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SINGLE-FAMILY RESIDENTIAL COMPLIANCE MANUAL

FOR THE 2025 BUILDING ENERGY EFFICIENCY STANDARDS

ENERGY CONSERVATION MANUAL

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CALIFORNIA ENERGY COMMISSION
Gavin Newsom, Governor

CALIFORNIA ENERGY COMMISSION

California Energy Commission

STAFF REPORT

2025 Single-Family Residential Compliance Manual

FOR THE 2025 BUILDING ENERGY EFFICIENCY STANDARDS

2025 Energy Code Conservation Manual

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California Energy Commission

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The Building Energy Efficiency Standards (Energy Code) were first adopted by the California Energy Commission and put into effect in 1978, and have been updated periodically as directed by statute. The Energy Code is a unique California asset that have placed the state on the forefront of energy efficiency, sustainability, energy independence, and climate change issues. These standards also have provided a template for national standards within the United States, as well as for other countries around the globe. They have benefitted from the conscientious involvement and enduring commitment to the public good of many persons and organizations along the way.

The 2025 Energy Code development and adoption process continues a longstanding practice of maintaining the standards with technical rigor, challenging but achievable design and construction practices, public engagement, and full consideration of the views of stakeholders. The 2025 Energy Code revision and the supporting documents were updated through the work of California Energy Commission (CEC) staff and consultants working under contract to the CEC. Support was provided by the utility-organized Codes and Standards Enhancement (CASE) Initiative. Input was also gained by the participation of stakeholders and the contribution of formal public comments.

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ABSTRACT

California’s Building Energy Efficiency Standards were adopted by the California Energy Commission in 1976 and have been updated periodically as directed by statute. In 1975, the California Department of Housing and Community Development adopted rudimentary energy conservation standards under State Housing Law authority that were a precursor to the first generation of the standards. However, the Warren-Alquist Act was passed one year earlier with explicit direction to the California Energy Commission (CEC), formally titled the State Energy Resources Conservation and Development Commission, to adopt and implement the standards. The CEC’s statute created separate authority and specific direction regarding what the standards are to address, what criteria are to be met in developing the Energy Code, and what implementation tools, aids, and technical assistance are provided.

The standards contain energy and water efficiency requirements (and indoor air quality requirements) for newly constructed buildings, additions to existing buildings, and alterations to existing buildings. Public Resources Code Sections 25402 subdivisions (a)-(b) and 25402.1 emphasize the importance of building design and construction flexibility by requiring the CEC to establish performance standards, in the form of an “energy budget” by building type in terms of the energy consumption per square foot of floor space.

Public Resources Code Section 25402.1 requires the CEC to support the Energy Code with compliance tools for builders and building designers. The Compliance Manuals provide information supplemental to the Energy Code regulations. The manuals are intended to help plans examiners, inspectors, owners, designers, builders, and energy consultants comply with and enforce California’s Energy Code.

Keywords:

California Energy Commission; mandatory; envelope insulation; California Building Code; prescriptive; HVAC; California Building Energy Efficiency Standards; performance; building commissioning; Title 24, Part 6; valuation; refrigeration; 2025 Building Energy Efficiency Standards; ducts in conditioned spaces; exhaust; residential; high-performance attics; compressed air; nonresidential; high-performance walls; acceptance testing; newly constructed; high-efficacy lighting; data collection; additions and alterations to existing buildings; water heating; cool roof; windows; on-site renewable; 2025 Energy Code; indoor air quality; field verification and diagnostic testing; swimming pool; photovoltaic; PV; battery; solar ready; electric-ready

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Introduction

This compliance manual is intended to help plans examiners, inspectors, owners, designers, builders, and energy consultants comply with and enforce California's 2025 Building Energy Efficiency Standards (Energy Code) for single-family residential buildings. The manual is written as a reference and instructional guide and can be helpful for anyone who is directly or indirectly involved in the design and construction of energy-efficient single-family residential buildings.

The compliance manual has ten chapters:

Chapter 1 introduces the Energy Code and discusses the application and scope of the standards for single-family residences.

Chapter 2 analyzes the compliance and enforcement process, including design and preparation of compliance documentation through field verification and diagnostic testing.

Chapter 3 details the building envelope.

Chapter 4 discusses heating, ventilation, and air-conditioning (HVAC) systems.

Chapter 5 outlines water-heating systems requirements, including the requirements for swimming pool systems.

Chapter 6 looks at requirements for hardwired interior lighting and for outdoor lighting permanently attached to the building.

Chapter 7 examines photovoltaic systems (PV), battery storage systems, and shared solar electric systems or community-shared battery system compliance option and solar-ready requirements for single-family residential buildings.

Chapter 8 outlines the performance approach to compliance.

Chapter 9 goes over additions, alterations, and repairs.

Chapter 10 covers the mandatory electric readiness requirements for mixed- fuel single-family buildings.

Related Documents

This compliance manual supplements four other related documents that are available from the California Energy Commission. These are:

- The *2025 Building Energy Efficiency Standards, Title 24, Part 1 and Part 6* (Energy Code). This compliance manual supplements, explains, and clarifies California's energy efficiency standards for buildings; it does not replace them. Readers should refer to a copy of the Energy Code while reading this manual, as well as a copy of the *2025 Reference Appendices*.
- The *2025 Reference Appendices*. The reference appendices have three main subsections: Reference Joint Appendices, Reference Residential Appendices, and Reference Nonresidential Appendices:

- The *2025 Reference Joint Appendices* contain information common to single-family residential, nonresidential, and multifamily buildings including, but not limited to, definitions, climate zone information, weather data, assembly properties, qualification requirements for high-efficacy light sources, compliance documentation registration procedures, qualification requirements for photovoltaic systems, and qualification requirements for battery storage systems.
    - The *2025 Reference Residential Appendices* contain information for single-family residential and low-rise multifamily buildings. The Reference Residential Appendices contain Energy Code Compliance (ECC) field verification and diagnostic testing procedures for HVAC equipment, air distribution ducts, and quality insulation installation.
    - The *2025 Reference Nonresidential Appendices* contain information for nonresidential and high-rise multifamily buildings. The reference nonresidential appendices contain ECC field verification and diagnostic testing procedures for HVAC equipment and air distribution ducts, acceptance testing procedures, and luminaire power default values.
- The *2025 Single-family Residential Alternative Calculation Method Reference Manual* lays out the technical rules for implementing the 2025 performance compliance path in software programs.

Material from related documents is referenced but not repeated in this compliance manual. If you are using the electronic version of this compliance manual, there are hyperlinks throughout the manual that will take you directly to referenced documents.

The Technical Chapters

Please refer to Chapter 1.2 of the *2022 Single-Family Residential Compliance Manual*.

Why California Needs Building Energy Efficiency

Standards

Please refer to Chapter 1.3 of the *2022 Single-Family Residential Compliance Manual*.

Energy Savings

Reducing energy use benefits everyone. Homeowners save money, Californians have a more secure and healthy economy, the environment is less negatively impacted, and the state electrical system can operate in a more stable manner. The 2025 Energy Code (for residential and nonresidential buildings) is expected to reduce the growth in electricity use and natural gas use.

Electricity Reliability and Demand

Buildings are a significant source of electricity demand. Following previous California electricity crises and blackouts, the Energy Commission has placed greater emphasis on demand reduction. The Energy Commission has learned that the electric distribution network is fragile, and system overloads caused by excessive demand from buildings can create unstable conditions. Moreover, blackouts can seriously disrupt business and cost the economy billions of dollars.

Comfort

Please refer to Chapter 1.3.3 of the *2022 Single-Family Residential Compliance Manual*.

Economics

Please refer to Chapter 1.3.4 of the *2022 Single-Family Residential Compliance Manual*.

Environment

Please refer to Chapter 1.3.5 of the *2022 Single-Family Residential Compliance Manual*.

Global Warming

Please refer to Chapter 1.3.6 of the *2022 Single-Family Residential Compliance Manual*.

Building Decarbonization

California has nearly 14 million homes and 7.5 million square feet of commercial buildings. These buildings produce a quarter of the state's greenhouse gas (GHG) emissions, making homes and businesses a major factor in climate change. Reducing these emissions, also referred to as building decarbonization, is a key part of California's climate strategy. Of the many tools in the state's building decarbonization toolbox, the decarbonizing co-benefits of the California Energy Code stand out as a proven solution of significance.

The Warren-Alquist Act

Please refer to Chapter 1.3.8 of the *2022 Single-Family Residential Compliance Manual*.

What's New for 2025

The most significant change in the 2025 Building Energy Efficiency Standards affecting single-family residential buildings is the change to a single fuel baseline with heat pump being prescriptively required for both water heating and space heating.

Summary of Changes for Residential Buildings Include:

Mandatory Requirements:

- Heat pump water heaters installed with inlet air from outside must have backup heat if compressor cutout temperature is above or equal to the local Heating Winter Median of Extremes (Section 110.3(c)7A).
- Ventilation is required when installing a heat pump water heater (Section 110.3(c)7B).
- Pool- and/or spa-heating systems must be sized appropriately in newly constructed single-family buildings with heated swimming pools and spas (Section 110.4(c)).
- Heat pump pool heaters with supplementary heaters shall have controls installed to ensure that the supplementary heater does not operate when the heating load can be met by the heat pump alone (Section 110.4(d)).

- Exception to mandatory roof deck insulation in newly constructed attic systems in Climate Zones 4 and 8–16 to meet an area-weighted average U-factor no greater than 0.184 (Section 150.0(a)1), if the space-conditioning system is a ductless systems or for space-conditioning duct systems buried within insulation in an attic that complies using Section 150.1(b) and is verified according to RA 3.1.4.1.
- Increased mandatory required minimum wall insulation from R-13 to R-15 (0.095 U-factor) for 2 x 4 wood framed wall assemblies, and R-20 to R-21 (0.069 U-factor) for 2 x 6 assemblies (Section 150.0(c)).
- Clarifies that *block loads* (the total load for all rooms combined that are served by the central equipment) may be used for the purpose of system sizing for additions (Section 150.0(h)1).
- Provides guidance on how to use authorized load calculations in system sizing and selection. Specifically, states that heat pump heating capacity must meet minimum requirements from the California Building Code without including supplementary heating capacity; clarifies that there is no limit on minimum cooling or maximum heating capacity, and furnace heating capacity is based on ACCA Manual S-2023, Table N2.5 (Section 150.0(h)5).
- Establishes defrost requirements. Specifically, if a heat pump is equipped with a installer-adjustable defrost delay timer, the delay timer shall be set to greater than or equal to 90 minutes. This control configuration shall be tested by the installer and certified on the CF2R. Exceptions include homes in Climate Zones 6 and 7, and homes with conditioned floor area of 500 square feet or less in Climate Zones 3, 5–10, and 15 (Section 150.0(h)6).
- Requires that heat pump supplementary heating (electric resistance or gas) shall operate only above an outdoor temperature of 35°F during defrost or when the user selects emergency operation. This control configuration shall be tested by the installer and certified on the CF2R. There are exceptions for room air-conditioner heat pumps, buildings in Climate Zones 7 and 15, and buildings with a conditioned floor area less than 500 square feet (Section 150.0(h)7).
- Requires that electric resistance supplementary heat can have a capacity no larger than the heat pump nominal cooling capacity (at 95°F ambient conditions) multiplied by 2.7 kilowatts (kW) per ton, rounded up to the closest kW (Section 150.0(h)8).
- Requires that variable- or multispeed systems controlled by third-party thermostats shall be capable of responding to heating and cooling loads by modulating system compressor speed and meet thermostat requirements in Section 150.0(i)2. This control configuration shall be tested by the installer and certified on the CF2R (Section 150.0(h)9).
- Requires that thermostats controlling heat pumps with supplementary heat (electric resistance or gas) shall receive outdoor air temperature from an outdoor air temperature sensor or from an internet weather service, display the outdoor temperature, have an indicator to notify when supplementary heat or emergency heat is in use, and lock out supplementary heat when the outdoor temperature is above 35°F (alone or in conjunction with heat pump operation). This control configuration shall be tested by the installer and certified on the CF2R. There are exceptions for room air-conditioner heat pumps (Section 150.0(i)).

- Allows ducts in unvented attics to be insulated to R-4.2, less than the mandatory minimum of R-6, provided certain other requirements are met (Section 150.0(m)1Bi).
- Allows multispeed or variable-speed compressor systems with controls that vary fan speed based on the number of zones to conditioning may demonstrate compliance with airflow and fan efficacy requirements of 150.0(m)13C by operating the system at maximum compressor capacity and system fan speed, with all zones calling for conditioning (Section 150.0(m)13).
- Revises to new whole dwelling unit mechanical ventilation rates for detached and attached single-family dwellings (Section 150.0(o)1C). The revision includes accessibility requirements to facilitate servicing balanced and supply-only ventilation systems including accessibility of indoor air quality (IAQ) filters and heat recovery ventilation/energy recovery ventilator (HRV/ERV) cores, IAQ System components, and outdoor air intake location, as well as outdoor air intake design (Section 150.0(o)1Civ).
- Mandatory minimum U-factor for fenestration, including skylights, decreased to a weighted average U-factor of 0.40 (Section 150.0(q)).
- Fenestration installed in buildings located in fire hazard severity zones or wildland-urban interface (WUI) fire areas as designated by the local enforcement agency, is excepted from mandatory fenestration requirements (Section 150.0(q)).
- The battery energy storage system ready requirements have been updated to apply only for newly constructed single-family buildings that have a minimum 125 amp service panel, and an exception was added for single-family buildings that have already installed battery energy storage systems (Section 150.0(s)).

Prescriptive Compliance:

- The prescriptive maximum U-factor requirement for window assemblies in most homes was reduced to 0.27 from 0.30 in Climate Zones 1 through 5, 11 through 14, and 16; all other climate zones remain at 0.30 U-factor. This change applies to homes 500 square feet or less except in Climate Zone 5, where the prescriptive maximum U-factor for homes 500 square feet or less remains at 0.30 (Section 150.1(c)3A).
- A new alternative prescriptive compliance pathway under Option C of Table 150.1-A, for cathedral ceilings in single-family new construction. Cathedral ceilings will require a minimum R-value of 38 across all climate zones (Section 150.1(c)1A).
- Under the prescriptive compliance approach, in all climate zones, the heating equipment is required to be a heat pump or shall meet the performance compliance requirements of Section 150.1(b)1 (Section 150.1(c)6).
- Refrigerant charge verification is now required for heat pumps in all climate zones (Section 150.1(c)7A, Table 150.1-A).
- Fault indicator displays have been removed as an available method for refrigerant charge verification (Section 150.1(c)7A).

- Introduce solar access roof area (SARA) multipliers for steep-sloped and low-sloped roofs that are used to determine the PV system size in kW for a given square foot area of usable SARA roof space (Section 150.1(c)14).

Performance Compliance:

- Long-term system cost (LSC) and source energy metrics used for compliance through the performance approach (Section 150.1(b)1).

Additions and Alterations:

- Mandatory requirement for heat pump water heaters installed with inlet air from outside must have backup heat if the compressor cutout temperature is above or equal to the local heating winter median of extremes (Section 110.3(c)7A).
- Mandatory requirement for ventilation when installing a heat pump water heater (Section 110.3(c)7B).
- For additions greater than 700 square feet, the prescriptive maximum U-factor requirement for window assemblies was reduced to 0.27 from 0.30 in Climate Zones 1–5 , 11–14, and 16; the prescriptive maximum U-factor in Climate Zones 6–10 and 15 remains at 0.30. For alterations that add fenestration area, the maximum solar heat gain coefficient (SHGC) value in Climate Zone 15 is 0.23 (Section 150.2(a)1A, Table 150.1-A).
- For additions 700 square feet or less, Option C for roof insulation provides a new alternative prescriptive pathway for cathedral ceilings. Cathedral ceiling will require a minimum R-value of 38 for all climate zones (Section 150.2(a)1B, Table 150.1-A).
- In addition to the requirements in Section 150.0(h) for additions, in situations where airflow is NOT field verified to be at least 350 cubic feet per minute (cfm)/ton, maximum capacity limits are provided in Tables 150.2-A and B that depend on the relative sizes of the calculated heating design load (HL) and cooling design load (CL), the type of space conditioning system, and the duct sizing (Section 150.2(a)1E). There is an exception for ductless space-conditioning systems, as well as variable-speed and multispeed systems.
- For additions, the envelope leakage specified in the space-conditioning load calculation shall be no greater than the values shown in Table 150.2-C ("average" for many load calculation software tools). If leakage is established through field verification and diagnostic testing, the tested envelope leakage value may be used in the load calculations (Section 150.2(a)1E).
- The energy budget for additions is expressed in terms of LSC (Section 150.2(a)2).
- For altered space-conditioning systems refrigerant charge verification is required for heat pumps in all climate zones, and for air conditioners in Climate Zones 2 and 8–15 (Section 150.2(b)1F).
- Fault indicator displays have been removed as an available method for refrigerant charge verification (Section 150.2(b)1F).

Scope and Application

Building Types

Though the Energy Code applies to nonresidential and residential buildings, this compliance manual addresses only the requirements for single-family residential buildings. Companion compliance manuals address the requirements for nonresidential buildings, including hotels, motels, and multifamily buildings.

Mixed Low-Rise Residential and Nonresidential Occupancies

Reference: Section 100.0(f)

When a building includes both low-rise residential and nonresidential occupancies, the requirements are different depending upon the percentages of the conditioned floor area (CFA) that is occupied by each occupancy type.

Minor Occupancy (Exception 1 to Section 100.0(f)).

When a residential occupancy occurs in the same building as a nonresidential occupancy, and if one of the occupancies is less than 20 percent of the total conditioned floor area, the smaller occupancy is considered a "minor" occupancy. Under this scenario, optionally, the entire building may be treated as if it is the major occupancy for envelope, HVAC, and water heating. Lighting requirements in Section 140.6 through Section 140.8 or Section 150.0(k) must be met separately for each occupancy. The mandatory requirements applicable to the minor occupancy, if different from the major occupancy, would still apply.

Mixed Occupancy

When residential occupancy is mixed with a nonresidential occupancy, and if neither occupancy is less than 20 percent of the total conditioned floor area, these occupancies fall under different sets of standards and must be considered separately. Two compliance submittals must be prepared, each using the calculations and forms of the respective standards. Separate compliance for each occupancy, to the respective standards, is an option when one of the occupancies is a minor occupancy, as discussed in the paragraph above.

The 2025 Energy Code definition of a *habitable story* is a story that contains habitable space and that has at least 50 percent of the volume above grade. *Habitable space* is space in a building for living, sleeping, eating, or cooking, excluding bathrooms, toilets, hallways, storage areas, closets, utility rooms and similar areas. Mezzanines are not counted as separate habitable stories, nor are minor conditioned spaces, such as an enclosed entry stair that leads to an apartment or dwelling unit on the next floor (Section 100.1(b)).

Single-Family Building Types Covered by the Energy Code

All single-family dwellings of any number of stories (Group R-3). These may include accessory dwelling units, townhouses and buildings of an accessory character (Group U) e.g. private garages.

All duplex (two-dwelling) buildings of any number of stories (Group R-3).

Residential facilities licensed by a governmental agency for a residentially based 24-hour care facility providing accommodations for six or fewer clients of any age (Group R-3.1).

Additions and alterations to the above buildings.

Explanation of Terms

The term building type refers to the classification of buildings defined by the CBC and applicable to the requirements of the Building Energy Efficiency Standards. This manual is concerned with the Energy Code that applies to all single-family residential buildings described in Single-Family Building Types Covered by the Energy Code. Multifamily residential buildings are addressed in the Energy Commission's *2025 Multifamily Compliance Manual*.

A *multifamily building* is any of the following:

- A building of Occupancy Group R-2, other than a hotel/motel building or timeshare property
- A building of Occupancy Group R-3 that is a nontransient congregate residence, other than boarding houses of more than 6 guests and alcohol or drug abuse recovery homes of more than 6 guests
- A building of Occupancy Group R-4

A *newly constructed* building is a building that has never been used or occupied for any purpose.

An addition increases the conditioned floor area and volume of an existing building, which can be from new construction or installation of space conditioning for an existing unconditioned space. See Chapter 9 for more information on energy compliance of additions.

An *existing building* is "... a building erected prior to the date of adoption of [the current] code, or one for which a legal building permit has been issued." (CBC, Part 2)

Building Orientation

Reference: Section 100.1(b)

Building orientation can affect the energy use of a building, particularly in cooling-dominated climate zones with a high amount of west-facing glass. When using the prescriptive approach, compliance with the Energy Code, a building's orientation must be determined in order to ensure compliance with the appropriate orientation dependent requirements When using the performance approach, the buildings orientation input is based on the actual azimuth of the front of the building.

"East-facing is oriented to within 45 degrees of true east, including 45°0'0" south of east (SE), but excluding 45°0'0" north of east (NE)." (Section 100.1)

"North-facing is oriented to within 45 degrees of true north, including 45°0'0" east of north (NE), but excluding 45°0'0" west of north (NW)." (Section 100.1)

"South-facing is oriented to within 45 degrees of true south, including 45°0'0" west of south (SW), but excluding 45°0'0" east of south (SE)." (Section 100.1)

"West-facing is oriented to within 45 degrees of true west, including 45°0'0" due north of west (NW) but excluding 45°0'0" south of west (SW)." (Section 100.1)

Historical Buildings

Please refer to Chapter 1.5.4 of the *2022 Single-Family Residential Compliance Manual*.

Buildings Not Required to Meet Prescriptive and Performance Standards

Please refer to Chapter 1.5.5 of the *2022 Single-Family Residential Compliance Manual*.

Building Systems Covered

The single-family residential standards affect the design of the building envelope, the HVAC system, the water-heating system, solar PV and battery energy storage systems, and the lighting system. The Energy Code does not regulate the efficiency requirements of residential appliances, such as elevators or dumbwaiters, or portable lighting systems that are plugged into a wall outlet. Residential appliances used for space conditioning, ventilation, and water heating are required to meet minimum efficiency requirements (Appliance Efficiency Regulations), which are federally regulated. Hardwired lighting, which includes lighting that is a permanent part of the building, is also regulated by the Energy Code.

Additions, Alterations, and Repairs

Reference: Section 100.1(b), Section 150.2(a), Section 150.2(b)

Additions, alterations, and repairs are common construction projects for California homeowners. The Energy Code applies to additions and alterations, but not to repairs. See Chapter 9 for details.

As described in the Scope section, an addition increases the conditioned floor area and volume of an existing building, which can be from new construction or installation of space conditioning for an existing unconditioned space.

Newly conditioned space is any space being converted from unconditioned to directly conditioned or indirectly conditioned space. Newly conditioned space must comply with the requirements for an addition.

Chapter 9 includes detailed guidance on showing compliance for accessory dwelling units and converting an existing unconditioned space to conditioned space.

Alterations that are not additions are changes to the water-heating system, space-conditioning system, lighting system, electrical power distribution system or envelope of a building.

Repairs are the reconstruction or renewal of any part of an existing building for maintenance purposes and are not under the scope of the standards. Replacement of any component systems (such as reroofing) or equipment for which there are requirements in the Energy Code is considered an alteration and not a repair.

Example 1-1

Question

The Energy Code does not specify whether buildings damaged by natural disasters can be reconstructed to the original energy performance specifications. What requirements apply under these circumstances?

Answer

Buildings destroyed or damaged by natural disasters must comply with the Energy Code requirements in effect when the builder or owner applies for a permit for those portions of the building that are being rebuilt.

Example 1-2

Question

Does the Energy Code apply to an addition to a manufactured ("mobile") home?

Figure 1-1: Mobile Home

Source: California Energy Commission (Brian Vahey)

Answer

No. Title 25, not Title 24, governs manufactured homes, including additions to the unit. Jurisdiction in a mobile home park falls under the authority of the Department of Housing and Community Development. Jurisdiction of a mobile home on private property may fall under the authority of the local building department.

Example 1-3

Question

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

Answer

It depends on how the townhouse is classified by the enforcement agency. If the enforcement agency classifies the townhouse as a Group R-3 occupancy, the single-family residential standards will apply. If the townhouse is classified by the enforcement agency as another Group R occupancy (i.e., Group R-2) and all four stories are habitable, the multifamily residential standards will apply. If the enforcement agency classifies the townhouse as a group R-2 occupancy but three or fewer stories are habitable, the single-family residential standards will apply.

Example 1-4

Question

A 2,100 ft^2 manager's residence is being constructed as part of a new 14,000 ft^2 conditioned warehouse building. Which Energy Code applies?

Answer

The whole building can comply with the nonresidential standards, and the residential unit is not required to comply separately since it is a subordinate occupancy comprising less than 20 percent of the total conditioned floor area. However, the residential dwelling unit must meet all single-family residential mandatory requirements, as well as the lighting and water-heating requirements.

Example 1-5

Question

Assume the same scenario as in the previous example, except that the dwelling unit is new, and the remainder of the building is existing. Do the residential standards apply?

Answer

Yes. Since 100 percent of the addition being permitted is a single-family residential occupancy, compliance under the residential standards is required.

Example 1-6

Question

A residence is being moved to a different location. What are the applicable compliance requirements?

Answer

Because this is an existing conditioned space, the requirements applicable to alterations would apply to any alterations being made. The building does not need to show compliance with the current Energy Code applicable to new buildings or additions.

Example 1-7

Question

A previously conditioned retail space is remodeled to become a residential dwelling. What are the applicable compliance requirements?

Answer

The remodeled dwelling is treated as if it were previously a residential occupancy. In this case, the rules that apply to residential alterations are applied.

Example 1-8

Question

A subdivision of detached homes includes several unit types, each of which may be constructed in any orientation. What are the applicable compliance requirements?

Answer

The single-family residential standards are applied to each building type. All four cardinal orientations may be shown to comply, or each unit in the planned orientation must comply.

Compliance Approaches and Mandatory Requirements

Please refer to Chapter 1.6 of the *2022 Single-Family Residential Compliance Manual.*

Approaches

The prescriptive approach, composed of a climate zone-dependent prescriptive package, is less flexible but simpler than the performance approach. Each energy component of the proposed building must meet a prescribed minimum efficiency. The prescriptive approach offers relatively little design flexibility but is easy to use. There is some flexibility for building envelope components. For example, if a portion of a wall does not meet the prescriptive insulation requirement, an area-weighted average of all walls can be used to meet the prescriptive requirement.

The performance approach is more complicated but offers considerable design flexibility. The performance approach uses an approved software program to model a proposed building and compare it to a calculated energy budget. Performance compliance is based on the building's envelope, HVAC systems, DHW systems, and solar PV system efficiencies. This approach is popular with builders because of the flexibility, and it provides a way to find the most cost-effective solution for complying with the Energy Code.

For additions and alterations, see Chapter 9 for details of compliance approaches that are available.

Mandatory Requirements

Reference: Section 150.0

With either the prescriptive or performance approaches, applicable mandatory requirements must always be met or exceeded. Some mandatory requirements deal with infiltration control and lighting, others require minimum insulation levels or equipment efficiencies.

Minimum mandatory levels are sometimes superseded by more stringent prescriptive or performance approach requirements. For example, if mandatory requirements specify R-22 ceiling insulation and the prescriptive approach is used, then R-38 ceiling insulation (depending on climate zone) must be installed.

Conversely, the mandatory requirements may be of a higher efficiency than permitted under the performance approach; in these instances, the higher mandatory levels must be installed. For example, a building may comply using the performance approach by modeling only R-7 insulation in a raised floor, but R-19 insulation must be installed because that is the mandatory minimum.

Prescriptive Approach

Reference: Section 150.1(c)

As described above, the prescriptive approach is a set of predefined performance levels for various building components. The prescriptive requirements are represented in Table 150.1-A for newly constructed single-family buildings. Each component shall meet or exceed the minimum efficiency level specified in Table 150.1-A and related footnotes in the Energy Code. In some climate zones, these prescriptive requirements specify that many cooling system types are ECC-tested to verify that they have the correct refrigerant charge.

Performance Approach

Reference: Section 150.1(b)

The performance approach described above requires that the building comply with the hourly source energy, efficiency long-term system cost (efficiency LSC), total long-term system cost (total LSC), and peak cooling. These metrics are detailed in the *2025 Single-Family Residential Buildings Alternative Calculation Method Reference Manual.*

LSC shall be calculated for the proposed building and compared to the standard LSC budget. LSC is the "currency" for the performance approach. LSC not only considers the type of energy that is used (electricity, gas, or propane), but when it is used. Energy saved during periods when California is likely to have a statewide system peak is worth more than energy saved at times when supply exceeds demand.

Reference Joint Appendix JA3 has more information on LSC.

See Chapter 8 of this manual for more information on the performance method.

Climate Zones

Please refer to Chapter 1.7 of the *2022 Single-Family Residential Compliance Manual*.

Building Location Climatic Data

Building location climatic data refer to specific outdoor design conditions used in calculating heating and cooling loads. These data typically include the warmest and coolest outdoor temperatures that a building is likely to experience in an average year in a particular location.

For heating, the minimum outdoor design temperature is the winter median of extremes. A higher design temperature is permitted but not a lower value. For cooling, the outdoor design temperature must be the 1.0 percent summer design dry bulb and the 1.0 percent wet bulb.

If a building location is not listed, the local enforcement agency may determine the location for which data are available that is closest in its design characteristics to the actual building site.

Conditioned Floor Area

Please refer to Chapter 1.8 of the *2022 Single-Family Residential Compliance Manual*.

Where to Get Help

Please refer to Chapter 1.9 of the *2022 Single-Family Residential Compliance Manual*.

Energy Commission Publications and Support Telephone Hotline

If the information contained in the Energy Code or this compliance manual are not sufficient to answer a specific question concerning compliance or enforcement, technical assistance is available from the Energy Code Hotline.

