with eight dwelling units and no common use areas. The case study tables in this chapter compare the proposed building water heating system features to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Figure 74: Garden Style Multifamily Case Study: Heat Pump Water Heater in Closet with Ducts to Outside

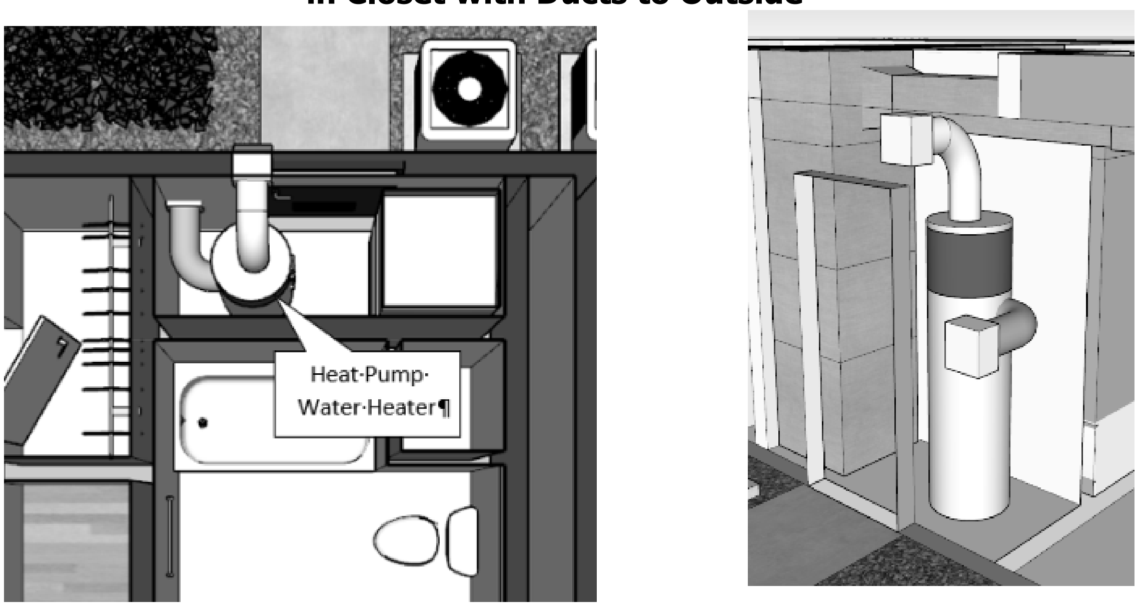


Table 11-56: Garden Style Multifamily Water Heating Schedule

Heat Pump Water Heater: One (1) 50 gallon heat pump water heater per dwelling unit	**Type:** 50 gallon 240 volt heat pump water **Efficiency**: NEEA Advanced Water Heater Specification Tier 3 (NEEA Tier 3), UEF ≥ 2.73	**Ducts:** Air inlet and exhaust outlet ducts installed to the outside	Water Heater Locations: 1st Floor: Exterior closets 2nd Floor: Interior closets	**Distribution:** Standard distribution, ¾ inch hot water piping insulated to R-7.7

Source: California Energy Commission

The proposed heat pump water heating system meets Mandatory efficiency and pipe insulation requirements, and it complies prescriptively by meeting the Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification

Tier 3 with standard distribution. NEEA maintains a list of qualified heat pump water heaters that are rated from Tier 1 lowest efficiency to Tier 5 highest efficiency: https://neea.org/img/documents/HPWH-qualified-products-list.pdf. The Prescriptive compliance option selected for this case study requires a product from the list rated at NEEA Tier 3 or higher, but the proposed water heating system would also comply as a non-NEEA-rated 240 volt heat pump water heater. Heat pump water heating systems in CZ 9 do not require Prescriptive compact distribution or drain water heat recovery

Table 11-57: Garden Style Multifamily Case Study Compared to Mandatory and Prescriptive Service Water Heating Requirements (Climate Zone 9)

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Multifamily Building	New two-story garden style multifamily building, eight dwelling units, no common use areas, Burbank, CA	Sections 160.4, 110.3 Title 20 Section 1605.1 Table F-2	Section 170.2(d), New multifamily building ≤ three stories, Climate Zone (CZ) 9	Case study Mandatory and Prescriptive compliance rated for each feature below as “Yes” (complies), “No” (does not comply) or “N/A” (not applicable). If “No”, see compliance options provided.
Total Conditioned Floor Area (CFA)	7,216 ft²	7,216 ft²	7,216 ft²	
Fuel Type	Electricity	No Mandatory fuel type requirements	Electricity or Dual Fuel	Mandatory: NR Prescriptive: Yes

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Equipment Type	One (1) 50 gallon storage heat pump water heater per dwelling unit, located in closet (1st floor exterior closet, 2nd floor interior closet), ducted to the outside	Meet or exceed Mandatory requirements for proposed system type	CZ 9: One (1) 240 volt heat pump water, or One (1) NEEA Tier 3 heat pump water heater, or A tankless gas water heater with input ≤ 200 kBtuh	Mandatory: Yes Prescriptive: Yes
Efficiency	NEEA Advanced Water Heater Specification Tier 3 (NEEA Tier 3), UEF ≥ 2.73	Meet or exceed current Federal minimum for storage electric water heater ≥ 20 gallons and ≤ 55 gallons (assumes high draw): UEF ≥ 0.93	CZ 9: NEEA Tier 3 or higher Note: Typical heat pump water heaters have UEF between 2.0 and 4.0, well over the storage electric resistance Federal minimums.	Mandatory: Yes Prescriptive: Yes
Distribution	Standard distribution, ¾ inch hot water piping insulated to R-7.7	Pipe insulation per Table 160.4 for water temperatures from 105°F to 140°F	Standard distribution	Mandatory: Yes Prescriptive: Yes
Controls	None		None	Mandatory: Yes Prescriptive: Yes
Verifications	None		None	Mandatory: Yes Prescriptive: Yes

Source: California Energy Commission

11.6.11.2 Mid-Rise Multifamily Case Study

The Mid-Rise Multifamily Case Study covers a new five-story multifamily building in Sacramento, California (Climate Zone (CZ) 12). This is a sample project created for training purposes, and it includes 112,044 ft² of conditioned floor area with 88 dwelling units, shared residential corridors, laundry rooms, fitness center and lounge, plus ground floor retail. The case study tables in this chapter compare the proposed building water heating system features to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Figure 75: Mid-Rise Multifamily Case Study: Central Heat Pump Water Heater on Roof

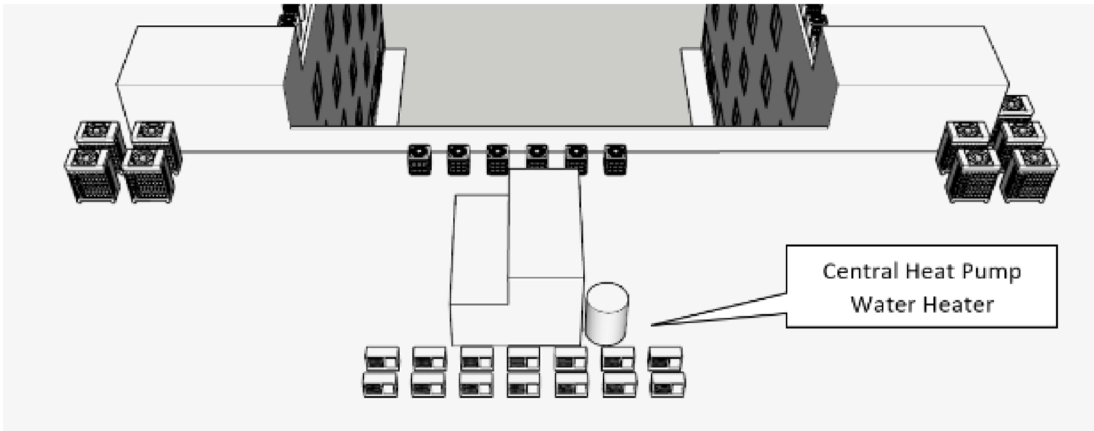


Table 11-58: Mid-Rise Multifamily Water Heating Schedule: Dwelling Units

Central Heat Pump Water Heating System: Central heat pump water heating system serving all 88 dwelling units: (13) NEEA-rated, 43 gallon, small integrated packaged electric heat pump water heaters, electric resistance loop tank with one heater, 300 gallon volume, R-16 tank insulation	Type: Central Heat Pump Water Heater Efficiency: UEF = 3.09	Water Heater Location: Roof of building	Distribution: Recirculation distribution, 1 inch hot water piping insulated to R-12.5, recirculation pump controls based on hot water demand and return temperature

Table 11-59: Mid-Rise Multifamily Water Heating Schedule: Retail and Multifamily Common Use

Electric Water Heater: One (1) 40 gallon storage electric resistance water heater	Type: 40 gallon storage electric resistance Efficiency: UEF = 0.93	Water Heater Location: Interior closet	Distribution: Standard distribution, first 8 feet of hot and cold water pipes insulated, ¾ inch hot water piping insulated to R-7.7

Table 11-60: Mid-Rise Multifamily Case Study Compared to Mandatory and Prescriptive Service Water Heating Requirements (Climate Zone 12) General Information, Total Conditioned Floor Area, Fuel and Equipment Types

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Mid-Rise Multifamily Building	New five-story mid-rise multifamily building, 88 dwelling units, common use areas, ground floor retail, Sacramento, CA	Sections 160.4, 110.3 Title 20 Section 1605.1 Table F-2	Section 170.2(d), Reference Appendix JA14 New multifamily building ≥ four stories, Climate Zone (CZ) 12	Case study Mandatory and Prescriptive compliance rated for each feature below as “Yes” (complies), “No” (does not comply) or “N/A” (not applicable). If “No”, see compliance options provided.
Conditioned Floor Area (CFA)	Dwelling Units: 78,384 ft²	78,384 ft²		
	Common Use Multifamily: 17,487 ft²	17,487 ft²		
	Nonresidential: 16,173 ft²	16,173 ft²		
	Total: 112,044 ft²	112,044 ft²		
Fuel and Equipment Types	MF DU: Central heat pump water heating system serving all 88 dwelling units: (13) NEEA-rated, 43 gallon, small integrated packaged electric heat pump water heaters, located on the roof, electric resistance loop tank with one heater, 300 gallon volume, R-16 tank insulation	Meet or exceed Mandatory requirements for proposed system type	CZ 12: Central electric heat pump water heating system meeting 170.2(d)2	Mandatory: Yes Prescriptive: Yes
	MF CU and Retail: One (1) 40 gallon storage electric resistance water heater	Meet or exceed Mandatory requirements for proposed system type	N/A	Mandatory: Yes Prescriptive: N/A

Source: California Energy Commission

Table 11-61: Efficiency, Distribution, Controls and Verifications

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Efficiency	MF DU: UEF = 3.09	Meet or exceed current Federal minimum for storage electric water heater ≥ 20 gallons and ≤ 55 gallons (assumes high draw): UEF ≥ 0.93	CZ 12: Central electric heat pump water heating system meeting 170.2(d)2	Mandatory: Yes Prescriptive: Yes
	MF CU and Retail: UEF ≥ 0.93	Same as MF DU	N/A	Mandatory: Yes Prescriptive: N/A
Distribution	MF DU: Recirculation distribution, 1 inch hot water piping insulated to R-12.5	Table 160.4-A: 1 inch multifamily hot water pipe, requires 1.5 inch R-12.5 pipe insulation	Recirculation distribution with pump controls based on hot water demand and return temperature	Mandatory: Yes Prescriptive: Yes
	MF CU and Retail: Standard distribution meeting Mandatory pipe insulation	120.3: First 8 feet of hot and cold water pipes insulated, ¾ inch hot water pipe, requires 1 inch R-7.7 pipe insulation	N/A	Mandatory: Yes Prescriptive: N/A
Controls	MF DU: Recirculation pump controls based on hot water demand and return temperature	N/A	Recirculation pump controls based on hot water demand and return temperature	Mandatory: N/A Prescriptive: Yes
	MF CU and Retail: None	N/A	N/A	Mandatory: N/A Prescriptive: N/A
Verifications	Design documentation per Reference Appendix JA14.4	N/A	Design documentation per Reference Appendix JA14.4	Mandatory: N/A Prescriptive: Yes

Source: California Energy Commission

The proposed water heating system meets all Mandatory and Prescriptive requirements, so it complies with the Energy Code as designed. The dwelling units clearly are the primary hot water users in this project, and the Energy Code has both Mandatory and Prescriptive requirements to make multifamily water heating systems more energy efficient. In Climate Zone 12, the Prescriptive central heat pump water heating system option helps California move toward the state goal of reducing carbon emissions.

11.7 Indoor and Outdoor Lighting

This chapter covers requirements for lighting in multifamily buildings, including dwelling units, interior common use areas, and outdoor areas. Requirements for lighting in nonresidential spaces in mixed use buildings are covered in Chapter 5 (Nonresidential Manual).

Lighting requirements in multifamily buildings vary between dwelling units, common use areas and outdoor areas. For dwelling units, all the lighting requirements are mandatory. There are luminaire requirements and lighting control requirements for dwelling unit lighting installations. For lighting in common use areas and outdoor areas, requirements include mandatory, prescriptive and performance options, and calculations of lighting power and maximum lighting power thresholds.

Table 11-62 provides an overview of the location of the lighting requirements in the *2022 Energy Code* by system building type and where descriptions reside in this document.

Table 11-62: Overview of Multifamily Lighting Requirements

Lighting Application	Mandatory Requirements	Prescriptive Requirements	Performance Requirements	Manual Section
Dwelling Unit	§110.9, §160.5(a)	N/A	N/A	11.8.2
Common Use Area Indoor	§110.9, §160.5(b), §160.5façade	§170.2(e)1, §170.2(e)2, §170.2(e)3, §170.2(e)4	§170.1	11.8.4, Chapter 5
Outdoor	§110.9, §160.5(c), §160.5(e)	§170.2(e)6	§170.1	11.8.5, Chapter 6
Signs	§160.5(d)	§170.2(e)7	§170.1	Chapter 7

11.7.1 What's New for the 2022 California Energy Code

This section summarizes changes to the requirements for multifamily lighting for the 2022 Energy Code.

- Compiles all lighting requirements for all parts of multifamily buildings into a standalone Multifamily Standard. Requirements for dwelling unit lighting largely align with the single-family residential lighting standards, and requirements for common use areas and outdoor areas in multifamily buildings largely align with the nonresidential lighting standards.

- Eliminates building proportion thresholds for common use areas and consolidates all requirements for multifamily common use areas under a single system.
- Eliminates all thresholds for variable outdoor lighting requirements and consolidates multifamily outdoor lighting requirements under a single system.

11.7.2 Dwelling Unit Mandatory Lighting Requirements

160.5(a), JA8

All requirements relating to lighting within dwelling units and any outdoor lighting controlled from within dwelling units are mandatory. All requirements for dwelling unit lighting align with the applicable single-family residential lighting requirements. Requirements for dwelling unit lighting are described in the sections below.

11.7.2.1 Dwelling Unit Luminaire Requirements

The Standards for dwelling unit lighting require all permanently installed luminaires to be high luminous efficacy, as specified in §160.5(a). Permanently installed lighting is defined in §100.1 and includes:

- Lighting attached to walls, ceilings, or columns.
- Track and flexible lighting systems.
- Lighting inside permanently installed cabinets.
- Lighting attached to the top or bottom of permanently installed cabinets.
- Lighting attached to ceiling fans.
- Lighting integral to exhaust fans.
- Lighting integral to garage door openers if it is used as general lighting, is switched independently from the garage door opener, and does not automatically turn off after a pre-determined amount of time.

The following are examples of non-permanently installed lighting:

- Portable lighting as defined by §100.1 (including, but not limited to, table and freestanding floor lamps with plug-in connections)
- Lighting installed by the manufacturer in refrigerators, stoves, microwave ovens, exhaust hoods for cooking equipment

Table 11-63 summarizes the requirements for dwelling unit high luminous efficacy luminaires. There are luminaires automatically classified as high luminous efficacy, luminaires that must use JA8-certified light sources or lamps, and recessed downlight luminaires in ceilings. These categories are described in more detail in the following sections.

Table 11-63: Summary of Compliant Luminaire Types for Dwelling Units

High Luminous Efficacy Luminaires*	JA8 High Luminous Efficacy Lighting – Lamps and Light Sources that must be JA8-certified	Recessed Downlight Luminaires in Ceilings
• LED light sources installed outdoors • Inseparable solid-state lighting (SSL) luminaires containing colored light sources for decorative lighting purpose • Pin-based linear fluorescent luminaires or compact fluorescent luminaires using electronic ballasts • High intensity discharge (HID) light sources including pulse-start metal halide luminaires and high pressure sodium luminaires • Luminaires with induction lamp and hardwired high frequency generator • Ceiling fan light kits subject to federal appliance regulations	• Light sources installed in ceiling recessed downlight luminaires. • LED luminaires with integral sources • Screw-based LED lamps (A-lamps, PAR lamps, etc.) • Pin-based LED lamps (MR-16, AR-111, etc.) • Any light source or luminaire not listed elsewhere in this table	• Must not have screw-based sockets • Must contain JA8-certified light sources

11.7.2.2 Dwelling Unit Luminaires – High Luminous Efficacy by Default

Luminaires in any of the following categories are classified high luminous efficacy and do not have to comply with the requirements of Reference Joint Appendix JA8 (refer to next section for details).

a. LED luminaires installed outdoors
b. Inseparable solid-state lighting (SSL) luminaires containing colored light sources for decorative lighting purpose.
c. Pin-based linear fluorescent luminaires or compact fluorescent luminaires using electronic ballasts
d. High intensity discharge (HID) luminaires including pulse-start metal halide luminaires and high pressure sodium luminaires
e. Luminaires with induction lamp and hardwired high frequency generator
f. Ceiling fan light kits that are subject to federal appliance regulations.