You can reach the Energy Code Hotline on weekdays from 8 a.m.–noon and 1 p.m.–4:30 p.m.:

- https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/energy-code-hotline-submission
- (800) 772-3300
- (916) 654-5106

Publications

Publications including the *2025 Building Energy Efficiency Standards*, the *2025 Reference Appendices*, the *2025 Residential ACM Reference Manuals*, and others are available from the Energy Commission's website at http://www.energy.ca.gov/title24. Paper copies may also be ordered from:

Publications Unit

California Energy Commission

715 P Street, MS-5

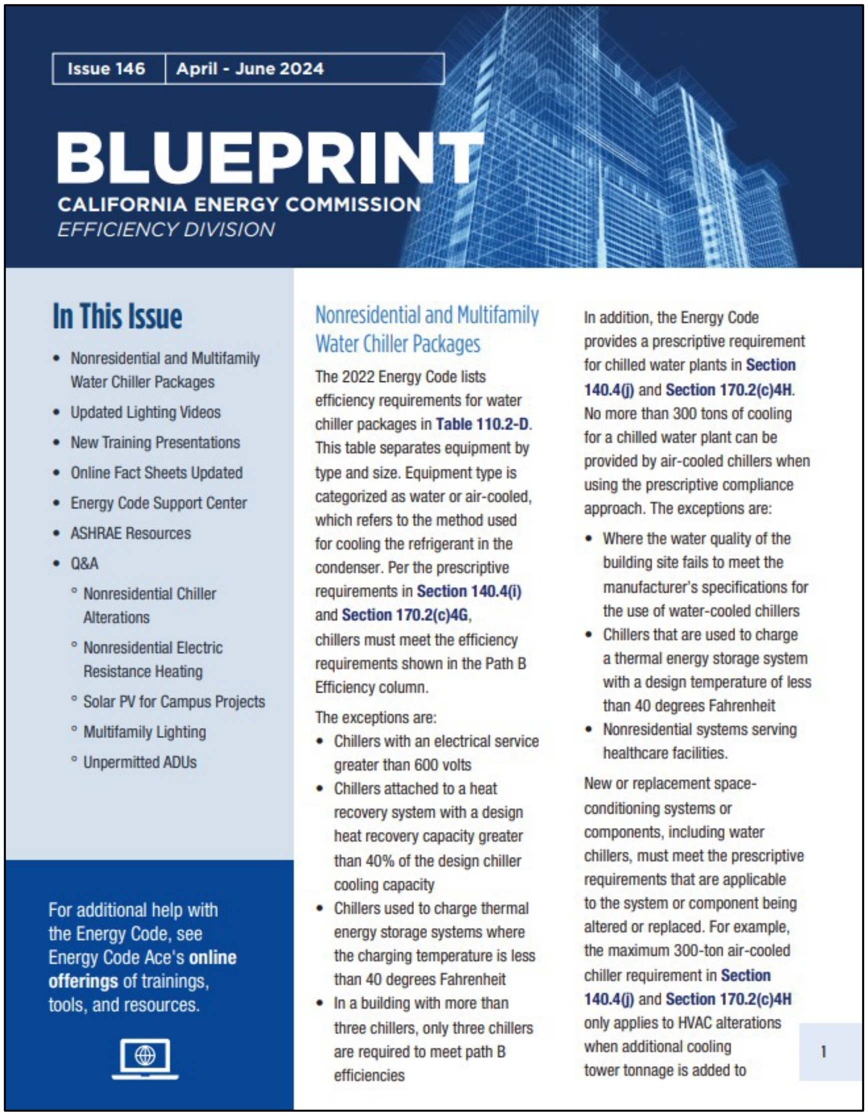
Sacramento, CA 95814

(916) 654-5200

Blueprint

The Energy Commission publishes the *Blueprint*, a newsletter that answers questions and addresses issues related to enforcement and compliance. The *Blueprint* also provides updated information on technical assistance and building energy modeling compliance software and lists training opportunities offered throughout the state. The *Blueprint* is available online at https://www.energy.ca.gov/newsroom/blueprint-newsletter.

Figure 1-2: Energy Commission Blueprint Newsletter



Issue 146 | April - June 2024

BLUEPRINT

CALIFORNIA ENERGY COMMISSION

EFFICIENCY DIVISION

In This Issue

- Nonresidential and Multifamily Water Chiller Packages
- Updated Lighting Videos
- New Training Presentations
- Online Fact Sheets Updated
- Energy Code Support Center
- ASHRAE Resources
- Q&A
  - Nonresidential Chiller Alterations
  - Nonresidential Electric Resistance Heating
  - Solar PV for Campus Projects
  - Multifamily Lighting
  - Unpermitted ADUs

For additional help with the Energy Code, see Energy Code Ace's **online offerings** of trainings, tools, and resources.

Nonresidential and Multifamily Water Chiller Packages

The 2022 Energy Code lists efficiency requirements for water chiller packages in **Table 110.2-D**. This table separates equipment by type and size. Equipment type is categorized as water or air-cooled, which refers to the method used for cooling the refrigerant in the condenser. Per the prescriptive requirements in **Section 140.4(i)** and **Section 170.2(c)4G**, chillers must meet the efficiency requirements shown in the Path B Efficiency column.

The exceptions are:

- Chillers with an electrical service greater than 600 volts
- Chillers attached to a heat recovery system with a design heat recovery capacity greater than 40% of the design chiller cooling capacity
- Chillers used to charge thermal energy storage systems where the charging temperature is less than 40 degrees Fahrenheit
- In a building with more than three chillers, only three chillers are required to meet path B efficiencies

In addition, the Energy Code provides a prescriptive requirement for chilled water plants in **Section 140.4(j)** and **Section 170.2(c)4H**. No more than 300 tons of cooling for a chilled water plant can be provided by air-cooled chillers when using the prescriptive compliance approach. The exceptions are:

- Where the water quality of the building site fails to meet the manufacturer's specifications for the use of water-cooled chillers
- Chillers that are used to charge a thermal energy storage system with a design temperature of less than 40 degrees Fahrenheit
- Nonresidential systems serving healthcare facilities.

New or replacement space-conditioning systems or components, including water chillers, must meet the prescriptive requirements that are applicable to the system or component being altered or replaced. For example, the maximum 300-ton air-cooled chiller requirement in **Section 140.4(j)** and **Section 170.2(c)4H** only applies to HVAC alterations when additional cooling tower tonnage is added to

1

Source: California Energy Commission

Appliance Standards

Appliances, as defined by the CEC, include everything from dishwashers and refrigerators to air conditioners and boilers. The performance of some appliances, such as air conditioners, water heaters, and furnaces, is critical to the *Building Energy Efficiency Standards.* The energy efficiency of other appliances, such as refrigerators, dishwashers, and clothes dryers, is important to homeowners but does not affect the *Building Energy Efficiency Standards* since these are considered home furnishings. The CEC has a comprehensive list of standards that affect the performance of many appliances. Appliance Standards information is available from the CEC website at https://www.energy.ca.gov/rules-and-regulations/appliance-efficiency-regulations-title-20.

Appliance Directories

The CEC publishes information on the energy efficiency of appliances. CEC-approved directories can be used to determine if appliances meet the mandatory requirements or the prescriptive requirements or both. Data may also be used in performance calculations. The

Energy Code Hotline can verify certification of appliances and provide information on appropriate directories.

The complete appliance database (including manufacturer, brand codes, rated efficiencies, and so forth) can be searched from the Energy Commission's website at

https://www.energy.ca.gov/programs-and-topics/programs/appliance-efficiency-program-outreach-and-education/modernized.

Directory of Certified Insulation Materials

Manufacturers of insulation materials certified for sale in California are listed in the Department of Consumer Affairs' *Consumer Guide and Directory of Certified Insulation Material*. Each building department receives a copy of this directory. If an insulation product is not listed in the directory, or if you want to purchase a directory, please contact the Department of Consumer Affairs, Bureau of Household Goods and Services (BHGS), at (916) 999-2041 or visit https://bhgs.dca.ca.gov/.

Energy Consultants

Please refer to Chapter 1.9.3 of the *2022 Single-Family Residential Compliance Manual*.

Online Videos

Please refer to Chapter 1.9.4 of the *2022 Single-Family Residential Compliance Manual*.

Energy Code Compliance (ECC) Program

To comply with the Energy Code, some projects require third-party field verification and diagnostic testing of energy-efficient systems or devices. ECC-Raters are expected to be hired by the builder or building owner to perform this work. Installing contractors may hire the ECC-Rater for HVAC changeouts only if the homeowner authorizes the installing contractor to do so. The CEC approves ECC-Providers to train, certify, and monitor ECC-Raters.

For a list of ECC-Providers, please visit the Energy Code Compliance Program web page at https://www.energy.ca.gov/programs-and-topics/programs/energy-code-compliance-program. To find an ECC-Rater, browse to the ECC-Providers' websites to find listings of certified ECC-Raters and ECC-Rating Companies.

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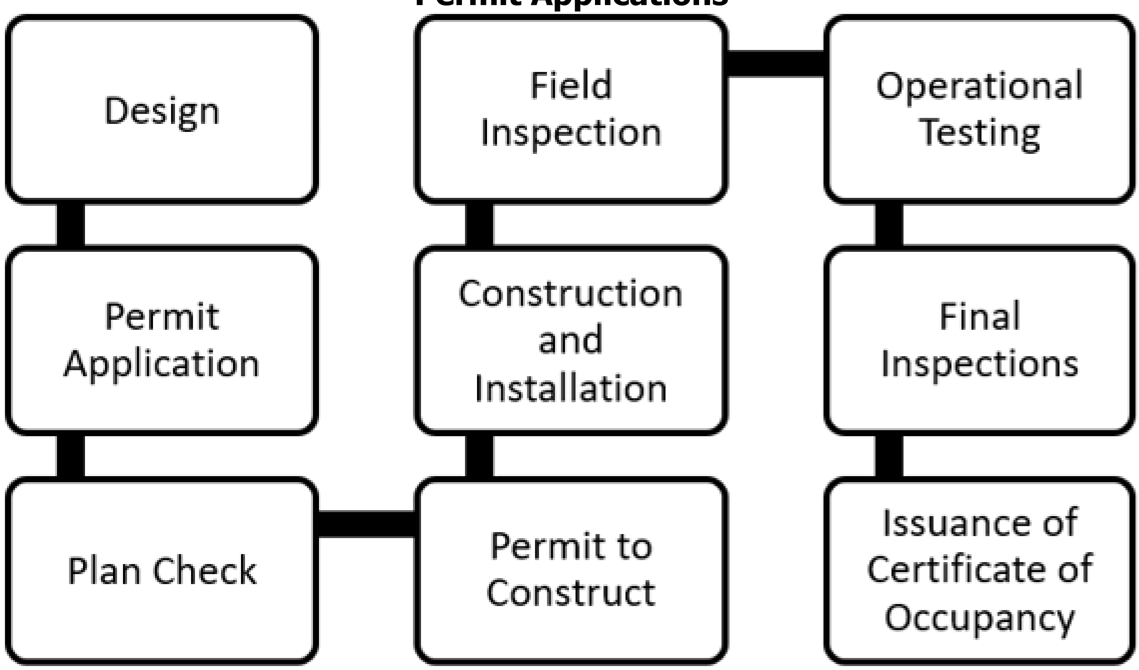
Compliance and Enforcement

Overview

The Energy Commission does not directly enforce California's 2025 Building Energy Efficiency Standards (Energy Code). Authorities having jurisdiction (AHJ) have the responsibility of issuing building permits for newly constructed buildings or additions and alterations to existing buildings and enforcing the California Building Code (CBC), Title 24 of the California Code of Regulations in totality, including the Energy Code. Most AHJs are local enforcement agencies, typically associated with a city or county government, but can also include other agencies such as the Division of the State Architect (for schools).

This chapter of the *Single-Family Compliance Manual* will show how compliance and enforcement of the Energy Code is achieved in the typical single-family residential building project permitting process used by most AHJs, which follow some version of the permitting process prescribed by the International Code Council (ICC). Figure 2-1: Idealized International Code Council Permitting Process for Building Permit Applications shows an idealized version of the ICC permitting process.

Figure 2-1: Idealized International Code Council Permitting Process for Building Permit Applications



Source: California Energy Commission staff

To assist the enforcement agency, the CEC created three categories of compliance documents for single-family construction projects used to demonstrate compliance with the Energy Code:

- Certificate of compliance documents (CF1R) are completed by the project proponent and submitted to the enforcement agency during the plan check phase (Section 10-103(a)1).
- Certificates of installation (CF2R) are completed by the installing technician or contractor during construction and submitted to the enforcement agency during field inspections throughout the construction phase (Section 10-103(a)3).

- Certificates of verification (CF3R) are completed by an Energy Code Compliance (ECC)-Rater certified by an Energy Commission-approved ECC-Provider and submitted to the enforcement agency during the final inspection phase and prior to the enforcement agency issuing the certificate of occupancy (Section 10-103(a)5).

ECC-Raters are independent, third-party agents, made available through the Energy Commission's ECC program. The ECC program consists of ECC-Providers, approved by the CEC to train, certify, and oversee ECC-Raters, who perform field verification and diagnostic testing as required for compliance with the Energy Code.

ECC-Verification ensures the proposed ECC measures are installed and comply with the Energy Code. The compliance and enforcement process requires participation from the architect, building designer, engineers, energy consultants, builders, contractors, the owner, ECC-Raters, and others. This chapter describes the overall compliance and enforcement process and responsibilities throughout the permit process.

Manufacturer Certification for Equipment, Products, and Devices

During the permit application phase, certain equipment, products, and devices must be selected for installation or use that are certified to be compliant with the Energy Code. These items are identified on the CF1Rs and are verified during inspection by the enforcement agency. The equipment, products, and devices must be certified to the Energy Commission by the manufacturer that it meets requirements under the Energy Code. The Energy Commission makes no claim that the listed equipment, products, or devices meet the indicated requirements or, if tested, will confirm the indicated results.

Inclusion on these lists only confirms that a manufacturer certification has been submitted to and accepted by the Energy Commission. [Additional information](http://www.energy.ca.gov/title24/equipment_cert/) about the required information for manufacturers to certify products and for lists of certified products may be found at http://www.energy.ca.gov/title24/equipment_cert/.

In single-family buildings, the following equipment must be certified by the manufacturer:

- Airflow measurement apparatus — forced air systems, ventilation systems, and whole house fan systems (RA3)
- Battery and energy storage systems (JA12)
- Central heat pump water heater (JA14)
- Drain water heat recovery (RA3.6.9)
- Ducted variable-capacity heat pump
- Intermittent mechanical ventilation systems (RA3.7.4.2)
- Heat pump water heater demand management system (JA14)
- Low leakage air-handling unit (JA9)
- Occupant-controlled smart thermostats (JA5)
- Residential fault indicator display (JA6)

Energy Code Compliance Program Compliance Document Registration

Reference: Section 10-103, Reference Residential Appendix RA2, Reference Joint Appendix JA7

The Energy Commission developed the ECC program in part to help ensure compliance with the Energy Code for residential projects that require field verification and diagnostic tests (ECC-Verification). Registration of compliance documentation (CF1Rs, CF2Rs, and CF3Rs) is required for any residential construction project for which a CF3R is required. (Not all residential construction projects require a CF3R.) Reference Residential Appendix RA2 and Reference Joint Appendix JA7 provide detailed descriptions of procedures and responsibilities for the registration of CF1R, CF2R, and CF3R.

Compliance document registration is required for all newly constructed homes, most additions, and many alterations. When registration is required, compliance documents must be electronically submitted to an Energy Commission approved ECC-Provider. ECC-Provider services include an ECC data registry (ECC registry) for the registration and retention of compliance documents.

All compliance documents (CF1Rs, CF2Rs, and CF3Rs) submitted to the ECC registry must be certified and signed by the applicable responsible person (Section 10-103) as well as any other required signatories. The ECC registry will assign a unique registration number to each document when completed, and certification (by an electronic signature) is provided by all signatories. The ECC registry will retain the unique registered documents, which are available via secure Internet access to authorized users. This allows authorized users to download unalterable electronic certificates or to make paper copies of the registered documents for purposes such as submittal to the enforcement agency, posting in the field for inspections, or sharing with the building owner (see Approval for Occupancy).

Types of ECC registry users include energy consultants, builders, building owners, construction contractors and installers, ECC-Raters, enforcement agencies, and the Energy Commission. Document authors are typically employed by the person responsible for the document, with specific exceptions. Authorized users are granted access rights to the electronic data associated with the projects under their direct control.

Compliance Phases

Compliance Documentation

Complying with and enforcing the Energy Code in residential buildings involves many parties. Those involved may include the architect or designer, builder/developer, purchasing agent, general contractor, subcontractor/installer, energy consultant, plan examiner, inspector, REALTOR®, and owner/first occupant. All these parties must communicate and cooperate for the compliance and enforcement process to run efficiently.

The Energy Code specifies detailed reporting requirements intended to provide design, construction, and enforcement parties with the information to ensure that the energy features are properly installed. Each party is accountable to ensure that the features that it is responsible for are correctly installed. This section outlines each phase of the process, responsibilities, and requirements.

The energy compliance documentation has been revised and reorganized. Prescriptive (Chapter 1.6) versions of the certificate of compliance (CF1R) have been designed to be used specifically with:

- Single-family residential newly constructed buildings (CF1R-NCB-01).

- Single-family residential additions (CF1R-ADD-01).
- Single-family residential additions that do not require ECC-Verification (CF1R-ADD-02)
- Single-family residential alterations (CF1R-ALT-01).
- Single-family residential HVAC changeouts (CF1R-ALT-02).
- Single-family residential alterations that do not require ECC-Verification (CF1R-ALT-05).

The certificate of installation (CF2R) is separated into:

- Envelope (CF2R-ENV).
- Lighting (CF2R-LTG).
- Mechanical (CF2R-MCH).
- Plumbing (CF2R-PLB).
- Photovoltaic and battery storage, solar-ready zone area, and solar thermal water heating (CF2R- PVB, SRA, and STH, respectively).

These categories and most compliance measures have a separate CF2R form that is specific to a particular installation. CF2R forms also incorporate references to applicable mandatory requirements. The ECC certificate of verification (CF3R) forms are categorized and organized in the same way as the CF2R forms. Refer to Appendix A of this manual for more information about the forms and to view samples of the forms. Additional information about the compliance documents will be provided throughout this manual.

When ECC-Verification is required for compliance, the Energy Code requires all residential energy compliance documents to be registered with an ECC registry. This registration accomplishes retention of a completed and signed copy of the submitted energy compliance documentation. To simplify the permit process for HVAC changeouts, Section 10-103 of the Energy Code allows the registered CF1R-ALT-02 document to be submitted to an enforcement agency at final inspection and not before obtaining a permit. More details are in Chapter 9 of this manual. Document retention is vital to compliance and enforcement follow-up and other quality assurance follow-up processes that ensure energy savings from installed energy features. Reference Residential Appendix RA2 and Reference Joint Appendix JA7 have more details about document registration procedures building energy code compliance and enforcement process.

Design Phase

Please refer to Chapter 2.2.2 of the *2022 Single-Family Residential Compliance Manual*.

Permit Application

Reference: Section 10-103(a)2, Section 10-103(a)1C

When the design is complete, the compliance documents are prepared (CF1Rs), and other approvals (planning department, water, and so forth) are secured, the owner, builder or contractor applies for a building permit with the enforcement agency. This application is the last step in the planning and design process.

To help the enforcement agency verify that the proposed building complies with the Energy Code, the CF1R documents are submitted with the building permit application, as required by the Energy Code. (See Section 10-103.) The length and complexity of the CF1R documentation varies depending on the scope of the project. For example, the number and type of components being installed/replaced (windows, space conditioning equipment, roof replacement, ceiling insulation, and so forth), the number of buildings being constructed/altered, the size of an addition, whether an orientation-independent permit is being requested, and whether the performance approach or the prescriptive approach is being used will all need to be documented in the CF1Rs. An energy consultant who understands the code and is able to help the builder or owner comply with the standards often prepares the CF1Rs.

The forms used to demonstrate compliance must be readily legible and shall conform to a format and informational order and content approved by the Energy Commission. If registration is required, the CF1R that is submitted to the enforcement agency must be a registered copy from an approved ECC registry.

Plan Check

The registration process requires the builder or designer to submit the certificate of compliance information and an electronic signature to an approved ECC registry to produce a completed, signed, and dated electronic CF1R that is retained by the ECC registry. Copies of the registered CF1R are available to authorized users of the ECC registry for use in making electronic or paper copies of the registered document(s) for submitting to the enforcement agency as described in Section 10-103.

Local enforcement agencies check plans to ensure that the building design conforms to the Energy Code. This plan check focuses primarily on the fire, life, and safety requirements of the CBC and secondarily on the building energy efficiency requirements. Vague, missing, or incorrect information on the construction documents are identified by the plans examiner. The permit applicant is required to make corrections or clarifications then resubmit revised plans and specifications.

Submitting complete and accurate plans and specifications provides the plans examiner with the information needed to complete the plan check quickly.

The plans examiner verifies that the information on the construction documents is consistent with the requirements specified on the CF1R. Examples of features detailed on the CF1R that the plans examiner will verify are specified in the respective sections of the building plans include:

- The window and skylight U-factor and solar heat gain coefficient (SHGC) values from the CF1R on the structural/architectural plans in a window/skylight schedule, window/skylight legend for the floor plan.
- The HVAC equipment and distribution information from the CF1R is clearly documented on the plans, such as SEER, EER, AFUE, mandatory, prescriptive, and elective ECC measures, and other values necessary to verify compliance.

The plans examiner compares the data on the CF1Rs against the rest of the plans and documents submitted for the permit applications, including all the following subject areas:

- Envelope (walls, ceiling, floors)
  - U-factors, solar heat gain coefficients of windows, skylights, and doors
  - Insulation and air sealing
  - Advanced wall, ceiling, and raised-floor construction and insulation
- Roofing materials and construction
  - Roof-deck insulation
  - Radiant barrier
  - Vented or unvented attic
  - Cool roof reflectivity requirements
- Heating, ventilating, and air conditioning (HVAC)
  - SEER2, EER2 and AFUE (if applicable) for HVAC equipment
  - Ducting design and register placement
  - Ventilation and indoor air quality requirements
  - Duct insulation and placement (in or outside conditioned space)
  - Thermostat requirements
  - Manufacturer certification check
- Lighting requirements
  - Luminaire efficacy requirements
  - Switching and control devices
  - Outdoor lighting and controls
- Domestic hot water
  - Manufacturer certification check
  - Water piping design and insulation
- Solar PV and battery systems
  - PV system capacity, orientation and tilt, shading obstructions
  - Solar shading analysis
  - Battery system capacity, control strategies
  - Battery-ready requirements

The enforcement agency should clearly articulate to the builder/designer the acceptable methods of specifying energy features on the building plans for approval.

Since those buying building materials and the construction staff may rely solely on a copy of the approved plans and specifications, it is important that the building design represented on the approved plans and specifications complies with the Energy Code as specified on the CF1R.

The enforcement agency's plans examiner must also verify that the CF1R does not contain errors. Newly constructed buildings using the performance approach are required to use Energy Commission approved compliance software; additions and alterations generally use the prescriptive approach, with the option of using the performance approach. When the CF1R is produced by Energy Commission approved compliance software, there is a lower chance of computational errors. The plans examiner must still verify that the design on the plans is consistent with the energy features on the certificate of compliance documents (CF1Rs). A list of Energy Commission approved Energy Code compliance software applications is available online at the Energy Commission Compliance Software website (https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/energy-code-support-center/compliance).

The Building Energy Efficiency Standards Hotline at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/energy-code-hotline-submission or at 1-800-772-3300 can assist with locating and installing this software.

With production homes, where a builder may be constructing several identical houses at roughly the same time, the compliance documentation may be prepared in such a way that a house or model can be constructed in any orientation. The plans examiner will verify that the home complies facing all four main compass points (north, south, east, and west) on the CF1R form.

Building Permit

Please refer to Chapter 2.2.5 of the *2022 Single-Family Residential Compliance Manual*.

Construction Phase

Upon receiving a building permit from the enforcement agency, the contractor begins construction. The permit requires the contractor to follow the plans and specifications, but often there are variations. Some variations are formalized through change orders. When change orders are issued, the permit applicant and the AHJ are responsible for verifying that the changes do not compromise compliance with the code. Code compliance is clear in some cases such as when a single-glazed, metal-frame window is substituted for a high-performance double-pane, vinyl-frame window. It may be difficult to determine compliance of changes such as orientation of the house or the location of a window. Field changes that result in noncompliance require enforcement agency approval of revised plans and revised energy compliance documentation to confirm that the building still complies with the Energy Code.

During construction, the general contractor or specialty subcontractors are required to complete various CF2Rs. These certificates verify that the contractor is aware of the Energy Code requirements and has followed the Energy Commission approved procedures for installation. These certificates are to identify the energy efficiencies and features of the installed building components. The CF2Rs are a collection of energy compliance information forms that apply to each regulated energy feature that may be included in the construction. The certificates are required to be completed by each of the applicable specialty contractors when they install regulated energy features such as windows, water heater and plumbing, HVAC ducts and equipment, lighting, and insulation.

The licensed person responsible for the building construction or installation of an energy-related feature must ensure their work is done in accordance with the approved plans and specifications for the building. The person must complete and sign a certificate of installation to certify that the installed features, materials, components, or manufactured devices for which they are responsible conform to the plans and specifications and the certificate of compliance documents approved by the enforcement agency for the building. A copy of the completed, signed, and dated CF2R must be posted at the building site for review by the enforcement agency in conjunction with requests for final inspection for the building. Copies of the registered CF2R forms shall be provided to the homeowner.

When any ECC-Verification is required for compliance, all CF2R forms must be registered with an approved ECC registry. When registration is required, the builder or installing contractor must submit information to an approved ECC registry to produce a completed, signed, and dated electronic CF2R that is retained by the ECC registry for use by authorized users of the ECC registry. After the information to complete the CF2R document is transmitted to the ECC registry and the form is electronically signed, the CF2R is assigned a registration number.

Copies of the unique registered CF2R are made available to authorized users of the ECC registry to make electronic or paper copies of the registered document(s) for submittal to the enforcement agency as required. The builder or installing contractor must provide a copy of the completed, signed, and registered CF2R to the ECC-Rater and post a copy at the building site for review by the enforcement agency in conjunction with requests for final inspection and provide copies of the registered CF2R forms to the homeowner.

More information about registering CF2R documents can be found in Reference Residential Appendix RA2 and Reference Joint Appendix JA7.

Enforcement Agency Field Inspection

Reference: Section 10-103(d)

Enforcement agency representatives inspect construction projects to ensure compliance with the Energy Code. Field construction changes and noncompliant energy features require parties associated with previous phases to repeat and revise their original energy compliance documents or reinstall building components that meet the building specifications and energy compliance documents.

Enforcement agencies make several visits to a building site to verify construction. The first visit is typically made before the slab or building foundation is poured. The building inspector verifies that the proper reinforcing steel is in place and necessary wiring and plumbing that will be embedded in the slab meet the requirements of the standards. The inspector should verify features that are to be installed in or under concrete slab floors, such as slab edge insulation or hot water recirculation loops that include piping in the slab. The inspector should also verify the front orientation and floor assembly types (such as slab on grade, raised floor, and others) of the building during this construction phase. Details of how the inspector should verify these components are in Chapter 3 of this manual.

The second visit occurs after the walls have been framed, and the HVAC equipment and ducting, fenestration, lighting cans, electrical wiring, plumbing, and other services have been constructed or installed. This inspection should be done before insulation is installed to ensure sealing and caulking around windows are completed, and the caulking and sealing of any holes bored through the framing members for installation of hot and cold water piping and electrical wiring.

During the rough frame inspection, the inspector should also verify the installation of the high-efficacy lighting so that the contractor can make any necessary corrections before the final inspection. This verification avoids having to remove drywall, insulation, and so forth to remove an incandescent can. The inspector should also verify the window/skylight U-factor and SHGC values, proper sealing/installation of HVAC ducts and duct insulation R-value, installation of exhaust fan housing and ducting in bathrooms and kitchens (ASHRAE 62.2), and installation of a radiant barrier or cool roof or a combination thereof when required. Details of how the inspector should verify these components will be discussed in the respective chapters of this manual.

The third visit is the insulation inspection, which takes place after the wall, ceiling, and floor insulation have been installed. This inspection occurs before the drywall is installed to verify that the insulation R-value matches the CF1R form, and the insulation has been properly installed without compressions, voids, or gaps. The inspector should verify that insulation is installed correctly around and behind piping and all exterior walls are insulated (especially behind obstructing objects like a bathtub). Details of how the inspector should verify these components are in Chapter 3 of this manual.

The next visit is a drywall inspection, where the inspector verifies that the drywall is installed properly to limit infiltration and exfiltration, especially at locations surrounding lighting cans, HVAC registers and vents, and electrical sockets.

The final inspection is conducted after the walls have been closed and the final electrical and plumbing fixtures are in place. The inspector should verify HVAC efficiency values, water heating efficiency values, exhaust fan and other ventilation system noise level ratings in bathrooms and kitchens (ASHRAE 62.2), filter MERV rating and thickness, exterior lighting and controls, and weather stripping on exterior/demising doors. The inspector will also verify that all required CF2R and CF3R forms have been completed, signed, and registered.

At final inspection, the inspector should verify that the builder has left in the building all applicable completed, signed, dated, and registered (when applicable) compliance documents (CF1R, CF2R, and CF3R if applicable) for the building owner at occupancy. These forms must be in paper or electronic format and must conform to the applicable requirements of Section 10-103(a). Details of how the inspector should verify these components is discussed in the Enforcement Agency section of this manual.

The typical enforcement agency inspection sequence can vary from jurisdiction to jurisdiction. It can be difficult for the enforcement agency to verify every energy efficiency measure required to be installed in the building. For example, exterior wall insulation will likely not be installed at the time of the framing inspection. If the enforcement agency does not include the insulation inspection in its field inspection schedule, the exterior wall insulation would be concealed from an inspector's view at the final inspection.

The CF2Rs and, when required, the CF3Rs are crucial for verifying code compliance. When inspection of an installed energy feature would be impossible because of subsequent construction, the enforcement agency may require the CF2R for the concealed feature to be posted at the site or made available to the inspector upon completion/installation of the feature. To simplify the inspection, the inspector would reference the efficiency values and building components specified on the submitted CF2R form to verify compliance with the Energy Code.

When registration is required, all certificates of installation must be registered through an approved ECC registry. For all measures requiring field verification, a registered certificate of verification shall also be made available to the building inspector.

Field Verification and Diagnostic Testing

Some building features require field verification and diagnostic testing completed by an ECC-Rater as a condition for compliance with the Energy Code. For these features, a certified ECC-Rater is required to perform the test according to procedures in Reference Residential Appendix RA2 using the protocols in Reference Residential Appendix RA3.

There are mandatory requirements, prescriptive requirements, and performance credits (Chapter 1) that require ECC testing. Many requirements that require verification and testing involve air-conditioning equipment and forced-air ducts that deliver conditioned air to the dwelling. Examples of measures requiring ECC testing are refrigerant charge measurement and duct sealing. An example of an installed feature that does not require ECC testing is lighting control in spaces like a laundry room or bathroom.

The Energy Code mandates that all newly constructed homes with central HVAC systems have duct sealing (leakage testing), duct system airflow and fan watt draw (an installed hole for the placement of a static pressure probe (HSPP)/permanently installed static pressure probe (PSPP), and exhaust fans/systems (ASHRAE 62.2) verified by a ECC-Rater when those systems are installed. Details about these measures are in Chapter 4 of this manual.

Additional measures requiring field verification include reduced duct surface area, increased duct R-value, high-SEER2 and -EER2 cooling equipment, and quality installation of insulation (QII). A full list of measures requiring field verification or diagnostic testing is in Table RA2-1 of the *2025 Reference Residential Appendices*. The requirements for field verification and diagnostic testing apply only when equipment or systems are installed. If a house has no air distribution ducts, then an ECC-Rater does not have to test them.

The ECC-Rater must verify the required features and transmit all required data describing the feature and the test results to an approved ECC registry. The ECC-Rater must confirm that the installed energy feature being verified is consistent with the requirements for that feature as specified on registered copies of the CF1R approved by the enforcement agency for the dwelling.

The ECC-Rater must confirm the information on the CF2R is consistent with the CF1R. The test results reported on the CF2R by the person responsible for the installation must be consistent with the ECC-Verification results determined by the ECC-Rater’s diagnostic verification and meet the criteria for standards compliance. A copy of the registered CF2R must be posted at the building site for review by the enforcement agency and made available for applicable inspections. A copy of the registered CF2R must also be left in the dwelling for the homeowner at occupancy.

Results from the ECC-Rater's field verification or diagnostic test are reported to the ECC registry with “pass” or “fail.” If the results are “pass,” the ECC registry will make a registered copy of the CF3R available. A copy of the registered CF3R must be posted at the building site for review by the enforcement agency and made available for all applicable inspections. Copies must be given to the builder and left in the dwelling for the homeowner at occupancy. If results are “fail,” that failure must be entered into the ECC registry. ECC-Providers shall not permit any user of the ECC registry to print or access forms for noncompliant entries unless the CF3R form contains a watermark with the word "FAIL" or "FAILURE." Corrective action on the failed requirement shall be taken by the builder or installer. The ECC-Rater will retest the requirement to verify that the corrective action was successful. Once the correction is made, the passing CF3R shall be entered into the ECC registry.

Approval for Occupancy

For newly constructed buildings and additions, the final step in the permitting process is for the enforcement agency to issue an occupancy permit so occupants can move in. Single-family homes and duplexes are often approved for occupancy without an occupancy permit being issued. Often a signed-off final inspection serves as an approval for occupancy, but this approval depends on the enforcement agency. When ECC-Verification is required before occupancy approval, the ECC-Rater must post paper copies of the registered CF3Rs for site review by the building owner, installers, and inspectors.

For alterations to existing buildings, the signed-off final inspection is all that is required. Since the project is in a building with an existing occupancy permit, the enforcement agency is not required to issue a new occupancy permit. It should be noted that the extent of the alteration is limited by the Energy Code and, typically, the local codes and standards. If an alteration is too extensive, it can be considered a newly constructed building. For example, a project that removes all wallboards, insulation, and exterior walls from a building could be considered a newly constructed building and not an alteration by the enforcement agency.

Occupancy

At the occupancy phase, the enforcement agency must require the builder to leave all compliance documentation in the building, which includes at a minimum the CF1R and all applicable CF2R forms. When ECC-Verification is required, copies of the registered CF3Rs must be left on site with the compliance documentation.

When registration is required, the CF1R and all required CF2R compliance documentation shall be registered copies. The builder is required to provide the homeowner with a manual that contains instructions for efficiently operating and maintaining the features of their building.

Compliance Documentation

Compliance documentation includes the forms, reports, and other information that are submitted to the enforcement agency with an application for a building permit. It also includes documentation completed by the contractor or subcontractors to verify that certain systems and equipment have been installed correctly. It may include reports and test results by ECC-Raters. The compliance documentation (CF1R, CF2R, and CF3R) is included with a homeowner's manual so that the end user knows what energy features are installed in the house.

Compliance documentation is completed at the building permit phase, the construction phase, the field verification and diagnostic testing phase, and the final inspection phase. The required forms and documents are listed in Appendix A. When registration is required, all the compliance documentation shall be registered copies from an approved ECC registry.

Building Permit Phase Documentation

Reference: Section 10-103(a)

The compliance documentation required at the building permit phase consists of the CF1R and is based on the building plans. Depending on the compliance approach, the energy compliance documentation package may also include the area weighted average calculation worksheet (CF1R-ENV-02-E), the solar heat gain coefficient (SHGC) worksheet (CF1R-ENV-03-E), and the cool roof and solar reflectance index (SRI) worksheet (SRI-WS). Blank copies of these worksheets for use in the prescriptive approach are in Appendix A of this manual. When the performance approach is used, only the registered CF1R-PRF documents are required on the building plans.

The compliance documentation enables the plans examiner to verify that the building design shown in the plans and specifications complies with the Energy Code. It enables the field inspector to identify which building features are required for compliance and will be verified in the field.

Certificate of Compliance (CF1R)

The Energy Code requires the CF1R to be incorporated into the plans for the building and submitted to the enforcement agency during the building permit phase. The CF1R form identifies the minimum energy performance specifications selected by the building designer or building owner for code compliance and must include the results of the heating and cooling load calculations. The information submitted on the CF1R must be consistent with the building design features in the plans and specifications for the building submitted to the enforcement agency.

To meet the requirement for filing a copy of the CF1R with the building plans for a permit application, builders/contractors should ask the enforcement agency for information about their preferences or requirements for document submittal procedures. Most local enforcement agencies may require the CF1R to be embedded in the building design computer-aided drafting (CAD) file for plotting on sheets that are the same size as the plan set sheets of the building design. Thus, the CF1R documentation would be submitted as energy compliance design sheets integral to the entire plan set for the building. Some jurisdictions may allow taping CF1R document sheets to the submitted design drawings for the building. Others may allow attaching 8½-inch x 11-inch printed CF1R document reports to the submitted design drawing package.

When the prescriptive approach is used for additions and alterations, the applicable prescriptive version of the CF1R shall be submitted with the building plans or with the permit application when no plans are required. In these instances, a CF1R- ADD form is required to be submitted for additions, a CF1R-ALT-01 form is required for alterations, and a CF1R-ALT-02 form is required for HVAC changeouts. More details are in Chapter 9.

For single-family residential buildings where compliance requires field verification and diagnostic testing by an ECC-Rater, the CF1R submitted to the enforcement agency must be a registered copy from an approved ECC registry. More information is in the Reference Residential Appendix RA2 and Reference Joint Appendix JA7.

Construction Phase Documentation (CF2R)

The CF2Rs are separated into envelope (CF2R-ENV), lighting (CF2R-LTG), mechanical (CF2R-MCH), plumbing (CF2R-PLB), and solar (CF2R-PVB and CF2R- STH) categories. Most compliance requirements have a separate CF2R form that is specific to a particular installation. The CF2R forms must be completed during the construction or installation phase. The documents must be completed by the applicable contractors responsible for installing regulated energy features such as windows (fenestration), the air distribution ducts and the HVAC equipment, the exhaust fans/ventilation system, the measures that affect building envelope tightness, the lighting system, and the insulation. The CF2Rs must be posted at the job site in compliance with instructions from the enforcement agency. Most typically, these forms will be with the building permit folder in a window or other accessible location.

When ECC-Verification of a feature is required for compliance (as shown in the ECC required certification section of the CF1R), the builder or the builder’s subcontractor must perform the initial field verification or diagnostic testing of the installation to confirm and document the applicable CF2R compliance with the standards using the applicable procedures specified in Reference Residential Appendix RA3. The builder, the builder’s subcontractor, or authorized representative must submit the CF2R information to an approved ECC registry. All CF2R information submittals must be done electronically when ECC-Verification/testing is required.

Field Verification and Diagnostic Testing Documentation (CF3R)

Reference: Section 10-103(a)5

Within the Energy Code, some mandatory requirements, some prescriptive requirements, and some requirements that may be used for compliance credit in the performance approach may require field verification or diagnostic testing or both.

This testing must be performed by an ECC-Rater who is specially trained by an ECC-Provider to perform field verification and diagnostic testing pursuant to the requirements of Section 10-103.3, and is independent from the builder or general contractor.

When ECC-Verification is required, the ECC-Rater must complete, register, and sign/certify the CF3R. The CF3R documents include information about the measurements, tests, and field verification results that were required to be performed. The ECC-Rater must verify that the requirements for compliance have been met.

The ECC-Rater chosen for the project must transmit the CF3R information to an approved ECC registry. This must be the same ECC registry through which the previous compliance documents (CF1R, CF2R) for the project were registered. The ECC-Rater used for the project must be certified by the ECC-Provider. A registered CF3R is made available to the enforcement agency and the builder when ECC testing confirms compliance. The builder ensures that the enforcement agency has received the CF3R. The enforcement agency cannot issue the certificate of occupancy before receiving all required compliance documents, including the CF3Rs.

The ECC-Rater shall provide a separate registered CF3R form for each house that the ECC-Rater determines has passed the ECC-Verification performed for compliance. The ECC-Rater shall not sign a CF3R for a house that does not have a registered CF2R that has been signed/certified by the installer. The only exception is for homes or projects within a sample group.

Sampling is a process where a builder or contractor may coordinate with an ECC-Rater to allow the ECC-Verification for one newly constructed home or project to stand for all homes or projects within the sample group. Sample groups may include similar homes or projects from one builder, contractor, or installer for a particular ECC-Verification. For example, an HVAC contractor, after installing a ducted HVAC system, may request up to seven existing homes in one sample group. Working with one ECC-Rater, the contractor will test only one of the seven homes for fan watt draw, duct air leakage, and refrigerant charge. If it passes, the ECC-Verification on this one home will stand for all seven installations in the sample group.

If the building was included in a sample group, the CF3R will identify whether the requirement passed compliance by testing or by sampling. The CF3R form for the tested home of a sample group will include the ECC test results, but the CF3Rs for the untested homes will not. CF3Rs for tested and untested homes in a sample group will still have a registration number, date, time, and watermark of the ECC-Provider's seal as for the CF3R of any other building that is not included in sampling. Refer to Reference Residential Appendix RA2 for more details on ECC-Verification and CF3R documentation procedures.

Compliance, Operating, Maintenance, and Ventilation Information to BE Provided by Builder

Please refer to Chapter 2.3.5 of the *2022 Single-Family Residential Compliance Manual*.

Roles and Responsibilities

Designer

Reference: 5537 and 6737.1 of California Business and Professions Code

The designer is responsible for the overall building design. The designer specifies the building features that determine compliance with the Energy Code and other applicable building codes. The designer is required to sign the certificate of compliance (CF1R) to certify that the building complies with the Energy Code.

The designer may personally prepare or delegate preparation of the energy analysis and certificate of compliance documents to an energy documentation author or energy consultant (see description of documentation author below). If preparation of the compliance documentation is delegated, the designer must remain in charge of the building design specifications, energy calculations, and all building feature information represented on the certificate of compliance. The designer's signature on the certificate of compliance affirms their responsibility for the information submitted. When the designer is a licensed professional, such as an architect or engineer, the signature block on the certificate must include the designer's license number.

A licensed design professional may not always be required for single-family residential buildings. The California Business and Professions Code allows unlicensed designers to prepare design documentation for wood-framed single-family residential buildings if the dwellings are no more than two stories high, not counting a possible basement. For homes that do not require a licensed design professional, the builder may sign the CF1R in the "Responsible Building Designer" signature block (see description of builder below). The ECC-Rater is not eligible to sign the CF1R as the Responsible Designer.

When registration is required, the certificate of compliance must be submitted to an approved ECC registry. All submittals to the ECC registry must be made electronically.

Documentation Author

Reference: Section 10-103(a)1

The person who designs the building may delegate preparation of the energy analysis and certificate of compliance documents to an energy documentation author or energy consultant.

The documentation author is not subject to the same limitations and restrictions of the *Business and Professions Code* as is the building designer because the documentation author is not responsible for specification of the building design features. The documentation author may provide the building designer with recommendations for building energy features. If building designer approves the recommendations, the features must be incorporated into the design plans and specification documents submitted to the enforcement agency at plan check.

The documentation author's signature on the certificate of compliance certifies that the documentation is accurate and complete but does not indicate documentation author's responsibility for the specification of the features that define the building design. The documentation author provides completed certificate of compliance documents to the building designer, who must sign the certificate before submitting it to the enforcement agency at plan check.

If registration of the CF1R is required, it must be submitted to an approved ECC registry and signed electronically by the designer and documentation author before submitting to the enforcement agency. When document registration is required, only registered certificates of compliance that display the registration number assigned to the certificate by an approved ECC registry are acceptable for submittal to the enforcement agency at plan check.

A list of Certified Energy Analyst (CEA) documentation authors is available through the California Association of Building Energy Consultants' (CABEC) homepage at https://cabec.org/.

Builder or General Contractor

Chapter 9 of the *Business and Professions Code* specifies the term "contractor" is synonymous with the term "builder." This manual uses "builder" to refer to the general contractor responsible for construction. For additions and alterations to existing homes, the contractor can act as the builder (typically for smaller projects). For production homes, the builder may also be the developer responsible for arranging financing, acquiring the land, subdividing the property, securing the necessary land planning approvals, and attending to the other necessary tasks that are required before the start of actual construction. Many production builders are involved in marketing and sales of homes after they are constructed.

During construction, the builder usually hires specialty subcontractors to provide specific services, such as installing insulation, designing, and installing HVAC systems, installing windows and skylights, installing water heating systems, and others (see description of specialty contractors below). For homes that do not require a licensed design professional, the builder may sign the CF1R in the "Responsible Building Designer" signature block.

The builder must ensure that CF2Rs are submitted to the enforcement agency by the person(s) responsible for the construction/installation of regulated features, materials, components, or manufactured devices. The builder may sign the CF2R on behalf of the specialty subcontractors they hire, but the preparation and signature responsibility reside with the specialty subcontractor who provided the installation services. The CF2R identifies the installed features, materials, components, or manufactured devices detailed in the plans and specifications, and the CF1R approved by the enforcement agency. If the installation requires ECC-Verification, the CF2R must report the results of the installer's testing of the regulated installations to measure performance. The CF1R and the CF2R shall be submitted to an approved ECC registry. A copy of the registered CF2R is required to be posted at the building site for review by the enforcement agency in conjunction with requests for intermediate and final inspections.

When the Energy Code requires registration of the compliance documents, the builder must:

- Ensure the transmittal/submittal of the required information to an approved ECC registry.
- Arrange for the services of a certified ECC-Rater if the CF1R indicates that ECC-Verification is required.
- Ensure that a copy of the CF1R that was approved by the designer/owner and submitted to the enforcement agency during the permitting phase is transmitted to the ECC registry. The CF1R should be made available to the ECC-Rater, who will perform any required ECC-Verification and diagnostic testing.

When installation is complete, the builder must ensure that the persons responsible for the installation have transmitted/submitted the required CF2R to the ECC registry. The builder must ensure that the ECC-Rater receives a copy of the completed CF2R or is provided access to the ECC registry where the CF2R signed by the builder or subcontractors responsible for the installation has been registered. When registration of the CF2R is required, the completed and signed copies that are posted at the building site for review by the enforcement agency, in conjunction with requests for final inspection, are required to be registered copies.

At final inspection, the builder is required to leave in the building all applicable completed, signed, dated, and registered (when applicable) compliance documents (CF1R, CF2R, and CF3R if applicable) for the building owner at occupancy. These forms must be in paper or electronic format and must conform to the applicable requirements of Section 10-103(a).

Specialty Subcontractors

Specialty subcontractors provide the builder with services from specific building construction trades for installation of features such as wall and ceiling insulation, fenestration, HVAC and air-distribution systems, or water heating and plumbing. These subcontractors may perform other trade-specific specialty services during construction. The builder is responsible for all aspects of building construction and has the authority to complete and sign/certify all sections of the required CF2Rs. The licensed specialty subcontractor, however, must complete and sign/certify all applicable CF2Rs that document the completion of the work they have performed.

The subcontractor's responsibility for documentation should include providing a registered (when applicable) and signed copy of all applicable CF2Rs to the builder and posting a registered (when applicable) and signed copy of all applicable CF2Rs at the building site for review by the enforcement agency. The subcontractors should make the registered and signed copies of the applicable CF2Rs available to the ECC-Rater if ECC-Verification is required for compliance, as specified on the CF1R or any CF2R.

When the Energy Code requires document registration, all copies of the CF2Rs submitted to the builder, the enforcement agency, and the ECC-Rater are required to be registered copies prepared by following the procedures in Reference Residential Appendix RA2, Reference Joint Appendix JA7, and Compliance Documentation of this manual.

Enforcement Agency

Please refer to Chapter 2.4.5 of the *2022 Single-Family Residential Compliance Manual*.

Plan Check

See additional detail, see description of Plan Check in Compliance Phases section. When the Energy Code requires document registration, the CF1R submitted for a plan check must be a registered document from an approved ECC registry. The one exception is the CF1R-ALT-02-E for HVAC changeouts. If approved by the enforcement agency, permit applicants may use unregistered CF1R-ALT-03-E or CF1R-ALT-04-E documents (dependent upon climate zone) to apply for permits and present the registered CF1R-ALT-02-E to the inspector at the time of the final permit.

Construction Inspection

For more detail, see description of Enforcement Agency Field Inspection in Compliance Phases section. During building construction, the enforcement agency should make several visits to the construction site to verify that the building is being constructed in accordance with the approved plans, specifications, and CF1R. At each site visit, the agency should review any applicable CF2Rs that have been posted or made available with the building permit(s). The enforcement agency should confirm that the energy efficiency features installed in the house are consistent with the requirements given in the CF1R for the building approved during plan check, that the installed features are described accurately on the CF2R, and that all applicable sections of the CF2R have been signed by the responsible licensed person(s). The enforcement agency should not approve a dwelling unit until it has received the applicable certificate(s). When the Energy Code requires registration of the energy compliance documents, the CF2R must be registered with an approved ECC registry.

Corroboration of Field Verification and Diagnostic Testing Procedures

As described in Reference Residential Appendix Section RA2.4.4, at its discretion, the enforcement agency may require that ECC-Verification by the builder or subcontractors or the ECC-Rater be scheduled so that the enforcement agency's field inspector can observe the ECC-Verification procedures to corroborate the results reported on the CF2R and CF3R.

Sampling Within Enforcement Agency Jurisdictions

When sampling is used for ECC testing for newly constructed buildings, all dwellings in a designated sample group must be located within the same enforcement agency jurisdiction and subdivision as specified in Reference Residential Appendix Section RA2.6.3.1

Final Approval

The enforcement agency may approve the dwelling at the final inspection phase if all field inspections have determined the following:

- The dwelling conforms to the requirements of the plans and specifications as approved by the enforcement agency.
- The dwelling conforms with the CF1R approved by the enforcement agency.
- The dwelling conforms with all other applicable codes and standards requirements.
- The enforcement agency is in receipt of all CF2R required by the Energy Code and as identified by the CF1R for the dwelling unit.
- The CF1R and CF2R are signed and registered (when applicable) by the builder or subcontractor.
- For dwelling units requiring ECC testing, the enforcement agency has received a copy of the CF3R as registered with an ECC registry.
- The CF3R has been signed and dated by the ECC-Rater.

The builder must ensure that all the required energy compliance documentation has been completed properly and posted at the job site or submitted to the enforcement agency in conjunction with the required inspections. However, the enforcement agency, in accordance with Section 10-103(d), as a prerequisite to approval of the building, must examine all required copies of the CF1R, CF2R, and CF3R posted at the site or made available with the building permits for the required inspections. This examination confirms that these compliance documents have been properly prepared and are consistent with the plans and specifications approved by the enforcement agency.

The enforcement agency may conditionally approve a building using the CF2R testing performed and documented by a Third Party Quality Control Program (TPQCP) contractor. (See Third Party Quality Control Program.) TPQCP contactors may not use group sampling for additions or alteration but may perform the CF2R testing and documentation required by the Energy Code for individual addition or alteration projects. TPQCP contractors may use group sampling (limited to no more than 30 members each) for newly constructed buildings as provided by the Energy Code. However, if subsequent ECC testing determines that resampling, full testing, or corrective action is necessary for such conditionally approved dwellings, the corrective work must be completed and retested. Additional information is in Reference Residential Appendix RA2.4.3, RA2.7, and RA2.8.

Corroboration of Information Provided for the Owner/Occupant

At final inspection, the enforcement agency shall require the builder to leave in the building (for the building owner at occupancy) Energy Code compliance documents, operating and maintenance manuals, and ventilation information, as specified by Section 10-103(b).

Compliance documents for the building shall include all valid certificates of compliance (CF1R), certificates of installation (CF2R), and certificates of verification (CF3R). These documents must conform to the applicable requirements of Section 10-103(a).

Three types of information operating and maintenance materials shall be provided for the owner/occupant:

- Operating information shall include instructions on how to operate or maintain the energy features, materials, components, and mechanical devices of the building correctly and efficiently.
- Maintenance information shall be provided for all features, materials, components, and manufactured devices that require routine maintenance for efficient operation. Required routine maintenance actions shall be clearly stated and incorporated on a readily accessible label. The label may be limited to identifying, by title or publication number, the operation and maintenance manual for that particular model and type of feature, material, component, or manufactured device.
- Ventilation information shall include a description of the quantities of outdoor air that the ventilation system(s) are designed to provide to the conditioned space of the building and instructions for proper operation and maintenance of the system.

All such information shall be in paper or electronic format, and in a folder or otherwise bound to provide all information in Section 10-103(b). For dwelling units, buildings, or tenant spaces that are not individually owned and operated, or are centrally operated, such information shall be provided to the person(s) responsible for operating the feature, material, component, or mechanical device installed in the building.

ECC-Provider

An ECC-Provider is an organization that the Energy Commission has approved to administer a ECC program. The ECC-Provider certifies, trains, and oversees ECC-Raters. ECC-Raters provide ECC-Verification on installed energy efficiency features in dwellings when required for compliance with the Energy Code. Visit the Energy Commission website for the list of approved ECC-Providers at https://www.energy.ca.gov/programs-and-topics/programs/energy-code-compliance-program.

The ECC-Provider must also maintain an ECC registry that incorporates a website-based user interface that accommodates the needs of the authorized users of the ECC registry who administer ECC compliance document registration. The ECC registry must receive and record information required by ECC testing in a specific dwelling. The ECC registry must have the capability to verify that the recorded information complies with the Extensible Markup Language (XML) schema developed by the Energy Commission.

When the input data are verified, the ECC registry must make available a unique registered certificate available to authorized users. These registered certificates (CF1R, CF2R, and CF3R) are used in complying with document submittal requirements to local enforcement agencies, builders, building owners, ECC-Raters, and other interested parties. The ECC registry helps simplify electronic submittal of the registered certificates to an Energy Commission document repository for retention of the certificates for use in regulations enforcement.

The ECC-Provider must make available (via phone or Internet communications interface) a way for authorized users of the ECC registry to verify the information displayed on copies of registered documents. Refer to Reference Residential Appendices Section RA2.4.2 and Reference Joint Appendix JA7 for additional information.

ECC-Rater

The ECC-Rater is trained and certified by an Energy Commission approved ECC-Provider to perform the ECC-Verification that may be required to demonstrate and document compliance with the Energy Code. ECC-Raters receive special training in diagnostic techniques and building science as part of the certification administered by the ECC-Providers. The ECC-Raters operate independently from the ECC-Providers and are to act as independent, third-party agents to the contractor installing the energy efficiency requirements for the construction project.

ECC-Raters shall be considered "special inspectors" by enforcement agencies, which is not to be confused with the same term used by local enforcement agencies regarding inspectors with specific ICC training and certification. ECC-Raters are not special inspectors for the local enforcement agencies; they are special inspectors for the project proponents, including the installing contractor. ECC-Raters may be required to attain business licenses in some jurisdictions.

The Energy Commission has determined that an ECC-Rater may act as a document author for the CF2R for a residential project with no violation of the provisions of "Conflict of Interest" (Title 20, Section 1673(j)). If requested to do so by the builder or subcontractor, the ECC-Rater may aid the builder or subcontractor to register the CF2R with an ECC registry. However, the ECC-Rater may not certify the information on a CF1R as the responsible person (that is, sign the CF1R as if they were the builder or subcontractor).

The builder or subcontractor responsible for the installation must provide the certification by electronic signature to confirm the information submitted to the ECC registry. Refer to Reference Residential Appendix Section RA2.5 and Reference Joint Appendix JA7 for more information. The ECC-Rater may not certify the information on a CF2R as the responsible person unless the ECC-Rater and installer have signed a written agreement that the ECC-Rater is an authorized representative that may sign on behalf of the installer. The installing contractor remains the responsible person. Qualifications for delegation of signature authority are detailed in Section 10-103(a)3A.

The ECC-Rater conducts the ECC-Verification of the installed energy efficiency features when required by the CF1R or CF2R. The ECC-Rater must transmit the results of the ECC-Verification to the ECC registry. The ECC-Rater must provide to the ECC registry all information required to complete the CF3R and must certify those data as accurate and complete to the ECC registry. The ECC registry will make available registered copies of the CF3R to authorized users. Printed copies, electronic or scanned copies, and photocopies of the completed, signed, and registered CF3R are allowed for document submittals, subject to verification that the information contained on the copy conforms to the registered document information on file in the ECC registry for the dwelling. A copy of the registered CF3R must be posted at the building site or made available to the inspector for review by the enforcement agency in conjunction with requests for final inspection for each dwelling unit.

Go to Reference Residential Appendix Section RA2.4.2 for more information.

Example 2-1

Question

Can a certified ECC-Rater who performs and registers the ECC testing for a dwelling also perform the ECC-Verification required of the builder or installer to certify compliance with the Title 24, Part 6, installation requirements on the CF2R?

Answer

Yes. This approach is allowed when the ECC-Rater is doing ECC-Verification for every dwelling (100 percent testing), but it is not allowed when the ECC-Rater performs verification using a designated sample group of dwellings.

When 100 percent testing is used for ECC-Verification, the builder or the installer may use the information from the ECC-Rater's ECC test results when completing the CF2R. When doing so, builders or installers signing the certification statement on the CF2R assume responsibility for the information in the form and certify that the installation conforms to all applicable codes and regulations. The ECC-Rater may sign using the installer's delegated signature authority but cannot be assigned the responsibilities of the builder or installer, as stated on the CF2R and as prescribed by the Energy Code. Refer to Section 10-103(a)3A for authorized representation.

If the ECC-Rater determines that the compliance requirements are not met (in other words, the ECC-Verification results in a failure), the ECC-Rater will submit the data of the failed ECC testing to the ECC registry for retention. The builder or installer must make the needed corrections. Once corrections have been made and the ECC-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 CF2R. The ECC-Rater can complete the CF3R documentation for the dwelling.

Example 2-2

Question

I heard that there are conflict of interest requirements that ECC-Raters must abide by when doing ECC-Verification. What are these requirements?

Answer

ECC-Raters are expected to be objective, independent third parties as field verifiers and diagnostic testers. By law, ECC-Raters must be independent from the builder or subcontractor installer of the energy efficiency features being tested and verified. They can have no financial interest in the installation of the improvements. ECC-Raters cannot be employees of the builder or subcontractor whose work they are verifying. Also, they 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 Energy Commission expects ECC-Raters to enter into a contract with the builder (not with subcontractors) to provide independent, third-party ECC-Verification. The procedures adopted by the Energy Commission call for direct reporting of results to the ECC registry where the project has been established by the builder.

ECC-Providers must have a system for receiving queries and complaints. Additionally, the ECC-providers must have a system to respond to, investigate and resolve queries and complaints related to the ECC program according to the rules in Section 10-103.3. The ECC-Provider is responsible for ensuring objective, accurate reporting of ECC testing results in compliance with the Energy Code to protect consumers from poor construction and installations.

Enforcement agencies have authority to require ECC-Raters to demonstrate their competence to the satisfaction of the building official. When the ECC-Rater's independence is in question, building officials can prohibit a particular ECC-Rater from being used in their jurisdiction or disallow practices that the building official believes will compromise the ECC-Rater's independence. For additional information please contact the Energy Commission Hotline.

Third-Party Quality Control Program

A TPQCP is a service that verifies the work of participating installers by gathering extensive diagnostic data and flagging potentially noncompliant installations.

The Energy Commission may approve TPQCPs that serve some of the functions of ECC-Verification by ECC-Raters, but TPQCPs do not have the authority of an ECC-Rater to sign compliance documentation. A TPQCP:

- Trains installers, contractors, technicians, and specialty subcontractors about compliance requirements for features that require field verification and diagnostic testing.
- Collects more data than would be required to demonstrate compliance with the Energy Code from participating installers for each installation.
- Performs validation and analysis of information from diagnostic ECC-Verification performed on a participating contractor's installation work to evaluate the validity and accuracy of the data and independently determine whether compliance has been achieved.
- Provides direction to the installer to retest and correct problems when data checking indicates that compliance has not been achieved.
- Ensures that the installer submits updated data when retesting and correction are directed.
- Maintains a database of all data submitted by the participating TPQCP contractor in a format that is acceptable and made available to the Energy Commission upon request.
- May arrange sample group of no more than 30 members for newly constructed buildings.
- May perform the CF2R testing and documentation for additions and alterations but may not place them into a sample group.

The ECC-Provider must arrange for an independent ECC-Rater to conduct independent ECC-Verification of the installation performed by the participating TPQCP contractor. If group sampling is used for ECC-Verification for jobs completed by a participating TPQCP contractor, the sample from the group that is tested for compliance by the ECC-Rater may be selected from a group composed of up to 30 dwellings for which the same participating contractor has performed the installation. Installations performed by TPQCP contractors may be approved at the enforcement agency's discretion and on the condition that, if subsequent ECC-Verification shows the installation(s) to fail CF3R testing and that retesting, resampling, full testing, or corrective action is necessary for such conditionally approved dwellings, either individually or in the group), the corrective work must be completed.

Refer to Reference Residential Appendix RA2.4.3, RA2.7, and RA2.8 for additional information.

Owner

Please refer to Chapter 2.4.9 of the *2022 Single-Family Residential Compliance Manual*.

ECC Field Verification and Diagnostic Testing

This section describes some procedures and requirements for ECC-Verification of energy efficiency features.

Measures Requiring ECC Field Verification and Diagnostic Testing

ECC-Verification is required only when certain regulated efficiency requirements or equipment features are installed. If such efficiency requirements or equipment features are not installed, then ECC-Verification is not required. For example, if a dwelling that must comply with the Energy Code does not have air distribution ducts, then ECC-Verification for duct leakage is not required for compliance.