11.7.2.3 Dwelling Unit Luminaires – JA-8 Compliant

Luminaires not listed in the previous section must have an integral light source or removable lamp that meets the performance requirements of JA8. The requirements in JA8 allow any type of light source, such as LED, as long as it provides energy-efficient lighting and meets minimum performance characteristics.

In addition to setting minimum efficacy requirements (lumens/Watt), JA8 establishes performance requirements that ensure accurate color rendition, dimmability, and reduced noise and flicker during operation.

Luminaires with integral sources, such as LED luminaires, must be certified to the Energy Commission as meeting the JA8 requirements. Luminaires that have changeable lamps (such as screw-base luminaires) must be installed with JA8-certified lamps.

Luminaires and lamps that are certified to the Energy Commission must be marked on the product as described in JA8. Lamps that will be installed in elevated temperature applications such as in enclosed luminaires must have a JA8-2022-E marking to indicate that the product has passed the more stringent ENERGY STAR Elevated Temperature Life test.

Luminaires that can be classified as high luminous efficacy by meeting the requirements of JA8 include:

- LED luminaires with integral light sources that are certified to the Energy Commission.
- Ceiling recessed downlight luminaires with JA8 certified light sources (the luminaire must not contain screw-based lamp sockets).
- Screw-based luminaires with JA8-certified lamps.
- Low-voltage pin-based luminaires with JA8-certified lamps.

Almost any luminaire can be classified as high luminous efficacy, as long as the luminaire is installed with a JA8 certified lamp or light source. The exception is recessed downlight luminaires in ceilings, which must meet additional requirements.

The Energy Commission maintains a database of certified JA8 certified luminaires, lamps, and light sources. The database can be accessed using a Quick Search Tool or an Advanced Search.

11.7.2.4 Recessed Downlight Luminaires in Dwelling Unit Ceilings

In addition to the high luminous-efficacy requirements described above, there are several additional requirements for dwelling unit downlight luminaires that are recessed in ceilings.

Recessed downlight luminaires are limited to specific light sources and lamp types that may be used. Recessed downlight luminaires:

1. Must contain light sources that are JA8-certified.
2. Must not contain screw-based lamps.
3. Must not contain light sources that are labeled not for use in enclosed luminaires or not for use in recessed luminaires.

All recessed downlight luminaires must contain a light source or lamp that is JA8-certified, such as an integral LED source or LED lamp. Screw-based lamps such as LED A-lamps or LED PAR lamps are not allowed. Pin-based lamps such as LED MR-16 lamps are allowed in recessed luminaires as long as they are JA8-certified.

In addition to the light source and lamp requirements listed, recessed downlight luminaires in ceilings must meet all the following requirements:

1. Have a label that certifies the luminaire is airtight with air leakage less than 2.0 cubic ft. per minute at 75 Pascals when tested in accordance with ASTM E283 (exhaust fan housings with integral lighting are not required to be certified airtight).
2. Be sealed with a gasket or caulk between the luminaire housing and ceiling, and have all air leak paths between conditioned and unconditioned spaces sealed with a gasket or caulk, or be installed per manufacturer's instructions to maintain airtightness between the luminaire housing and ceiling.
3. Meet the clearance and installation requirements of California Electrical Code Section 410.116 for recessed luminaires which requires the following.
   - A recessed luminaire that is not identified for contact with insulation, non-Type IC, must have all recessed parts spaced not less th½1/2 inch from combustible materials. The points of support and the trim finishing off the openings in the ceiling must be permitted to be in contact with combustible materials.
   - A recessed luminaire that is identified for contact with insulation, Type IC, must be permitted to be in contact with combustible materials at recessed parts, points of support, and portions passing through or finishing off the opening in the building structure.
   - Thermal insulation must not be installed above a recessed luminaire or within 3 inches of the recessed lumina're's enclosure, wiring compartment, ballast, transformer, LED driver, or power supply unless the luminaire is identified as Type IC for insulation contact.

Luminaires that meet the air leakage requirement or luminaires that are Type IC rated will have this information listed on luminaire cut sheets or packaging. Contractors are responsible for ensuring that luminaires are properly sealed to prevent air leakage between the luminaire housing and ceiling.

Recessed luminaires that are marked for use in fire-rated installations and recessed luminaires installed in non-insulated ceilings are exempt from the air leakage requirement and sealing requirement, however, must meet all other requirements for recessed luminaires.

11.7.2.5 Enclosed Luminaires and Recessed Luminaires other than Ceiling-Recessed Downlight Luminaires

For enclosed luminaires and recessed luminaires other than ceiling-recessed downlights, the installed light source must be JA8 compliant and meet the elevated temperature requirement. The JA8-compliant lamps and light sources must be marked with "JA8-2022-E" to signify that they are suitable to be installed in an enclosed or recessed luminaire.

11.7.2.6 Screw-Base Luminaires

For screw-base luminaires to be installed in residential spaces, the installed lamps must be JA8 certified. Recessed downlight luminaires in ceilings cannot have screw base lamp sockets.

11.7.2.7 Navigation Lighting – Night Lights, Step Lights, and Path Lights in Dwelling Units

Navigation lighting such as night lights, step lights, and path lights must either:

1. Be rated to consume no more than 4 watts; or
2. Comply with luminaire efficacy requirement in §160.5(a)1A and Table 160.5-A.

11.7.2.8 Lighting internal to Drawers, Cabinets, and Linen Closets

Luminaires or light sources internal to drawers, cabinets, and linen closets must either:

1. Have an efficacy of 45 lumens per watt or greater
2. Comply with luminaire efficacy requirements in §160.5(a)1A and Table 160.5-A.

Light sources in drawers and cabinets with opaque fronts or doors must also have controls that automatically turn the light off when the drawer or door is closed.

Example 11-37: Screw-based luminaires

Question

I am using a screw-based luminaire that is rated to take a 60W lamp for lighting over a sink, and I plan to install a 10W LED lamp. Does it meet the dwelling unit lighting requirement for screw-based luminaires?

Answer

If the LED lamp is JA8-certified and marked JA8-2022 or JA8-2022-E, then it meets the dwelling unit lighting requirement for screw-based luminaires in §160.5(a)1B and Table 160.5-A.

Example 11-38: Kitchen Exhaust Hood Lighting

Question

I am installing an exhaust hood over my kitchen range that has lamps in it. Do these lamps have to be high efficacy?

Answer

This lighting is integrated into the appliance and does not have to meet the dwelling unit luminaire efficacy requirements for permanently installed lighting.

11.7.2.9 Blank Electrical Boxes

The number of blank electrical boxes that are more than five feet above the finished floor and do not contain a luminaire or other device must be no greater than the total number of bedrooms in the dwelling unit. These electrical boxes must be served by a dimmer, vacancy sensor control, low voltage wiring, or fan speed control.

11.7.3 Dwelling Unit Lighting Control Requirements

As with the luminaire requirements described in the previous section, all dwelling unit lighting control requirements are mandatory.

11.7.3.1 Lighting Control Installation Requirements

Following are general requirements for how and where lighting controls must be implemented in multifamily dwelling units:

A. Readily Accessible Manual Controls

All permanently installed luminaires must have readily accessible wall-mounted controls that permit the luminaires to be manually turned on and off. Per §100.1 Definitions, readily accessible is capable of being reached quickly for operation, repair, or inspection without requiring climbing or removing obstacles, or resorting to access equipment

B. Multiple Switches

A lighting circuit can be controlled by more than one switch, such as by three-way or four-way switches. For a lighting circuit with multiple switches, and where a dimmer or vacancy sensor has been installed to comply with §160.5(a), the following requirements must be met:

1. No controls must bypass the dimmer or vacancy sensor function.
2. The dimmer or vacancy sensor must comply with the applicable requirements of §110.9(b).

C. Energy Management Control Systems (EMCS) and Multiscene Programmable Controllers

An EMCS or a multiscene programmable controller can be installed to meet the dimming, occupancy, and lighting control requirements in §160.5(a)2 if it provides the functionality of the specified controls in accordance with §110.9 and the physical controls specified in §160.5(a)2A.

D. Exhaust Fan Integrated Lighting

Integrated lighting in exhaust fans must be controlled independently from the fan.

E. Light Sources in Drawers and Cabinets

Undercabinet lighting, undershelf lighting, and interior lighting of display cabinets must be controlled separately from ceiling-installed lighting such that one can be turned on without turning on the other.

Drawers and cabinetry with internal lights and opaque fronts or doors must have controls that turn the lights off when the drawer or door is closed.

F. Independent Control of Other Lighting

Switched outlets must be controlled separately from ceiling-installed lighting such that one can be turned on without turning on the other.

G. Ceiling Fan Lighting

Ceiling fans with integrated light sources can be controlled with a remote control for on, off and dimming control. The remote control does not need to be wall mounted.

H. Spaces Required to Have Vacancy Sensors or Occupancy Sensors

The following dwelling unit spaces are required to have at least one installed luminaire in the space controlled by an occupancy or vacancy sensor:

- Bathrooms
- Garages
- Laundry Rooms
- Utility Rooms
- Walk-in Closets

I. Luminaires Required to Have Dimming Controls

Lighting in habitable spaces such as living rooms, dining rooms, kitchens, and bedrooms must have readily accessible wall-mounted dimming controls that allow the lighting to be manually adjusted up and down.

The exceptions are as follows:

- Ceiling fans may provide control of integrated lighting via a remote control.

- Luminaires connected to a circuit with controlled lighting power less than 20 watts or controlled by an occupancy or vacancy sensor providing automatic-off functionality.
- Navigation lighting such as night lights, step lights, and path lights less than 5 watts, and lighting internal to drawers and cabinetry with opaque fronts or doors with automatic off controls.

Also, lighting integral to appliances including kitchen range hoods and exhaust fans are not required to be provided with dimming controls.

Forward phase cut dimmers controlling LED light sources in these spaces must comply with NEMA SSL 7A. The combined use of a NEMA SSL-7A-compliant dimmer with LED luminaires can ensure flicker free operation when the luminaire is dimmed. This dimmer/light source compatibility information is included in dimmer cut sheets or dimmer product packaging.

Example 11-39: Using vacancy sensors and dimmers

Question

Can I install vacancy sensors and dimmers in hallways and non-walk-in closets even though the Energy Code does not require it?

Answer

Installing controls such as vacancy sensors and dimmers in hallways and closets is allowed.

A vacancy sensor automatically turns lighting off when a space is unoccupied. This can save energy compared to a manual on-off switch where the light may be left on while the space is unoccupied.

Using vacancy sensors is recommended for any application where they can provide additional energy savings for the homeowner or occupant.

A dimmer varies the intensity of the light to suit the occasion or the time of the day. When less light is needed, the homeowner can reduce the light intensity with a dimmer to save energy.

11.7.3.2 Lighting Control Functionality Requirements

All installed lighting control devices and systems must meet the functionality requirements in §110.9(b). In addition, all components of a lighting control system installed together must meet all applicable requirements for the application for which they are installed as required in §160.5 and §170.2(e).

Designers and installers should review features of their specified lighting control products for meeting the requirements of §110.9(b) as part of the compliance process.

A. Time-Switch Lighting Controls

Time-switch lighting control products must provide the functionality listed in §110.9(b)1 of the Energy Code.

B. Dimmers

Dimmer products must provide the functionality listed in §110.9(b)3 of the Energy Code.

Forward phase cut dimmers used with LED lighting must comply with NEMA SSL 7A, as mentioned earlier in this manual.

C. Occupant Sensing Controls

Occupant sensing control products (including occupant sensors, partial-ON occupant sensors, partial-OFF occupant sensors, motion sensors, and vacancy sensor controls) must provide the functionality listed in §110.9(b)4 of the Energy Code.

One important feature of occupant sensing controls is that it must automatically reduce lighting or turn the lighting off within 20 minutes after the area has been vacated.

Occupant sensing control systems may consist of a combination of single or multi-level occupant, motion, or vacancy sensor controls, if components installed for manual-on compliance don't allow occupants to change the functionality from manual-on to automatic-on.

D. Using Vacancy Sensors or Occupancy Sensors

Occupancy sensors automatically turn lights on when a space becomes occupied, and automatically turn lights off within 20 minutes of the room being vacated.

Vacancy sensors, also known as manual-on/automatic-off occupant sensors, require occupants to turn lights on manually, and automatically turn lights off within 20 minutes of the room being vacated.

Occupancy and vacancy sensors are required to provide the occupant with the ability to manually turn the lights on and off. The manual off feature provides the occupants with the flexibility to control the lighting environment by turning off the lights when they are not needed.

The Energy Code allows occupancy sensors or vacancy sensors to be installed to meet the automatic off control requirements.

Example 11-40: Bathroom vacancy sens–s--manual off

Question

For a bathroom with vacancy sensor, the lighting turns off automatically once the space is unoccupied. Is it necessary to provide a manual off control?

Answer

Vacancy and occupancy sensors must provide the occupant with the option to turn the lights off manually.

If an occupant forgets to turn the lights off when a room is unoccupied, the vacancy or occupancy sensor must turn the lights off automatically within 20 minutes. The occupant must also have the ability to turn the lights off upon leaving the room.

This provides occupants flexibility to control the lighting environment and can achieve greater energy savings, since the lights can be turned off when they are not needed.

Example 11-41: Use of automatic-shut off controls

Question

What type of automatic shut off control can be used in a bathroom, garage, laundry room, utility room, or walk-in closet?

Answer

Occupant or vacancy sensing controls that provide automatic off functionality must be installed to meet the dwelling unit lighting control requirements for bathrooms, garages, laundry rooms, utility rooms, and walk-in closets.

11.7.3.3 Outdoor Lighting Controlled from Dwelling Units

All outdoor lighting attached to the building and controlled from within the dwelling unit must be high luminous efficacy. Outdoor LED luminaires and LED light sources installed outdoors are automatically classified as high luminous efficacy and are not required to comply with JA8.

Outdoor lighting controlled from within the dwelling unit must be controlled by a manual ON and OFF control switch and one of the following automatic control types:

- Photocontrol and either a motion sensor or an automatic time switch control
- Astronomical time clock control

Any override to the above automatic controls to ON must return to automatic control operations within six hours.

11.7.4 Common Service Area Lighting

This section covers the requirements for multifamily indoor common service area lighting design and installation. The requirements for common service area lighting largely align with indoor lighting requirements for nonresidential buildings.

The Energy Code requires that total common service area lighting power is within a specified budget, and lighting controls are installed for the efficient operation of installed lighting. This ensures that energy efficient equipment is used to satisfy common use area lighting needs.

In addition to meeting all mandatory requirements, design teams can choose between prescriptive and performance approaches for compliance. These requirements and approaches are described in sections below.

Lighting systems in common use areas providing shared provisions for living, eating, cooking, or sanitation to dwelling units that would otherwise lack these provisions may instead comply with the requirements for dwelling units per §160.5(a) and detailed in Section 11.7.1.

11.7.4.1 Mandatory Requirements

§110.9, §160.5(b)

The following mandatory requirements must be met regardless of the compliance approach used.

Indoor common service area lighting mandatory requirements include:

- Requirements for luminaire classification (according to technology) and installed lighting power determination
- Required indoor lighting controls
- Lighting control acceptance testing
- Lighting control Certificates of Installation

The mandatory indoor lighting requirements for common service areas are analogous to corresponding nonresidential building mandatory indoor lighting requirements.

Refer to Section 5.3 for information on luminaire classification and power requirements.

Refer to Section 5.4 for information on mandatory lighting control requirements.

Refer to Section 5.9.2 and Section 5.11.7 for information on indoor lighting controls acceptance testing requirements.

Although not related exclusively to lighting, the Energy Code imposes mandatory requirements for electrical power distribution systems. See Section 11.9 for information about mandatory requirements for electrical power distribution systems.

11.7.4.2 Prescriptive Requirements

The prescriptive compliance approach establishes an adjusted lighting power for a proposed design as well as a maximum lighting power that can be installed based on the prescriptive method and the common use area space types. The process for calculating adjusted lighting power for multifamily indoor common use area lighting is closely aligned to the corresponding process for nonresidential buildings. Please refer to Section 5.6 for information on the prescriptive compliance approach for indoor lighting.