The following features require ECC-Verification (see Tables RA2-1, RA2-2, RA2-3, RA2-4, RA2-5, RA2-6 for more details):

- Duct sealing
- Duct location, surface area, and R-value
- Low-leakage ducts entirely in conditioned space
- Low-leakage air handlers
- Verification of return duct design
- Verification of air filter device design, filter MERV rating, and labeling
- Verification of prescriptive bypass duct requirements
- Refrigerant charge in ducted split-system and ducted packaged unit air conditioners and heat pumps, and mini-split systems
- Installation of fault indicator display
- Verified system airflow
- Air handler fan efficacy
- Verified energy efficiency ratio 2(EER2)
- Verified seasonal energy efficiency ratio 2(SEER2)
- Verified heating seasonal performance factor 2(HSPF2)
- Heat pump-rated heating capacity
- Evaporatively cooled condensers
- Variable-capacity heat pump credit
- Whole-house fan
- Central fan ventilation cooling systems
- Continuous whole-building mechanical ventilation airflow
- Intermittent whole-building mechanical ventilation airflow
- Kitchen exhaust (including vented range hoods)
- HRV/ERV system heat recovery efficiency or fan efficacy

- Building envelope air leakage
- Quality insulation installation (QII)
- Quality insulation installation for spray polyurethane foam
- Verified pipe insulation for single dwelling
- Verified central parallel piping (PP-H)
- Verified compact hot water distribution system expanded credit (CHWDS-H-EX)
- Demand recirculation: manual control (R-DRmc-H)
- Demand recirculation: sensor control (R-DRsc-H)
- Verified drain water heat recovery system (DWHR-H)

Verification Testing and Sampling

At the builder's option, ECC testing may be completed for each newly constructed dwelling unit (100 percent testing) or for a group of newly constructed dwelling units (sampling). Sampling is permitted only for newly constructed units when multiple dwelling units of similar design are constructed within the same subdivision by the same subcontractor.

More details are in Reference Residential Appendix Section RA2.6 and RA2.8.

To be included in a sample group, the builder or subcontractor must provide the ECC-Rater with a copy of the registered CF1R and CF2R as specified in Reference Residential Appendix Section RA2.5. The building owner or installer must give the ECC-Rater project access on the ECC registry to simplify planning and execution of sampling.

The installer must self-test every requirement and sign as the responsible person on the appropriate CF2Rs. The ECC-Rater may test a representative home (referred to as the "model") to help the installer identify any issues before self-testing the remaining homes. (See Initial ECC Testing for Subdivision Projects.)

Before performing any ECC-Verification, the ECC-Rater must confirm that the CF1R and CF2Rs have been registered for each dwelling unit to be tested. The ECC-Rater simplifies dwelling unit grouping without direction from the installer or builder. The ECC-Rater also chooses the first of each type of ECC requirement to test without any forewarning.

The ECC-Rater will transmit all test results to the ECC registry and sign as the responsible person on the CF3Rs. The ECC-Provider will make available a registered copy of the completed and signed CF3Rs to all approved authorized users of the ECC registry. Printed copies, electronic or scanned copies, and photocopies of the registered CF3Rs will be allowed for document submittals, subject to authentication between the copy and the registered certificate. A registered copy of the CF3R must be posted at the building site or made available for review by the enforcement agency in conjunction with requests for final inspection for each dwelling unit.

The ECC-Provider will provide, via phone or Internet, a way for authorized users of the ECC registry to verify the information displayed on copies of registered documents on file in the ECC registry for the dwelling unit.

If the builder chooses the sampling option, the procedures in Reference Residential Appendix Sections RA2.6 and RA2.8 must be followed.

Initial ECC Testing for Subdivision Projects

The ECC-Rater must perform the required ECC-Verification on the first dwelling unit of each model within a subdivision. 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 CF1Rs. Variations in the basic floor plan layout, energy design, compliance features, zone floor area, or zone volume that do not change the features to be verified, the heating or cooling capacity of the HVAC unit(s), or the number of HVAC units specified for the dwelling units will not cause dwelling units to be considered a different model.

ECC-Verification of the initial model allows the builder to identify and correct any potential construction flaws or practices in the build-out of each model. If ECC-Verification determines that the requirements for compliance are met, the ECC-Rater will transmit the ECC-Verification results to the ECC registry.

Group Sample ECC Testing for Subdivision Projects

After ECC-Verification of the initial model is completed, the builder or the builder's authorized representative determines which sampling procedure is to be used for the group of dwellings that require ECC testing. There are two procedures for ECC testing using group sampling:

- Sampling a closed group of up to seven dwellings
- Sampling of an open group of up to five dwellings

The group sampling requirements for each procedure will be discussed in this section. If available, a TPQCP allows up to 30 dwelling units to be grouped.

Transmittal/submittal of the CF2R information, for at least one dwelling, to the ECC registry is required to open a new group. Additional dwellings may be entered into the ECC registry and included in an "open" group over a specific period, subject to transmittal/submittal of the CF2R to the ECC registry for each additional dwelling.

However, the group shall not remain open to receive additional dwellings for a period longer than six months from the earliest date shown on any CF2R 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 one dwelling to a maximum of seven dwellings. When a group is closed, no additional dwellings shall be added to the group.

To receive a CF3R for a closed group of up to seven dwellings requires the following conditions to be met:

- All the dwelling units in the sample group have been identified. Up to seven dwellings are allowed to be included in a closed sample group.
- Installation and diagnostic testing of all the features that require ECC-Verification have been completed by the installer in all dwellings in the group, and all CF2Rs are registered.
- The group has been classified as a closed group in the ECC registry.
- At the request of the builder or the builder's authorized representative, an ECC-Rater will randomly select one dwelling unit from the closed sample group to begin ECC-Verification. If the dwelling unit meets the compliance requirements, this tested dwelling and each of

the other nontested dwellings in the group will receive a registered certificate of verification. Alternatively, the rater may test and verify requirements in different dwelling units in the group.

ECC-Verification of an open group of up to five dwellings requires the following conditions to be met:

- At least one dwelling unit from the sample group has been identified. Up to five dwellings are allowed to be included in an open sample group.
- Installation of all the features that require ECC testing shall be completed by the installer in all dwellings. Registration of the CF2Rs for all the dwellings has been completed.
- At the request of the builder or the builder's authorized representative, an ECC-Rater will randomly select one dwelling unit from the open sample group for ECC-Verification. If the dwelling unit meets the compliance requirements, the tested dwelling and each of the other nontested dwellings shall receive a registered CF3R. If there are fewer than five dwelling units, the group shall be allowed to remain open and eligible to receive additional dwelling units. Dwelling units entered into the open group after the successful ECC-Verification of the tested dwelling shall also receive a registered CF3R as a nontested dwelling subject to receipt by the ECC registry of the registered CF2R for the dwelling. The group shall be closed when it reaches the limit of five dwellings, when the six-month limit for open groups has been exceeded, or when the builder requests that the group be closed.

The ECC-Rater must confirm that the CF2Rs have been registered and are consistent with the CF1R for the dwelling unit.

The ECC-Rater must perform one or more ECC-Verification on the selected dwelling unit and enter the results into the ECC registry regardless of whether the results indicate a pass or fail. If the test fails, then the failure must be entered into the ECC registry, even if the installer immediately corrects the problem. In addition, any applicable procedures for resampling, full testing, and corrective action must be followed as described in Resampling Full Testing and Corrective Action below.

If ECC-Verification determines that the requirements for compliance are met, the ECC-Rater will enter the test results into the ECC registry. The ECC-Provider will make available to approved users of the ECC registry a registered copy of the CF3R for the tested requirement and for all other nontested requirements in the group at the time of the sample test. To avoid confusion by listing test results for untested requirements, the ECC registry will not report the results of tested requirements on the corresponding CF3Rs for untested requirements in the sample group. The results will be reported only on the CF3R for the tested requirements within the sample group. However, CF3Rs for untested features will conform to all other registration requirements and specify that the feature was not tested but has passed compliance as part of a sample group.

The ECC-Provider must close any open group within six months after the earliest signature date shown on any CF2R for a dwelling entered in the group. When such group closure occurs, the ECC-Provider shall notify the builder that the group has been closed and require that a sample dwelling be selected for ECC-Verification by an ECC-Rater if ECC-Verification has not yet been conducted on a sample dwelling entered in the group.

Resampling Full Testing and Corrective Action

When a failure is encountered during sample testing, the failure must be entered into the ECC registry for retention by the ECC-Rater. Corrective action must be taken on the failed dwelling unit. The dwelling unit must be retested to verify that corrective action was successful and the dwelling complies. Corrective action and retesting on the dwelling unit must be repeated (and registered) until the testing determines that the dwelling complies and the successful compliance results have been entered into the ECC registry. A registered CF3R for the dwelling shall be made available to authorized users of the ECC registry.

In addition, the ECC-Rater must resample and test a second randomly selected dwelling within the sample group to assess whether the first failure is unique or if the rest of the dwelling units are likely to have similar failings. "Resampling" is the procedure that requires testing of additional dwellings within a group when the initial selected sample dwelling from a group fails to pass ECC-Verification.

When resampling in a closed group, if the testing of a second randomly selected dwelling in the group confirms that the requirements for compliance credit are met for that unit, then the unit with the initial failure does not indicate failure in the remaining untested units. A copy of the CF3R will be made available for the remaining dwelling units in the group, including the unit in the resample. If the second sample results in a failure, the ECC-Rater must report the second failure to the ECC registry. All the nontested units in the group must be individually ECC-Verified.

Additional information is in Reference Residential Appendix RA2.6.

Installer Requirements and ECC Procedures for Alterations

When compliance for an alteration requires ECC-Verification by a certified ECC-Rater, the building owner may choose the same installing company that completed the work for ECC-Verification compliance. The building owner or its agent must arrange for registration of the CF1R information to the ECC registry, identifying the altered HVAC system and features that require ECC-Verification. The building owner must also submit a registered copy of the CF1R to the ECC-Rater.

When the installation is complete, the person responsible for the performance of the installation must complete the CF2Rs.

After confirming that the CF1R and all required CF2Rs are registered, the ECC-Rater must perform the ECC-Verification for each ECC requirement. Retesting and corrective action must be completed, if necessary, as specified by Reference Residential Appendix RA2.6.4.

The enforcement agency(ies) cannot approve the alteration until the agency has a registered CF1R, CF2R, and CF3R for the altered HVAC system. The agency will also verify that the installing contractor provides copies of all these forms to the homeowner.

TPQCP, as specified in Reference Residential Appendix RA2.7, may also be used with alterations but may not be used in sample groups. When a TPQCP is used, the enforcement agency may approve compliance based on the CF2Rs where data checking has indicated that the unit complies, on the condition that if the required ECC testing procedures determine that resampling, full testing, or corrective action is necessary, such work shall be completed.

For More Information

More details on ECC-Verification and ECC registries are in the *2025 Reference Residential Appendices* and *2025 Reference Joint Appendices,* as described below:

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

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Introduction

Overview

Please refer to Chapter 3.1 of the *2022 Single-Family Residential Compliance Manual*.

Navigating This Chapter

This chapter is organized by building envelope component as seen in the Table of Contents.

This chapter includes:

- An overview of changes to building envelope requirements for the 2025 Energy Code.
- A description of fenestration terminology, requirements and labeling, U-factor and solar heat gain coefficient (SHGC) requirements, and credits that can be used under the performance approach.
- Description of opaque envelope terminology, requirements related to insulation, roof products, radiant barriers, air barriers, vapor retarders, and attic ventilation.
- Compliance approaches for alternative construction assemblies such as log homes, straw bale, structural insulated panels (SIPs) and insulated concrete form (ICF) construction.

What's New for 2025

The *2025 Building Energy Efficiency Standards* for residential buildings include increased efficiencies for several envelope requirements, and there are improvements that have been made to better aid the designer, builder, and building official.

MANDATORY Section 150.0

- Exception to mandatory roof deck insulation in newly constructed attic systems in Climate Zones 4 and 8–16 to meet an area-weighted average U-factor no greater than 0.184 for ductless space-conditioning systems.(Section 150.0(a)1), for space-conditioning duct systems buried within insulation in an attic that complies using Section 150.1(b) and is verified according to RA 3.1.4.1.
- Increased mandatory required minimum wall insulation from R-13 to R-15 (overall assembly maximum U-0.095) for 2x4 wood framed assemblies, and R-20 to R-21 (overall assembly maximum U-0.069) for 2x6 assemblies (Section 150.0(c)).
- Mandatory maximum weighted average U-factor for fenestration products including skylight decreased to 0.40 (Section 150.0(q)).
- Fenestration installed in buildings located in fire hazard severity zones or wildland-urban interface (WUI) fire areas as designated by the local enforcement agency, is excepted from mandatory fenestration requirements (Section 150.0(q)).

PRESCRIPTIVE Section 150.1

- A new alternative prescriptive compliance pathway under Option C of Table 150.1-A, for cathedral ceilings in single-family new construction. Cathedral ceilings will require an R-value of 38 in all California climate zones. (Section 150.1(c)1Aiii).

- The prescriptive maximum U-factor requirements of window assemblies reduced from 0.30 to 0.27 in Climate Zones 1 through 5, 11 through 14, and 16. Climate Zones 6–10 and 15 remain at 0.30 U-factor. Exception 1 for new dwelling units that are 500 square feet or less in Climate Zone 5 allows maximum U-factor of 0.30 (Section 150.1(c)3A).

Fenestration (Window/Skylight/Glazed Door) and Opaque Doors

Please refer to Chapter 3.3 of the *2022 Single-Family Residential Compliance Manual*.

Fenestration Types

Windows and Glazed Doors

A *window* is a vertical fenestration product that is an assembled unit consisting of a frame and sash component holding one or more pieces of glazing. Window performance is measured with the U-factor and solar heat gain coefficient (SHGC).

Glazed doors are doors having a glazed area of 25 percent or more of the area of the door. Glazed doors are treated the same as windows and must meet the U-factor and SHGC requirements for windows. Most sliding glass doors, French doors, and some entry doors with large amounts of glazing will meet the definition to be treated as glazed doors.

Opaque Doors

Please refer to Chapter 3.3.1.2 of the *2022 Single-Family Residential Compliance Manual*.

Skylights and Tubular Daylight Devices

Please refer to Chapter 3.3.1.3 of the *2022 Single-Family Residential Compliance Manual*.

Fenestration Subcategories

Please refer to Chapter 3.3.1.4 of the *2022 Single-Family Residential Compliance Manual*.

Fenestration Definitions

- Center of glass U-factor, solar heat gain coefficient (SHGC), and visible transmittance (VT) are measured only through glass at least 2.5 inches from the edge of the glass or dividers.
- Clear glass has little, if any, observable tint with an insulated glass (IG) unit with an SHGC of 0.5 or greater.
- *Chromogenic* is a class of glazing that can change the optical properties by including active materials (e.g., electrochromic) and passive materials (e.g., photochromic and thermochromic) permanently integrated into the glazing assembly.
- *Electrochromatic* is a class of glazing that tints on demand using a small amount of electricity.
- Divider (muntin). An element that physically or visually divides different lites of glass. (See Definition K.) It may be a true divided lite, between the panes, or applied to the exterior or interior of the glazing.
- Double-pane window. *Double-pane* (or dual-pane) *glazing* is made of two panes of glass (or other glazing material) separated by space (generally ¼" [6 mm] to ¾" [18 mm]) filled

with air or other gas. Two panes of glazing laminated together do not constitute double-pane glazing

- Dynamic glazing. Glazing systems that have the ability to reversibly change the performance properties, including U-factor, solar heat gain coefficient (SHGC), or visible transmittance (VT), or both between well-defined end points. Includes active materials (e.g., electrochromic) and passive materials (e.g., photochromic and thermochromic) permanently integrated into the glazing assembly.

  With appropriate controls, electrochromic glass can be darkened or lightened to adjust the levels of daylight and solar heat gain. These products have the ability to reversibly change the SHGC and VT between well-defined endpoints.

- Integrated shading systems is a class of fenestration products including an active layer (e.g., shades, louvers, blinds, or other materials) permanently integrated between two or more glazing layers and that has the ability to reversibly change performance properties, including U-factor, SHGC, or VT between well-defined end points, or a combination.
- Fixed. The fenestration product cannot be opened.
- Gap width. The distance between glazing in multiglazed systems (e.g., double or triple glazing). This dimension is measured from inside surface to inside surface. Some manufacturers may report "overall" IG unit thickness, which is measured from outside surface to outside surface.
- Grille. See Divider.
- Insulating glass unit (IG unit or IG). An IG unit includes the glazing, coatings, tinting, spacer(s), films (if any), gas infills, and edge caulking.
- Light or lite. A layer of glazing material, especially in a multilayered IG unit. Referred to as panes in Section 110.6 when the lites are separated by a spacer from inside to outside of the fenestration.
- Low-emissivity (Low-e) coatings. Low-e coatings are special coatings applied to the second, third, or fourth surfaces in double- or triple-glazed windows or skylights. As the name implies, the surface has a low emittance, meaning that radiation from that surface to the surface it “looks at” is reduced. Since radiation transfer from the hot side to the cool side of the window is a major component of heat transfer in glazing, low-e coatings are very effective in reducing the U-factor. They do nothing, however, to reduce losses through the frame.

  Low-e coatings can be engineered to have different levels of solar heat gain. Generally, there are two kinds of low-e coatings:

  - Low-solar-gain low-e coatings are formulated to reduce air-conditioning loads. Fenestration products with low-solar-gain low-e coatings typically have an SHGC of 0.40 or less. Low-solar-gain low-e coatings are sometimes called *spectrally selective coatings* because they filter much of the infrared and ultraviolet portions of the sun’s radiation while allowing visible light to pass through.
  - High-solar-gain low-e coatings, by contrast, are formulated to maximize solar gains. Such coatings would be preferable in passive solar applications or where there is little air conditioning.

Another advantage of low-e coatings, especially low-solar-gain low-e coatings, is that when they filter the sun's energy, they generally remove between 80 percent and 85 percent of the ultraviolet light that would otherwise pass through the window and damage fabrics and other interior furnishings. This is a major advantage for homeowners and can be a selling point for builders.

- Mullion. A frame member that is used to join two windows into one fenestration unit.
- Muntin. See Dividers.
- Nonmetal frame includes vinyl, wood, fiberglass, and other low-conductance materials. Vinyl is a polyvinyl chloride (PVC) compound used for frame and divider elements with a significantly lower conductivity than metal and a similar conductivity to wood. Fiberglass has similar thermal characteristics. Nonmetal frames may have metal strengthening bars entirely inside the frame extrusions or metal cladding only on the surface.
- Operable. The fenestration product can be opened for ventilation.
- Solar heat gain coefficient (SHGC). A measure of the relative amount of heat gain from sunlight that passes through a fenestration product. SHGC is a number between zero and one that represents the ratio of solar heat that passes through the fenestration product to the total solar heat that is incident on the outside of the window. A low SHGC number (closer to 0) means that the fenestration product keeps out most solar heat. A higher SHGC number (closer to 1) means that the fenestration product lets in most of the solar heat.
- *SHGC* or $SHGC_t$ is the SHGC for the total fenestration product and is the value used for compliance with the Energy Code.
- Spacer or gap space. A material that separates multiple panes of glass in an IG unit.
- Thermal break frame includes metal frames that are not solid metal from the inside to the outside but are separated in the middle by a material with a significantly lower conductivity.
- Tinted. Glazing products formulated to have the appearance of color that alters the solar heat gain and visible transmittance. Common colors include gray, bronze, green, and blue. Some coatings can also appear tinted.
- Triple-pane window. Triple-pane glazing is made of three panes of glass (or other glazing material) separated by space (generally ¼" [6 mm] to ¾" [18 mm]) filled with air or other gas. Three panes of glazing laminated together do not constitute triple-pane glazing.
- U-factor. A measure of how much heat can pass through a construction assembly or a fenestration product. The lower the U-factor, the more energy efficient the product is. The units for U-factor are British thermal units (Btu) of heat loss each hour per square foot (ft^2) of window area per degree Fahrenheit (°F) of temperature difference (Btu/hr-ft^2-°F). U-factor is the inverse of R-value.

  The U-factor considers the entire product, including losses through the center of glass, at the edge of glass where a metal spacer typically separates the double-glazing panes, losses through the frame, and through the mullions. For metal-framed fenestration products, the frame losses can be significant.
- Visible transmittance (VT) is the ratio of visible light transmitted through the fenestration. The higher the VT rating, the more light is allowed through a window.

- Window films are composed of a polyester substrate to which a special scratch-resistant coating is applied on one side, with a mounting adhesive layer and protective release liner applied to the other side.

Mandatory Requirements Section 10-111, Section 10-112, Section 110.6, and Section 150.0(q)

Please refer to Chapter 3.3.2.1 of the *2022 Single-Family Residential Compliance Manual*.

Certified Product Labels: Temporary and Permanent

Please refer to Chapter 3.3.2.2 of the *2022 Single-Family Residential Compliance Manual*.

Default Label: Temporary

Please refer to Chapter 3.3.2.3 of the *2022 Single-Family Residential Compliance Manual*.

Fenestration Products Section 150.0(q)

A weighted maximum weighted average U-factor of 0.40 is required for fenestration products separating conditioned and unconditioned spaces or outdoors. Several exceptions to this requirement are provided as these scenarios are not expected to result in enough heat transfer between conditioned and unconditioned spaces or outdoors to support the costs. These exceptions are based on the fenestration area, the use of dual-glazed greenhouse or garden windows up to 30 square feet, or if the building meets Part 7 of the California Building Code, California Wildland-Urban Interface Code.

U-Factor and SHGC Ratings Section 110.6(a), Table 110.6-A, and Table 110.6-B

Determining U-Factor and SHGC

The Energy Code requires that U-factor and solar heat gain coefficient (SHGC) be calculated using standardized procedures to ensure that the thermal performance or efficiency data for fenestration products is accurate. The data provided by different manufacturers within each fenestration type (i.e., windows, doors, skylights) can easily be compared to others within that type and can be verified independently. Acceptable methods of determining U-factor and SHGC are shown in Table 3-2.

Table 3-1: Methods for Determining U-Factor and SHGC

U-Factor/SHGC Determination Method	Manufactured Windows and Doors	Manufactured Skylights	Site-Built Fenestration (Vertical & Skylight)	Field-Fabricated Fenestration	Glass Block
NFRC-100 (U-Factor) NFRC-200 (SHGC)	X	X	X	N/A	N/A
Energy Code Default Table 110.6-A (U-Factor) Table 110.6-B (SHGC)	X	X	X	X	X
NFRC's Component Modeling Approach (CMA)[1]	N/A	N/A	N/A	N/A	N/A
NA6[2]	N/A	N/A	X	N/A	N/A

The NFRC CMA method is limited to nonresidential and is not approved for residential use.

The Alternative Default U-factors and SHGCs from Reference Appendices, Nonresidential Appendix NA6 may be used only for total site-built vertical fenestration plus skylights up to 250 ft^2 or 5 percent of the conditioned floor area, whichever is larger. Residential area allowances are defined in NA6.1(b).

Source: California Energy Commission

Note for architects/designers: When the alternative procedure from NA6 for unrated site-built fenestration is used in a residential application, it may not meet the mandatory or prescriptive values as required by Section 150.0(q) and Table 150.1-A, respectively, even if area-weighted averaging is implemented. If NA6 glazing meets mandatory, but not prescriptive values, then it would be necessary to use the performance approach to meet energy compliance.

Example 3-1: Multiple Window Types in a Project

Question:

My new home 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 Energy Code?

Answer:

All windows must meet the mandatory requirements of Section 110.6 and Section 110.7 and the mandatory maximum area-weighted average U-factor of 0.40 from Section 150.0(q), 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. No fenestration products in the default tables meet the mandatory maximum U-factor of 0.40 individually. If the area-weighted average U-factors or SHGC values do not comply with the prescriptive requirements, 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.

Example 3-2: Glass Block

Question:

Which U-factor is used for an operable metal-framed glass block?

Answer:

For glass block, use the U-factor from Table 110.6-A of the Energy Code for the frame type in which the glass blocks are installed and for the fenestration product type. The U-factor for operable metal-framed glass block from Table 110.6-A is 0.87.

Example 3-3

Question:

Which SHGC is used for clear glass block, and can it be used for tinted glass block?

Answer 2: Use the default SHGC values from Table 110.6-B, depending upon whether the glass block has a metal or nonmetal frame and whether it is operable or fixed. The default SHGC table does not include tinted glass block, so use the clear glass block SHGC as the default for both clear and tinted glass block.

Example 3-4

Question:

Does it need a label?

Answer:

Glass block is considered a field-fabricated product and may be installed only if compliance is demonstrated on the compliance documents. Temporary labels described in Default Label: Temporary above must be applied to the installation for review by the building inspector, with corresponding values in the compliance report.

Example 3-5: Sunrooms

Question:

Is there a default U-factor for the glass in sunrooms?

Answer:

If the sunroom is part of the conditioned floor area, then yes. For the horizontal or sloped portions of the sunroom glazing, use the U-factor for skylights. For the vertical portions, use the U-factors for fixed windows, operable windows, or doors, as appropriate. As a simple alternative, the manufacturer may label the entire sunroom with the highest U-factor of any of the fenestration types within the assembly.

Example 3-6: Glazed Doors

Question:

How are exterior glazed doors treated in compliance documentation for U- factor and SHGC?

Answer:

All doors with glass area greater than or equal to 25 percent of the door area, which includes French doors, are defined as fenestration products and are covered by the NFRC Rating and Certification Program. The U-factor and SHGC for doors with 25 percent or more glass area may be determined in one of two ways:

- Use the NFRC rated and labeled values.
- Refer to Table 110.6-A and 110.6-B of the Energy Code. The values are based upon glazing and framing type.

In special cases where site-built fenestration is being installed in a residential application, the site-built windows and glazed doors can use an alternative method to calculate the U- factor and the SHGC by using the manufacturer's center-of-glass values (COG). The COG values are calculated in accordance with Reference Appendices, Nonresidential Appendix NA6. To use this calculation, the maximum allowed site-built fenestration is 250 ft^2 or 5 percent of the conditioned floor area, whichever is larger.

Example 3-7:

Question:

How can I determine a U-factor and SHGC for doors when less than 25 percent of the door area is glass?

Answer:

Doors with less than 25 percent glass area are treated as opaque exterior doors. For prescriptive or performance approaches, only the U-factor is used for this product type. Use one of the following options for U-factor of the door:

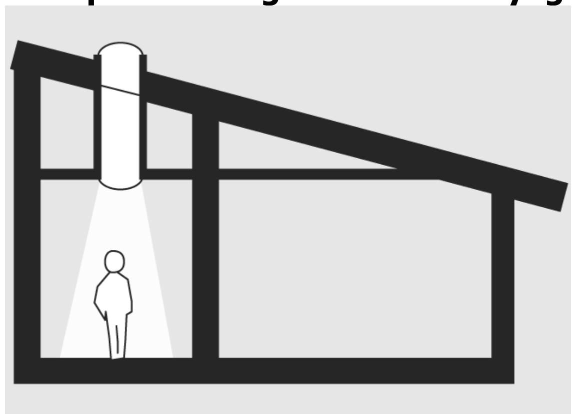
- The NFRC label if one is available
- The default values from Table JA4.5.1 of the Reference Appendices
- Tubular daylighting device with single-pane diffuser

Example 3-8:

Question:

A tubular daylighting device (TDD) will be used to get daylight into a house. The skylight has a clear plastic dome exterior to the roof, a single-pane ¼-inch (6 mm)- thick acrylic diffuser mounted at the ceiling, and a metal tube connecting the two. How are U-factor and SHGC determined for the performance approach to comply with the Energy Code, if U_c is 1.20 and $SHGC_c$ is 0.85?

Figure 3-1: Example Drawing of Tubular Daylighting Device



Source: California Energy Commission

Answer:

There are three methods available for determining the U-factor for TDD:

- Use the NFRC label if the product has been tested and certified under NFRC procedures. This requires a label that states: "Manufacturer stipulates that this rating was determined in accordance with applicable NFRC procedures NFRC 100," followed by the U-factor.
- Use the default U-factor from Table 110.6-A of the Energy Code. This tubular product would be considered a metal frame, fixed, single-pane skylight resulting in a U-factor of 1.19, which must appear on a label preceded by the words "CEC Default U-factor." (A tubular daylighting device would have to have two panes of glazing with an air space of less than 2 inches [50 mm] between them at the plane of the ceiling insulation for it to be considered double-pane.)
- Determine the U-factor from Reference Appendices, Nonresidential Appendix NA6, Equation NA6-1. The U-factor for this tubular daylighting device would be based on metal with no curb (Table NA6-5). The U-factor for this skylight, using Equation NA6-1, is 1.25, where $U_t = (0.195 + (0.882 \times 1.20))$. This must appear on a label stated as "CEC Default U-factor 1.25."

There also are three methods available for determining SHGC for TDD:

- Use the NFRC label if the skylight has been tested and certified under NFRC procedures and requires a label that states: "Manufacturer stipulates that this rating was determined in accordance with applicable NFRC procedures."
- Use the default table SHGC in Table 110.6-B of the Energy Code. This tubular daylight device would be considered a metal-frame, fixed, clear, single-pane skylight resulting in an SHGC of 0.83, which must appear on a label stated as "CEC Default SHGC 0.83."
- Determine the SHGC from Reference Appendices, Nonresidential Appendix NA6, Equation NA6-2. The SHGC for this skylight using Equation NA6-2 is 0.81, where $SHGC_t = (0.08 + (0.86 \times 0.85))$. This must appear on a label stated as "CEC Default SHGC 0.81."

Example 3-9: Tubular Daylighting Device With Dual-Pane Diffuser

Question:

How are the U-factor and the SHGC determined if the TDD in the previous example has a dual-pane diffuser (instead of single-pane) mounted at the ceiling?

Answer:

The procedure would be the same as Example 3-8, except that the double-pane U-factor and SHGC values from Tables 110.6-A and 110.6-B of the Energy Code would be used instead of single-pane values. Up to 3 ft^2 of tubular daylighting device with a dual-pane diffuser is assumed to have the prescriptive U-factor and SHGC from Table 150.1-A for compliance calculations (Exception 1 to Section 150.1(c)3A).

Air Leakage Section 110.6(a)1, Section 110.7

Please refer to Chapter 3.3.4 of the *2022 Single-Family Residential Compliance Manual*.

Prescriptive Requirements Section 150.1(c)3, Section 150.1(c)4, Section 150.1(c)5, and Table 150.1-A

Fenestration

Prescriptive requirements described in this chapter typically refer to Table 150.1-A. The maximum fenestration U-factor required prescriptively is 0.27 for Climate Zones 1 through 5, 11 through 14, and 16, and 0.30 for all other climate zones. Newly constructed homes with a conditioned floor area of 500 square feet or less in Climate Zone 5 may comply with a maximum U-factor of 0.30. The maximum SHGC is 0.23 for single-family homes in Climate Zones 2, 4, and 6–14. The maximum SHGC is 0.20 for single-family homes in Climate Zone 15. Single-family homes in Climate Zones 1, 3, 5, and 16 have no SHGC prescriptive requirements.

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 SHGC of windows, glazed doors, and skylights can be area weight-averaged together to meet the prescriptive requirement using the CF1R-ENV-02-E compliance document in Appendix A of this manual.

Opaque Doors

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 considered a glazed door and is treated like a fenestration product (Section 3.5.8).

Opaque doors are prescriptively required to have an area-weighted average U-factor no greater than U-0.20, per Table 150.1-A. Swinging doors between the garage and conditioned space that are required to have fire protection are exempt from the prescriptive requirement. The U-factor must be rated in accordance with NFRC 100, or the applicable default U-factor defined in Reference Appendices, Joint Appendix Table JA4.5.1 must be used.

Note for Building Inspectors: 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 (Figure 3-3).

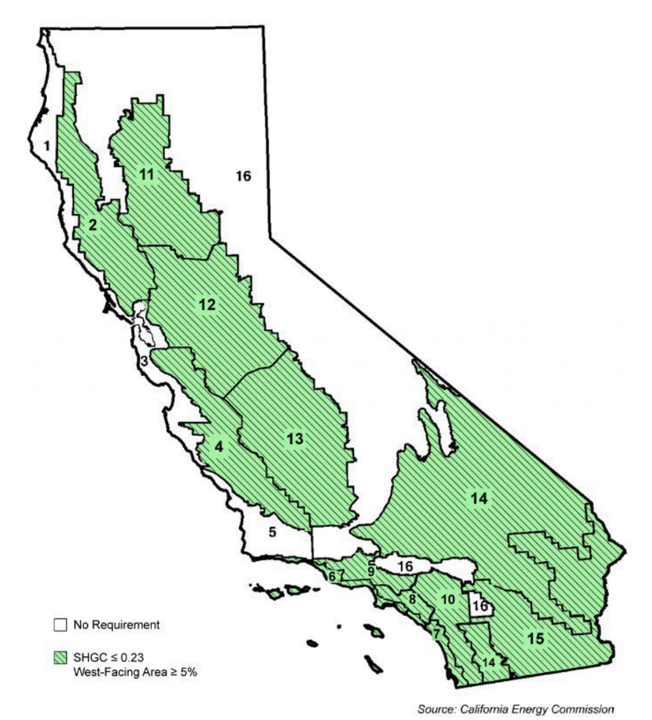
Table 3-2: Maximum U-Factors, SHGC, and Fenestration Area by Climate Zone in the Prescriptive Package

Climate Zone	1,3,5,16	2,4,11-14	6-10	15
Maximum Fenestration U-Factor	0.27*	0.27	0.30	0.30
Maximum Fenestration SHGC	NR	0.23	0.23	0.20
Maximum Fenestration Area	20%	20%	20%	20%
Maximum West-Facing Fenestration Area	NR	5%	5%	5%
Maximum Opaque Door U-Factor	0.20	0.20	0.20	0.20

***In Climate Zone 5, newly constructed homes with a conditioned floor area of 500 square feet or less may install U-0.30 windows.**

Source: California Energy Commission

Figure 3-2: Prescriptive Package, SHGC, and West-Facing Area Criteria by Climate Zone



Source: California Energy Commission

Fenestration and Opaque Door Prescriptive and Mandatory Exceptions

Glazed Doors

Any door that is more than 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. Up to 3 ft^2 of glass in a door is exempt from the U-factor and SHGC requirements (or can be considered equivalent to the prescriptive package values). The U-factor and SHGC shall be based on either the NFRC values for the entire door, including glass area, or use default values in Table 110.6-A for the U-factor and Table 110.6-B for the SGHC. If the door has less than 25 percent glazing, the glazing portion of the door is ignored in the prescriptive approach.

Tubular Daylighting Device (TDD)

In each dwelling unit, up to 3 ft^2 of tubular daylighting devices area with dual-pane diffusers at the ceiling are exempt from the prescriptive U-factor and SHGC requirements, where the TDD area is included in the maximum of 20 percent fenestration area. However, the U-factor shall not exceed a maximum of 0.40. See Section 150.0(q) and Exception 1 of Section 150.1(c)3A.

Opaque Doors

Opaque doors between the garage and conditioned space that are required to have fire protection are not required to meet the prescriptive U-factor requirement of 0.20. See Exception to Section 150.1(c)5.

Skylights

Each new dwelling unit in Climate Zones 2, 4, 6–15, may have up to 16 square feet of skylight area with a maximum 0.40 U-factor and a maximum SHGC of 0.30. The total area of skylights is included in the maximum of 20 percent fenestration area. In Climate Zones 1, 3, 5, and 16, there is no SHGC prescriptive requirement. See Exception 3 of Section 150.1(c)3A.

Aside from the specific exceptions to the fenestration prescriptive requirements, the area weight-averaged U-factor and SHGC must not exceed the U-factor specified in Table 150.1-A and cannot be greater than the SHGC specified in Table 150.1-A when large numbers of skylights are used for prescriptive compliance. Alternatively, the performance approach may be used to meet energy compliance.

Dynamic Glazing

If a dwelling unit includes a type of dynamic glazing that is electrochromatic, chromogenic, or an integrated shading device and the glazing is automatically controlled, use the lowest U-factor and lowest SHGC to determine compliance with prescriptive package fenestration requirements. Since this type of product has compliance ratings that vary, it cannot be weight-averaged with nonchromogenic products as per Exception 3 of Section 150.1(c)3A.

Site-Built Fenestration

When a dwelling unit contains a combination of manufactured and site-built fenestration, only the site-built fenestration values can be determined by using Reference Appendices, Nonresidential Appendix NA6. All fenestration, including site-built, can default to Table 110.6-A and Table 110.6-B.

Maximum Area

The prescriptive requirements limit total glass area to a maximum of 20 percent of the conditioned floor area in all climate zones.

Note: There are exceptions to the prescriptive requirements for alterations in Section 150.2(b)1A that allow additional glass area beyond the 20 percent limitation, including west-facing glass. See Chapter 9 for more information on alterations.

Greenhouse Windows/Garden Windows

Compared to other fenestration products, the NFRC-rated U-factor for greenhouse windows are comparatively high. Section 150.0(q) includes an exception from the U-factor requirement for dual-glazed greenhouse or garden windows that total up to 30 ft^2 of fenestration area.

Prescriptive Credit for Exterior Shading Devices Section 150.1(c)4

Please refer to Chapter 3.3.5.2 of the *2022 Single-Family Residential Compliance Manual*.

Fenestration in the Performance Approach Section 150.1(b)

Please refer to Chapter 3.3.6 of the *2022 Single-Family Residential Compliance Manual*.

Fenestration Area and Orientation

The performance approach includes consideration of the fenestration area and orientation, which can have a big effect on energy use. Compliance is determined by comparing the proposed fenestration to the standard design fenestration.

For buildings with glazing areas less than or equal to 20 percent of the conditioned floor area (CFA), the standard design fenestration fora newly constructed building is modeled with the same glazing area as the proposed home with one-quarter of the window area on the north, east, south, and west orientations.

For buildings with more than 20 percent of the CFA, the standard design is limited to 20 percent glass area.

The effects of orientation, the fenestration product performance levels and other building features like overhangs, judging the particular area, orientation, and performance level should be considered when determining performance approach calculations.

Improved Fenestration Performance

The fenestration weighted average U-factor in the standard design for newly constructed buildings is 0.27 in Climate Zones 1 through 5, 11–14, and 16, and is 0.30 in all other climate zone. Choosing high-performance fenestration that performs better than the prescriptive requirements level can earn significant credit through the performance method. For example, in warmer climates (e.g., Climate Zones 8–15), choosing a window with a lower SHGC can reduce the cooling loads compared to the standard design. In colder climates (e.g., Climate Zones 1, 3, 5 and 16) where there are no prescriptive SHGC requirements, choosing a window with an SHGC of 0.35 or lower can increase the heating loads compared to the standard design.

The magnitude of the effect will vary by climate zone. In mild coastal climates, the benefit from reducing fenestration U-factor will be smaller than in cold, mountain climates. 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 wood, aluminum, vinyl, fiberglass, 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 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 coating and argon gas fill with an improved spacer. The choice of low-emissivity 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. There are many ways to improve performance beyond the prescriptive levels. Adding glazing layers such as triple glazing and low-emissivity coatings such as those facing the conditioned space are two likely improvements.

Dynamic glazing with appropriate controls may also offer opportunities for improving performance.

Fixed Permanent Shading Devices

Please refer to Chapter 3.3.6.3 of the *2022 Single-Family Residential Compliance Manual*.

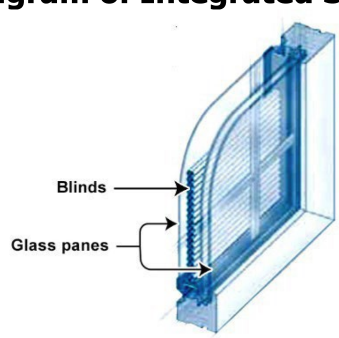
Interior Shading Devices

Please refer to Chapter 3.3.6.4 of the *2022 Single-Family Residential Compliance Manual*.

Dynamic Glazing

Dynamic glazing products are either integrated shading systems or electrochromatic devices and are considered a fenestration product.

Figure 3-3: Diagram of Integrated Shading System



Source: NFRC Dynamic Glazing Products Fact Sheet

Integrated shading systems. These systems include blinds positioned between glass panes that can be opened and closed using automatic controls. See Figure 3-5.

The labels for integrated shading systems will reflect the endpoints of the product performance for U-factor and SHGC (Figure 3-4: Example of Integrated Shading System NFRC Label). The unique rating "variable arrow" identifier helps consumers understand the "dynamics" of the product and allows comparison with other similar dynamic fenestration products.

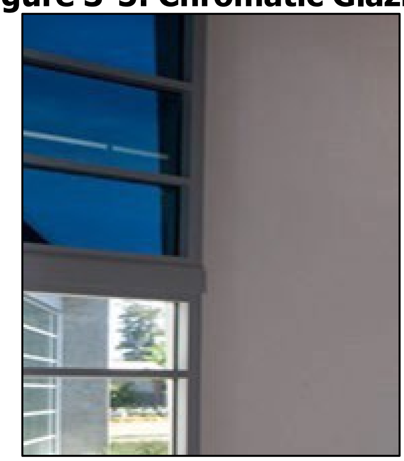
If the fenestration product can operate at intermediate states, a dual directional arrow (↔) with the word "Variable" will appear on the label. Some dynamic glazing can adjust to intermediate states, allowing for a performance level between the endpoints.

Figure 3-4: Example of Integrated Shading System NFRC Label

Source: NFRC Dynamic Glazing Products Fact Sheet

In Figure 3-4: Example of Integrated Shading System NFRC Label, the low value rating is displayed to the left (in the closed or darker position), and the high value rating is displayed to the right (in the open or lighter position). These value ratings let the consumer know at a glance the best and worst case performance of the product and the default performance level. To use the high-performance values for integrated shading systems, the product must have an NFRC Certified Label sticker. Otherwise, the default values from Tables 110.6-A and 110.6-B must be used.

Figure 3-5: Chromatic Glazing



Source: Sage Electrochromics

Chromatic glazing. One type of dynamic glazing product uses a chromatic type of glass that can change the performance properties, allowing occupants to control their environment manually or automatically by tinting or darkening a glass with the flip of a switch. Some fenestration products can change performance automatically with the use of an automatic control or environmental signals. These high-performance windows can reduce energy costs because of controlled daylighting and unwanted heat gain or heat loss.

A view of chromatic glazing in the open (off) and closed (on) position is shown in Figure 3-5: Chromatic Glazing. Best-rated performance values may be used for compliance with an NFRC Certified Label sticker and when automatic controls are installed.

- If the window includes either an NFRC label or automatic controls, but not both, then default to Table 150.1-A maximum U-factors and maximum SHGC values.

If neither an NFRC label nor automatic controls are included, then the default values from Tables 110.6-A and 110.6-B of the Energy Code must be used.

Window Films Section 150.1(b)

Please refer to Chapter 3.3.6.6 of the *2022 Single-Family Residential Compliance Manual*.

Bay Windows Section 150.1(b)

Please refer to Chapter 3.3.6.7 of the *2022 Single-Family Residential Compliance Manual*.

Opaque Envelope

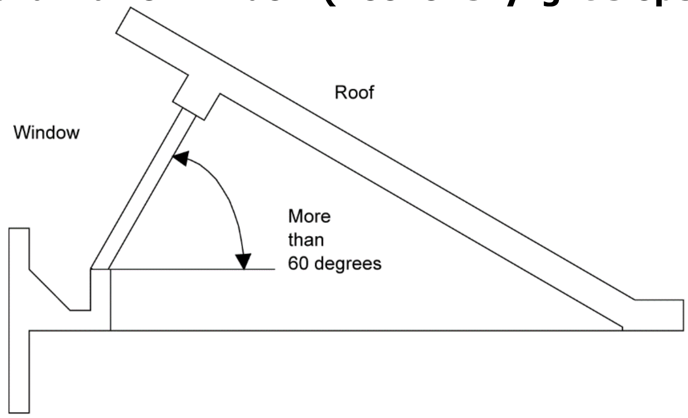
Please refer to Chapter 3.4 of the *2022 Single-Family Residential Compliance Manual*.

Opaque Envelope Definitions

Opaque elements of the building envelope significantly contribute to the related energy efficiency. Components of the building envelope include walls, floors, soffits, roofs, and ceilings. Envelope and other building components definitions are listed in Section 100.1(b) of the Energy Code and the Reference Appendices, Joint Appendix JA1.

- The *exterior partition* is an opaque, translucent, or transparent solid barrier that separates conditioned space from ambient air or unconditioned space.
- The *demising partition* is a wall, fenestration, floor, or ceiling that separates conditioned space from enclosed unconditioned space.
- The *conditioned space* is an enclosed space within a building that is either directly conditioned or indirectly conditioned.
- *Unconditioned space* is enclosed space within a building that is neither directly conditioned nor indirectly conditioned.
- *Plenum* is an air compartment or chamber, including uninhabited crawl space, areas above a ceiling or below a floor, or attic spaces, to which one or more ducts are connected and that forms part of either the supply-air, return-air, or exhaust air system, other than the occupied space being conditioned.
- *Attic* is an enclosed space directly below the roof deck and above the ceiling.
- Sloping surfaces are considered either a wall or a roof, depending on the slope. (See Figure 3-6: Slope of a Wall or Window (Roof or Skylight Slope Is Less Than 60°).) If the surface has a slope of less than 60° from horizontal, it is considered a roof; a slope of 60° or more is a wall. This definition extends to fenestration products, including windows in walls and any skylight types in roofs.

Figure 3-6: Slope of a Wall or Window (Roof or Skylight Slope Is Less Than 60°)



Source: California Energy Commission

- The *exterior roof* is an exterior partition that has a slope less than 60 degrees from horizontal, that has conditioned space below, and that is not an exterior door or skylight.
- The *roof deck* is the surface that supports the roofing material. Typically made of plywood or OSB, it is supported by the roof framing members such as rafters or trusses.
- *Exterior floor/soffit* is a horizontal exterior partition, or a horizontal demising partition, under conditioned space.
- *Vapor retarder* or *vapor barrier* is a material or assembly designed to limit the amount of vapor moisture that passes through that material or assembly.
- *Roofing products* are the top layer of the roof that is exposed to the outside, which has properties including, but not limited to, solar reflectance, thermal emittance, and mass.
- *Cool roof* is a roofing material with high thermal emittance and high solar reflectance, or low thermal emittance and exceptionally high solar reflectance, as specified in Part 6, that reduces heat gain through the roof.
- *Solar reflectance* is the fraction of solar energy that is reflected by the roof surface.
- *Thermal emittance* is the fraction of thermal energy that is emitted from the roof surface.
- A *low-sloped roof* is a surface with a pitch less than 2:12 (less than 9.5 degrees from the horizon).
- A *steep-sloped roof* is a surface with a pitch greater than or equal to 2:12 (9.5 degrees or greater from the horizontal).
- *Air leakage* is a measurement of heat loss and gain by infiltration and exfiltration through gaps and cracks in the envelope.
- *Infiltration* is the *unintentional* replacement of conditioned air with unconditioned air through leaks or cracks in the building envelope. It can be a major component of heating and cooling loads. Infiltration can occur through holes and cracks in the building envelope and around doors and fenestration framing areas. Reducing infiltration in the building envelope can result in significant energy savings, especially in climates with severe winter and summer conditions. It also can result in improved occupant comfort, reduced moisture intrusion, and fewer air pollutants. Infiltration is balanced with an equal amount of exfiltration.

- *Exfiltration* is uncontrolled outward air leakage from inside a building, including leakage through cracks, joints, and intersections; around windows and doors; and through any other exterior partition or duct penetration. Exfiltration is balanced by an equal amount of infiltration.
- *Ventilation* is the *intentional* replacement of conditioned air with unconditioned air through open windows and skylights or mechanical systems.

Air Sealing and Air Leakage Section 110.7, Section 150.0

Joints and Other Openings Section 110.7

Please refer to Chapter 3.4.2.1 of the *2022 Single-Family Residential Compliance Manual*.

Fireplaces, Decorative Gas Appliances, and Gas Logs Section 150.0(e)

Please refer to Chapter 3.4.2.2 of the *2022 Single-Family Residential Compliance Manual*.

Roofing Products Section 10-113, Section 110.8(i), Section 150.1(c)11

Please refer to Chapter 3.4.3 of the *2022 Single-Family Residential Compliance Manual*.

Product Labels Section 10-113

Figure 3-7: Sample CRRC Product Label and Information shows a sample Cool Roof Rating Council product label. The label includes solar reflectance and thermal emittance values.

Figure 3-7: Sample CRRC Product Label and Information

CRRC COOL ROOF RATING COUNCIL ®

	Initial	Weathered
Solar Reflectance	0.00	Pending
Thermal Emittance	0.00	Pending
Rated Product ID Number		_ _ _ _
Licensed Seller ID Number		_ _ _ _
Classification		Production Line

Cool Roof Rating Council ratings are determined for a fixed set of conditions, and may not be appropriate for determining seasonal energy performance. The actual effect of solar reflectance and thermal emittance on building performance may vary.

Manufacturer of product stipulates that these ratings were determined in accordance with the applicable Cool Roof Rating Council procedures.

Source: Cool Roof Rating Council

Solar reflectance and thermal emittance are measured from 0 to 1; the higher the value, the "cooler" the roof. There are numerous roofing materials in a wide range of colors that have adequate cool roof properties. Reducing heat gains through the roof will reduce the cooling load of the home, resulting in reduced air-conditioned energy needed to maintain occupant comfort. High-emitting roof surfaces reject absorbed heat quickly (upward and out of the building) than roof surfaces with low- emitting properties.

Solar reflectance (SR). There are three solar reflectance measurements:

- Initial solar reflectance
- Three-year aged solar reflectance
- Accelerated aged solar reflectance

All requirements of the Energy Code are based on the three-year aged solar reflectance (SR). If the aged SR value is not available in the CRRC's Rated Product Directory, then the aged value shall be derived from the CRRC aged value equation (using the initial value for solar reflectance) or an accelerated process. Until the appropriate aged-rated value for the reflectance is posted in the directory, the equation below can be used to calculate the aged rated solar reflectance, or a new method of testing is used to find the accelerated solar reflectance.

Calculating Aged Solar Reflectance from Initial Reflectance

$$AAAAAAAA\ RRAARRRRAARRRRRRRRRRAA = 0.2 + \beta\beta \times (\rho\rho_{iiiiiiiiiiii} - 0.2)$$

Where,

- $\rho\rho_{iiiiiiiiiiii}$ = Initial reflectance listed in the CRRC rated product directory
- $\beta\beta$ = soiling resistance is 0.65 for field applied coating or 0.70 for other

Thermal emittance (TE). The Energy Code does not distinguish between initial and aged thermal emittance, meaning either value can be used to demonstrate compliance with the Energy Code.

Note for contractors/installers: What is the solar reflectance index (SRI)?

An alternative to the aged solar reflectance and thermal emittance required values is to use the solar reflectance index (SRI) to show compliance. A calculation worksheet is available to calculate the SRI by inputting the three-year aged solar reflectance and thermal emittance of the desired roofing material.

The calculation worksheet can be found at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

By using the SRI alternative, a cool roof may comply with a lower emittance, as long as the aged reflectance is higher, and vice versa.

Example 3-10: ENERGY STAR® Roofing Products

Question:

I am a salesperson who represents several roofing products. Many of them are on the ENERGY STAR® list published by the U.S. Environmental Protection Agency (EPA) for cool roofing materials. Is this sufficient to meet the Energy Code?

Answer:

No. ENERGY STAR has different requirements than the Energy Code for reflectance and no requirements for emittance. Per Section 10-113, the Cool Roof Rating Council (www.coolroofs.org) is the only entity recognized by the California Energy Commission to determine what qualifies as a cool roof.

Example 3-11: Certifying Products With the Cool Roof Rating Council (CRRC)

Question:

How does a product get CRRC cool roof certification?

Answer:

CRRC publishes its certification procedures in the CRRC-1 Program Manual, available for free at www.coolroofs.org or by calling CRRC at (866) 465-2523 (toll free within the USA) or (510) 485-7176. Anyone new to the certification process and wishing to have one or more products certified should contact CRRC by phone or by email at info@coolroofs.org. Working with CRRC is strongly recommended; staff walks interested parties through the procedures.

Example 3-12: Reflectance vs. Emittance

Question:

I understand reflectance, but what is emittance?

Answer:

Material that reflects the sun's energy will still absorb some of that energy as heat; there are no perfectly reflecting materials being used for roofing. The absorbed heat is given off (emitted) to the environment in varying amounts depending on the materials and surface types. This emittance is given a value between 0 and 1, and this value represents a comparison (ratio) between what a given material or surface emits and what a perfect blackbody emitter would emit at the same temperature.

A higher emittance value means more energy is released from the material or surface; scientists refer to this emitted energy as *thermal radiation*. *Emittance* is a measure of the relative efficiency with which a material, surface, or body can cool itself by radiation.

Lower-emitting materials become relatively hotter due to holding in heat. Roof materials with low emittance hold onto more solar energy as heat, and that held heat can be given off downward into the building. More heat in the building increases the need for air conditioning for comfort. A cool roof system that reflects solar radiation (has high reflectance) and emits thermal radiation well (has high emittance) will result in a cooler roof and a cooler building with lower air-conditioning costs.

Mandatory Requirements

Please refer to Chapter 3.4.3.2 of the *2022 Single-Family Residential Compliance Manual*.

Prescriptive Requirements Section 150.1(c)11

Steep-sloped and low-sloped energy-efficient cool roofs are prescriptively required in some climate zones. The prescriptive requirement is based on an aged solar reflectance and thermal emittance tested value from the Cool Roof Rating Council (CRRC). If a cool roof is being installed to comply with the Energy Code, it must meet mandatory product and labeling requirements.

Table 3-3: Prescriptive Cool Roof Requirements

Roof Type	Climate Zone	Minimum Three-Year Aged Solar Reflectance	Minimum Thermal Emittance	Minimum SRI
Steep-sloped	10 through 15	0.20	0.75	16
Low-sloped	13 and 15	0.63	0.75	75

Source: California Energy Commission

There are two exceptions to meeting these prescriptive requirements:

- Roof area with building-integrated photovoltaic panels or building-integrated solar thermal panels. *Building-integrated photovoltaics* are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades.
- Roof constructions that have a weight of at least 25 lb/ft².

The project could choose to pursue the performance approach and trade off the prescriptive cool roof requirements. See Opaque Envelope in the Performance Approach and Chapter 8 for more on the performance approach.

Compliance and Enforcement

Please refer to Chapter 3.4.3.4 of the *2022 Single-Family Residential Compliance Manual*.

Radiant Barriers Section 110.8(j), Section 150.1(c)2

Please refer to Chapter 3.4.4 of the *2022 Single-Family Residential Compliance Manual*.

Mandatory Requirements Section 110.8(j)

Please refer to Chapter 3.4.4.1 of the *2022 Single-Family Residential Compliance Manual*.

Prescriptive Requirements Section 150.1(c)2, RA4.2.1

The prescriptive requirements call for a radiant barrier under Option C for vented attics in Climate Zones 2–15. The same requirement applies to cathedral ceilings under Option C if an air gap is present between the roof deck and the roof insulation. Option B vented attics only require a radiant barrier in Climate Zones 2, 3, and 5–7. There also needs to be ventilation to the outside to reduce moisture effects on the deck.

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.

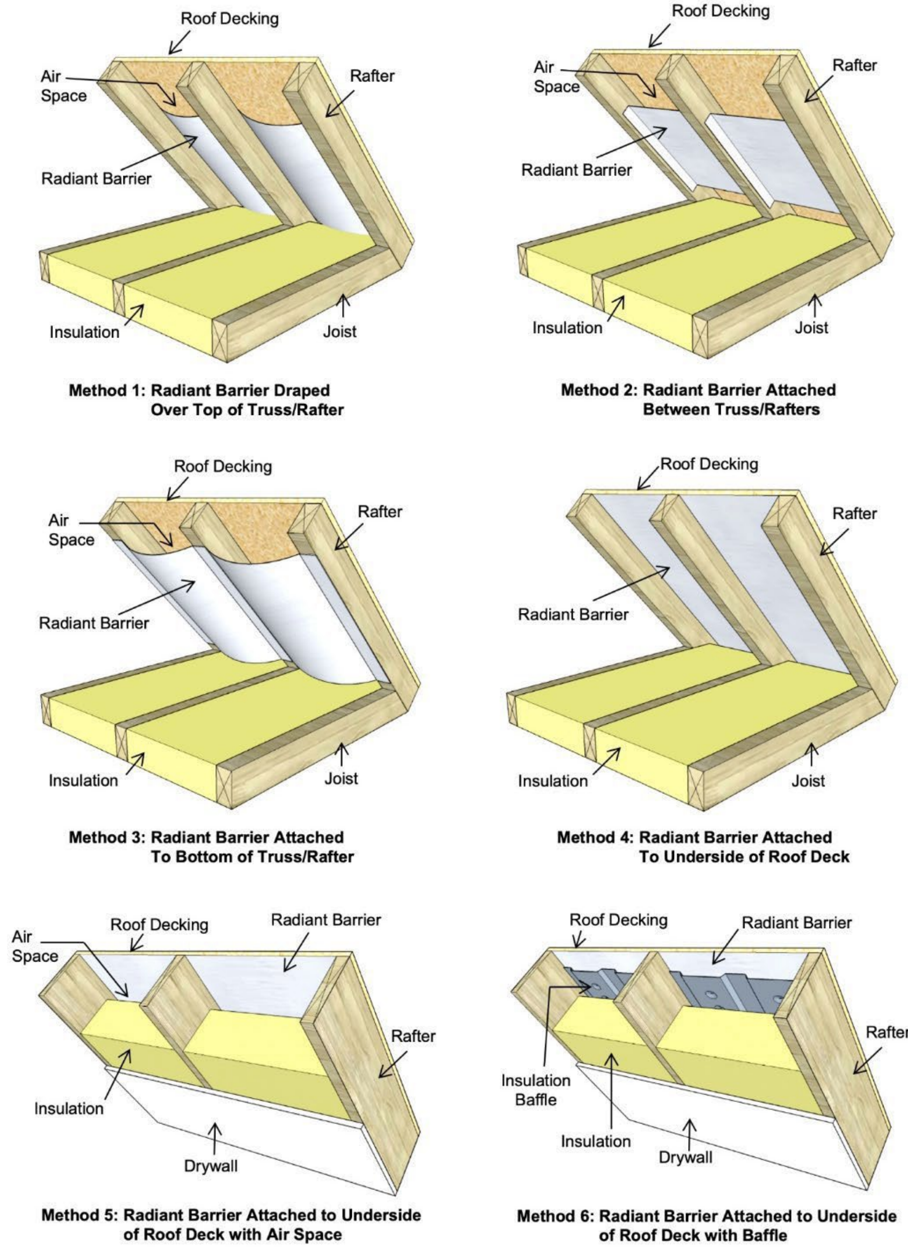
Alternatively, a radiant barrier material that meets the same ASTM test and moisture perforation requirements that apply to factory-laminated foil can be field-laminated. Field lamination must use a secure mechanical means of holding the foil-type material to the bottom of the roof decking such as staples 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 Reference Appendices, Residential Appendix RA4.2.1.1. See Figure 3-8: Methods of Installation for Radiant Barriers for drawings of radiant barrier installation methods.

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

Figure 3-8: Methods of Installation for Radiant Barriers



Source: California Energy Commission

Radiant Barriers in the 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. See more in Opaque Envelope in the Performance Approach and Chapter 8.

Vapor Retarder Section 150.0(g) and RA4.5.1

When is a vapor retarder required?

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 that are unvented in all climates 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 Reference Appendices, Residential Appendix RA4.5.1.

Product Requirements

Please refer to Chapter 3.4.5.1 of the *2022 Single-Family Residential Compliance Manual*.

Insulation Products

The Energy Code encourages the use of energy-saving techniques and designs for showing compliance. Insulation is one of the least expensive requirements to improve building energy efficiency. Insulation requires no maintenance, helps improve indoor comfort, and provides excellent sound control. Adding extra insulation later is more expensive than maximizing insulation levels at the beginning of construction. Innovative construction techniques and building products are being used more often by designers and builders who recognize the value of energy-efficient, high-performance buildings.

When the performance compliance method is used, an energy credit can be taken for design strategies that reduce building energy use below the standard design energy budget (compliance credit). Some strategies may require third-party verification by an Energy Code Compliance (ECC)-Rater; others do not. For more on the performance method, see Opaque Envelope in the Performance Approach and Chapter 8.