The differences between the prescriptive requirements for common use areas in multifamily buildings and nonresidential buildings include:

Common use areas may not use the complete building method for lighting power allowance calculations. Only the area category method or tailored method may be used per §170.2(e)3.

The primary function area types included in the lighting power density Tables 170.2-M, Table 170.2-N, and Table 170.2-O differ from the corresponding nonresidential primary function area types included in Table 140.6-C, Table 140.6-D, and Table 140.6-E respectively.

The primary function area types included in Table 170.2-M, Table 170.2-N, and Table 170.2-O are specific to multifamily common use areas and do not include nonresidential primary function area types.

Common use areas providing shared provisions for living, eating, cooking, or sanitation to dwelling units that would otherwise lack these provisions may instead comply with the requirements for dwelling units per §160.5(a) and detailed in Section 11.7.1.

11.7.4.3 Performance Requirements

The performance approach is applicable when the designer uses a compliance software program approved by the Energy Commission to demonstrate that the proposed build’ng's energy consumption (including common use area indoor lighting power) meets the energy budget. The performance approach uses the prescriptive approach lighting power allotment in calculating the building’s custom energy budget.

No additional lighting power allotment is gained by using the performance method unless it is traded from the space conditioning, mechanical ventilation, service water heating, envelope, or covered process systems.

The energy budget does not include the dwelling unit lighting mandatory requirements and cannot be traded off using the performance approach.

The performance approach for common service area lighting is analogous to the corresponding code section for nonresidential buildings as applied to multifamily common use areas. Please refer to Section 5.8.

11.7.5 Outdoor Lighting

This section covers the requirements for multifamily outdoor lighting systems and related lighting design and installation, luminaires, and lighting controls. In a mixed use building with a multifamily occupancy, the multifamily outdoor lighting requirements described in this section are to be used for the entire site.

For outdoor lighting controlled from within multifamily dwelling units please see Section 11.8.3.3.

11.7.5.1 Mandatory Requirements

§110.9 and §160.5(c)

The mandatory outdoor lighting requirements for multifamily buildings largely align with mandatory outdoor lighting requirements for nonresidential buildings.

A. Luminaire Shielding Requirements

§160.5(c)1

Refer to Section 6.4.1 for information on luminaire shielding requirements.

11.7.5.2 Outdoor Lighting Controls Requirements

§160.5(c)2

Refer to Section 6.4.2 for information on outdoor lighting controls requirements.

11.7.5.3 Outdoor Lighting Controls Acceptance Testing Requirements

§160.5(e)

Refer to Section 6.7.5 and Section 6.7.6 for information on outdoor lighting controls acceptance testing requirements.

11.7.5.4 Prescriptive Requirements

§170.2(e)

An outdoor lighting installation complies with the Energy Code if the actual outdoor lighting power is no greater than the allowed outdoor lighting power.

The process for determining actual lighting power for multifamily outdoor lighting applications is consistent with the requirements for nonresidential lighting, as described in Section 6.5.1.

Allowed outdoor lighting power densities for multifamily buildings are structured using a layered approach. The first layer of allowed lighting power is general hardscape for the entire site. After the allowed lighting power has been determined for this first layer, additional layers of lighting power are allowed for specific applications when they occur on the site. The total allowed lighting power is the combined total of the allowed lighting power layers.

The allowed outdoor lighting power must be determined according to the outdoor lighting zone in which the site is located as defined in §10-114. Outdoor Lighting Zone definitions for multifamily lighting are analogous to the corresponding code section for nonresidential buildings. Please refer to Section 6.3 for information on outdoor lighting zones.

Figure 11-76. Concept of a Layered Lighting Approach for Outdoor Lighti–g - Lighting Power Allowance (LPA)

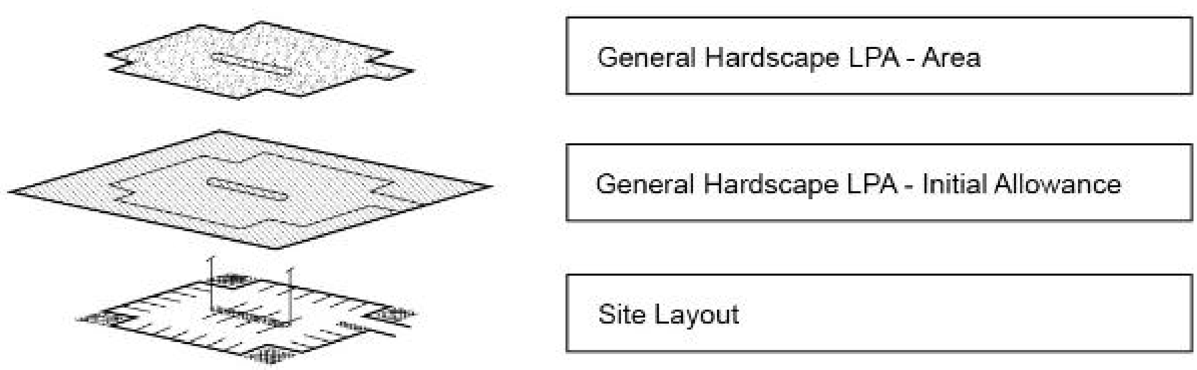


Image Source: Energy Solutions

The outdoor lighting applications addressed by the Energy Code are shown in the first two columns of Table 11-64. The first column is general site illumination applications, which allow trade-offs within the outdoor portion only. The second column is specific outdoor lighting applications, which do not allow trade-offs, and are considered "*use it or lose it"*. The lighting applications in the third column are exempt from lighting power requirements. However, these lighting applications must meet applicable lighting control requirements.

For the purpose of determining outdoor lighting allowances, only those areas where lighting is provided are considered *illuminated areas*, excluding any areas that do not have luminaires, areas that are obstructed by any other structure or within a building, and any areas beyond the property line of the project site. The details of the process for determining the illuminated area for multifamily outdoor lighting are consistent with the requirements for nonresidential outdoor lighting, as described in Section 6.5.

Hardscape is defined in §100.1 as an improvement to a site that is paved and has other structural features, including but not limited to, curbs, plazas, entries, parking lots, site roadways, driveways, walkways, sidewalks, bikeways, water features and pools, storage or service yards, loading docks, amphitheaters, outdoor sales lots, and private monuments and statuary. This definition is also consistent with the nonresidential outdoor lighting Standards, as described in more detail in Section 6.5.2.

Table 11-64: Scope of the Multifamily Outdoor Lighting Requirement

General Hardscape (trade-offs permitted)	Specific Applications (trade-offs not permitted)	Lighting Applications Not Regulated
The general hardscape area of a site must include parking lot(s), roadway(s), driveway(s), sidewalk(s), walkway(s), bikeway(s), plaza(s), bridge(s), tunnel(s), and other improved area(s) that are illuminated.	• Building Entrances or Exits • Primary Entrances for Senior Care Facilities • ATM Machine Lighting • Hardscape Ornamental Lighting • Building Facades • Canopies • Tunnels • Student Pick-u/.Drop-off zone • Outdoor Dining • Special Security Lighting for Retail Parking and Pedestrian Hardscape • Security Cameras	• Temporary outdoor lighting • Required and regulated by FAA • Required and regulated by the Coast Guard. • For public streets, roadways, highways, and traffic signage lighting, and occurring in the public right-of-way • For sports and athletic fields, and children's playground • For public monuments • Signs regulated by §160.5(d) and §170.2(e)7 • For stairs and wheelchair elevator lifts • For ramps that are not parking garage ramps • Landscape lighting • For outdoor theatrical and other outdoor live performances • For qualified historic buildings

Source: California Energy Commission

11.7.5.5

Other outdoor lighting applications that are not included in Energy Code Tables 170.2-R and 170.2-S are assumed to be not regulated by the Energy Code. This includes decorative gas lighting and emergency lighting powered by an emergency source as defined by the California Electrical Code. The text in the above list of multifamily outdoor lighting applications that are not regulated has been shortened for brevity. Please see the section, §170.2(e)6A for details about unregulated lighting applications.

11.7.5.6 Trade-offs

§170.2(e)6B

All outdoor lighting trade-off requirements are analogous to the corresponding code sections for nonresidential buildings as applied to multifamily outdoor lighting. Please refer to Sections 6.5.3-A and 6.5.3-B.

11.7.5.7 Outdoor Lighting Applications Not Regulated by §170.2(e)6

When a luminaire is installed only to illuminate one or more of the applications listed in the rightmost column of Table 11-65, the lighting power for that luminaire must be exempt from §170.2(e)6. The Standards clarify that at least 50% of the light from the luminaire must fall within the unregulated lighting application to qualify as being installed for that application.

Even if the lighting is exempted from the wattage allowance requirements, it is still subject to the lighting controls requirements that may apply to the respective lighting systems.

11.7.5.8 General Hardscape Lighting Allowance

Determine the general hardscape lighting power allowances as follows:

General Hardscape lighting allowance = (Hardscape Area x AWA) + IWA

Where,

1. The general hardscape area of a site must include parking lot(s), roadway(s), driveway(s), sidewalk(s), walkway(s), bikeway(s), plaza(s), bridge(s), tunnel(s), and other improved area(s) that are illuminated, as defined in §100.1. The illuminated hardscape area must include portions of planters and landscaped areas that are within the lighting application and are less than or equal to 10 ft. wide in the short dimensions and are enclosed by hardscape or other improvement on at least three sides.
2. Multiply the illuminated hardscape area by the Area Wattage Allowance (AWA) from Table 11-65 (Table 170.2-R) for the appropriate lighting zone.
3. Determine the Initial Wattage Allowance (IWA). The purpose of the IWA is to provide additional watts for small sites, or for odd hardscape geometries. Add the IWA for general hardscape lighting from Table 11-65 (Table 170.2-R) for the appropriate lighting zone. The IWA may only be used one time per site.

Table 11-65 (from Table 170.2-R): General Hardscape Lighting Power Allowance

Type of Power Allowance	Lighting Zone 0[2]	Lighting Zone 1[2]	Lighting Zone 2[2]	Lighting Zone 3[2]	Lighting Zone 4[2]
Area	No	0.026	0.030	0.038	0.055
Initial	No	300 W	350 W	400 W	450 W

Footnotes to Table:

1 Continuous lighting is explicitly prohibited in Lighting Zone 0. A single luminaire of 15 Watts or less may be installed at an entrance to a parking area, trail head, fee payment kiosk, outhouse, or toilet facility, as required to provide safe navigation of the site infrastructure. Luminaires installed must meet the maximum zonal lumen limits as specified in Section 160.5(c)

46 2 Narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm – as mandated by local, state, or federal agencies to minimize the impact on local, active professional astronomy or nocturnal habitat of specific local fauna – must be allowed a 2.0 lighting power allowance multiplier.

Source: Table 170.2-R from the Standards

Example 11-42: Power Allowance for a Parking Lot

Question

In a parking lot in front of a multifamily building, we are not using the full lighting power allowed according to Table 170.2-R. Can we use the remaining allowance to illuminate the building entrance and the walkways near the store to a higher level?

Answer

Yes. Because general hardscape power allowances are tradable, you may use the unused portion of the power allowance for the parking lot to increase the illumination levels for other lighting applications, including building entrance and walkway areas.

Example 11-43: Calculating the Power Allowance for a Parking Lot

Question

The parking lot illustrated below has two luminaires that are mounted at a height of 25 ft. What is the illuminated hardscape area and what is the general hardscape lighting power allowance? The lot is in Lighting Zone 3.

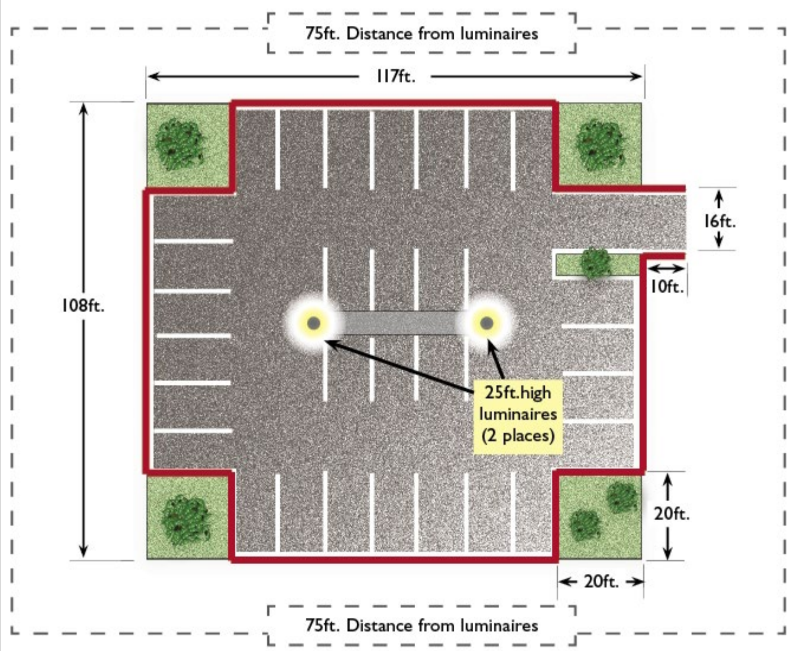


Image: California Energy Commission

Answer

The poles are 40 ft. apart, and using the 10 times mounting height rule, the illuminated area can be as large as 250 ft. by 290 ft. The boundary of this illuminated area extends beyond the edges of the parking lot as well as the entrance driveway, so the entire paved area is considered illuminated. The landscaped island in middle and peninsula below the entrance driveway are less than 10 ft. wide, so they are included as part of the illuminated area. The landscaped cutouts (20 x 20 ft.) in the corners of the parking lot are bound by pavement on only two sides so they are not included. The total paved area is 11,196 sq. ft. [(12,636 sq. ft. + 160 sq. ft. (driveway) – 1,600 sq. ft (cutouts)].

Two allowances make up the general hardscape allowance: Area and Initial. All allowances are based on a Lighting Zone 3 and found in (Table 170.2-R of the Standards).

The area wattage allowance is equal to 425.4 W.

The initial wattage allowance (IWA) is 400 W for the entire site.

The sum of these two allowances gives a total wattage allowance for the site of 825.4 W.

The calculations are tabulated below.

Type of Allowance	Allowance	Area/Perimeter Value	Power Allowance
Initial	400 W	-	400 W
Area	0.038 W/sq. ft.	11,196 sq. ft.	425.4 W
-	-	**Total Power Allowance:**	**825.4 W**

Source: California Energy Commission

The Standards includes a lighting power provision for narrow band spectrum light source application to minimize the impact of electric light on local, active professional astronomy or nocturnal habitat of specific local fauna. The provision is in the format of lighting power multiplier as specified on the footnote of Table 170.2-R (footnote 2). This provision is consistent with the requirement for narrow band spectrum light sources in nonresidential outdoor lighting.

11.7.5.9 Additional Lighting Power Allowances and Requirements

§170.2(e)6Dii

The lighting power allowances for specific applications provide additional lighting power that can be layered in addition to the general hardscape lighting power allowances, as applicable. Some portions of the site may fit use categories that permit the inclusion of an additional lighting allowance for that portion of the site. These specific applications are detailed in Table 11-66 (Table 170.2-S of the Energy Code). Additional allowances for specific applications can be per application, per hardscape area, per specific application unit length, or per specific application area.

As noted previously, all these additional allowances are *use it or lose it* allowances and cannot be traded between applications or to general hardscape lighting. However, general hardscape lighting allowance may be traded to supplement these specific applications.

Table 11-66 (from Table 170.2-S): Additional Lighting Power Allowance for Specific Applications

Lighting Application **WATTAGE ALLOWANCE PER APPLICATION. Use all that apply as appropriate.**	**Lighting Zone 0**	**Lighting Zone 1**	**Lighting Zone 2**	**Lighting Zone 3**	**Lighting Zone 4**
Building Entrances or Exits. Allowance per door. Luminaires must be within 20 ft. of the door.	Not applicable	9 watts	15 watts	19 watts	21 watts
Primary Entrances to Senior Care Facilities Allowance per primary entrance(s) only. Primary entrances are entrances that provide access for the general public. This allowance is in addition to the building entrance or exit allowance above. Luminaires must be within 100 ft. of the primary entrance.	Not applicable	20 watts	40 watts	57 watts	60 watts
ATM Machine Lighting. Allowance per ATM machine. Luminaires must be within 50 ft. of the dispenser.	Not applicable	100 watts for first ATM machine, 35 watts for each additional	100 watts for first ATM machine, 35 watts for each additional	100 watts for first ATM machine, 35 watts for each additional	100 watts for first ATM machine, 35 watts for each additional

Lighting Application **WATTAGE ALLOWANCE PER APPLICATION. Use all that apply as appropriate.**	**Lighting Zone 0**	**Lighting Zone 1**	**Lighting Zone 2**	**Lighting Zone 3**	**Lighting Zone 4**
		ATM machine.	ATM machine.	ATM machine.	ATM machine.
Lighting Application WATTAGE ALLOWANCE PER HARDSCAPE AREA (W/sq. ft.). May be used for any illuminated hardscape area on the site.	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Hardscape Ornamental Lighting. Allowance for the total site illuminated hardscape area. Luminaires must be rated for 100 watts or less and be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	Not applicable	No Allowance	0.007 W/sq. ft.	0.013 W/sq. ft.	0.019 W/sq. ft.
Lighting Application WATTAGE ALLOWANCE PER SPECIFIC AREA (W/sq. ft.). May be used as appropriate provided that only one is used for a given area (i.e., provided that two allowances are not applied to the same area).	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Building Facades. Only areas of building façade that are illuminated must qualify for this allowance. Luminaires qualifying for this allowance must be aimed at the façade and must be capable of illuminating it without obstruction or interference by permanent building features or other objects. This allowance calculation must not include portions of the building facades within 20 ft. of residence bedroom windows.	Not applicable	No Allowance	0.100 W/sq. ft.	0.170 W/sq. ft.	0.225 W/sq. ft.
Canopies and Tunnels. Allowance for the total area within the drip line of the canopy or inside the tunnel. Luminaires must be located under the canopy or tunnel.	Not applicable	0.057 W/sq. ft.	0.137 W/sq. ft.	0.270 W/sq. ft.	0.370 W/sq. ft.
Outdoor Dining. Allowance for the total illuminated hardscape of outdoor dining. Outdoor dining areas are hardscape areas used to serve and consume food and beverages. Qualifying luminaires must be within 2 mounting heights of the hardscape area of outdoor dining.	Not applicable	0.004 W/sq. ft.	0.030 W/sq. ft.	0.050 W/sq. ft.	0.075 W/sq. ft.

Lighting Application **WATTAGE ALLOWANCE PER APPLICATION. Use all that apply as appropriate.**	**Lighting Zone 0**	**Lighting Zone 1**	**Lighting Zone 2**	**Lighting Zone 3**	**Lighting Zone 4**
Special Security Lighting for Retail Parking and Pedestrian Hardscape. This additional allowance is for illuminated retail parking and pedestrian hardscape identified as having special security needs. This allowance must be in addition to the building entrance or exit allowance.	Not applicable	0.004 W/sq. ft.	0.005 W/ft²	0.010 W/ft²	No Allowance
Security Camera. This additional allowance is for the illuminated general hardscape area. This allowance must apply when a security camera is installed within 2 mounting heights of the general hardscape area and mounted more than 10 ft. away from a building.	Not applicable	No Allowance	0.018 W/ft²	0.018 W/ft²	0.018 W/ft²

Source: California Energy Commission

Most of these allowances are comparable to the same allowance in the nonresidential portions of the code. See section 6.5.3 for more details. The one category of allowance that differs is buildifaçadeade lighting.

façadeng facade lighting is permitted in a similar manner as the nonresidential sections of the code, however, multifamily buildings have a specific stipfaçaden to the facade lighting allowance that the allowance is not permitted to be counfaçader areas of the facade that are within 20 feet of a bedroom window. This means thafaçadeions of the buifaçadefacade will either have no facade lighting or the allowance will be smaller because of the excluded area for the allowance.

See Section 6.5.4-Afaçade detailed discussion of building facade lighting.

Example 11-44: Power Allowance for Multifamily BuifaçadeFacades

Question

Portions of the front facade of a proposed multifamily building in Lighting Zone 3 are going to be illuminated. The front wall dimensions are 80 ft. wide by 50 ft. tall. There is a column of 6 ft. wide bedroomfaçadews, aligned vfaçadelly, in the centerfaçadee facade. All areas of the facafaçadel be illuminated by facade lighting, except those areas of the facade near bedroom windows that are excluded from the facade lighting allowance. What is the allowed front facade lighting power?

Answer

The gross wall area is 4,000 sq. ft. (80 x 50). However, we must subtract all those areas that are within 20 ft. of a bedroom window.

The areas not eligible for power calculations include the 6 ft. width of the column of bedroom windows, plus 20 ft. of width on either side of the windows, or a total of 46 ft. of width:

46 ft. of width on or near bedroom windows x 50 ft. facade height = 2,300 sq. ft.

The net wall area used to determine facade lighting allowance: 4,000 sq. ft. – 2,300 sq. ft. = 1,700 sq. ft.

From Table 11-67 (Table 170.2-S of the Standards), the allowed facade lighting power density in Lighting Zone 3 is 0.17 W/ sq. ft.

The calculated allowed power based on net wall area is 1,700 sq. ft. x 0.17 W/ sq. ft. = 289 W.

The allowed power is therefore the smaller of actual wattage used for facade lighting or 289 W.

11.7.6 Additions and Alterations

Additions to dwelling units must meet all applicable mandatory dwelling unit lighting requirements as described in Section 11.8.2. For alterations to dwelling units, any existing lighting may stay in place, but all newly installed lighting must meet the mandatory dwelling unit lighting requirements.

For details on lighting requirements for additions and alterations to multifamily common use areas, please refer to Section 5.10.

For details on lighting requirements for additions and alterations to multifamily outdoor areas, please refer to Section 6.6.

11.7.7 Code in Practice

11.7.7.1 CASE Example 1: A Garden Style Multifamily Building

This case example considers a new two-story garden style multifamily building in Burbank, California (Climate Zone (CZ) 9) . This is a sample project created for training purposes, and it consists of 7,216 ft² of conditioned floor area with eight dwelling units and no common use areas. The tables below provide details about the proposed lighting design and the possible compliance options for meeting the Energy Code which includes mandatory and prescriptive requirements for indoor and lighting outdoor lighting.

Note that the mandatory requirements in §160.5(a) govern the lighting installed inside the dwelling units and the outdoor lighting that is controlled from within the dwelling units.

On the other hand, outdoor lighting for the overall building site must meet prescriptive wattage allowances in §170.2(e)6 plus mandatory lighting controls and acceptance testing requirements in §160.5(c) and (e).

The outdoor lighting for the overall site must also meet the prescriptive wattage allowance. The outdoor lighting for the overall building site consists of two pole lights at 35 watts each for a total of 70 watts. Since the prescriptively allowed hardscape lighting for the site is 386 watts, the site lighting complies with the Energy Code.

The figure below shows the outdoor lighting on the site as well as the lighting at the entry to the dwelling unit.

Figure 77: Garden Style Multifamily CASE Example: Outdoor Luminaires located on site (left); Dwelling Unit Entry Light and the entry switch on/off switch located inside the unit (right)

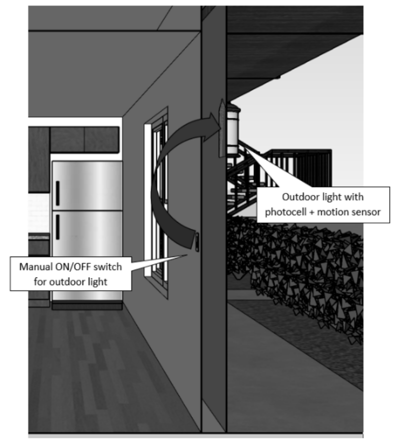


Image: IOU CASE Team

The table below provides an overview of the compliance to the mandatory and prescriptive requirements for this case study.

Table 11-67: Lighting of Garden Style Multifamily Building (Case Example 1)

Item: Dwelling Unit Lighting	Proposed Design	Applicable Mandatory Requirements	Applicable Prescriptive Requirements	Compliance Option
Luminaires (light fixtures)	All rooms: JA8 dimmable LED fixtures All fixtures are controlled by on/off switch plus dimmers.	§160.5(a)1 and 2.	Prescriptive: None	1.The proposed luminaires meet the efficacy requirements of Table 160.5-A. 2.Besides the efficacy requirements, there could be applicable luminaire related requirements depending on the luminaire types (screw based luminaires, recessed luminaires, and enclosed luminaires).
Bathroom Lighting	Bathrooms: Light in exhaust fan unit controlled with vacancy sensor	§160.5(a)1 and 2E.	Prescriptive: None	1.The proposed design meet the requirement of §160.5(a)2E. 2.The code requires at least one bathroom luminaire must be controlled by an occupancy sensor or vacancy sensor with automatic-off functionality. If there is a second luminaire installed in the bathroom, it is optional for the luminaire to meet
Entry Door Lighting outside the unit	One 25 watt LED light installed by the entry door to each residence unit, motion sensor and photocontrol plus on/off switch controlled from inside each dwelling unit.	1. Luminaire efficacy per Table 160.5-A. 2.§160.5(a)3A requires manual on/off combined with photocell plus motion sensor or auto time switch OR astronomical time clock.	Prescriptive: None	1.The proposed luminaire meets the efficacy requirements of Table 160.5-A. 2.The proposed photocontrol plus on/off switch and motion sensor control meet the requirements of §160.5(a)3A.

Table 11-68: Outdoor Lighting of Garden Style Multifamily Building (Case Example1 1)

Outdoor Lighting System	Proposed Design	Applicable Mandatory Requirements	Applicable Prescriptive Requirements	Compliance Approach/option
Outdoor Lighting Zone (LZ)	LZ2	LZ2 per Table 10-114-A for all multifamily project locations	Prescriptive: None	N/A
Outdoor Luminaires (fixtures)	Two 16 ft high light poles with one 35 watt, 90 lumen lamp per fixture.	Backlight, Uplight, and Glare (BUG) Shielding if ≥ 6,200 initial lumens. Lighting Controls: - Daylight Availability, - Motion Sensors if > 40 watts/fixture and within 24 ft of ground, - Automatic Scheduling	Hardscape area: 1,200 ft² General hardscape lighting allowance = 0.03 W/ft² x 1,200 ft² = 36 W Initial lighting Allowance = 350 W Total Allowance: 36 W + 350 W = 386 W	1.The luminaire BUG requirements do not apply to this lighting design as the luminaires are below the code trigger threshold on initial lumens. 2.The proposed outdoor lighting power is below the maximum allowed lighting power. Therefore, the proposed outdoor luminaires meet the code requirements.
Outdoor Lighting Controls	The light poles are controlled by programmable astronomical time clock. The entire site of 1,200 ft² hardscape including the outdoor lighting is operated by a property	Lighting Controls: - Daylight Availability, - Motion Sensors if > 40 watts/fixture and within 24 ft of ground, - Automatic Scheduling	Prescriptive: None	The motion sensors requirements do not apply to this lighting design as the luminaire rated wattage (35W) is below the code trigger threshold (40W). The proposed programmable astronomical time clock meets the

Outdoor Lighting System	Proposed Design	Applicable Mandatory Requirements	Applicable Prescriptive Requirements	Compliance Approach/option
	management firm.			daylight availability requirement and automatic scheduling requirement.
Verifications:	Outdoor lighting will have ATT verification for astronomical time clocks	Mandatory ATT for site lighting controls	Prescriptive: N/A	Outdoor lighting controls acceptance test is required.

Source: California Energy Commission

11.7.7.2 Case Example 2: A Five-story Mid-Rise Multifamily Building

This Mid-Rise Multifamily Case Study covers a new five-story multifamily building in Sacramento, California (Climate Zone (CZ) 12). This is a sample project created for training purposes, and it includes 112,044 ft² of conditioned floor area with 88 dwelling units, shared residential corridors, laundry rooms, fitness center and lounge, plus ground floor retail. The tables below provide details about the proposed lighting design and the possible compliance options for meeting the Energy Code which includes mandatory and prescriptive requirements for indoor and lighting outdoor lighting.

Table 11-69: Building Information about the Mid-rise Multifamily Building in CASE Example 2

General Information and Total Conditioned Floor Area	Applicable Lighting Code Requirements (mandatory)	Applicable Lighting Code Requirements (Prescriptive)
New five-story mid-rise multifamily building, 88 dwelling units, common use areas, ground floor retail, Sacramento, CA. Conditioned Floor Area (CFA) as follows:	§160.5(c) for outdoor lighting of the multifamily building site. §160.5(e) for sign lighting (indoor and outdoor).	§170.2(e)6: Outdoor lighting for overall site, new multifamily building ≥ four stories, Climate Zone (CZ) 12. §170.2(e)7 for sign lighting.
Dwelling Units: 78,384 ft²	§160.5(a)	None.
Multifamily Common Service Areas: 17,487 ft²	§160.5(b)	§170.2(e)1 thru 4.

General Information and Total Conditioned Floor Area	Applicable Lighting Code Requirements (mandatory)	Applicable Lighting Code Requirements (Prescriptive)
Nonresidential: 16,173 ft²	Requirements for lighting in nonresidential spaces in mixed use buildings are covered by nonresidential lighting requirements. (Refer to Chapter 5.)	Requirements for lighting in nonresidential spaces in mixed use buildings are covered by nonresidential lighting requirements. (Refer to Chapter 5.)
Total: 112,044 ft²	(blank space)	(blank space)

Source: California Energy Commission

Figure 78: Dwelling Unit Balcony Light for Case Example 2: Sideview of the Balcony Light with On/Off Switch Controls (left); Plan view of the Balcony Light On/Off Switch (right)

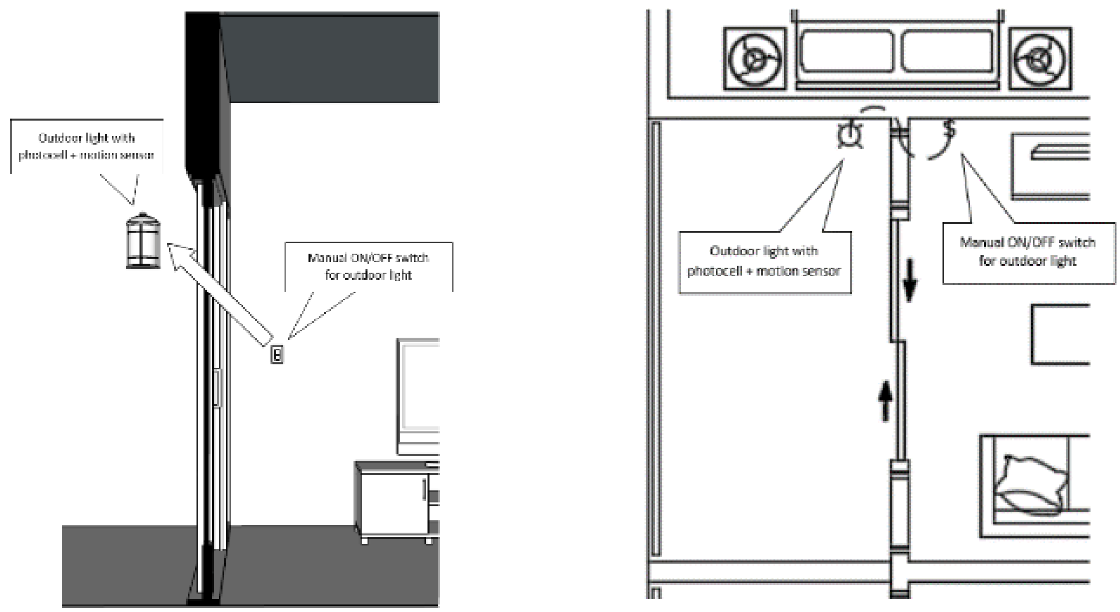


Table 11-70: Dwelling Unit Lighting for CASE Example 2

Outdoor Lighting System	Proposed Design	Applicable Mandatory Requirements	Applicable Prescriptive Requirements	Compliance Option
Dwelling Units: Indoor Lighting	All rooms: JA8 dimmable LED fixtures with on/off switch plus dimmers,	§160.5(a)1 and 2.	Dwelling Units: Indoor Lighting	All rooms: JA8 dimmable LED fixtures with on/off switch plus dimmers,
Dwelling Units: Outdoor Lighting	One 25 watt LED light installed next to the sliding glass door between the balcony and conditioned space for dwelling units with balconies on 3rd and 5th floors, occupancy sensor and photocontrol plus on/off switch controlled from inside each dwelling unit, Installed per §160.5(a)1 and 3	Luminaire Efficacy per Table 160.5-A,		Dwelling Units: Outdoor Lighting

Source: California Energy Commission

Table 11-71: Multifamily Common Service Area and Retail Indoor Lighting for CASE Example 2

Outdoor Lighting System	Proposed Design	Applicable Mandatory Requirements	Applicable Prescriptive Requirements	Compliance Option
MF Common Service Area: Indoor Lighting	Common service areas designed to meet prescriptive wattage allowances and mandatory controls	§160.5(b): Lighting Controls: - Manual On/Off - Multi-level - Automatic Shut Off - Automatic Daylighting -Demand Responsive Controls	Meet allowed wattage requirements of §170.2(e) for each space type	Mandatory: Yes Prescriptive: Yes
Retail: Indoor Lighting	Indoor lighting for retail spaces to comply with Prescriptive wattage allowances and Mandatory controls as tenant improvements on occupancy	§130.1: Lighting Controls: - Manual On/Off - Multi-level - Automatic Shut Off - Automatic Daylighting -Demand Responsive Controls	Meet allowed wattage requirements of §140.6 for each space type	Mandatory and Prescriptive compliance to be shown as tenant improvements under separate permit
Verifications:	Common service area lighting, retail indoor lighting will have ATT verification for lighting controls	Mandatory ATT for lighting controls	N/A	Mandatory: Yes Prescriptive: N/A