Table 3-4: Relevant Sections in the Energy Code

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
Insulation	Section 110.8(a) - (d), Section 110.8(g) - (h), Section 150.0(a) - (d), Section 150.0(f)	Section 150.1(c)1 Table 150.1-A	Section 150.1(a), Section 150.1(b)

Source: California Energy Commission

Types of Insulation Products

Please refer to Chapter 3.5.1 of the *2022 Single-Family Residential Compliance Manual*.

Batt and Blanket

Please refer to Chapter 3.5.1.1 of the *2022 Single-Family Residential Compliance Manual*.

Loose-Fill Insulation

Please refer to Chapter 3.5.1.2 of the *2022 Single-Family Residential Compliance Manual*.

Spray Polyurethane Foam (SPF)

Please refer to Chapter 3.5.1.3 of the *2022 Single-Family Residential Compliance Manual*.

Rigid Insulation

Rigid board insulation sheathing is made from fiberglass, mineral wool, expanded polystyrene (EPS), extruded polystyrene (XPS), polyisocyanurate (ISO), or polyurethane (PUR). It varies in thickness, and some products can provide up to R-6 per inch of thickness.

Figure 3-9: Properly Installed Rigid Insulation With Sealant Tape

Source: U.S. Environmental Protection Agency

This type of insulation is used for above-roof decks, exterior walls, cathedral ceilings, basement walls; as perimeter insulation at concrete slab edges; and to insulate special framing situations such as window and door headers and around metal seismic bracing. Rigid board insulation may also be integral to exterior siding materials. Properly sealed rigid insulation can be used continuously across an envelope surface to reduce air infiltration and exfiltration and thermal bridging at framing.

Note for contractors/installers: Proper installation of continuous rigid insulation may include button cap nails, furring strips, flashing, sealant tape, and design of the drainage plane. See Figure 3-9: Properly Installed Rigid Insulation With Sealant Tape.

The 2025 California Residential Code (CRC) provides guidance on fastener penetration depth, diameter, and spacing for exterior foam sheathing in Section R703.15.

Insulation Product Requirements Section 110.8(a)

Please refer to Chapter 3.5.2 of the *2022 Single-Family Residential Compliance Manual*.

Urea Formaldehyde Foam Insulation Section 110.8(b)

Please refer to Chapter 3.5.2.1 of the *2022 Single-Family Residential Compliance Manual*.

Flame Spread Rating of Insulation Section 110.8(c)

Please refer to Chapter 3.5.2.2 of the *2022 Single-Family Residential Compliance Manual*.

Ceiling and Roof Insulation Section 110.8(d), Section 150(a)

Loose Fill Insulation in the Attic Section 150.0(b)

Please refer to Chapter 3.5.3.1 of the *2022 Single-Family Residential Compliance Manual*.

Wet Insulation Systems Section 110.8(h)

Please refer to Chapter 3.5.3.2 of the *2022 Single-Family Residential Compliance Manual*.

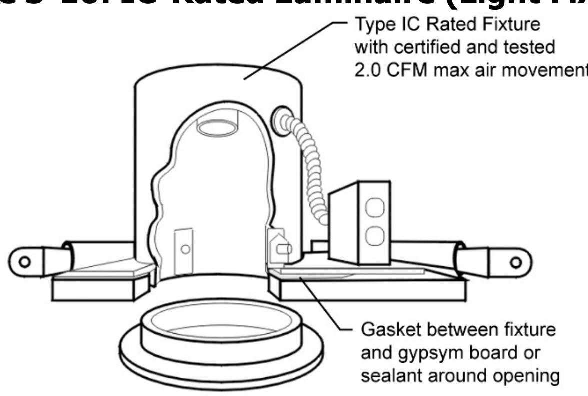
Recessed Luminaires Section 150.0(k)1C

Luminaires recessed in 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. Refer to the Lighting Chapter 6 for more information regarding the applicable requirements for recessed luminaires.

Luminaires recessed in ceilings must meet three requirements.

- 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.
- The luminaire must have a label certified as per Section 150.0(k)1Cii 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.
- The luminaire must be sealed with a gasket or caulk between the housing and ceiling.

Figure 3-10: IC-Rated Luminaire (Light Fixture)



Source: California Energy Commission

Mandatory Requirements

Wood-framed roof/ceiling construction assemblies must have at least R-22 insulation or a maximum U-factor of 0.043 based on 16-inch-on-center wood-framed rafter roofs, as determined from Reference Appendices, Joint Appendix JA4. Some areas of the roof/ceiling can be greater than the maximum U-factor if other areas have a U-factor lower than the requirement and the weighted average U-factor for the overall ceiling/roof is 0.043 or less.

Metal-framed and roof/ceiling constructions other than wood-framed must have a U-factor of 0.043 or less to comply with the mandatory requirement. If the insulation is not penetrated by framing, such as rigid insulation laid over a structural deck, then the rigid insulation can actually 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.

Newly constructed attics above conditioned space must have roof deck insulation in Climate Zones 4 and 8–16. Insulation may either be above or below the roof deck so long as the area-weighted average U-factor of the roof assembly is not greater than 0.184. This is equivalent to

R-3 or R-4 insulation depending on the location of the insulation (above or below the roof deck) and the roof type. See Table 3-5: Examples of Wood-Framed Roof Assemblies and U-Factors, Assuming a Vented Attic for examples of assemblies that can be constructed to meet the requirement.

Exceptions to the mandatory roof deck insulation include:

- If the space-conditioning system air handler and ducts are located entirely in conditioned space below the ceiling separating occupiable space from the attic. (NOTE: Duct systems located in conditioned space can be uninsulated if specific conditions are met, as explained in Section 4.4.1 (Section 150.0(m)1B))
- If no greater than 12 linear feet of supply duct, including the air handler and plenum, are located in unconditioned space with all other portions of the supply ducts located in conditioned space below the ceiling separating the occupiable space from the attic.
- The space-conditioning system is ductless.
- Space-conditioning ducts system are buried within insulation in an attic that complies using Section 150.1(b) and is verified according to RA 3.1.4.1.

Table 3-5: Examples of Wood-Framed Roof Assemblies and U-Factors, Assuming a Vented Attic

Roofing	Above Deck Continuous Insulation	Below Deck Cavity Insulation	U-Factor[1]
Tile (10 PSF w/ airgap)	R-3	n/a	0.180
Tile (10 PSF w/ airgap)	n/a	R-3	0.184
Tile (10 PSF no airgap)	R-4	n/a	0.175
Tile (10 PSF no airgap)	n/a	R-4	0.181
Asphalt Shingle	R-4	n/a	0.178
Asphalt Shingle	n/a	R-4	0.184
Metal Tile	R-3	n/a	0.182
Metal Tile	n/a	R-4	0.159

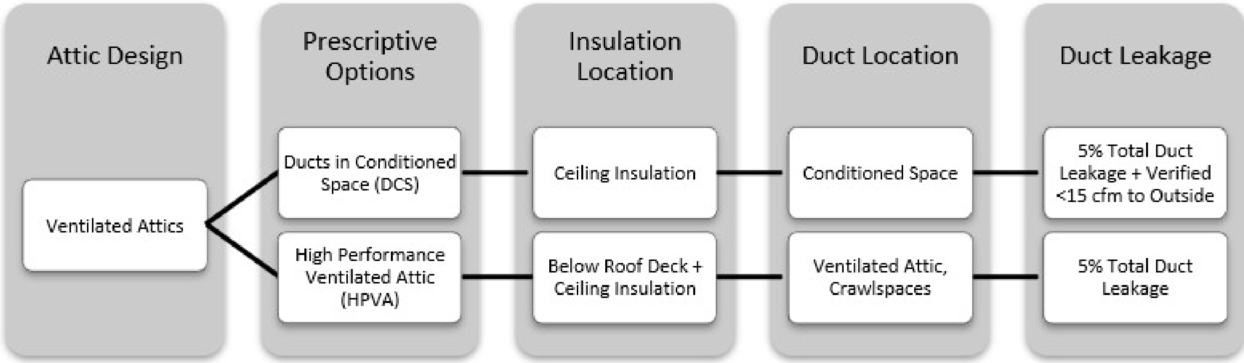
1. **U-factor based on 2x4 at 24 inch on-center roof framing.**

Source: California Energy Commission

Prescriptive Requirements Section 150.1(c) and Table 150.1-A

The 2025 Energy Code is designed to offer flexibility to the builders and designers of residential newly constructed buildings in terms of achieving the intended energy efficiency targets. As such, the Energy Code offers several options for achieving one of two design objectives related to improving energy performance of homes built with ventilated attics in Climate Zones 4, 8-16, as shown in Figure 3-11: Ventilated Attic Prescriptive Compliance Choices.

Figure 3-11: Ventilated Attic Prescriptive Compliance Choices



Source: California Energy Commission

High-performance ventilated attic (HPVA). This approach reduces 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 deck (Option B) in addition to insulation at the ceiling, R-6 or R-8 ducts, and 5 percent total duct leakage of the nominal air handler airflow.

Ducts in conditioned space (DCS). Ducts and air handlers are within the thermal and air barrier envelope of the building.

Note for contractors/installers: The ducts in conditioned space (Option C) requires field verification by a ECC Rater to meet the prescriptive requirement.

All the prescriptive requirements for HPVA or DCS are based on the assumption that the home is built with the following construction practices:

- The attic is ventilated with an appropriate free vent area as described below.
  - The roof is constructed with standard wood rafters and trusses.
  - For HPVA, 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.
  - The air handler and ducts are in the ventilated attic for HPVA and are in conditioned space for DCS.
- The air barrier is located at the ceiling.

If a building design does not meet all of these specifications, it must comply through the performance approach.

Example 3-13: Cathedral Ceilings

Question:

If 5 percent of a roof will be a cathedral ceiling, can it still comply under the prescriptive requirements?

Answer:

Yes. The 2025 Energy Code adds a prescriptive alternative for cathedral ceilings under Option C. In all climate zones, a cathedral ceiling will comply with R-38 cavity insulation.

Example 3-14: 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 wood rafter trusses to comply with the prescriptive requirements. This project must comply through the performance approach.

Example 3-15: 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 3-16: Asphalt Shingles

Question:

A home 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 home 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, or have an air gap built into the assembly between the product and the roof deck 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 3-17: 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 3-18: 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:

- 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.
- 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.

High Performance Ventilated Attics Section 150.1(c).1

This section describes the prescriptive requirements and approaches necessary for HPVA as they relate to roof/ceiling insulation. HVAC aspects of the HPVA including duct insulation and duct leakage are described in Chapter 4. Requirements and approaches to meet the ducts in conditioned space (DCS) are described in Chapter 4 of this manual.

Section 150.1(c).1 requires different values of roof and ceiling insulation, depending on whether the HPVA (Option B) or DCS (Option C) is chosen. Table 3-6: Prescriptive Insulation Options shows a prescriptive requirements checklist for each option based on Tables 150.1-A. For additions and alterations please see chapter 9.

Table 3-6: Prescriptive Insulation Options

High Performance Ventilated Attics **Option B1**	**Ducts in Conditioned Space Option C**
R-19 (CZ 4, 8 – 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, 5 – 7) Radiant barrier (CZ 2, 3, 5 – 7) Air space between roofing and the roof deck R-6 or R-8 duct insulation (climate zone specific) 5% total duct leakage	<u>Vented attic</u> R-38 (CZ 1, 8 – 16) ceiling insulation or R-30 (CZ 2 – 7) R-6 or R-8 ducts (climate zone-specific) Radiant barrier (CZ 2 – 15) Air space between roofing and the roof deck ECC-verified ducts in conditioned space (5% Total Duct Leakage + Verified <25 cfm to Outside) <u>Cathedral Ceiling</u> R-38 roof deck insulation in all climate zones

	ECC-verified ducts in conditioned space (5% Total Duct Leakage + Verified <25 cfm to Outside)
Table 150.1-A Assembly Option B	Table 150.1-A Assembly Option C

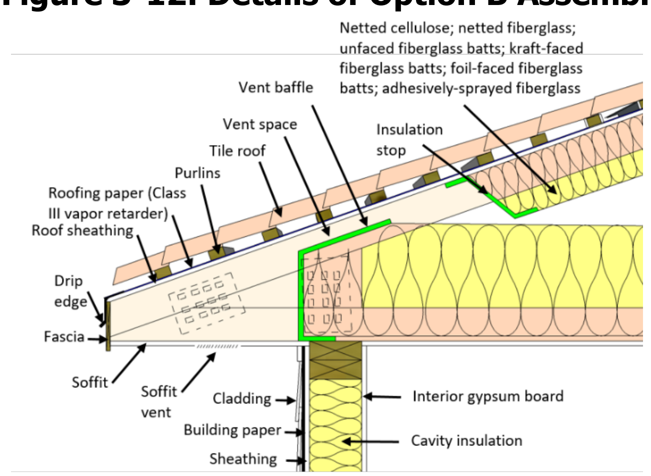
Note: 1 Option B is the standard design used to set the energy budget for the performance approach.

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 for the attic space. 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 shall have supports that are less than or equal to 16” apart and no farther than 8” from the end of the batt.

- 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.

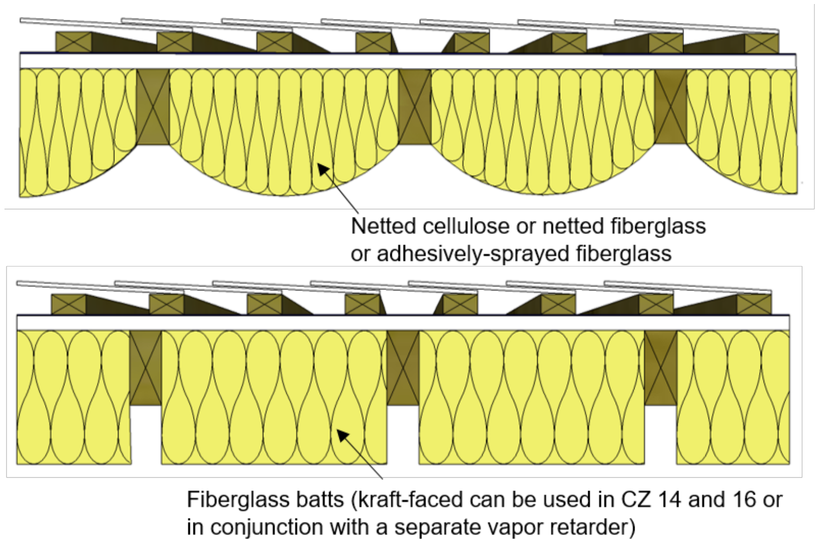
Figure 3-12: Details of Option B Assembly



Note: In order to comply with CRC 806.3, where eave or cornice vents are installed, blocking, bridging and insulation shall not block the free flow of air. Not less than a 1-inch (25 mm) space shall be provided between the insulation and the roof sheathing and at the location of the vent.

Source: California Energy Commission

Figure 3-13: Placement of Insulation Below the Roof Deck



Source: California Energy Commission

When insulation is installed below the roof deck to meet the prescriptive requirements of Option B, a radiant barrier is not required. However, a draped radiant barrier may be installed to receive performance credit.

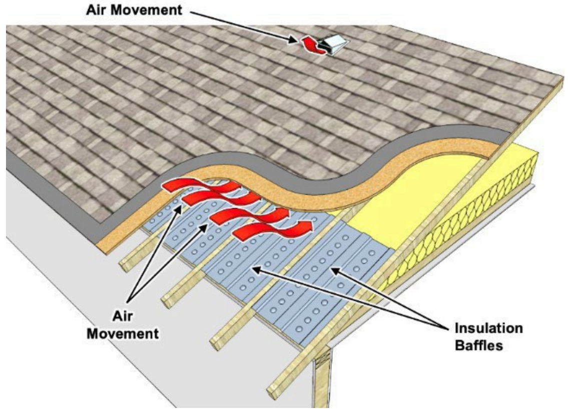
Vapor Retarders (Option B). Attic vapor retarders are not required by the Energy Code in most climates when using spray foam, blown-in insulation, or unfaced batts, and when sufficient attic ventilation is maintained. Although not required, the use of vapor retarders can provide additional security against 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 as stated in California Building Code (CBC), Title 24, Part 2.5, Section R806.2.

Attic Ventilation (Options B and C)

When venting an attic according to CRC 806, ridge or eyebrow venting (if installed) must be maintained, as shown in Figure 3-14: Insulation Air Baffles.

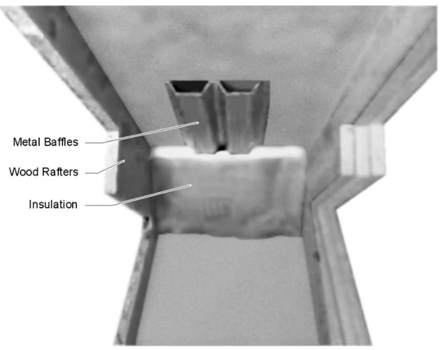
When installing insulation below the roof deck, vent baffles and insulation barriers should be used to maintain proper ventilation space. Proper airflow through the space helps remove moisture and prevents any associated issues.

Figure 3-14: Insulation Air Baffles



Source: Building Science Corporation

Figure 3-15: Baffles at the Eave in Attics



Source: California Energy Commission

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 3-15: Baffles at the Eave in Attics.) 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 air, including preformed baffles made of either cardboard or plastic. In some cases, plywood or rigid foam baffles are used.

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

- CBC, Title 24, Part 2, Vol. 1, Section 1202.2 requires that the net-free ventilating area shall not be less than 1/300 of the area of the space ventilated.
- CBC, Title 24, Part 2.5, Section R806.2 requires that the net-free ventilating area shall 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 in the upper portion of the space being ventilated at least 3 feet above the eave or cornice vents.

Insulation shall not block the free flow of air, and a minimum 1-inch air space shall 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 fire resistance for the building. These regulations require special vents that are expressly tested to resist the intrusion of flames and burning embers. Check with the building department to ensure compliance with local codes.

Note for Contractors/Installers: Tips for Successfully Implementing the High Performance Attics Requirements.

- Commit to a compliance strategy early in the building design process.
- Have a kick-off meeting with builder, subcontractor, designer, energy consultant, and ECC Rater to set expectations and express the value of the design.
- Communicate strategy and schedule to subcontractors and other team members early.
- Include insulation specifications according to the CF1R on the building plans.
- Insulation contractor will install insulation below roof deck (ideally at the same time as ceiling insulation).
- All relevant subcontractors must be aware of where the air barrier is located and be conscious of where they make penetrations, especially if designing for verified ducts in conditioned space or reduced building envelope leakage.
- Duct and Air Handlers Located in Conditioned Space Option C.

Allows a project to place and verify that ducts are located 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 150.1-A for Option C, and a radiant barrier is required in most climate zones.

ECC-Verification (Option C). Simply locating ducts in conditioned space does not qualify for this requirement; a ECC Rater must test and verify for low leakage ducts within conditioned space and that the ducts are insulated to a level required in Table 150.1-A of the Energy Code and Section 150.1(c)9B.

Note for Architects/Designers*:* 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 key is that the ducts and equipment are placed within the thermal 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 is not required but may be desirable in some applications.

Example 3-19: Installation Doesn't Match Compliant Design Option

Question:

A newly constructed building project in climate zone 12 with HVAC ducts in the attic was designed to meet the prescriptive requirements for below roof deck and ceiling insulation. Due to miscommunication amongst the team, the roof deck insulation was not installed, and R-49 attic ceiling insulation was installed instead. Does this project still comply?

Answer:

This project no longer meets the prescriptive requirements and must follow the performance approach. For future projects, clearly communicating the project expectations to all team members early in the construction process is the key to succeeding at this design strategy. Having a project initiation meeting with all subcontractors and team members is a best practice, at least for the first few projects, until the entire team is aware of the design needs.

Note: If the design was changed so that the roof deck has a radiant barrier and the HVAC equipment and ducts are verified to be in conditioned space, the altered design will meet the prescriptive requirements under Option C.

Wall Insulation

Mandatory Requirements Section 150.0(c)

- 2x4 inch wood-framed walls above grade. Shall have a U-factor not exceeding U-0.095. In a wood-framed wall assembly, this requirement is met with at least R-15 insulation installed between 16 inch-on-center framing members. Tables found in JA4 can also provide U-factors for other wall assemblies.
- 2x6 inch or greater wood-framed walls above grade. Shall have a U-factor not exceeding U-0.069. In a wood-framed wall assembly, this requirement is met with at least R-21 insulation installed between 16 inch-on-center framing members. Tables found in JA4 can also provide U-factors for other wall assemblies.
- Mass and Masonry walls above grade. Must be insulated to meet the prescriptive requirements in Table 150.1-A for mass walls.

  Note: a mass wall is defined as a wall with a heat capacity greater than or equal to 7.0 Btu/h-ft2 per footnote 5 of Table 150.1-A
- Opaque non-framed wall assemblies. Must meet a maximum U-factor of U-0.102.
- Demising partitions and knee walls. Demising and knee walls must meet or exceed minimum insulation requirements listed above, depending on wall type.

Exceptions: There are several cases where the mandatory requirements for wall insulation do not apply or apply in a special way. For best practice, the following should be implemented:

- The mandatory requirements apply to foundation walls of heated basements and heated crawl space walls where they are above grade, but not to the portion that is located below grade. Note that Prescriptive requirements will apply to below grade walls.
- For additions to existing buildings, existing wood-framed walls that are not being altered and are already insulated to a U-factor of 0.110 or lower, or that have existing R-11 insulation need not comply with the mandatory R-15 wall insulation. For more on additions and altered walls see Chapter 9.
- Altered wood-framed walls where the existing siding is not being removed or replaced may meet the requirement with insulation between framing members are covered in Chapter 9.
- Rim joists between floors of a multistory building will comply with these mandatory requirements if they have R-15 insulation installed on the inside of the rim joist and are properly installed between intersecting joist members.

Demising Partitions and Knee Walls

Demising partitions and knee walls are not required to meet the prescriptive requirements in Table 150.1-A. Demising partitions and knee walls shall meet the mandatory minimum wall insulation requirements from Section 150.0(c).

Prescriptive Requirements (Table 150.1-A)

Please refer to Chapter 3.5.4.2 of the *2022 Single-family Residential Compliance Manual*.

Raised-Floor Insulation Section 150.0(d)

Mandatory Requirements

Please refer to Chapter 3.5.5.1 of the *2022 Single-family Residential Compliance Manual*.

Prescriptive Requirements

While the requirements for framed floors are the same in all climate zones, the requirements for concrete raised floors differ.

Framed Raised Floors. Table 150.1-A (prescriptive requirements) call for a minimum of R-19 insulation installed between wood framing or an overall assembly U-factor of 0.037 for framed raised floors in all climate zones. The requirement may be satisfied by installing the specified amount of insulation in a wood-framed floor or by meeting an equivalent U-factor. U-factors for raised floor assemblies are listed in Reference Appendices, Joint Appendix JA4.4.

Table 3-7: Wood-Framed Raised Floor Constructions Meeting Prescriptive Requirements

Insulation R-Value	Crawlspace?	Reference Joint Appendix JA4 Construction and Table Cell Entry	Equivalent U-Factor
R-19	No	4.4.2 A4	0.049
R-19	Yes	4.4.1 A4	0.037

Source: California Energy Commission

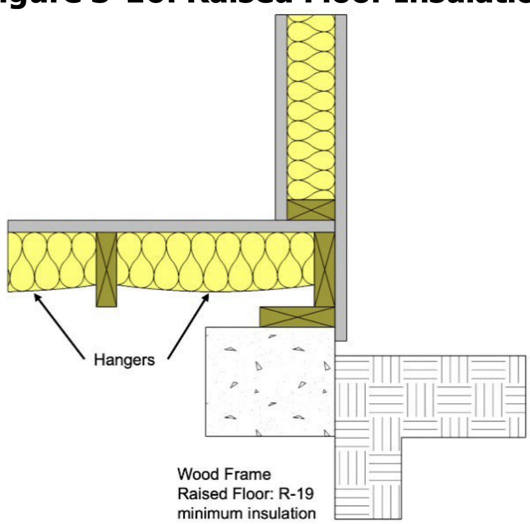
Concrete Raised Floors. Insulation requirements for concrete raised floors differ by climate zone, summarized in Table 3-8: Insulation Requirements for Concrete Raised Floors per Table 150.1-A.

Table 3-8: Insulation Requirements for Concrete Raised Floors per Table 150.1-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

Figure 3-16: Raised Floor Insulation



Source: California Energy Commission

Installation. Cavity floor insulation should be installed in direct contact with the air barrier, which is typically the subfloor. If the air barrier is the subfloor, then cavity insulation should be installed so that there is no air space between the insulation and the floor. Support is typically needed for friction fit cavity insulation 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. See Figure 3-16: Raised Floor 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.

Slab Insulation

Mandatory Requirements Section 150.0(f)

Slab Insulation Products

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.

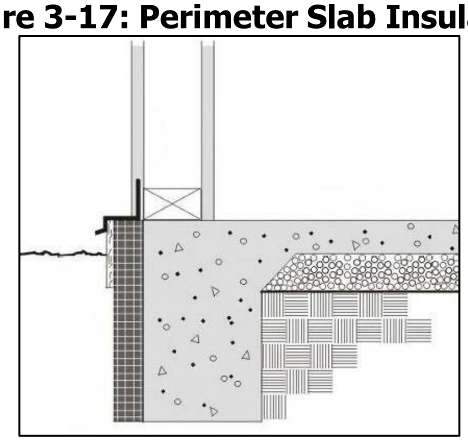
In addition, the California Residential code CRC 318.4 has requirements for foam plastic insulation in Very High Termite areas.

A common location for the slab insulation is on the foundation perimeter (Figure 3-17: Perimeter Slab Insulation). 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 shall 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.

Figure 3-17: Perimeter Slab Insulation



Source: California Energy Commission

Heated Slab Floor Insulation Section 110.8(g)

Heated slab-on-grade floors must be insulated according to the requirements in Table 110.8-A and Table 3-9: Slab Insulation Requirements for Heated Slab Floors.

One option is to install the insulation between the heated slab and foundation wall. In this case, insulation must extend downward to the top of the footing and then extend horizontally inward four feet toward the center of the slab. R-5 vertical insulation is required in all climates except climate zone 16, which requires R-10 of vertical insulation and R-7 horizontal insulation.

Table 3-9: Slab Insulation Requirements for Heated Slab Floors

Insulation Location	Insulation Orientation	Installation Requirements	Climate Zone	Insulation R-Value
Outside edge of heated slab, either inside or outside the foundation wall	Vertical	From the level of the top of the slab, down 16 inches or to the frost line, whichever is greater. Insulation may stop at the top of the footing, where this is less than the required depth. For below-grade slabs, vertical insulation shall 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.	1 – 15 16	5 10
Between heated slab and outside foundation wall	Vertical and Horizontal	Vertical insulation from top of slab at inside edge of outside wall down to the top of the horizontal insulation. Horizontal insulation from the outside edge of the vertical insulation extending 4 feet toward the center of the slab in a direction normal to the outside of the building in plain view.	1 – 15 16	5 10 vertical and 7 horizontal

Source: California Energy Commission

Prescriptive Requirements

Please refer to Chapter 3.5.6.2 of the *2022 Single-family Residential Compliance Manual*.

Thermal Mass

Please refer to Chapter 3.5.7 of the *2022 Single-family Residential Compliance Manual*.

Quality Insulation Installation (QII) RA 3.5

Prescriptive Requirements (Table 150.1-A)

The prescriptive requirements shown in Table 150.1-A calls for QII in all climate zones for newly constructed buildings and additions greater than 700 square feet.

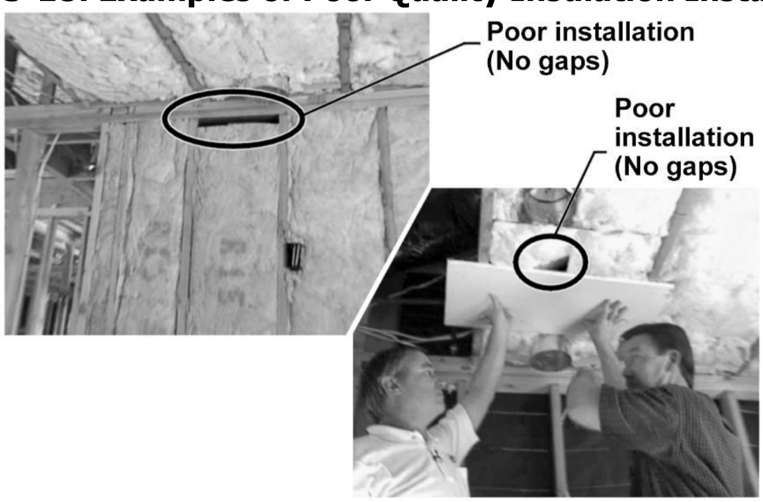
All insulation shall be installed properly throughout the building. A third-party ECC-Rater is required to verify the integrity of the installed insulation. The installer shall provide evidence to the ECC-Rater using compliance documentation that all insulation specified is installed to meet specified 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 ECC 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 residential insulation installations have flaws that degrade thermal performance. Four problems are generally responsible for this degradation:

- There is an inadequate air barrier in the building envelope or holes and gaps within the air barrier system that inhibit the ability to limit air leakage.
- Insulation is not in contact with the air barrier, creating air spaces that short- circuit the thermal break of the insulation when the air barrier is not limiting air leakage properly.
- 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 (Figure 3-18: Examples of Poor Quality Insulation Installation).
- The insulation is compressed, creating a gap near the air barrier and/or reducing the thickness of the insulation.

Figure 3-18: Examples of Poor Quality Insulation Installation



Source: California Energy Commission

QII requires third-party ECC inspection to verify that an air barrier and insulation are installed correctly to eliminate or reduce common problems associated with poor installation. Guidance for QII is provided in Reference Appendices, Residential Appendix RA3.5. QII applies to framed and non-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 include structural insulated panels (SIP), insulated concrete forms (ICF), and mass walls of masonry, concrete and concrete sandwich panels, log walls, and straw bale.

Tips for implementing QII:

- QII applies to the whole building - roof/ceilings, walls, and floors - and requires field verification by a third-party ECC Rater.
- If slab edge insulation is installed, then the integrity of the slab edge insulation must also be field-verified in addition to the air barrier and insulation system for walls and the roof/ceiling.
- Combinations of insulation types (hybrid systems) are allowed.
- An air barrier shall be installed for the entire envelope. Air barrier must be verified prior to insulation being installed.
- QII is prescriptively required for additions to existing buildings more than 700 square feet. Refer to Chapter 9 for additional information specific to additions.
- Headers shall 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. Note: All single member window and door headers shall be insulated to a minimum of R-3 for a 2x4 framing, or equivalent width, and a minimum of R-5 for all other assemblies.
    - 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 provided that the entire wall has at least R-2 continuous rigid insulation installed on the exterior.
- Wood structural panel box headers may also be used as load-bearing headers in exterior wall construction, when built in accordance with California Residential Code (CRC) Figure R602.7.3 and Table R602.7.3.
- 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.