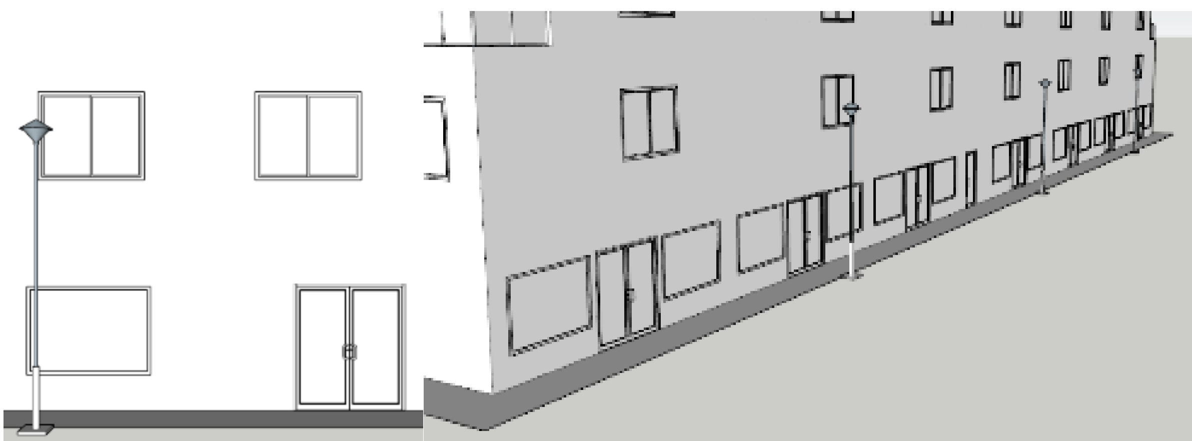
Source: California Energy Commission

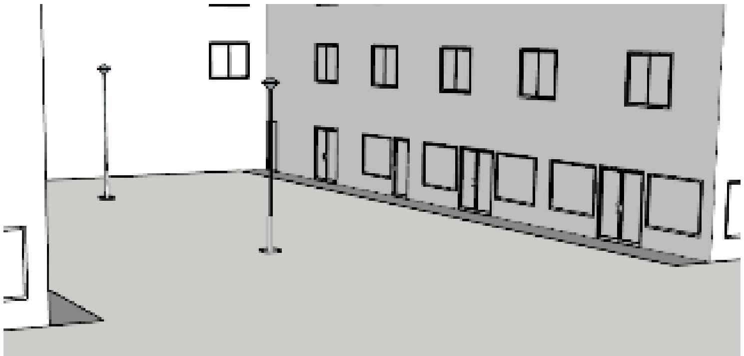
Table 11-72: Outdoor Lighting for CASE Example 2 – Proposed Design and Compliance Option

Outdoor Lighting System	Proposed Design	Applicable Mandatory Requirements	Applicable Prescriptive Requirements	Compliance Option
Site: Outdoor Lighting Zone (LZ)	LZ2	LZ2 per Table 10-114-A for all multifamily project locations	None.	
Site: Outdoor Lighting	Controlled by management and serves entire site, 7,274 ft² hardscape,	Site: Outdoor Lighting	Controlled by management and serves entire site, 7,274 ft² hardscape,	Site: Outdoor Lighting
Verifications:	Site lighting will have ATT verification for programmable astronomical time clock	Mandatory ATT for lighting controls	N/A	Mandatory: Yes

Source: California Energy Commission

Figure 79: Outdoor Lighting for CASE Example 2: Sideview of an Outdoor Luminaire at the Multifamily Building Site (top left); Outdoor Luminaires for Walkway Lighting (top right); Outdoor Luminaires for Courtyard Lighting (bottom)





This mixed use mid-rise building has separate indoor lighting requirements for the dwelling units compared to the multifamily common service areas and nonresidential retail spaces, and it also has different requirements for the outdoor lighting for the dwelling unit balconies versus the outdoor lighting for the building overall.

The lighting installed inside the dwelling units and the outdoor lighting that is controlled from within the dwelling units must comply with luminaire efficacy and mandatory lighting control requirements.

All of the proposed dwelling unit lighting has been designed to meet applicable mandatory requirements, so all the indoor and outdoor dwelling unit lighting complies with the Energy Code without any other requirements.

The outdoor lighting for the overall building site needs to comply with mandatory outdoor lighting controls, acceptance testing, and prescriptive outdoor requirements, and must also meet the prescriptive outdoor lighting power allowance requirements. The site lighting consists of nine pole lights at 35 watts each for a total of 315 watts. The prescriptively allowed hardscape lighting power allowance for the site is 568 watts, so the site lighting complies with the Energy Code.

Indoor lighting for the multifamily common service areas and nonresidential retail spaces must comply with mandatory indoor lighting control, acceptance testing, and prescriptive indoor lighting power allowance requirements. The prescriptive lighting power allowances for multifamily common service areas versus nonresidential retail spaces are very similar, but they are found in different sections of the Energy Code.

One common situation for retail spaces in buildings like this is that the lighting is not fully permitted or installed until new tenants move in.

11.8 Electrical Power Distribution

This section describes the Title 24, Part 6, Building Energy Efficiency Standards (California Energy Code or the Energy Code) requirements in §160.6 for energy efficiency features used for electrical power distribution systems in multifamily buildings. The requirements are mandatory and, therefore, are not included in the energy budget for the performance approach. The requirements of §160.6 apply to all newly constructed buildings and additions.

11.8.1 What's New for the 2022 Energy Code

There have been no significant changes for electrical power distribution systems in the 2022 update to the Energy Code.

11.8.2 Service Electrical Metering Requirements

§160.6(a)

All service electrical metering requirements are analogous to the corresponding code section for nonresidential buildings as applied to multifamily buildings. Please refer to Section 8.2 for a detailed discussion of the code language that applies to this section.

11.8.3 Separation of Electrical Circuits for Electrical Energy Monitoring

§160.6(b)

All separation of electrical circuits requirements are analogous to the corresponding code section for nonresidential buildings as applied to multifamily buildings. Please refer to Section 8.3 for a detailed discussion of the code language that applies to this section.

The separation of load is not required for the electrical distribution system that provides power to the dwelling units and has a separate meter for each unit.

11.8.4 Voltage Drop Requirements

§160.6(c)

All voltage drop requirements are analogous to the corresponding code section for nonresidential buildings as applied to multifamily buildings. Please refer to Section 8.4 for a detailed discussion of the code language that applies to this section.

11.8.5 Circuit Controls and Controlled Receptacles for 120-Volt Receptacles

§160.6(d)

All circuit controls and controlled receptacle requirements are analogous to the corresponding code section for nonresidential buildings as applied to multifamily buildings with the added clarification that this section applies to common use areas.

Receptacles in common use areas providing shared provisions for living, eating, cooking, or sanitation to dwelling units that would otherwise lack these provisions are exempt from the controlled receptacle requirements.

Dwelling units are exempt from these requirements. Please refer to Section 8.5 for a detailed discussion of the code language that applies to this section.

11.8.5.1 Demand Response

§160.6(e), §110.12(a)

All demand response requirements are analogous to the corresponding code section for nonresidential buildings as applied to multifamily buildings. Please refer to Appendix D for guidance on demand response for multifamily buildings.

11.8.6 Equipment Requirements – Electrical Power Distribution Systems

§110.11

All electrical power distribution system requirements are analogous to the corresponding code section for nonresidential buildings as applied to multifamily buildings. Please refer to Section 8.7 for a detailed discussion of the code language that applies to the selection of transformers for the building.

11.8.7 Additions and Alterations

§180.0

All additions and alterations requirements are analogous to the corresponding code section for nonresidential buildings as applied to multifamily buildings. Please refer to Section 8.6 for a detailed discussion of the code language that applies to this section.

11.9 Photovoltaic, Community Shared Solar, Battery Storage, and Solar Ready Buildings

This section describes the compliance requirements for solar photovoltaic (PV) systems, solar readiness, battery storage systems, and community-shared solar electric generation and/or storage systems for newly constructed multifamily buildings. For information about solar water heating system, please see Section 6.

Table 11-73 provides an overview of the location of the multifamily PV and battery storage requirements in the 2022 Energy Code and where descriptions reside in this document.

Table 11-73: Overview of Multifamily PV and Battery Requirements

	Mandatory Energy Code	Prescriptive Energy Code	Performance Energy Code	Compliance Manual Section
Solar PV	N/A	§170.2(f), §170.2(g), JA11	§170.1(b), JA11	11.9.2
Solar Ready	§160.8(a), §110.10	N/A	N/A	Chapter 9
Battery Storage	N/A	§170.2(h), JA12 (four or more habitable stories only)	§170.1(b), JA12	11.9.4
Community-shared Solar	N/A	N/A	§170.1(b), §10-115	11.9.5

Source: California Energy Commission

11.9.1 What's New for the 2022 Energy Code

The PV and battery storage installation are new prescriptive requirements in 2022 Energy Code for newly constructed multifamily buildings with four or more habitable stories. The prescriptive PV requirement sets the standard design budget for the performance approach. A definition for solar access roof area (SARA) was added to define the PV sizing requirement for multifamily buildings based on available unshaded roof area. As a result of the new definition of SARA and changes in Exception 1 to §170.2(f), previous exceptions were removed, and new exceptions added. There is a new exception for multifamily buildings unable to comply with ASCE Snow Load requirements with the addition of solar panels and other mounting equipment. For multifamily buildings with four or more habitable stories, an exception based on availability of virtual net energy metering or community shared solar is added to avoid the added costs of direct wiring to individual tenant spaces.

Changes to community solar requirements include clarification of additionality requirements, opt-out requirements, and a new section for maximum size for community scale system. There is also a new annual reporting requirement and a public review process for local adoption of public agencies administering community shared solar PV and/or battery storage system.

11.9.2 Photovoltaic System

This section describes the prescriptive PV requirements for multifamily buildings, performance approach compliance and the Joint Appendix 11 requirements for orientation, shading, solar access verification, remote monitoring capability and interconnection requirements.

11.9.2.1 Prescriptive Requirements

§170.2(f), 170.2(g)

Solar PV sizing, installation, and enforcement requirements vary for buildings of up to three habitable stories and four or more habitable stories. JA11 requirements apply to all multifamily buildings.

The prescriptive PV size is calculated using either 1) an equation based on conditioned floor area or 2) solar access roof area (SARA).

SARA includes any roof space on newly constructed buildings, including covered parking areas and carports that can support a PV system per Title 24 Part 2 Section 1511.2, and has 70 percent or greater annual solar access. It does not include occupied roof areas as specified by CBC Section 503.1.4. SARA does not include roof area that is otherwise required to comply with other building code requirements if confirmed by the Executive Director.

Annual Solar Access is calculated by dividing the total annual solar insolation accounting for shading obstructions by the total annual solar insolation if the same areas were unshaded by obstructions. Annual solar access is determined by a qualified solar assessment tool meeting JA11.4 requirements, explained further in the Solar Access Verification section below.

$$\text{Solar Acccess} = \frac{\text{Solar Insolation including Shading}}{\text{Solar Insolation without Shading}}$$

Shading obstructions to be considered for solar access calculations include:

- For steep slope roofs in buildings up to three habitable stores, existing permanent natural or manmade obstructions, such as trees, hills, adjacent structures, that are external to the building.
- For buildings with four or more habitable stories and buildings up to three habitable stories with low-sloped roofs, all obstructions including those that are external to the building and obstructions that are part of the building design and elevation features

B. Up to Three Habitable Stories

Multifamily buildings with up to three habitable stories are required to have a PV system installed unless the building qualifies for an exception. The minimum qualifying PV system size is calculated as a minimum of,

- Projected annual electrical usage as described by the Equation 11-3 below or
- Maximum PV system size that can be installed in SARA

Equation 11-3

kWPV required = (CFA x A)/1000 + (N_{DU} x B)

WHERE:

kWPV = kWdc size of the PV system

CFA = Conditioned floor area

N_{DU} = Number of dwelling units

A = CFA Adjustment factor from Table 11-74

B = Dwelling unit adjustment factor from Table 11-74

Table 11-74: CFA Adjustment Factor

Climate Zone	A - CFA	B - Dwelling Units
1	0.793	1.27
2	0.621	1.22
3	0.628	1.12
4	0.586	1.21
5	0.585	1.06
6	0.594	1.23
7	0.572	1.15
8	0.586	1.37
9	0.613	1.36
10	0.627	1.41
11	0.836	1.44
12	0.613	1.40
13	0.894	1.51
14	0.741	1.26
15	1.56	1.47
16	0.59	1.22

Source: California Energy Commission

11.9.3 Photovoltaic System Exceptions –Low-rise Multifamily

There are five allowable exceptions to the prescriptive PV requirements for multifamily buildings with up to three habitable stories as listed below.

- No PV system is required if the SARA is less than 80 contiguous sq. ft. For steep slope roofs, SARA must not consider roof areas with a northerly azimuth that lies between 300 degrees and 90 degrees, from true north.
- No PV system is required if the minimum PV system size specified by §170.2(f) is less than 1.8 kW_{dc}.

- No PV system is required if it is not possible for the PV system, including panels, modules, components, supports, and attachments to the roof structure, to meet the requirements of the American Society of Civil Engineers (ASCE), Standard 7-16, Chapter 7, Snow Loads.
- No PV system is required if buildings are approved by the planning department prior to January 1, 2020. SARA can be determined using shading designs from the approval process demonstrating the roof areas that are now allowed to have PVs. It does not require an additional solar assessment to determine SARA per 2022 Title 24 requirements.
- The required PV sizes from Equation 11-3 may be reduced by 25 percent if a battery storage system is installed. The battery storage system must have a minimum usable capacity equivalent to 7.5 kWh and meet the qualification requirements specified in Joint Appendix JA12.

11.9.3.1 Four or More Habitable Stories

Multifamily buildings with four or more habitable stories also require a newly installed PV system. See chapter 9 for the prescriptive and performance requirements for buildings with more than three habitable stories.

11.9.3.2 Stepwise Guide for Compliance

The prescriptive compliance approach for solar PV system is summarized in Table 11-75, which provides the appropriate sequence of steps that identifies if the PV system's installation is triggered and the corresponding requirements to comply with the prescriptive approach. The requirements verify that the roof has enough appropriate roof space, with no obstruction and adequate structural strength.

Table 11-75: Guide to Solar PV Prescriptive Requirements

Step	Three or fewer stories	Four or more stories
Check for Virtual Net Energy Metering feasibility*	N/A	If program is not available, PV is not required
Calculate SARA using approved solar assessment tool	SARA determines the maximum bound of prescriptive PV size requirement.	SARA determines the prescriptive PV size requirement. If SARA is less than 3%, no PV is required.
Check contiguous SARA	If SARA is less than 80 contiguous ft., no PV is required.	If SARA is less than 80 contiguous ft., no PV is required.

Step	Three or fewer stories	Four or more stories
Calculate prescriptive PV size using both equation and SARA approach	Minimum of PV size calculated per Eq 11-3 and maximum possible PV in available SARA.	Minimum of PV size calculated per Eq 11-4 and SARA*14W/ft^2.
Check equation calculated PV size is more than minimum requirement	If PV size is less than 1.8kW, PV is exempted.	If PV size is less than 4kW, PV is exempted.
Check snow load design per ASCE 7-16**	If the roof cannot support the required PV structure per snow load design, PV is exempted.	If the roof cannot support the required PV structure per snow load design, PV is exempted.
Check for battery installation plan	If a minimum of 7.5kWh battery storage system is installed complying with JA12 requirements, PV size (From step 4) can be reduced by 25%.	N/A
Prepare documentation		

Source: California Energy Commission

*If VNEM is not feasible for multiple tenant buildings, solar PV is not required.

**For regions expecting heavy snowfall, snow loads need to be considered in structural design calculations and possible interference to solar access can occur.

Example 11-45: PV size calculation for three habitable stories or less

Question:

How is the prescriptive PV size calculated for a multifamily building with two habitable stories of 7,000 sq. ft. and eight dwelling units in Climate Zone 3?

Answer:

Follow steps 1 to 3 from Table 11-75 to ensure that the multifamily building does not qualify for an exception. The prescriptive size in step 4 is calculated using the two approaches below,

Applying Equation 11-3,

CFA = 7,000

N_{DU}= 8

A = CFA Adjustment factor from Table 11-74 = 0.628

B = Dwelling unit adjustment factor from Table 11-74 = 1.12

kW_{PV} required = (CFA x A)/1000 + (N_{DU} x B)

= (7,000 x 0.628)/1000 + (8 x 1.12)

= 4.396 + 8.96

= 13.4

Therefore, prescriptive PV size calculated per equation approach is 13.4 kW.

Check maximum allowable PV in the available SARA,

Assuming 50% of roof space is available for installing solar panel, which is calculated to be 0.5x3,500 = 1,750 ft^2.

Assuming a typical size of solar panel to be 20 ft^2. and allowing a margin of area around the solar panel, an approximate of 58 panels can be fit into the available SARA. This would roughly calculate to a PV size of 14.5 kW.

The PV size that can be accommodated in available SARA is bigger than the size of 13.6kW calculated using the Equation 11-3. Hence, the prescriptive size is calculated to be 13.6kW.

Example 11-46: PV size calculation for four or more habitable stories

Question: How is the prescriptive PV size calculated for a multifamily building with ten habitable stories, 125,400 ft^2. and 117 dwelling units in Climate Zone 3?

Answer:

Follow steps 1 to 3 from Table 11-75 to ensure that the multifamily building does not qualify for an exception. The prescriptive size in step 4 is calculated using the two approaches below:

i. Applying Equation 11-3,

CFA = 125,400

A = CFA Adjustment factor from Table 11-3= 1.82

kW_{PV} required = (CFA x A)/1000

= (125,400 x 1.82)/1000

= 228.2 kW

Therefore, prescriptive PV size calculated per equation approach is 228.2 kW.

ii. Applying SARA approach,

SARA calculated per solar assessment tool, described in JA11, is multiplied by 14W/ft^2 to determine the prescriptive PV size.

Assuming 30% of roof space (12,540 $ft^2$to qualify to be SARA, then the prescriptive PV size calculated using SARA approach is,

= 0.3 x 12,540ft^2 x 14 W/ft^2

= 52,668 W

= 52.7 kW

The prescriptive PV size is calculated to be a minimum of PV sizes calculated using both approaches,

= MIN (228.2,52.7)

= 52.7 kW

=

The PV size that can be accommodated in available SARA is smaller than that calculated using the Equation 11-3. Hence, the prescriptive size is calculated to be 52.7kW.

11.9.3.3 Joint Appendix 11 (JA11) Requirements

The installed PV system for any multifamily building must meet the applicable requirements specified in JA11 for both the prescriptive and performance approach. Requirements include considerations such as system orientation, shading criteria, solar access verification, remote monitoring, and interconnection requirements.

11.9.3.4 System Orientation

For prescriptive compliance, if a PV system is installed with a pitch greater than 2:12 or 10 degrees, the arrays must be oriented between 90 to 300 degrees from true north. If the pitch is less than 10 degrees, the orientation has insignificant impact on the array's performance; therefore, the PV system can be installed with any azimuth range.

Using the performance approach, the PV array may be oriented (and modeled) in any direction, including due north; however, the more the orientation deviates from the southwest optimum, the worse the system performs, resulting in a larger PV system size to meet the same load.

The California Flexible Installation (CFI) is a simplified modeling option in the performance approach. This option allows flexibility, and it has no specific requirements on orientation and tilt, while meeting the minimum shading criterion outlined in JA11.3.1. To use the CFI option for compliance:

- For CFI1, the PV array azimuth angle must be anywhere between 150 to 270 degrees from true north, and the tilt of all PV modules must be the same as the roof for pitches up to 7:12.
- For CFI2, the PV array azimuth angle must be anywhere between 105 to 300 degrees from true north, and the tilt of all PV modules must be the same as the roof for pitches up to 7:12.

11.9.3.5 Shading

The PV system should eliminate or avoid shading from any obstruction to the array Obstructions include the following:

- Any vent, chimney, architectural feature, mechanical equipment, or other obstruction that is on the roof or any other part of the building.
- Any part of the neighboring terrain.
- Any tree that is mature at the time of installation of the PV system.
- Any tree that is planted on the building lot or neighboring lots or planned to be planted as part of landscaping for the building. (The expected shading must be based on the mature height of the tree.)
- Any existing neighboring building or structure.

- Any planned neighboring building or structure that is known to the applicant or building owner.
- Any telephone or other utility pole that is closer than 30 ft. from the nearest point of the array.

Any obstruction located directly north of the array does not count as shading obstruction.

For prescriptive compliance, the weighted average of annual solar access, determined by solar access verification tool approved per JA11.4 requirements, across each solar panel must be at least 98 percent. The individual roof areas that constitute SARA must be greater than 70 percent per its definition. This requirement assumes that SARA is more than 80 contiguous sq. ft. and that the exception 1 to section 170.2(f) does not apply. If the annual solar access is less than 98%, then the building does not meet the prescriptive requirement and the performance compliance method must be used instead.

For the performance approach, the annual solar access is a required input and there is no minimum requirement for annual solar access. However, shading on the PV array must be avoided to get maximum benefit to meet the TDV energy.

For more information on software inputs, please refer to the software user's manual.

Example 11-47: Shading

Question:

What impact does shading have on the solar PV sizing requirement?

Answer:

Prescriptively the PV array cannot have any shading and must meet the minimum shading criteria in JA11. Under the performance path the shading condition must be modeled, and it will result in a larger PV size that meets the same TDV budget as a smaller unshaded PV system.

Example 8-4: Shading

Question:

How are the shading requirements of JA11.3 verified using prescriptive compliance approach?

Answer:

- Assess SARA using solar access verification tool as required by JA11.4.1
- If SARA is greater than 80 contiguous sq. ft., assess annual solar access for each solar panel
- Take weighted average of annual solar access across each solar panel
- Verify if the weighted average of annual solar access at each solar panel is greater than 98%. If yes, then the shading requirements of JA11.3 are met.

11.9.3.6 Solar Access Verification

A solar assessment tool that is certified by the Executive Director and complies with JA11.4.1 requirements must be used to document and verify the shading conditions of the PV system. The results of the solar access verification tool should be used to demonstrate compliance with:

- Prescriptive approach of at least 98% weighted average of solar access across all solar panels per JA11.3.1
- Performance approach of actual shading condition modeled in compliance software and indicated on certificate of compliance
- Exceptions related to SARA, Exception 1 of greater than 80 contiguous sq. ft. in §170.2(f) and greater than 3% of roof area in §170.2(g).

The CEC approved solar assessment tools can be of one of the following types:

- Physical tool that measures the availability of solar energy on installation site
- Software tool that models the physical features of the building and surrounding shading conditions including roofs and trees, and then calculates their solar potential by analyzing it against historical weather data
- Satellite or drone imaging data if it can demonstrate solar access percentages similar to on-site measurements

Table 11-76 summarizes the solar access verification tool requirements from JA11.4.1.

Table 11-76: Solar Access Verification Tool Requirements

Category	Requirements
Input	Physical features of building Obstructions to the roof listed in Section 0: Shading above per JA11.3 Historical weather data
Calculations	Calculate annual solar access percentage of each individual solar array. Calculate annual solar access percentage as a weighted average of the whole. Include all obstructions, including any tree that is planted on the building lot or neighboring lots or planned to be planted in landscaping. Not to include horizon shading in the calculation
Reporting	Produce a shade report with a summary of the PV system, including the address of the project, individual array panel count, orientation, annual solar access percentage, and weighted average of the PV system as whole.

Source: California Energy Commission

11.9.3.7 System Monitoring Requirements

The PV system must be integrated with a monitoring system that can provide remote monitoring capability to its user. The monitoring data should be accessible via a web-based portal or mobile device application that enables the building manager, owner, or occupants to monitor the performance of their PV system. This data can be useful to identify, report, and correct performance issues with the panels, inverters, shading, or other issues that may adversely impact the performance of the PV system. At a minimum, the building manager, building owner, or occupants must have access to the following information:

- The nominal kW rating the PV system.
- Number of PV modules and the nominal watt rating of each module.
- Hourly (or 15-minute interval), daily, monthly, and annual kWh production in numeric and graphic formats for the system.
- Running total of daily kWh production.
- Daily kW peak power production.
- Current kW production of the entire PV system.

Example 11-48 Remote Monitoring

Question:

How do I implement monitoring to meet section JA11.5.1 including the current reading?

Answer:

There are multiple options. Many inverters can connect via ethernet and wirelessly to the building manager's, building owner's, or occupant's internet, and others use independent cellular connections. For cellular, the data should be updated to the monitoring portal periodically as allowed by the cellular plan.

11.9.3.8 Interconnection Requirements

The installed inverters must be tested in accordance with the applicable requirements in UL1741 and UL1741 Supplement A.

The PV system and the associated components, including the inverters, must comply with the California Public Utilities Commission (CPUC) Electric Tariff Rule 21, which governs CPUC-jurisdictional interconnections for all net energy metering customers. Rule 21 requires that inverters have certain capabilities to ensure proper operation of the electrical grid as more renewables are interconnected. The inverters must perform functions that, when activated, can autonomously contribute to grid support during excursions from normal operating voltage and frequency system conditions by providing dynamic reactive/real power support, voltage and frequency ride-through, ramp rate controls, communication systems with ability to accept external commands, and other functions.

11.9.3.9 Compliance and Enforcement

To certify that the PV system complies with all JA11 requirements, the installer must provide:

- Certificate of Installation for PV system that all provisions of JA11 are met. The certificate of installation must be available on the building site for inspections.
- **Solar Assessment Report:** Solar assessment report produced by a CEC approved solar access verification tool to verify the shading conditions that all requirements pertaining to SARA are met. If satellite, drone, or other digital image is used for solar access verification, the solar assessment report must be created or dated after the installation of the PV system. If the digital image is dated before the installation of PV system, additional on-site pictures must be attached to clearly show that the installed system matches the system modeled in the solar assessment report.

The local enforcement agency must verify that the Certificate of Installation is valid complete and correct, and uploaded into a Commission-approved registry.

11.9.4 Solar Ready

§110.10

Solar ready requirements are mandatory for newly-constructed multifamily buildings with fewer than 10 habitable stories that do not have a photovoltaic system installed. These requirements are explained in Chapter 9.

11.9.5 Battery Storage System

Multifamily buildings with four or more habitable stories are required to have battery storage under the prescriptive approach if solar PV is installed and meets the prescriptive requirements. The battery system can also be installed as a stand-alone system for additional compliance credit. The battery storage system is required to meet the qualifications of Joint Appendix JA12 for both prescriptive and performance approach. For multifamily buildings with 3 or less habitable stories, battery storage is not required and is available as compliance credit under the performance compliance approach.

The primary function of the battery storage system is load shifting to harmonize the onsite PV system with the grid and deliver benefits to the environment, building owner, and building occupants.

11.9.5.1 Prescriptive Requirements

§170.2(h)5

All buildings that are required by §170.2(g) to have a PV system must also have a battery storage system meeting the minimum qualification requirements of

§170.2(h) and Reference Joint Appendix JA12. Reference chapter 9 of this manual for the prescriptive battery storage requirements.

11.9.5.2 Performance Approach

§170.1(b)

C. Energy Budget Calculation

Battery storage system is added to the list of compliance loads in the 2022 Title 24 energy budget per the §170.1. The TDV energy budget is calculated by the software as the sum of all building loads, including PV and the battery storage system, in addition to space conditioning, indoor lighting, mechanical ventilation, service water heating, and covered process loads.

The TDV energy budget can also be met partially or fully by connecting the building to a community battery storage system that complies with Title 24, Part 1, §10-115. The requirements of community shared storage system compliance pathway are detailed in Section 11.11.4 below.

11.9.5.3 Exceptions to Battery Storage Requirements

Exception 1 of §170.2(h) from the prescriptive requirements can also be used under the performance approach. Multifamily buildings with installed PV less than 15 percent of the prescriptive size calculated by the equation 11-5 and 11-6 are exempt from installing battery storage. The building permit applicant must select the appropriate exception in the software and provide documentation to the building department with the building permit application.

11.9.5.4 Additional Requirements

The battery storage system must comply with all the applicable requirements of Joint Appendix 12 (JA12) reference standard as described in Section 11.11.3.3.

11.9.5.5 Joint Appendix (JA 12) Requirements.

The battery storage system must meet all applicable requirements in JA12, listed in chapter 9 of this manual, and be self-certified to the CEC by the manufacturer as a qualified product. The list of qualified JA12 products can be found here: https://www.energy.ca.gov/programs-and-topics/topics/rnewable-energy/solar-equipment-lists

Coupling a PV system with a battery storage system and appropriate control strategy will allow for a smaller PV system than otherwise would not have been possible.

11.9.6 Community Shared Solar Electric Generation and Storage System

§170.1(b)

A community-shared solar electric generation system, other renewable electric generation system, and/or community shared battery storage system may offset part or all the solar electric generation system time dependent valuation (TDV) energy required to comply with the standards. This compliance pathway under the performance approach should provide dedicated power, utility energy reduction credits to the permitted building and is approved by the Energy Commission as specified in Title 24, Part 1, Section 10-115.

Community Shared Solar Electric Generation means solar electric generation or other renewable technology electric generation that is installed at a different site.

Community Shared Battery Storage refers to the battery storage systems installed at a different site, separately or in combination with Community Shared Solar Electric Generation.

The community shared systems should be approved by Commission and be available for inspection by enforcement agency during compliance verification process.

11.9.6.1 Qualification Requirements

The Community Shared Solar Electric Generation system should meet the following requirements discussed below.

D. Enforcement Agency

The Community Shared Solar Electric Generation system and/or Community Shared Battery Storage system must exist and be available for enforcement agency review early in the permitting process, and it must not cause delay in the enforcement agency review and approval of the building that will be served. The enforcement agency should have jurisdiction and facilitated access to the Community Shared Solar Electric Generation system to verify the validity and accuracy of compliance documentation. All documentation required to demonstrate compliance for the building for Community Shared Solar Electric Generation system and/or Community Shared Battery Storage system must be completed prior to the building permit application.

11.9.6.2 Energy Performance

Energy Commission approved compliance software must be used to show that the energy performance of the building’s share of the Community Shared Solar Electric Generation system is equal to or greater than the partial or full offset claimed for the solar electric generation and battery storage system, which would otherwise be required for the building to comply with the Standards.

The minimum community shared solar size dedicated to the building and the annual kWh equivalence may be measured in one of two ways: 1) Using the CBECC Simplified approach for PVs and the CFI orientation option, or 2) by modeling the actual attributes of the system using the detailed approach. When the detailed approach is used, the compliance software will determine a minimum kW size that will represent the portion of the community solar resource dedicated to the building, based on PV system component performance characteristics, azimuth, inverter type, tracking versus fixed systems, climate zone, and CEC weather files containing solar availability data.

Additionally, If the community shared solar resources are coupled with a community shared battery storage system in the CBECC-Com, the modeled PV system must also be coupled with at least a battery storage system to determine the size share of the community solar resource dedicated to the building. Also, the portion of the community shared battery storage system dedicated to the dwelling must match the battery storage size modeled in CBECC software.

11.9.6.3 Participating Building Energy Savings Benefits

A specific share of the Community Shared Solar Electric Generation system, determined to comply with the energy performance requirement, must be dedicated on an ongoing basis to the building. The energy savings benefits allocated to the building must be provided in one of the following ways:

- Actual reductions in the energy consumption of the participating building
- Energy reduction credits that will result in virtual reductions in the building’s energy consumption, including but not limited to generation credit, solar charge, program charge, and power charge indifference adjustment charge
- Payments to the building that will have an equivalent effect as energy bill reductions that would result from one of the other two options above

For all three options, the reduction in energy bills resulting from the share of the Community Shared Solar Electric Generation system dedicated to the building must be greater than the added cost that is charged to the building to obtain that share of the Community Shared Solar Electric Generation system and/or battery storage system.

11.9.6.4 Durability, Participation, and Building Opt-out

1. Durability

   The benefits from the specific share of the Community Shared Solar Electric Generation system and/or Community Shared Battery Storage system must be provided to each participating building for a period of at least 20 years.

   A. Participation

   The administrator(s) approved by the Energy Commission pursuant to Section 10-115(b)1, of community shared solar and/or community battery storage system should ensure that the “participation period” for all the participating building is 20 years regardless of the ownership of the building. However, the building owner can opt out of the community shared solar electric generation and/or community shared battery storage system if they install an on-site solar electric generation system and follow interconnection requirements pursuant to the opt-out requirements in Building Opt-Out section below. To demonstrate compliance, administrator(s) are required to fulfil one of the two options below.

- Equitable Servitude
  - The participating builders must impose an equitable servitude through a properly recorded declaration of covenants, conditions, and restrictions or other properly recorded covenant, deed restriction or other legally binding method referenced in each deed transferring title for each participating building.
  - This equitable servitude must obligate the original owner(s)/tenant(s) and all subsequent owner(s)/tenant(s) of the participating building to maintain the building's participation in the community shared solar and/or community shared battery storage system for the participation period or ensure installation and interconnection of an on-site solar electric generation system that satisfies the opt-out requirements.
  - The builder must ensure that the equitable servitude provides Commission-approved administrator the right to enforce the above provisions.
  - The equitable servitude must remain in force for a period of 20 years from the date of first participation of the building in the community shared solar and/or battery system.
  - The equitable servitude must not be revocable.
  - The equitable servitude must be delivered to all responsible parties through transfer disclosure statements.
- Other System
  - The Commission may approve another program, structure, or system by which an administrator (or other entity approved by the Commission) ensures the participation requirements of Section 10-115(a)4B will be satisfied for a participation period of no less than 20 years.

B. Compliance Documentation

This section determines requirements for administrator(s) to comply with record maintenance of compliance documents.

- The administrator must maintain record(s) of the compliance documentation that determined the requirements for the on-site solar electric generation system and/or battery storage system, which is in effect at the time the builder applied for the original building permit, and it establishes participants' obligations to meet the opt-out requirements.