QII in the Compliance Modeling Software. QII is not a mandatory requirement; therefore, when using the performance approach, QII may be traded off with other efficiency requirements. 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. The effect of a poorly installed air barrier system and envelope insulation results in higher wall heat loss and heat gain than standard R-value and U-factor calculations would indicate. 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 ECC verified quality insulation installation.

Air Barrier RA3.5.2

An air barrier shall 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 shall 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.

Note for ECC Raters: For QII, a third-party ECC-Rater is required to verify that the air barrier has been installed properly and is integral with the insulation being used throughout the building.

Note for Contractors/Installers: Continuous Air Barrier Requirements

A combination of interconnected materials and assemblies are joined and sealed together to provide a continuous barrier to air leakage through the building envelope separating conditioned from unconditioned space or adjoining conditioned spaces of different occupancies or uses. An air barrier must meet one of the following:

- Using materials that have an air permeance not exceeding
- 0.004 cfm/ft2 under a pressure differential of 0.3 in. w.g. (1.57 psf) (0.02 L/s.m2 at 75 pa) when tested in accordance with ASTM E2178.
- Using assemblies of materials and components that have an average air leakage not to exceed 0.04 cfm/ft2 under a pressure differential of 0.3 in. w.g (1.57 psf) (0.2 L/s.m2 at 75 pa) when tested in accordance with ASTM E2357, ASTM E1677, ASTM E1680 or ASTM E283.
- Testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 0.40 cfm/ft2 at a pressure differential of 0.3 in w.g. (1.57 psf) (2.0 L/s.m2 at 75 pa) in accordance with ASTM E779 or an equivalent approved method.

The following materials meet the air permeance testing performance levels of 1 above. Manufacturers of these and other product types must provide a specification or product data sheet showing compliance to the ASTM testing requirements to be considered as an air barrier.

- Plywood – minimum 3/8 inch
- Oriented strand board – minimum 3/8 inches
- Extruded polystyrene insulation board – minimum 1/2 inch
- Foil-backed polyisocyanurate insulation board – minimum 1/2 inch
- Foil-backed urethane foam insulation – 1 inch
- Closed-cell spray polyurethane foam (ccSPF) with a minimum density of 2.0 pcf and a minimum thickness of 2.0 inches. Alternatively, ccSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m2 at 75 Pa pressure differential when tested in accordance with ASTM E2178 or ASTM E283.
- Open cell spray polyurethane (ocSPF) foam with a minimum density of 0.4 to1.5 pcf and a minimum thickness of 5½ inches. Alternatively, ocSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m2 at 75 Pa pressure differential when tested in accordance with ASTM E2178 or ASTM E283.
- Exterior or interior gypsum board – minimum 1/2 inch
- Cement board – minimum 1/2 inch
- Built-up roofing membrane
- Modified bituminous roof membrane
- Particleboard – minimum 1/2 inch
- Fully adhered single-ply roof membrane
- Portland cement/sand parge, or gypsum plaster – minimum 5/8 inch
- Cast-in-place and precast concrete
- Fully grouted uninsulated and insulated concrete block masonry
- Sheet steel or aluminum

Materials and assemblies of materials that can demonstrate compliance with the air barrier testing requirements must be installed according to the manufacturer's instructions, and a ECC-Rater shall verify the integrity of the installation.

Opaque Envelope in the Performance Approach

Some residential projects may not wish to use or do not meet the requirements for prescriptive compliance. The performance approach offers increased flexibility as well as compliance credits for certain assemblies, usually those requiring ECC-Verification. The designs described below are examples of residential envelope strategies that can be implemented under the performance approach. The proposed design used under the performance approach is compared to the standard design, which is determined by the prescriptive requirements. Remember that when using the performance approach, all applicable mandatory requirements must still be met.

Advanced Assemblies. Common strategies for exceeding the minimum energy performance level set by the 2025 Energy Code include the use of better components such as:

- Higher insulation levels.
- More efficient fenestration.
- Reducing 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.
- Greater use of non-framed assemblies or panelized systems (such as SIPs and ICFs).
- More efficient heating, cooling, and water-heating equipment.

The performance approach encourages the use of energy-saving techniques for showing compliance with the Energy Code.

Advanced Building Design. The design of a building, floor plan, and site design layout all affect energy use. A passive design building uses elements of the building to heat and cool itself, in contrast to relying on mechanical systems to provide the thermal energy needs of the building. Passive solar strategies encompass several advanced high-performance envelope techniques, such as:

- Carefully choosing the size, type, and placement of fenestration and shading.
- Providing and controlling fresh air ventilation during the day and night.
- Having internal and external thermal mass components that help store useful heat and cooling energy.
- Having highly insulated envelope assemblies.
- Using high performing roofing materials (cool roofs) and radiant barriers.
- Having very low air leakage.

Some requirements designed as part of an advanced assembly system may require specific installation procedures or field verification and diagnostic testing to ensure proper performance. Field verification and diagnostic testing are ways to ensure that the energy efficiency features used in compliance calculations are realized as energy benefits to the occupants.

Unvented Attics

Please refer to Chapter 3.6.1 of the *2022 Single-family Residential Compliance Manual*.

Below-Roof Deck Netted Insulation in Unvented Attics

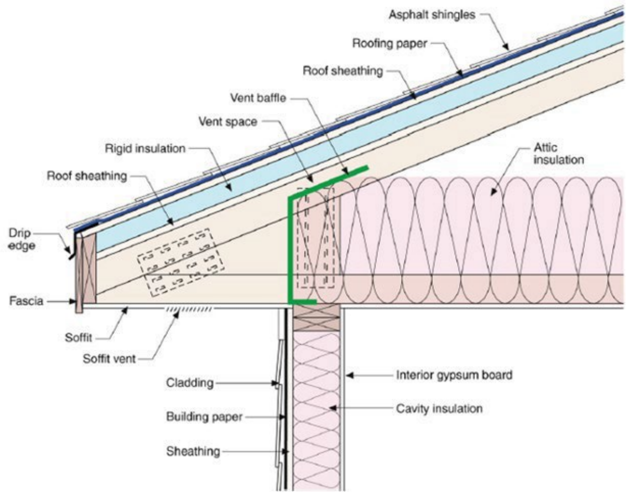
Please refer to Chapter 3.6.1.1 of the *2022 Single-family Residential Compliance Manual*.

Above-Roof Deck Insulation

A layer of continuous rigid insulation above and in direct contract with the roof deck (sheathing) increases the thermal integrity of the roof system. Continuous above-roof deck insulation is suitable for use with either asphalt shingles or clay/concrete tiles.

Required R-values for insulation installed above the roof deck are lower than R-values for insulation installed below the roof deck due to reduced thermal bridging when continuous insulation is applied directly above the roof deck. Further, an air space installed between the roof deck and the roofing tiles or shingles improves cooling of the roof assembly.

Figure 3-19: Detail of Above-Roof Deck Insulation

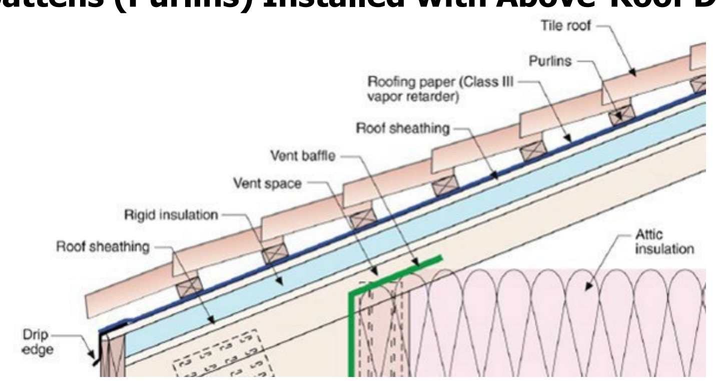


Source: Building Science Corporation

Note for ECC-Raters: Check manufacturer's specifications for proper nail schedules (fastening patterns); this will change depending on the roof pitch, truss spacing, and roofing material.

With concrete and clay tiles. Standard construction practice in California for concrete and clay tiles is to have an air gap between the tiles and roof deck because the tiles are installed over horizontal battens (or purlins). One option is to install continuous rigid insulation over the roof deck and a second layer of roof sheathing above the rigid insulation. If required by climate zone, a vapor retarder would be installed above the second sheathing layer to host the purlins with the tiles installed over them (Figure 3-20: Battens (Purlins) Installed with Above-Roof Deck Insulation).

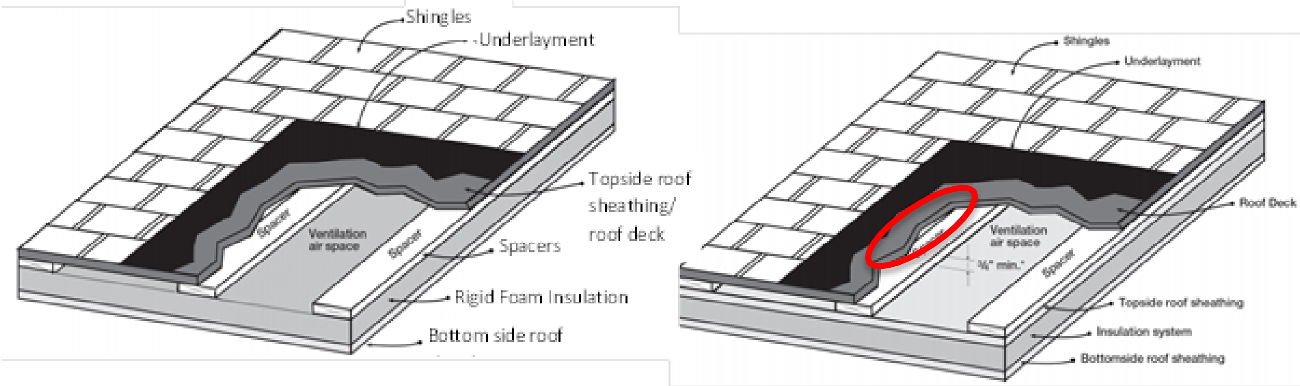
Figure 3-20: Battens (Purlins) Installed with Above-Roof Deck Insulation



Source: Building Science Corporation

With asphalt shingles. When installing asphalt shingles over above-roof deck insulation, it is best practice to ensure an air gap between the shingles and the top sheathing or insulation, as shown in Figure 3-21: Above-Roof Deck Insulation and Air Spaces with and without A Second Layer of Roof Sheathing, to mitigate the effect of high temperatures that reduce the effective life of roofing products.

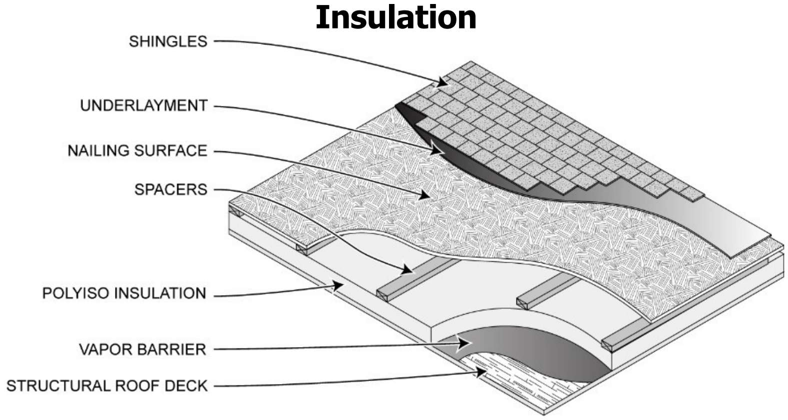
Figure 3-21: Above-Roof Deck Insulation and Air Spaces with and without A Second Layer of Roof Sheathing



Source: ARMA technical bulletin No. 211-RR-94

Spacers can be inserted above or below a second roof sheathing to provide roof deck ventilation and a nailable base for asphalt shingles (Figure 3-22: Asphalt Shingles and Spacers Installed with Above-Roof Deck Insulation). Prefabricated insulation products with spacers and top sheathing are available Check manufacturers' and trade association websites for a list of products that provide an air space and nailable base.

Figure 3-22: Asphalt Shingles and Spacers Installed with Above-Roof Deck Insulation



Source: PIMA Tech Bulletin #106

Example 3-20: Two Layers of Rigid Foam Board Above-Roof Deck

Question:

Can two layers of R-4 rigid foam board be installed as an equivalent performance to R8 rigid foam insulation above the roof deck? If so, are there best practices for installing the two layers of insulation?

Answer:

Yes, installing two R-4 rigid foam board layers is equivalent in performance to R-8. To prevent water infiltration, it is best to stagger the horizontal and vertical joints of the two layers and take care to seal each joint properly.

Example 3-21: Roof Material Directly Over Rigid insulation

Question:

A project plans to install R-6 rigid foam insulation above the roof deck with roofing material placed *directly* over the insulation. What are the best practices for installing the insulation?

Answer:

Insulation can be installed directly on the roof deck with no air gap, but performance is improved if an air gap is installed between the rigid insulation and the roofing material by using spacers or battens (purlins). Products exist that combine insulation, spacers, and additional sheathing for nailing asphalt shingles. Check with insulation manufacturers for available products.

Example 3-22: Fire Ratings Required by CBC, Chapter 15

Question:

Does a roof assembly using above-roof deck insulation meet Class A/B/C fire rating specifications, as determined by California Building Code (CBC), Chapter 15?

Answer:

Application of above-roof deck insulation affects the fire rating classification of roof covering products. Roof covering products are rated to Class A/B/C based on the ASTM E108 (NFPA 256, UL790) test. Class A/B/C ratings are done with specific roof assemblies, and ratings are valid only when the installation is the same as the assembly as rated. Under current building code requirement, tile roof products installed directly over the roof deck or over purlins are automatically rated Class A. Chapter 15 in the California Building Code (and International Building Code Section 1505 for Fire Classification) specify that certain roofing materials are Class A without having to test to ASTEM E108. These materials include slate, clay, concrete roof tile, an exposed concrete roof deck, and ferrous and copper shingles; however, asphalt shingles are not covered under this category.

Insulation products, on the other hand, are subject to a different fire test from roof- covering products. The California Building Code and International Building Code (Section 2603 for Foam Plastic Insulation) require foam plastic insulation to be tested to demonstrate a flame-spread index of not more than 75 and a smoke-developed index of not more than 450 according to ASTM E84 (UL723). The requirements apply to roof insulation products, including XPS/polyiso/polyurethane above-deck insulation and SPF below-deck insulation products.

To ensure that insulated roof assemblies meet the proper fire rating classification, roof product manufacturers and insulation manufacturers must test and develop assemblies that meet the CBC testing specifications.

Insulated Roof Tiles

Please refer to Chapter 3.6.3 of the *2022 Single-family Residential Compliance Manual*.

Raised Heel, Extension Truss, or Energy Truss

Please refer to Chapter 3.6.4 of the *2022 Single-family Residential Compliance Manual*.

Nail Base Insulation Panel

Please refer to Chapter 3.6.5 of the *2022 Single-family Residential Compliance Manual*.

Advanced Wall Systems and Advanced Framing

Please refer to Chapter 3.6.6 of the *2022 Single-family Residential Compliance Manual*.

Metal Framing

Please refer to Chapter 3.6.7 of the *2022 Single-family Residential Compliance Manual*.

Structural Foam Wall Systems

Please refer to Chapter 3.6.8 of the *2022 Single-family Residential Compliance Manual*.

Raised Floor Insulation Requirements

Please refer to Chapter 3.6.9 of the *2022 Single-family Residential Compliance Manual*.

ECC-Verified Reduced Building Air Leakage RA3.8

An energy credit is allowed for single-family buildings through the performance approach when the rate of envelope air leakage of the building is less than the air leakage rate assumed for the standard design building of 5 ACH50.

Note for ECC-Raters: A third-party ECC-Rater shall verify the air leakage rate shown on compliance documentation through diagnostic testing of the air leakage of the building.

Figure 3-23: Blower Door Testing

Source: California Energy Commission

Blower Door Testing. The blower door air leakage testing involves closing all the windows and doors; pressurizing the house with a special fan, usually positioned in a doorway Figure 3-23:

Blower Door Testing); and measuring the leakage rate, measured in cubic feet per minute at a 50 Pa pressure difference (CFM50).

The measurement procedure is described in Reference Appendices, Residential Appendix RA3.8 and was derived from the Residential Energy Services Network's (RESNET) Mortgage Industry National Home Energy Rating Standards, Standard 800, which is based on ASTM E779 air-tightness measurement protocols. This procedure requires the use of software consistent with ASTM E779. This test method is intended to produce a measure of the airtightness of a building envelope for determining the energy credit allowance for reduced building air leakage.

Note for Contractors/ Installers: Tips for Implementing the Reduced Building Air Leakage Compliance Credit

This procedure shall be used only to verify the building air leakage rate before the building construction permit is finalized when an energy credit for reduced air leakage is being claimed on compliance documentation.

The ECC-Rater shall measure the building air leakage rate to ensure measured air leakage is less than or equal to the building air leakage rate stated on the certificate of compliance and all other required compliance documentation. ECC-Verified building air leakage shall be documented on compliance forms.

This is a whole-building credit; therefore, no credit is allowed for the installation of envelope requirements that may help reduce the air leakage rate of the building, such as for an exterior air retarding wrap or for an air barrier material or assembly meeting the requirements described in Quality Insulation Installation (QII) RA 3.5.

Alternative Construction Assemblies

Log Homes

Please refer to Chapter 3.7.1 of the *2022 Single-family Residential Compliance Manual*.

Straw Bale

Please refer to Chapter 3.7.2 of the *2022 Single-family Residential Compliance Manual*.

Structural Insulated Panels (SIPs)

Please refer to Chapter 3.7.3 of the *2022 Single-family Residential Compliance Manual*.

Insulating Concrete Forms (ICF)

Please refer to Chapter 3.7.4 of the *2022 Single-family Residential Compliance Manual*.

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Building HVAC Requirements

Overview

Introduction and Organization

This chapter addresses the requirements for heating, ventilation, and air- conditioning (HVAC) systems, which include *space conditioning systems* and *indoor air quality systems* in the Energy Code, for newly constructed single-family residential buildings including single-family residences, duplexes, townhouses, and triplexes. The requirements are a source of information for the general public, mechanical system designers and installers, energy consultants, Energy Code Compliance (ECC)-Raters, and enforcement agency personnel.

Each section in this chapter outlines the mandatory measures and, when applicable, the prescriptive and performance compliance options pertaining to residential HVAC systems. If the overall home design does not achieve the minimum prescriptive requirements, the designer may use the performance compliance option that allows using higher performance measures in some areas to offset lower performance measures in other areas. See Chapter 1.6 for a more detailed discussion of the compliance process.

Each section of this chapter includes mandatory measures, prescriptive requirements, and performance compliance options.

Chapter 9 of the Residential Compliance Manual covers the heating and cooling requirements for additions to existing dwellings and for alterations to existing heating and cooling systems.

Chapter 10 of the Residential Compliance Manual covers the electric ready requirements including electric readiness for gas and propane furnaces and domestic hot water heaters.

What's New for 2025

Mandatory Features and Devices – §150.0

- Adds the ASHRAE Handbook Fundamentals Volume and ACCA Manual J as sources for outdoor design conditions (§150.0(h)2).
- Provides guidance on how to use authorized load calculations in system sizing and selection. Specifically, states that heat pumps be sized to meet minimum requirements from the California Building Code without supplementary heating; clarifies that there is no limit on minimum cooling or maximum heating capacity, and furnace heating capacity is based on ACCA Manual S-2023, Table N2.5 (§150.0(h)5).
- Establishes defrost requirements. Specifically, if a heat pump is equipped with a installer-adjustable defrost delay timer, the delay timer shall be set to greater than or equal to 90 minutes. This setting shall be tested by the installer and certified on the Certificate of Installation (CF2R). Exceptions include homes in Climate Zones 6 and 7, and homes with a conditioned floor area of 500 square feet or less in Climate Zones 3, 5-10, and 15 (§150.0(h)6).
- Requires that heat pump supplementary heating (electric resistance or gas) shall only operate below an outdoor air temperature of 35°F, during defrost, or when the user selects emergency operation. This setting shall be tested by the installer and certified on the CF2R.

There are exceptions for room air-conditioner heat pumps, buildings in Climate Zones 7 and 15, and buildings with a conditioned floor area of less than 500 square (§150.0(h)7).

- Requires that electric resistance supplementary heat shall have a capacity no larger than the heat pump nominal cooling capacity (at 95°F ambient conditions) multiplied by 2.7 kW per ton, rounded up to the closest kW (§150.0(h)8).
- Requires that variable or multi-speed systems controlled by third-party thermostats shall be capable of responding to heating and cooling loads by modulating system compressor speed and meet thermostat requirements in §150.0(i)2. This control configuration shall be tested by the installer and certified on the CF2R (§150.0(h)9).
- Requires that thermostats controlling heat pumps with electric resistance or gas furnace supplementary heat shall receive outdoor air temperature from an outdoor air temperature sensor or from an internet weather service, display the outdoor air temperature, have an indicator to notify when supplementary heat or emergency heat is in use, and lock out supplementary heat when the outdoor temperature is above 35°F (alone or in conjunction with heat pump operation). This functionality shall be tested by the installer and certified on the CF2R. There are exceptions for room air-conditioner heat pumps (§150.0(i)).
- Allows ducts in unvented attics to be insulated to R-4.2, less than the mandatory minimum of R-6, provided certain other requirements are met (§150.0(m)1Bi).
- Allows multispeed or variable speed compressor systems with controls that vary fan speed with respect to the number of zones to demonstrate compliance with airflow and fan efficacy requirements by operating the system at maximum compressor capacity and system fan speed, with all zones calling for conditioning (§150.0(m)13).
- Revises requirements for new whole dwelling unit mechanical ventilation for detached and attached single-family dwellings (§150.0(o)1.C). The revision includes requirements for balanced and supply-only ventilation systems regarding accessibility of indoor air quality (IAQ) filters and HRV/ERV, IAQ System components, outdoor air intake design, and outdoor air intake location and accessibility.

Prescriptive and Performance Compliance Approaches – §150.1

- Heat pumps are required for prescriptive compliance in all climate zones (§150.1(c)6, Table 150.1-A).
- The energy budget for the performance approach uses Long-Term System Cost (LSC) instead of Time Dependent Valuation (TDV) energy (§150.1(b)).
- Refrigerant charge verification is now required for Heat Pumps in all Climate Zones (§150.1(c)7A, Table 150.1-A).
- Fault indicator displays have been removed as an available method for refrigerant charge verification (Section 150.1(c)7A).
- Fault Indicator Displays have been removed as an available method for Refrigerant Charge Verification (§150.1(c)7AicII).
- All HRV/ERV systems serving individual dwelling units shall have a Fault Indicator Display (FID) as specified in Joint Reference Appendix JA17. The FID shall also be field verified by an ECC-Rater (§150.1(c)15).
- Performance compliance software validates that new construction projects use no more than 120% of the standard design building’s peak cooling energy use in kWh . Peak cooling

is measured in cooling energy kWh used between the hours of 4 – 9 pm. To reduce Peak Cooling energy use, upgrades to the opaque envelope, fenestrations, HVAC efficiency, and HVAC distribution systems may be necessary (See Alternative Calculation Method Manual for more details).

California Appliance Standards and Equipment Certification

Please refer to Chapter 4.1.3.1 of the 2022 Single-family Residential Compliance Manual.

Plan Review (Compliance)

Please refer to Chapter 4.1.3.2 of the 2022 Single-family Residential Compliance Manual.

Heating Equipment

Please refer to Chapter 4.2 of the 2022 Single-family Residential Compliance Manual.

Mandatory Measures for Heating Equipment

Equipment Efficiency

Reference: §110.1 and §110.2(a)

The efficiency of most heating equipment is regulated by the National Appliance Energy Conservation Act of 1987 (NAECA, the federal appliance standard) and the California Appliance Efficiency Regulations. These regulations are not contained in the Energy Code but are published separately. These regulations are referenced in §110.1. The heating efficiencies are generally reported in terms of annual fuel utilization efficiency (AFUE), thermal efficiency, combustion efficiency, heating seasonal performance factor (HSPF2), and coefficient of performance (COP). 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.

The energy efficiency of other equipment is regulated by §110.2(a). Also, see the *Nonresidential Compliance Manual* for more information on larger equipment.

Gas and Oil-Fired Furnaces

The *Appliance Efficiency Regulations* require gas- and oil-fired central furnaces with outputs less than 225,000 Btu/h 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/h are rated according to the respective thermal (or steady-state) efficiency. Refer to Table 4-1: Minimum Efficiency for Gas- and Oil-Fired Central Furnaces for the applicable efficiency requirements.

Table 4-1: Minimum Efficiency for Gas- and Oil-Fired Central Furnaces

Appliance	Rated Input (Btu/h)	Minimum Efficiency (%) AFUE	Minimum Efficiency (%) Thermal Efficiency
Weatherized gas central furnaces with single phase electrical supply	< 225,000	81	NA
Non-weatherized gas central furnaces with single phase electrical supply	< 225,000	80	NA
Weatherized oil central furnaces with single phase electrical supply	< 225,000	78	NA
Non-weatherized oil central furnaces with single phase electrical supply	< 225,000	83	NA
Gas central furnaces	≥ 225,000	NA	81
Oil central furnaces	≥ 225,000	NA	82

Source: California Appliance Efficiency Regulations Title-20 - Table E-5 and E-6

Noncentral gas furnaces and space heaters manufactured on or after April 16, 2013, shall be certified to have AFUE values greater than or equal to those listed in Table 4-2: Minimum Heating Efficiency for Non-ducted, Noncentral, Gas- Fired Heating Equipment.

Table 4-2: Minimum Heating Efficiency for Non-ducted, Noncentral, Gas- Fired Heating Equipment

Type	Capacity (Btu/h)	AFUE
Wall Furnace (fan type)	≤ 42,000	75%
Wall Furnace (fan type)	> 42,000	76%
Wall Furnace (gravity type)	≤ 27,000	65%
Wall Furnace (gravity type)	> 27,000 to ≤ 46,000	66%
Wall Furnace (gravity type)	> 46,000	67%
Floor Furnace	≤ 37,000	57%
Floor Furnace	> 37,000	58%
Room Heater	≤20,000	61%
Room Heater	> 20,000 to ≤ 27,000	66%
Room Heater	> 27,000 to ≤ 46,000	67%
Room Heater	> 46,000	68%

Source: California Appliance Efficiency Regulations Title 20 - Table E-2

Heat Pumps and Electric Heating

Heat pumps shall be certified to have a HSPF2 or coefficient of performance (COP) equal to or better than those listed in Table 4-3: Minimum Heating Efficiency for Heat Pumps.

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

Note: Minimum Cooling Efficiency for Heat Pump equipment types are in the Cooling Equipment section.

Table 4-3: Minimum Heating Efficiency for Heat Pumps

Equipment Type	Configuration/Size	Minimum Heating Efficiency
Packaged terminal heat pumps (heating mode)	Newly constructed or newly conditioned buildings or additions	3.7-(0.052 x Cap[1]/1000) = COP
Packaged terminal heat pumps (heating mode)	Replacements	2.9-(0.026 x Cap[1]/1000) = COP
Single-phase air source heat pumps (NAECA)	< 65,000 Btu/h cooling capacity	Packaged 6.7 HSPF2 Split 7.5 HSPF2
Single-phase air source heat pumps (NAECA)	Space constrained < 65,000 Btu/h cooling capacity	6.3 HSPF2
Single-phase air source heat pumps (NAECA)	Small duct, high velocity < 65,000 Btu/h cooling capacity	6.1 HSPF2
Three-phase air source heat pumps	Split-system < 65,000 Btu/h	7.5 HSPF2
Three-phase air source heat pumps	≥ 65,000 and <135,000	3.4 COP
Three-phase air source heat pumps	≥ 135,000 and <240,000	3.3[2] COP
Three-phase air source heat pumps	≥ 240,000 and <760,000	3.2 COP

Equipment Type	Configuration/Size	Minimum Heating Efficiency
Water-source heat pumps	≥ 65,000 and < 135,000 Btu/h	4.3 COP
Single package vertical heat pumps	< 65,000 single-phase and 3-phase	3.3 COP
Single package vertical heat pumps	≥ 65,000 and < 135,000	3.0 COP
Single package vertical heat pumps	≥ 135,000 and < 240,000	3.0 COP

1. Cap = Cooling Capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
2. Electric resistance heating or no heating
3. All other types of heating

Source: California Appliance Efficiency Regulation Title 20 and Energy Code

Gas- and Oil-Fired Central Boilers and Electric Boilers

Gas- and oil-fired central boilers shall be certified to have and AFUE or *Combustion Efficiency* equal to or better than those listed in Table 4-4: Minimum Efficiency for Gas- and Oil-Fired Central Boilers.

Table 4-4: Minimum Efficiency for Gas- and Oil-Fired Central Boilers

Appliance	Rated Input (Btu/h)	Minimum Efficiency (%)	Efficiency Metric
Gas steam boilers with single-phase electrical supply	< 300,000	82 [1]	AFUE
Gas hot water boilers with single-phase electrical supply	< 300,000	84 [1,2]	AFUE
Oil steam boilers with single-phase electrical supply	< 300,000	85	AFUE
Oil hot water boilers with single-phase electrical supply	< 300,000	86 [2]	AFUE
Electric steam residential boilers	< 300,000	NA	NA
Electric hot water residential boilers	< 300,000	NA	NA
All other boilers with single-phase electrical supply	< 300,000	NA	NA

1. No constant burning pilot light design standard.
2. Automatic means for adjusting water temperature design standard.

Source: California Appliance Efficiency Regulations Title 20 Table E-3

Table 4-5: Minimum Efficiency for Gas- and Oil-Fired Central Boilers

Appliance	Rated Input (Btu/h)	Minimum Thermal Efficiency (%)	Minimum Combustion Efficiency (%)
Steam boilers; gas-fired, except natural draft;	≥ 300,000	79	81
Steam boilers; gas-fired, natural draft	≥ 300,000	79	81
Steam boilers; oil-fired	≥ 300,000	81	82

Source: California Appliance Efficiency Regulations Title 20 Table E-4

Heating System Controls

Reference: §150.0(i), §110.2(b), Exceptions to §110.2(b), §110.2(c), Exception to §110.2(c), §150.0(h)

Heating systems must be controlled by a central energy management control system (EMCS) or by a setback thermostat.