- The administrator must provide a copy of this compliance documentation upon a participating building owner's request to every new owner of a participating building, when the administrator is notified that title has transferred.
- The administrator must provide a copy of this compliance documentation to any participating building owner who requests to opt-out.

C. Building Opt-Out

At any time during this period, the building owner must have the option to discontinue participation in the community shared solar and/or battery storage system if the building satisfies the opt-out requirements.

- Prior to opt-out, the building owner must demonstrate an on-site solar electric generation system to be installed, which meets the requirements of §170.0(a)3, which were in effect at the time the building was permitted.
- Prior to opt-out, the building owner should provide documentation from the installer of the on-site solar system or an attestation of the building owner with supporting documentation along with taking responsibility of all costs associated with it.
- The administrator must compare the opt-out documentation received from building owner to the original compliance documentation specified in Section 10-115(a)4C. Based on the opt-out documentation, the administrator must provide written confirmation that the installed solar system meets or exceeds the opt-out requirements within 30 days of receiving from building owner.
- The administrator may, at its discretion, verify the documentation through a physical inspection.
- The administrator must maintain record of the documentation that demonstrates and confirms the on-site solar generation system met the opt-out requirements for the remainder of the participation period.
- Upon the building owner's exercise of the opt-out, all costs and benefits associated with participation in the community shared solar and/or battery storage system must cease. If any balance of costs or benefits is owed to either party at the time of opt-out, such balance must be paid to that party.
- The administrator (or other entity approved by the Commission pursuant to Section 10-115(a)4Bii) must not impose any penalty related to a participating building's opt-out or charge participants for recuperation of

unrealized revenue that would have been expected to accrue beyond the end of participation. If the administrator (or other entity approved by the Commission) plans to charge any other fees at the time of building opt-out, the Application for Commission Approval must explain the purpose of those fees.

11.9.6.5 Additionality

The specific share of the Community Shared Solar Electric Generation System must provide the benefits to the participating building that are in no way made available or attributed to any other building or purpose. Renewable Energy Credits that are unbundled from the Community Shared Solar Electric Generation System do not meet this additionality requirement.

- The participating building(s) must be served primarily by renewable resources developed specifically for the community solar electric generation system.
- Other renewable resources may be used when participating buildings are permitted before the renewable resources developed for the program start operating or after they cease operating. During these times, other renewable resources may be used to meet the requirements of Section 10-115(a)4 for each participating building.
- The renewable resources, including those developed primarily to serve participating buildings and those utilized to fill before and after time gaps for the purpose of meeting the requirements of Section 10-115(a)4, must meet the following requirement:
  - For each renewable resource used to serve participating buildings, bundled (Product Content Category 1) Renewable energy credits (RECs) must be retired and tracked in the Western Renewable Energy Generation Information System on the behalf of program participants, to ensure that they will not be allocated to or used for any other purpose, including Renewable Performance Standard compliance, resale of RECs or renewable generation to any other person or entity, or any other mandatory or voluntary renewable electricity program requirement or claim.
- Renewable resources developed to serve participating buildings may also be used to serve other loads when there is excess generation beyond what is needed to serve participating buildings. Any excess generation used for such other loads must be isolated from the generation serving participating buildings and must not result in violation of Section 10-115(a)5C.

Example 11-51

Question

To help entities that might want to apply to the Energy Commission for approval of a Community Shared Solar Energy Generation System, please provide examples of each of the three optional ways energy savings benefits could be provided to comply with Participating Building Energy Savings Benefits requirements.

Answer

Examples would include:

Actual reductions in the energy consumption of the building: This could be accomplished by locating the PV systems for several houses on a carport on common land in a subdivision, and direct wiring the unique PV panels serving each house to an inverter that is located on the home's site. For homes served by utilities that are subject to compliance with Net Energy Metering requirements, the common land that is hosting the PVs on the carport would have to be adjacent to (could be directly across a street) the houses that are being served by the PV system. All other requirements of Section 10-115 would have to be met.

Utility energy reduction credits that will result in virtual reductions in the building's energy consumption that is subject to energy bill payments: This could be accomplished through a community shared solar program administered by a utility (like the Green Tariff Shared Renewables, or GTSR), for which a remote renewable resource is paid for through shares purchased for each home, and energy bill credits are that reduce monthly electricity bills are allocated based on the homes' shares, including but not limited to generation credit, solar charges, program charges, and nonparticipant charges. All other requirements of Section 10-115 would have to be met.

Payments to the building that will have an equivalent effect as energy bill reductions would result from one of the two options above: This could be accomplished by builders installing PV systems on other properties they own to offset the compliance requirement for onsite PVs on homes, they build. The homes would pay for a share of the PV systems on the other properties. The builders would be obligated to make an ongoing cash payment back to the homes for the home's share of the electricity generation achieved by the PV systems on the other properties. The share of the ownership of the PV systems on the other properties and the corresponding sharing of the electricity generation achieved by the PV systems on the other properties would not be accounted for through a utility system – the ownership share would not be paid to the utility and the payment for the share of the electricity generation achieved by the PV systems on the other properties would not be provided through a utility bill. The entire program would be administered by the builder for a 20-year period for each home. All other requirements of Section 10-115 would have to be met.

Example 11-52

Question

Explain what the cost requirements in Participating Building Energy Savings Benefits section above that says: "In other words, a building that participates in an approved community solar program cannot be charged more than the nonparticipating building that has no onsite PV system and does not participate in a community shared solar electric generation and/or battery storage program."

Answer

Regardless of the three options above is chosen, it must be cost effective to the home for the home to participate in a community shared solar electric generation system program. The home will pay for its share of the community renewable resource, and will receive either energy bill reductions, credits or cash payments for the electricity that is generated by the community renewable resource. The $ value of the bill reductions, credits or cash payments must exceed the cost to the home to pay for its share of the community renewable resource.

Let's take a hypothetical example of a Green Tariff Shared Renewables Program (GTSR) that is required by statute to be operated by the IOUs. The following shows the costs that the program charges a home to obtain shares of the program's community solar resources, and the energy bill credit. The charges and credit are allocated per KWh generated by the home's share of the community renewable resource.

Example Green Tariff Shared Renewables Program Details

Solar Charge	6.48 cents per kWh
Program Charge	2.956 cents per kWh
Power Charge Indifference Adjustment (PCIA) Charge	3.346 cents per kWh
Total Program Charges	12.782 cents per kWh
Generation Credit	-10.78 cents per kWh

The total cost that the home pays per kWh for its share of the community renewable resource is 12.8 cents per kWh and the energy bill credits for generation from the home's share of the community renewable resource is 10.8 cents per kWh. Since the value of the home's energy bill credit does not exceed the cost for the home to participate in the community solar program, the cost requirement is not met. Cost requirements can be brought into compliance through a combination of an increase in the generation credit and reductions in solar charge, program charge, and power charge indifference adjustment (PCIA) charge. In this example, if the generation credit raises by one cent, up to 11.8 cents, and combined charges decrease by 1.1 cents, down to 11.7 cents, then the program meets the cost requirements.

11.9.7 Code in Practice

11.9.7.1 Garden Style Multifamily Case Study

The Garden Style Multifamily Case Study considers a new two-story garden style multifamily building in Burbank, California (Climate Zone 9). This is a sample project created for training purposes, and it consists of 7,216 ft² of conditioned floor area with eight dwelling units and no common use areas. The case study tables in this chapter compare the proposed building solar electricity and battery storage to mandatory and prescriptive Energy Code requirements and evaluate possible compliance options.

Table 11-77: Garden Style Multifamily Case Study Compared to Mandatory and Prescriptive Renewable Energy Requirements (Climate Zone 9)

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Multifamily Building	New two-story garden style multifamily building, eight dwelling units, no common use areas, Burbank, CA	Section 110.10	Section 170.2(f), Joint Appendix JA11 New multifamily building ≤ three stories, Climate Zone (CZ) 9	Case study Mandatory and Prescriptive compliance rated for each feature below as "Yes" (complies), "No" (does not comply) or "N/A" (not applicable). If "No", see compliance options provided.
Total Conditioned Floor Area (CFA)	7,216 ft²		7,216 ft²	
PV System Electrical Output (kWdc)	15.6 kWdc	N/A	kWpv calculated per Equation 170.2-C: ≥ 15.3 kWdc	Mandatory: N/A Prescriptive: Yes
PV Panel Tilt	3:12 Pitch	N/A	Any PV with ≥ 2:12 pitch is defined as steep-sloped and must meet applicable orientation requirements	Mandatory: N/A Prescriptive: Yes
PV Panel Orientation	180 degrees (due South)	Section 110.10(b)	Section 170.2(f), JA11 PV for steep-sloped roofs must be installed between 90 degrees (due east) and 300 degrees (30 degrees north of due west)	Mandatory: Yes Prescriptive: Yes
Battery Storage	None	N/A	Not required for new multifamily buildings ≤ three stories	Mandatory: N/A Prescriptive: No

Source: California Energy Commission

Providing electricity generated using solar photovoltaics (PV) is a prescriptive requirement for multifamily buildings with three or fewer habitable stories. The minimum kWdc PV output capacity is the smaller of that calculated using Equation 170.2-C or the maximum that can be installed on the building's Solar Access Roof Area (SARA). SARA includes all of the building's unobstructed roof area (including garage roofs and other roofs on-site) with at least 70 percent solar access and structurally capable of supporting a PV system.

Figure 80: Garden Style Multifamily Case Study: Photovoltaics (PV) on South-Facing Roof

The total roof area for this case study including overhangs is 4,284 ft² measured in plan view and 4,416 ft² accounting for the 3:12 roof pitch. Half of the roof faces due south (180 degrees) and half faces due north (0 degrees). PV for steep-sloped roofs must be installed at orientations between 90 degrees (due east) and 300 degrees (30 degrees north of due west), so only the south-facing roof meets prescriptive orientation requirements. The south-facing roof has no obstructions and nothing shading it, so the SARA equals 2,208 ft².

The proposed PV system has 60 solar panels at 260 watts each or 15.6 kWdc. The total area of the panels is 1,056 ft² or less than half the SARA.

The minimum electrical output of the PV system calculated using Equation 170.2-C is:

$kWpv = (CFA \times A)/1000 + (N_{Dwell} \times B)$.
kWpv = kWdc size of the PV system
CFA = Conditioned floor area
N_{Dwell} = Number of dwelling units
A = Adjustment factor from Table 170.2-T
B = Dwelling adjustment factor from Table 170.2-T

The minimum Prescriptive electrical output for this project is:
kWpv = (7,216 x 0.613)/1,000 + (8 x 1.36) = 15.3 kWdc

The proposed system has 15.6 kWdc output, so it complies prescriptively as designed.

11.9.7.2 Mid-Rise Multifamily Case Study

The Mid-Rise Multifamily Case Study covers a new five-story multifamily building in Sacramento, California (Climate Zone 12). This is a sample project created for training purposes, and it includes 112,044 ft² of conditioned floor area with 88 dwelling units, shared residential corridors, laundry rooms, fitness center and lounge, plus ground floor retail. The case study tables in this chapter compare the proposed building solar electricity and battery storage to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Table 11-78: Mid-Rise Multifamily Case Study Compared to Mandatory and Prescriptive Renewable Energy Requirements (Climate Zone 12)

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Mid-Rise Multifamily Building	New five-story mid-rise multifamily building, 88 dwelling units, common use areas, ground floor retail, Sacramento, CA	Section 110.10	Sections 170.2(g), 170.2 (h) and 140.10, Joint Appendices JA11 and JA12 New multifamily building ≥ four stories, Climate Zone (CZ) 12	Case study Mandatory and Prescriptive compliance rated for each feature below as "Yes" (complies), "No" (does not comply) or "N/A" (not applicable). If "No", see compliance options provided.
Dwelling Unit Conditioned Floor Area	78,384 ft²	N/A	170.2(g) and (h)	
Common Use Area Conditioned Floor Area	17,487 ft²	N/A	170.2(g) and (h)	
Retail Conditioned Floor Area	16,173 ft²	N/A	140.10	
Total Conditioned Floor Area	112,044 ft²	N/A		
Total Percent Multifamily in Mixed Occupancy Building	(78,384 + 17,487)/ 112,044 = 85.6%	N/A	Per 170.2(g) and 140.10(a), since multifamily is ≥ 80% of total CFA, the multifamily Prescriptive PV requirements apply to the whole building.	

Table 11-79: Photovoltaics (PV) and Battery Storage

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
PV System Electrical Output (kWdc)	123.2 kWdc	N/A	kWpvdc calculated per Equation 170.2-D: 247.6 kWdc kWpvdc calculated as SARA x 14 W/ft²: 194.8 kWdc Required kWpvdc is	Mandatory: N/A Prescriptive: No Compliance Options: 1. Redesign the PV panel installation to fit a total of 455 panels at 320 watts each.

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
			the smaller of these two calculations: ≥ 194.8 kWpvdc	2. Keep the same layout, but use 378 watt PV panels 3. Performance Approach
PV Solar Access Roof Areas (SARA)	10,395 ft² SARA to be verified using a certified solar assessment tool	N/A	Solar access to be verified using a certified solar assessment tool per Reference Appendix Section JA11.4	Mandatory: N/A Prescriptive: Yes
PV Panel Tilt	< 2:12 pitch	N/A	JA11 Any PV with < 2:12 pitch is defined as low-sloped	Mandatory: N/A Prescriptive: Yes
PV Panel Orientation	Installed on flat roof	Section 110.10	PV with < 2:12 pitch do not have orientation restrictions	Mandatory: Yes Prescriptive: Yes
Battery Storage Rated Single Charge-Discharge Cycle AC to AC (round trip) Efficiency	80%	N/A	≥ 80% per Reference Appendix Section JA12.2.2.1(b)	Mandatory: N/A Prescriptive: Yes
Battery Storage Rated Energy Capacity	225 kWh	N/A	Minimum kWhbatt calculated per Equation 170.2-E: (194.8 kWdc x 1.03 Wh/W)/√0.80 = 224.3 kWh	Mandatory: N/A Prescriptive: Yes
Battery Storage Rated Power Capacity	51 kWdc	N/A	Minimum kWbatt calculated per Equation 170.2-F: 194.8 kWdc x 0.26 = 50.6 kWdc	Mandatory: N/A Prescriptive: Yes
Verifications:	Contractor to verify solar access	N/A	Solar access verified using certified solar assessment tool	Mandatory: N/A Prescriptive: Yes

Source: California Energy Commission

Figure 81: Mid-Rise Multifamily Case Study: Photovoltaics (PV) on Flat Roof (viewed from South)

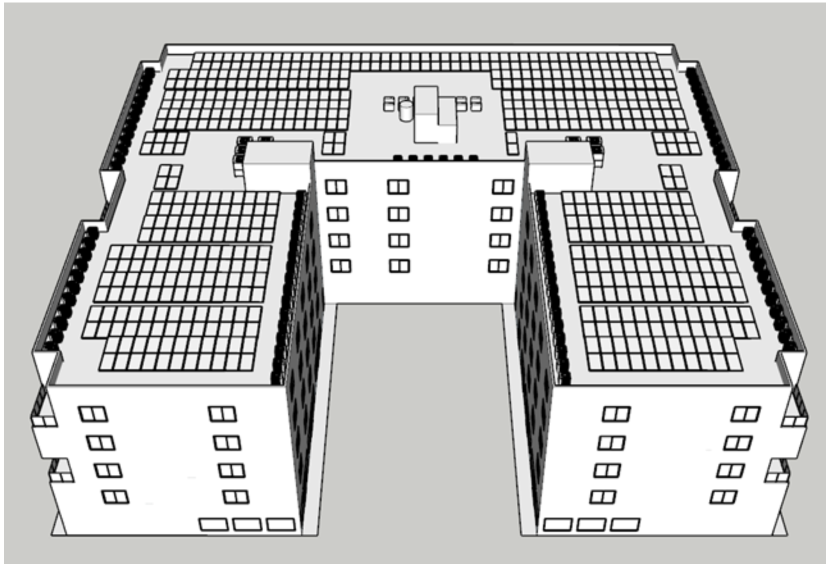
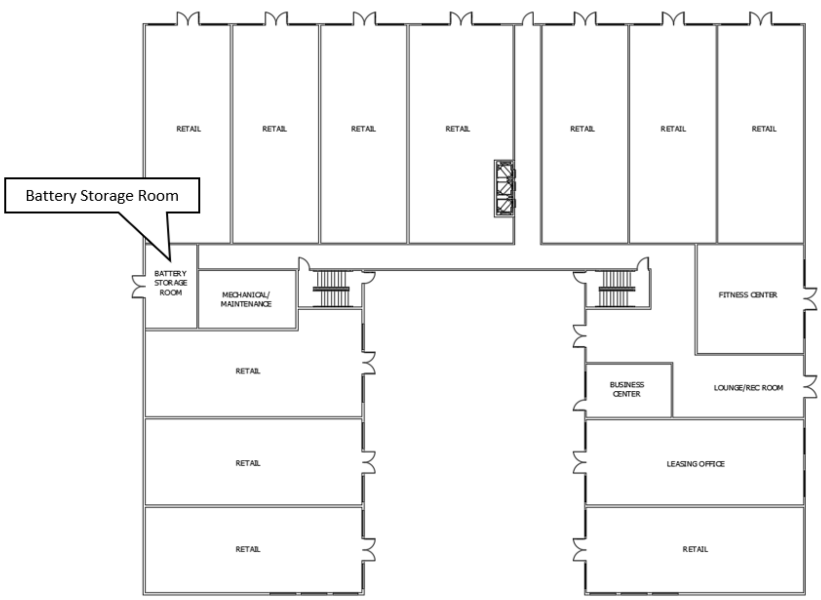


Figure 82: Mid-Rise Multifamily Case Study: 1st Floor Battery Storage Room



One important element of solar design is to make sure that the photovoltaic (PV) modules are installed in locations that have enough sunlight. The Energy Code requires solar access to be verified using a certified solar assessment tool per Reference Appendix Section JA11.4. The Solar Access Roof Area or SARA is the area of available roof surfaces for a building project that have at least 70 percent solar access and that are also structural able to support solar panels. SARA does not include the following:

- Occupied roofs per California Building Code Section 503.1.4:

  The deck roofs at the third and fifth floor balconies of this project are considered occupied roofs excluded from the SARA.

- sRoof space needed to comply with other building codes as confirmed by the Energy Commission Executive Director:

  Roof areas needed to meet California Fire Code (Title 24, Part 9) roof access and egress pathway requirements and roof areas needed around HVAC equipment to meet California Mechanical Code (Title 24, Part 4) requirements are both excluded from the potential SARA for this case study.

The Energy Code has two ways to calculate the prescriptive minimum kWdc of PV to be installed for multifamily buildings of more than three habitable stories. One way is to calculate it using Equation 170.2-D which is based on the total building floor area:

EQUATION 170.2-D PHOTOVOLTAIC DIRECT CURRENT SIZE

kWPVdc = (CFA x A)/1000

WHERE:

kWPVdc = Size of the PV system in kW

CFA = Conditioned floor area in square feet

A = PV capacity factor specified in Table 170.2-U for the building type

For this case study, this strategy results in:

kWpvdc calculated per Equation 170.2-D:
(112,044 ft^2 x 2.21 W/ft^2)/1,000 =
247.6 kWdc

Based on the size and wattage of available PV panels, 247.6 kWdc will not fit on the proposed roof. The other way to calculate the Prescriptive PV requirement is to determine the available SARA square footage and multiply it by 14 watts per square foot. Using this method with a SARA of 10,395 ft^2 gives the following results:

kWpvdc calculated as SARA x 14 W/ft^2:
(10,395 ft^2 x 14 W/ft^2)/1000 =
145.5 kWdc

The Prescriptive minimum required kWpvdc is the smaller of these two calculations or 145.5 kWpvdc. The design team did not achieve 145.5 kWpvdc in the available SARA. Their PV design only fit 385 PV panels at 320 watts each or 123.2 kWpvdc, so the PV system is out of compliance with the Prescriptive method as designed.

The design team has several Energy Code options to consider. One would be to see they can find a way to fit 455 – 320 watt PV panels in the available SARA. Another would be to keep the same layout with 385 PV panels, but to use a higher performing panel design with at least 378 watts output per panel. If the design team or the client objects to those options, they could work with an energy analyst to model the building overall using the Performance Approach to evaluate possible energy tradeoffs to achieve compliance.

11.10 Electric Ready Requirements

This section describes the mandatory requirements for electric readiness in multifamily buildings. The electric ready requirements apply to gas equipment used for dwelling unit space heating, water heating, and cooking as well as dwelling unit and common area clothes dryers. Electric ready requirements minimize future retrofit costs when electric appliances replace gas appliances. California has aggressive decarbonization goals: 100% carbon-free electricity by 2045 (Senate Bill 100) and reducing greenhouse gas emissions from buildings 40% below 1990 levels by 2030 (Assembly Bill 3232). To achieve these decarbonization goals, existing buildings will need to be retrofitted to use 100% carbon-free electricity.

11.10.1 What's New in 2022 Energy Code

Electric-readiness is a new mandatory requirement for dwelling unit gas space heating, water heating, cooking, and laundry for the 2022 Energy Code. Common use areas are exempt from the electric-ready requirement, with the exception of common use area clothes dryers.

11.10.2 Mandatory Requirements

§160.4, §160.9

Electric readiness requires the following for the applicable gas appliances listed in 11.12.

Installation of branch circuits within three ft. of existing gas appliances with no obstructions. These circuits are dedicated to future electric replacement equipment and cannot be used for other appliances. Other electrical components must be installed in accordance with the *California Electrical Code.*

1. Table 11-80 below describes the different circuit requirements for each gas end-use.
2. Dedicated space for double breakers in the main service panel that will serve the future in-unit space heating, electric cooktop and in-unit clothes dryers. The code does not require the installation of breakers at time of construction.

Dedicated space in the panel next to the location of the water heater breaker to accommodate converting it to 240V in the future, per §160.4. The dedicated space in the panels must be identified as "Future 240V Use." The code does not require the installation of breakers at time of construction.

Table 11-80 summarizes the electrical capacity, panel, and other equipment requirements for electric-readiness for each natural gas appliance installed in a new multifamily building. There are no electric ready requirements for additions or alterations. There are no performance or prescriptive electric ready requirements for multifamily buildings.

Table 11-80: Compliance Requirements for Electric Readiness

Gas or Propane Equipment Installed	Electrical Capacity requirements for new circuit (amps, volts)	Other Equipment Requirements
Furnace (dwelling unit only) §160.9(a)	240V, 30 amp	
Gas tankless or storage water heater (dwelling unit only) §160.4(a)	125V, 20 amp	A Category III or IV or Type B Vent with straight pipe from space where water heater is installed to outside termination Condensate drain no more than 2 inches higher than the base of installed water heater to allow for natural drainage with pump assistance
Gas or propane range (dwelling unit only) §160.9(b)	240V, 50 amp	
Dwelling unit gas clothes dryer §160.9(c)1	240V, 30 amp	
Common use area gas clothes dryer §160.9(c)2	24 amps at 208/240V per dryer or 2.6 kVA for each 10,000 btu/hr of rated gas input or electrical power required to provide equivalent function. This is usually determined by the electrical engineer on the project.	Conductor or raceway from the main electrical panel to within 3 ft. of the future electric equipment. Both ends of conductor labelled "Future 240V Use" Conductors, raceways and intervening electrical equipment must be sized to meet the future electrical load from the service voltage to the utility distribution system connection

Source: California Energy Commission

Receptacles are not required for the dwelling unit space heating, laundry, and cooking circuits. However, the unused circuits must have a blank cover identified as "240V ready." Receptacles are required for dwelling unit water heating, and must be connected to the panel with a 120/240V, 3-conductor 10AWG copper wire with both ends of the unused conductor labeled as *spare* and be electrically isolated.

Example 11-53

Question

Can I receive any compliance credit for making gas appliances electric-ready that are not required by code?

Answer

Because there are not any prescriptive or performance requirements for electric-readiness, you will not receive compliance credit for making a gas appliance electric-ready where not required by code. However, by doing so, you will minimize future retrofit costs. The project engineer should be able to recommend equivalent equipment and electrical requirements to ensure conduit and wires are sized appropriately, along with identifying additional physical space and panel capacity needs to accommodate the future heat pump technology.

Example 11-54

Question

There I am designing an apartment building with natural gas for in-unit water heating, clothes drying, and cooking. How much more electrical capacity can I expect from replacing my existing gas appliances with electrical appliances in the future on a subpanel for a 780 square foot apartment unit?

Answer

The example below demonstrates an estimated additional electrical capacity of 18,264 watts that a designer might account for when sizing panels for electrification of existing gas equipment in the future. The electric appliances that contributed to the additional capacity are shown in bold.

Figure 11-83: Electrical Load for All-Electric Dwelling Unit

Dwelling Unit Panel Calculation			
Electricity only	780	ft2	
	Volts	**Nameplate Amps**	**Total Watts**
General lighting & receptacle (sq.ft x 3 watts/sq.ft)	120	24	2,925
2 small appliance branch circuits	120	25	3,000
Clothes washer	120	10	1,200
Refrigerator	120	7	1,050
Bath fans	120	1	120
Range hood	120	5	600
Dishwasher	120	13	1,500
Waste disposal	120	5	600
Microwave	120	13	1,560
Range	**208**	**40**	**8,320**
Clothes dryer	**208**	**23**	**4,784**
Water heater	**208**	**24**	**5,000**
Total Watts			*30,659*
Total kVA			***31***
Diversity Factors (per California Electrical Code)			
First 10,000 watts at 100%			*10,000*
Remaining 20,659 Watts at 40%			*8,264*
Total Watts			*18,264*
Total kVA			***18***
Heat Pump	208	15	3,120
Heating element	120	2	240
Total A/C Watts at 100%			*3,360*
Total kVA			***3***
Total KVA Calculated (with diversity factors)			**21**
Total Amps for Panel @208V to provide 21 kVA			**101**

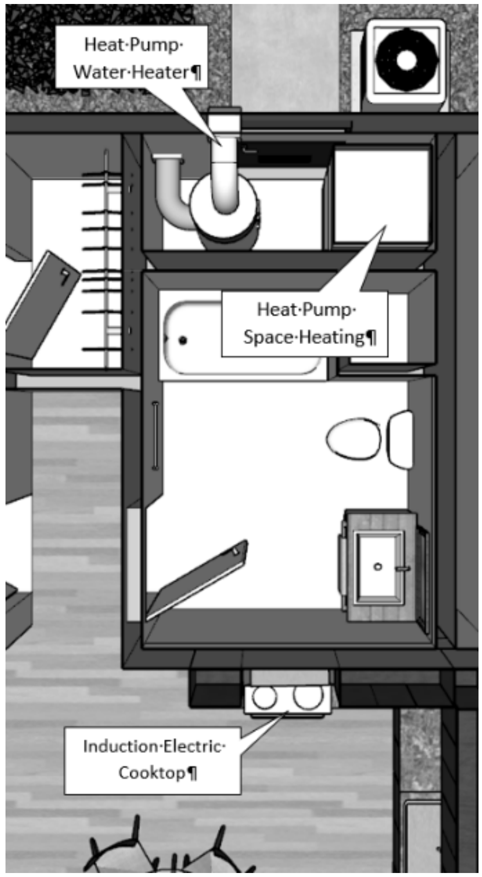
This example only considers the additional load requirements for an individual dwelling unit. To determine the additional load on the main service panel to accommodate whole building electrification, the additional capacity requirements for all dwelling units along with the applicable electric-ready requirements in common use area gas end uses will need to be considered in accordance with the California electrical code.

11.10.3 Code in Practice

11.10.3.1 Garden Style Multifamily Case Study

The Garden Style Multifamily Case Study considers a new two-story garden style multifamily building in Burbank, California (Climate Zone (CZ) 9). This is a sample project created for training purposes, and it consists of 7,216 ft² of conditioned floor area with eight dwelling units and no common use areas. The case study table in this chapter compare the proposed building electric readiness to Mandatory and Prescriptive Energy Code requirements and evaluate possible compliance options.

Figure 84: Garden Style Multifamily Case Study: Approved Electric Appliances Installed



The electric ready requirements are all mandatory requirements for new multifamily dwelling units that have gas or propane space or water heating, stoves, or clothes dryers. There are no other prescriptive electric ready requirements. This case study meets those requirements by actually installing electric heat pump space and water heating and an induction electric cooktop. The case study residences do not have clothes dryers, so that requirement does not apply.

Table 11-81: Garden Style Multifamily Case Study Compared to Mandatory and Prescriptive Electric Ready Requirements (Climate Zone 9)

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
New Multifamily Building	New two-story garden style multifamily building, eight dwelling units, no common use areas, Burbank, CA	Sections 160.9, 160.4(a): Systems and equipment using gas or propane to serve individual dwelling units must prepare for future electric replacements as highlighted below. See Energy Code for full details.	N/A	Case study Mandatory and Prescriptive compliance rated for each feature below as "Yes" (complies), "No" (does not comply) or "N/A" (not applicable). If "No", see compliance options provided.
Heat Pump Space Heating Ready	Not required, heat pump space heating being installed	Section 160.9(a): - Dedicated 240 volt branch circuit wiring installed, blank cover labeled "240V ready" - Reserve space in main electrical service panel for double pole circuit breaker for future heat pump labeled "For Future 240V Use"	N/A	Mandatory: Yes Prescriptive: N/A
Heat Pump Water Heater Ready	Not required, heat pump water heater being installed	Section 160.4(a)1: - Dedicated 125 volt, 20 amp electrical receptacle connected to electrical panel with 120/240 volt branch circuit - Unused conductor labeled "spare" and electrically isolated - Reserve space in panel for single pole circuit breaker next to branch circuit and label "Future 240V Use"	N/A	Mandatory: Yes Prescriptive: N/A
Electric Cooktop Ready	Not required, induction electric cooktop being installed	Section 160.9(b): Similar to 160.9(a) for heat pump space heating	N/A	Mandatory: Yes Prescriptive: N/A
Electric Clothes Dryer Ready	Not required, no dwelling unit clothes dryer being installed	Section 160.9(c)1: Similar to 160.9(a) for heat pump space heating	N/A	Mandatory: Yes Prescriptive: N/A
Verifications:	N/A	N/A	N/A	N/A

Source: California Energy Commission

11.10.3.2 Mid-Rise Multifamily Case Study

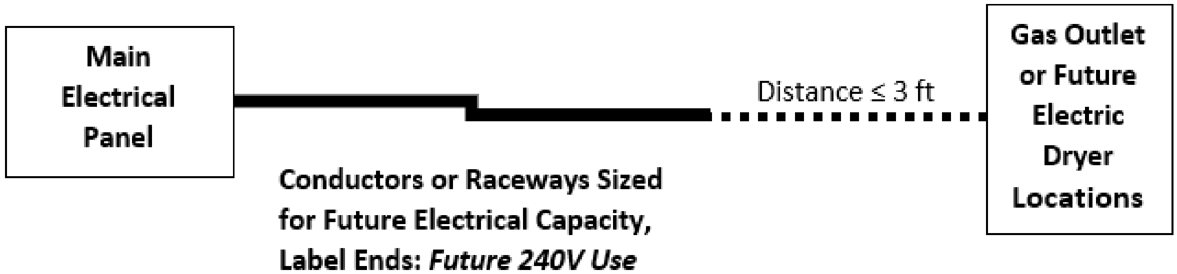
The Mid-Rise Multifamily Case Study covers a new five-story multifamily building in Sacramento, California (Climate Zone (CZ) 12). This is a sample project created for training purposes, and it includes 112,044 ft² of conditioned floor area with 88 dwelling units, shared residential corridors, laundry rooms, fitness center and lounge, plus ground floor retail. The case study table in this chapter compares the proposed building electric readiness to Mandatory and Prescriptive Energy Code requirements and evaluates possible compliance options.

Table 11-82: Proposed Building Electric Readiness to Mandatory and Prescriptive Energy Code Requirements

	CASE STUDY	MANDATORY	PRESCRIPTIVE	COMPLIANCE
Electric Cooktop Ready	Not required, induction electric cooktop being installed	Section 160.9(b): Similar to 160.9(a) for heat pump space heating	N/A	Mandatory: Yes Prescriptive: N/A
Electric Clothes Dryer Ready	Central laundry rooms with gas dryer(s) on 2nd through 5th floors: Electric ready requirements for common use clothes dryers will apply	Section 160.9(c)2A: - Conductors or raceways from main electrical panel to 3 feet or less from each gas outlet or location of future electric dryers. Label both ends "Future 240V Use." Size to meet future electrical loads per i, ii or iii below: i. 24 amps at 208/240V per dryer. ii. 2.6 kVA per 10 kBtuh rated gas input or gas pipe capacity; or iii. Electrical power calculated and documented by responsible person as equivalent to gas capacity.	N/A	Mandatory: Yes Prescriptive: N/A
Verifications:	N/A	N/A	N/A	N/A

Source: California Energy Commission

Figure 85: Electric Clothes Dryer Ready Diagram



The electric ready requirements are all mandatory requirements for new multifamily dwelling units that are served by gas or propane space or water heating or stoves, or by individual or common use clothes dryers. There are no other Prescriptive electric ready requirements. This case study meets the electric ready space heating, water heating and cooktop requirements by actually installing electric heat pump space and water heating and induction electric cooktops.

The case study residences share common laundry rooms with gas clothes dryers, so those areas must meet the electric ready requirements for common use clothes dryers. The basic requirement is to install electrical conductors or raceways that go from the main electrical panel to no more than three feet from each gas outlet or the proposed location of future electric clothes dryers. Generally, conductors may be different types of electrical wiring and raceways are supports or enclosures for electrical wires. The conductors or raceways must be sized according to Energy Code section 160.9(c)2A to meet the future electrical capacity needed for replacement electric dryers. Both ends of the conductors or raceways must be labeled "Future 240V Use."