The setback thermostat must be capable of allowing the occupant to program temperature set points for at least four periods within a 24-hour time span (§110.2(c)). The exception to this requirement is for gravity gas wall heaters, floor heaters, room heaters, fireplaces, wood stoves, and noncentral electric heaters.

There are thermostat requirements for heat pump systems with electric resistance or gas furnace supplementary heat (§150.0(i)). For these systems, thermostats must be able to control the use of the supplementary heating. These features include the ability to monitor and display the outdoor air temperature either through an outdoor temperature sensor or from an internet weather service. The thermostat must also be capable of notifying the occupant when the supplementary heater is in use.

Per Section 150.0(h)7, heat pumps with supplementary heat, including, but not limited to, electric resistance heaters or gas furnace supplementary heating, shall lock out supplementary heating any time the outdoor air temperature is above a setpoint of no more than 35°F. This control can be on the heat pump or the thermostat, and there are additional thermostat requirements in Section 150.0(i)2. The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements.

The controls may allow supplementary heater operation above 35°F only during defrost; or when the user selects emergency operation.

Room air-conditioner heat pumps are an exception to the above requirements. For buildings with a conditioned floor area less than 500 square feet, and for buildings of any size in climate zones 7 and 15, heat pumps with supplementary heaters shall have controls that meet Option A or Option B below:

Option A:

- Prevent supplementary heater operation when the heating load can be met by the heat pump alone; and
- In which the cut-on temperature for heat pump heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for heat pump heating is higher than the cut-off temperature for supplementary heating.

Option B:

- The controls may allow supplementary heater operation during defrost mode and transient periods, such as start-ups and following a room thermostat setpoint advance, if the controls prevent the unnecessary operation of supplementary heating.

Some heat pumps are equipped with a field-adjustable defrost delay timer, with delay settings of 30, 60, 90, or 120 minutes (for example). The longer this delay is set for, the less frequently the defrost mode will be enabled. When these heat pumps are used, the delay timer must be set to at least 90 minutes. The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements. Exceptions include homes in climate zones 6 and 7, and homes with a conditioned floor area of 500 square feet or less in climate zones 3, 5 – 10, and 15 (§150.0(h)6). Note that this requirement does not apply to heat pumps with more sophisticated types of defrost control, or systems with automatic timer settings.

Variable or multi-speed heat pumps, even when they are controlled by third-party thermostats (thermostats that are made to be used with any system, and are not proprietary to the HVAC manufacturer), must be capable of modulating system compressor speed in response to varying loads. In some cases, this may require special adapters that are provided by the HVAC manufacturer and must be configured by the installer. Thermostats used in these applications must also meet the thermostat requirements described above (§150.0(i)2). The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements. (§150.0(h)9).

Equipment Sizing

Reference: §150.0(h)1, 2, 5 and 8

Inappropriately sized equipment typically operates less efficiently and can create comfort problems due to excessive cycling and improper airflow. Ensuring appropriate sizing requires attention in two areas: 1) Load Calculation, and 2) System Selection.

The Energy Code requires that heating loads be calculated for new space heating systems.

Acceptable load calculation procedures include methods described in the following publications:

- ACCA Manual J
- The SMACNA Residential Comfort System Installation Manual
- The ASHRAE Handbook – Equipment, Applications, and Fundamentals Volumes

Load Calculations are sensitive to the appropriate selection of outdoor and indoor Design Conditions. The Energy Code requires that the indoor design temperature for heating load calculations shall be 68°F.

The outdoor design conditions for load calculations are to be selected from one of the following sources:

- Reference Joint Appendix (JA) JA2,
- The ASHRAE Handbook, Fundamentals Volume, or
- ACCA Manual J.

The outdoor design temperature for heating must be no lower than the 99.0 percent Heating Dry Bulb or the Heating Winter Median of Extreme values for the project city. If the actual city location for a project is not included in Joint Appendix (JA) 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.

According to Section 150.0(h)8, if a heat pump has electric resistance supplementary heat, the capacity of that supplementary heater cannot be larger than the heat pump nominal cooling capacity (at 95°F ambient conditions) multiplied by 2.7 kW per ton, rounded up to the closest kW. For example, a heat pump with a nominal cooling capacity of 3 tons, the maximum allowed electric resistance allowed would be:

3 tons x 2.7 kW/ton = 8.1 kW rounded to the nearest kW would be 8 kW.

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, such as an energy consultant.

The California Business and Professions Code allows unlicensed persons to prepare plans, drawings, or specifications for wood-framed single-family residential buildings if the dwellings are no more than two stories high, not counting a possible basement, or for certain buildings containing no more than four dwelling units of wood-frame construction not more than two stories and basement in height.

System Selection

To meet the minimum requirements of the CBC, selected heating systems must meet the heating loads of Section 150.0(h)1 and 2. In general, ACCA Manual S-2023 shall be used for system selection. For example, furnaces shall be sized based on ACCA Manual S-2023, Table N2.5. There are some important differences between ACCA Manual S-2003 and the Energy Code. Notably, heating systems are required to meet this minimum capacity *not including* any supplementary heating provided. Also, for the Energy Code, there is no limit on the maximum heating capacity for heat pumps.

For example, in a very cold climate, the heating load will be much larger than the cooling load. ACCA Manual S-2003 would allow sizing a heat pump system to the cooling load and making up the difference with supplementary heating. The Energy Code, however, requires designers to select a system that meets the larger heating load without use of supplementary heating. (Supplementary heating can still be used, but it should not be used to meet the design load, only to meet the load during defrost, morning warmup, or emergency situations). This system will be oversized for cooling, but the inefficiency introduced for cooling during the typically much smaller number of cooling hours in these climates is overshadowed by avoiding the inefficiency of using supplementary heating for a large number of heating hours.

When an addition is served by an existing HVAC system, load calculations per 150.0(h)1 should include the entire area served by the HVAC system. This will ensure that the system can properly serve the existing building area and addition.

Standby Losses and Pilot Lights

Please refer to Chapter 4.2.1.4 of the 2022 Single-family Residential Compliance Manual.

Pipe Insulation

Please refer to Chapter 4.2.1.5 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements for Heating Equipment

Reference: §150.1(c)6

Prescriptive compliance requires the installation of a heat pump as the main heating system. The heat pump shall meet minimum energy efficiency ratings (See Table 4-1 through Table 4-4: Minimum Efficiency for Gas- and Oil-Fired Central Boilers).

There are no restrictions on the type of heat pump that can be installed if it meets the minimum efficiency rating requirements.

Supplemental heating systems, which are independent from the primary heating system, are allowed under the Exception to 150.1(c)6, 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 directly or indirectly 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. This supplemental heating system should not be confused with the supplemental heat integrated into some heat pumps that is regulated under the mandatory sections 150.0(h)7 and 8.

Electric resistance and electric radiant heating installations are not allowed as the primary heating system when using the prescriptive compliance approach.

Performance Compliance Options for Heating Equipment

Please refer to Chapter 4.2.3 of the 2022 Single-family Residential Compliance Manual.

High-Efficiency Heating

Heating system efficiencies are explained in the Equipment Efficiency subsection of the Heating Equipment section. The minimum efficiency is required to be met for prescriptive compliance or performance compliance. When the performance compliance approach is used, additional compliance credit may be available by using heating equipment that exceeds minimum efficiency requirements which can be used to offset less efficient building features.

When a heat pump is providing space heating, if the efficiency used for compliance is higher than the minimum required HSPF2, the system efficiency must be verified by an ECC-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 performance compliance software, the Air Conditioning, Heating, and Refrigeration Institute (AHRI) ratings for heating capacity of the installed heat pump must be verified by an ECC-Rater to confirm the heating capacities at 47 °F and 17 °F are equal or greater than the heating capacities listed on the certificate of compliance (CF1R). See Reference Residential Appendix RA3.4 for more information about this ECC-Verification.

Cooling Equipment

Mandatory Measures for Cooling Equipment

Equipment Efficiency

Reference: §110.1 and §110.2(a)

The efficiency of most cooling equipment is regulated by NAECA (the federal appliance standard) and the California Appliance Efficiency Regulations. These regulations are not contained in the Energy Code but are referenced in §110.1. The energy efficiency of larger equipment is regulated by §110.2(a). The cooling efficiencies are generally reported in terms of seasonal energy efficiency ratio (SEER2) and energy efficiency ratio (EER2), except for Room air conditioner efficiencies, which are reported in combined energy efficiency ratio (CEER). See the *Nonresidential Compliance Manual* for information on larger equipment.

Central, Single-Phase Air Conditioners and Air Source Heat Pumps (Under 65,000 Btu/h)

The central, single-phase air conditioners and air source heat pumps that are most commonly installed in homes have a capacity less than 65,000 Btu/h. The *Appliance Efficiency Regulations* for this equipment require minimum seasonal energy efficiency ratios (SEER2).

The SEER2 of all new central, single-phase air conditioners and air source heat pumps with output less than 65,000 Btu/h shall be certified to the Energy Commission to have values no less than the values listed in Table 4-6: Minimum Cooling Efficiencies for Central Air Conditioners and Heat Pumps (Cooling Capacity Less Than 65,000 Btu/h) (NR = No Requirement).

Note: Minimum Heating Efficiency for Heat Pump equipment types are in the Heating Equipment section.

Table 4-6: Minimum Cooling Efficiencies for Central Air Conditioners and Heat Pumps (Cooling Capacity Less Than 65,000 Btu/h) (NR = No Requirement)

Appliance	Type	SEER 2	EER 2
Central Air Conditioners	Split-System <45,000 Btu/h	14.3	11.7
Central Air Conditioners	Split-System ≥45,000 Btu/h	13.8	11.2
Central Air Conditioners	Single-Package	13.4	10.6
Central Air Source Heat Pumps	Split-System	14.3	NR
Central Air Source Heat Pumps	Single-Package	13.4	NR
Space-Constrained Air Conditioner	Split-System	14.3	NR
Space-Constrained Air Conditioner	Single-Package	11.7	NR
Space-Constrained Heat Pump	Split-System	11.9	NR
Space-Constrained Heat Pump	Single-Package	11.9	NR
Small-Duct, High-Velocity Air Conditioner	All	12.0	NR
Small-Duct, High-Velocity Heat Pump	All	12.0	NR

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

Other Air Conditioners and Heat Pumps

Appliance Efficiency Regulations

The current *Appliance Efficiency Regulations* for three-phase models, larger-capacity central air conditioners and heat pumps, and all room air conditioners and room air conditioner heat pumps shall be certified to the Energy Commission by the manufacturer to have values no less than the values listed in Table 4-7: Minimum Cooling Efficiency for Three-Phase Models and Larger Capacity Central Air Conditioners and Heat Pumps and Table 4-8: Minimum Cooling Efficiency for Noncentral Space-Cooling Equipment.

Table 4-7: Minimum Cooling Efficiency for Three-Phase Models and Larger Capacity Central Air Conditioners and Heat Pumps

Equipment Type	Size Category (Btu/h)	SEER2 or EER2
Central Air-Conditioners	≥65,000 but <135,000	10.8[1] EER2 10.6[2] EER2
Central Air-Conditioners	≥135,000 but <240,000	10.6[1] EER2 10.4[2] EER2
Central Air-Conditioners	≥240,000 but <760,000	9.6[1] EER2 9.4[2] EER2
Central Air-Source Heat Pumps	< 65,000 Split-System	14.3 SEER2
Central Air-Source Heat Pumps	< 65,000 Single-Packaged	14.3 SEER2
Central Air-Source Heat Pumps	≥ 65,000 but <135,000	10.6[1] EER2 10.4[2] EER2
Central Air-Source Heat Pumps	≥135,000 but <240,000	10.2[1] EER2 10[2] EER2
Central Air-Source Heat Pumps	≥240,000 but <760,000	9.1[1] EER2 8.9[2] EER2
Central Water-Source Heat Pumps	< 17,000	11.7 EER2
Central Water-Source Heat Pumps	≥ 17,000 and < 65,000	12.5 EER2
Central Water-Source Heat Pumps	≥ 65,000 and < 135,000	12.5 EER2
Central Water-Source Heat Pumps	≥ 135,000 and < 240,000	12.0 EER2
Central Water-Source Heat Pumps	≥ 240,000 and < 760,000	11.9 EER2
Water-Cooled Air Conditioners	< 17,000	11.7.2 EER2

Water-Cooled Air Conditioners	≥ 17,000 < 65,000	12.5 EER2
Water-Cooled Air Conditioners	≥ 65,000 and < 135,000	11.6[3] EER2
Water-Cooled Air Conditioners	≥ 135,000 and < 240,000	12.0[3] EER2
Water-Cooled Air Conditioners	≥ 240,000 and < 760,000	11.9[3] EER2

* 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 4-8: Minimum Cooling Efficiency for Noncentral Space-Cooling Equipment

Equipment Type	Size Category (Input)	Minimum Efficiency
Room Air Conditioners, With Louvered Sides	< 6,000	13.1 CEER
Room Air Conditioners, With Louvered Sides	≥ 6,000 and < 7,900	13.7 CEER
Room Air Conditioners, With Louvered Sides	≥ 8,000 and < 13,900	16.0 CEER
Room Air Conditioners, With Louvered Sides	≥ 14,000 and < 19,900	16.0 CEER
Room Air Conditioners, With Louvered Sides	≥ 20,000 and < 27,900	13.8 CEER
Room Air Conditioners, With Louvered Sides	≥ 28,000	13.2 CEER
Room Air Conditioners, Without Louvered Sides	< 6,000	12.8 CEER
Room Air Conditioners, Without Louvered Sides	≥ 6,000 and < 7,900	12.8 CEER
Room Air Conditioners, Without Louvered Sides	≥ 8,000 and < 10,900	14.1 CEER
Room Air Conditioners, Without Louvered Sides	≥ 11,000 and < 13,900	13.9 CEER
Room Air Conditioners, Without Louvered Sides	≥ 14,000 and < 19,900	13.7 CEER
Room Air Conditioners, Without Louvered Sides	≥ 20,000	13.8 CEER
Room Air Conditioner Heat Pumps With Louvered Sides	< 20,000	14.4 CEER
Room Air Conditioner Heat Pumps With Louvered Sides	≥ 20,000	13.7 CEER
Room Air Conditioner Heat Pumps Without Louvered Sides	< 14,000	13.7 CEER
Room Air Conditioner Heat Pumps Without Louvered Sides	≥ 14,000	12.8 CEER

Casement-Only Room Air Conditioner	All Capacities	13.9 CEER
Casement-Slider Room Air Conditioner	All Capacities	15.3 CEER
Standard Sized PTAC (cooling mode)	All Capacities	13.4 - (0.300 x Cap/1000) = EER2
Non-Standard Sized PTAC (cooling mode)	All Capacities	10.5 - (0.213 x Cap/1000) = EER2
Standard Sized PTHP (cooling mode)	All Capacities	13.4 - (0.300 x Cap/1000) = EER2
Non-Standard Sized PTHP (cooling mode)	All Capacities	10.4 - (0.213 x Cap/1000) = EER2
SPVAC (cooling mode)	< 65,000	11.0 EER
SPVAC (cooling mode)	≥ 65,000 and < 135,000	10.0 EER
SPVAC (cooling mode)	≥ 135,000 and < 240,000	10.0 EER
SPVHP (cooling mode)	< 65,000 Btu/h	11.0 EER
SPVHP (cooling mode)	≥ 65,000 and < 135,000	10.0 EER
SPVHP (cooling mode)	≥ 135,000 and < 240,000	10.0 EER

Cap. = Cooling Capacity (Btu/h)

Note: Including room air conditioners and room air conditioner heat pumps, package terminal air conditioners (PTAC), package terminal heat pumps (PTHP), single-package vertical air conditioners (SPVAC), and heat pumps (SPVHP).

Source: California Appliance Efficiency Regulations Title 20, Table B-2, B-3, B-4; Energy Code

Insulation for Refrigerant Lines in Split-System Air Conditioners

Reference: 150.0(j)2, 150.0(m)9

Two refrigerant lines connect the indoor and outdoor units of split-system air conditioners and heat pumps. These are the liquid line (the smaller diameter tube) and the suction line (the larger diameter tube).

If the liquid line remains at an elevated temperature relative to outdoor and indoor temperatures, it should not be insulated. In this situation, the heat loss 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) as specified in Table 120.3-A-1 and 120.3-A-2 of the Energy Code.

Insulation used for refrigerant suction lines located outside a condition 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.

Figure 4-1: Refrigerant Line Insulation

Source: Airex Manufacturing Inc.

Outdoor Condensing Units

Reference: 150.0(h)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 shall not be placed within 5 feet of a dryer vent. This requirement is applicable to new installations and to replacements. Regardless of location, condenser coils should be cleaned regularly in all homes. 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 4-2: Refrigerant Line Insulation

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 contaminates 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, which makes it difficult for technicians to access. Because of this difficulty, manufacturers have begun changing this practice by installing liquid line filter dryers outside condensers, so that they can be easily serviced by technicians and more easily verified by ECC-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.

Cooling System Controls

Reference: §150.0(h)9, §150.0(i)2

Variable or multi-speed heat pumps and air conditioners, even when they are controlled by third-party thermostats (thermostats that are made to be used with any system, and are not proprietary to the HVAC manufacturer), must be capable of modulating system compressor speed in response to varying loads. In some cases, this may require special adapters that are provided by the HVAC manufacturer and must be configured by the installer. Thermostats used in these applications must meet thermostat requirements in §150.0(i)2. The intent of this requirement is to ensure that the installer selects an appropriate thermostat for the space conditioning system being installed. Manufacturers are not expected to make their systems compatible with all thermostats. The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements.

Equipment Sizing

Reference: §150.0(h)1, 2, and 5

Similarly to heating systems, inappropriately sized cooling equipment typically operates less efficiently and can create comfort problems due to excessive cycling and improper airflow. Ensuring appropriate sizing requires attention in two areas: 1) Load Calculation, and 2) System Selection.

Load Calculation

The Energy Code requires that cooling loads be calculated for new space cooling systems. Acceptable load calculation procedures include methods described in the following publications:

- ACCA Manual J
- The SMACNA Residential Comfort System Installation Manual
- The ASHRAE Handbook – Equipment, Applications, and Fundamentals Volumes

Load Calculations are sensitive to the appropriate selection of outdoor and indoor Design Conditions. The Energy Code requires that the indoor design temperature for cooling load calculations shall be 75 °F.

The outdoor design conditions for load calculations are to be selected from one of the following sources:

- Reference Joint Appendix (JA) JA2,
- The ASHRAE Handbook, Fundamentals Volume, or
- ACCA Manual J.

The outdoor design temperature for cooling must be equal to the 1.0 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values for the project city. If the actual city location for a project is not included in Joint Appendix (JA) 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 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, such as an energy consultant.

The California Business and Professions Code allows an unlicensed person to prepare plans, drawings, or specifications for wood-framed single-family residential buildings if the dwellings are no more than two stories, not counting a possible basement, or for certain buildings containing no more than four dwelling units of wood-frame construction not more than two stories and basement in height.

System Selection

Reference: §150.0(h)5

In general, ACCA Manual S-2023 shall be used for system selection. Note that there is no lower limit on the size of an air conditioner, since meeting cooling loads is not a requirement of the CBC.

Hole for Static Pressure Probe (HSPP) or Permanently Installed Static Pressure Probe (PSPP)

Reference: §150.0(m)13

Space-conditioning systems that use forced air ducts to cool occupiable space shall have a hole for the placement of a static pressure probe (HSPP) or permanently installed static pressure probe (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 (RA) RA3.3. The HSPP or PSPP is required to promote system airflow measurement when using devices/procedures that depend on supply plenum pressure measurements. The

HSPP or PSPP allows ECC-Raters to perform the required diagnostic airflow testing in a nonintrusive manner, by eliminating the necessity for the ECC-Raters to drill holes in the supply plenum for placement of pressure measurement probes.

The size and placement of the HSPP/PSPP shall be in accordance with RA3.3.1.1 and shall be verified by an ECC-Rater. In the event that 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 ECC-Rater will verify this. Not installing an HSPP/PSPP will limit the airflow measurement method to either a powered flow hood or passive (traditional) flow hood.

When the mandatory measure for minimum system airflow rate is in effect (for entirely new systems), there must be a hole in the supply plenum, provided by the installing contractor, for the placement of a HSPP. Alternatively, a PSPP must be installed in the same location.

This 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 ECC-Rater.

See Air Distribution System Ducts, Plenums, Fans, and Filters for discussion regarding mandatory sizing/airflow requirements for ducted systems with cooling.

Prescriptive Requirements for Cooling Equipment

Reference: §150.1(c)7

Prescriptive compliance does not require that a cooling system be installed. However, if a cooling system is to be installed, the minimum cooling equipment efficiency requirements apply (See Mandatory Measures for Cooling Equipment).

Prescriptive requirements for air-cooled air conditioners in Climate Zones 2 and 8 – 15 and air-source heat pumps installed in any Climate Zone 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 ECC-Rater. The MAH provides a nonintrusive means of measuring return air temperature, which is a parameter important to the RCV process.

Note: The refrigerant charge verification is discussed below (Refrigerant Charge Verification (RCV)) and in greater detail later in Refrigerant Charge.

Measurement Access Hole (MAH)

Please refer to Chapter 4.3.2.1 of the 2022 Single-family Residential Compliance Manual.

The MAH provides a nonintrusive means for refrigerant charge verification by ECC-Raters and other third-party inspectors. They eliminate the need for raters/inspectors to drill holes into the installed air conditioning equipment enclosures for placement of the temperature sensors required by the refrigerant charge verification test procedures described in 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 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)

Minimum System Airflow

Please refer to Chapter 4.3.2.2 of the 2022 Single-family Residential Compliance Manual.

Refrigerant Charge Verification (RCV)

Reference: Table 150.1-A

The prescriptive standards require that an ECC-Rater verify that ducted air-cooled air conditioners in climate zones 2 and 8 – 15, and ducted air-source heat pumps, small- duct high-velocity systems; and mini-split systems in all climate zones have the correct refrigerant charge. The RCV procedures are documented in RA1.2, RA2.4.4, and RA3.2.

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). *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.

Performance Compliance Options for Cooling Equipment

Please refer to Chapter 4.3.3 of the 2022 Single-family Residential Compliance Manual.

High-Efficiency Air Conditioner

Air conditioner efficiencies are explained in the Equipment Efficiency section of the Cooling Equipment section. The minimum efficiency is required to be met for prescriptive compliance or performance compliance. When the performance compliance approach is used, additional compliance credit may be available by using cooling equipment that exceeds the minimum efficiency requirements which can be used to offset less efficient building features.

The EER2 is the full-load efficiency at specific operating conditions. It is possible that two units with the same SEER2 can have different EER2s. In cooling-dominated climate zones of California, for two units with a given SEER2, the unit with the higher EER2 is more effective in saving energy. Using the performance compliance method, credit is available for specifying an air conditioner with an EER2 greater than the minimum (Table 4-6: Minimum Cooling Efficiencies for Central Air Conditioners and Heat Pumps (Cooling Capacity Less Than 65,000

Btu/h) (NR = No Requirement)). When credit is taken for a high EER2 and/or SEER2, field verification by an ECC-Rater is required. (See RA3.4.4).

Air Handler Fan Efficacy and System Airflow

Please refer to Chapter 4.3.3.2 of the 2022 Single-family Residential Compliance Manual.

Whole-House Fan Ventilation Cooling

Please refer to Chapter 4.3.3.3 of the 2022 Single-family Residential Compliance Manual.

A whole-house fan (WHF) is not a mandatory requirement. It is required in some climate zones when using prescriptive compliance. The three performance compliance options are the following:

- No WHF is assumed in the performance compliance software (no ventilation cooling). Whether or not the applicable climate zone assumes the effects of a WHF will affect the energy usage simulated in the model.
- A default WHF means this proposed feature is equivalent to the standard feature used to establish the energy budget of the building (The performance of the fan is derated to account for deficiencies from installing undersized or inefficiently designed WHF).
- The ECC-verified WHF option allows for modeling the effects of the WHF without derating the system performance. The ECC-verified option also allows modeling a WHF with a higher airflow rate or lower fan efficacy than the default, which improves the compliance credit.

Central Fan Ventilation Cooling

Central fan ventilation cooling (CFVC) performs a function similar to a whole-house fan (WHF) using the central space-conditioning ducts to distribute outside air. When using the performance compliance approach, a CFVC system may be selected instead of a conventional whole-house fan in the compliance software. Three compliance options are:

- No CFVC is assumed in the performance compliance software (no ventilation cooling). Whether or not the applicable climate zone assumes the effects of a WHF will affect the energy usage simulated in the model.
- A default CFVC system means the proposed system is equivalent in size and features to a derated WHF.
- The ECC-verified CFVC system option allows system performance without derating. It also allows for modeling a system with greater capacity, a higher airflow rate or lower fan efficacy than default.

After installation, the contractor must test the actual fan power and airflow of the system using the procedure in RA3.3 and show that it is equal to or better than what was proposed in the compliance software analysis.

Field verification by an ECC-Rater is required. (See RA3.3.)

Air Distribution System Ducts, Plenums, Fans, and Filters

Air distribution system performance can have a big effect on overall HVAC system efficiency. Therefore, air distribution systems are required to meet several mandatory and prescriptive requirements as discussed below.

The 2025 Energy Code specifies mandatory requirements for 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 (e.g., attic, crawlspace, basement, inside conditioned space, etc.).
- Specific conditions in the unconditioned space, for example, presence of a radiant barrier.
- Duct insulation characteristics.
- Duct internal 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 computer program will use default assumptions for the proposed design when the user does not intend to make improvements in duct efficiency.

Mandatory Measures for Air Distribution System Ducts, Plenums, Fans, and Filters

Minimum Insulation

Reference: §150.0(m)1B

Space conditioning supply-air and return-air ducts and plenums are required to have a minimum duct insulation level of R-6, except for when the duct or plenum is located in conditioned space or in an unvented attic as described below.

For duct systems located entirely in conditioned space, the ducts do not require insulation. To determine whether ducts are entirely in conditioned space as defined in §100.1, a, ECC-Rater must field verify by visual inspection and by using the protocols of RA 3.1.4.3.8.

For duct systems located in unvented attics meeting the three requirements of Exception 2 to 150.0(m)1Bi, ducts must be insulated to a minimum of R-4.2. The three conditions that must be met in order to qualify for this exception are:

- Minimum R-30 insulation between the roof rafters in contact with the roof deck;
- Gable ends meet the wall insulation requirements of 150.1(c)1B; and,
- Dwelling unit meets 3.0 ACH50 air leakage or less, as confirmed by field verification and diagnostic testing with the attic hatch open in accordance with RA3.8.

For duct systems located in both unconditioned and conditioned space, the portions of the duct system located in conditioned space are not required to be insulated if all of the following conditions are met and visually confirmed by the building inspector:

- The non-insulated portion of the duct system is located below the ceiling that separates the occupiable space from the attic and is entirely inside the building's thermal envelope.
- At all locations where the non-insulated portions of the duct system penetrate into unconditioned space, the penetration must be draft stopped in compliance with California Fire Code (CFC) Sections 703.1 and 704.1. The penetration must also be air-sealed to the

construction materials that are penetrated using materials compliant with California Mechanical Code (CMC) Section E502.4.2 to prevent air infiltration into the building cavity. Any connections in the unconditioned space must be insulated to a minimum R-6.

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 duct systems must be made airtight by means of mastics, gasketing, or other means.

RA 3.1.4.3.8 describes the test of duct leakage to outside that determines whether the ducts are within the pressure boundary of the space being served by the duct system. Also, a basic visual inspection of the ducts is required to ensure 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.

Exception to §150.0(m)1: Ducts and fans integral to a wood heater or fireplace are exempt from §150.0(m)1.

Reference: §150.0(m)5

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 shall 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 shall be used.

Connections and Closures

Please refer to Chapter 4.4.1.2 of the 2022 Single-family Residential Compliance Manual.

Factory-Fabricated Duct Systems

Please refer to Chapter 4.4.1.3 of the 2022 Single-family Residential Compliance Manual.

Field-Fabricated Duct Systems

Please refer to Chapter 4.4.1.4 of the 2022 Single-family Residential Compliance Manual.

Draw Bands Used With Flexible Duct

Please refer to Chapter 4.4.1.5 of the 2022 Single-family Residential Compliance Manual.

Aerosol-Sealant Closures

Aerosol sealants shall meet the requirements of UL 723 and be applied according to manufacturer specifications.

Tapes or mastics used in combination with aerosol sealing shall 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 an ECC-Rater may examine ducts installed in these building spaces 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.

Reference: §150.0(m)2D, §150.0(m)3D

Duct systems may not use cloth-backed, rubber-adhesive duct tape (typical, "old fashioned," nonrated duct tape) unless it is installed in combination with mastic and draw bands. Mastic and draw bands alone are adequate for sealing most connections. Cloth–backed, rubber-adhesive duct tape may be used to hold the outer vapor barrier in place or for some purpose other than prevention of duct leakage. Cloth-backed rubber adhesive duct tape alone is not adequate to serve as an air-sealing method or as a mechanical connection.

The enforcement of these minimum standards is normally the responsibility of the building official; however, ECC-Raters will also verify compliance with this requirement in conjunction with duct leakage verification.

Product Markings

Please refer to Chapter 4.4.1.7 of the 2022 Single-family Residential Compliance Manual.

Dampers to Prevent Air Leakage

Please refer to Chapter 4.4.1.8 of the 2022 Single-family Residential Compliance Manual.

Protection of Insulation

Reference: Section 150.0(m)9

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 shall be protected as above or painted with a coating that is water-retardant and shields from solar radiation that can degrade the material.

If ducts are in the soil beneath the slab or embedded in the slab, the insulation material should be designed and rated for such installation. Insulation installed in below-grade applications should resist moisture penetration. (Closed-cell foam is one moisture-resistant product.) Common premanufactured duct systems are not suitable for below-grade installations. If concrete is to be poured directly over the ducts, then the duct construction and insulation system should be sturdy enough to resist the pressure and not collapse. Insulation should be of a type that will not compress, or it should be inside a rigid duct enclosure. The only time that common flex ducts are suitable in a below-grade application is when a channel is provided in the slab.

Porous Inner Core Flex Duct

Please refer to Chapter 4.4.1.11 of the 2022 Single-family Residential Compliance Manual.

Duct System Sealing and Leakage Testing

Please refer to Chapter 4.4.1.12 of the 2022 Single-family Residential Compliance Manual.

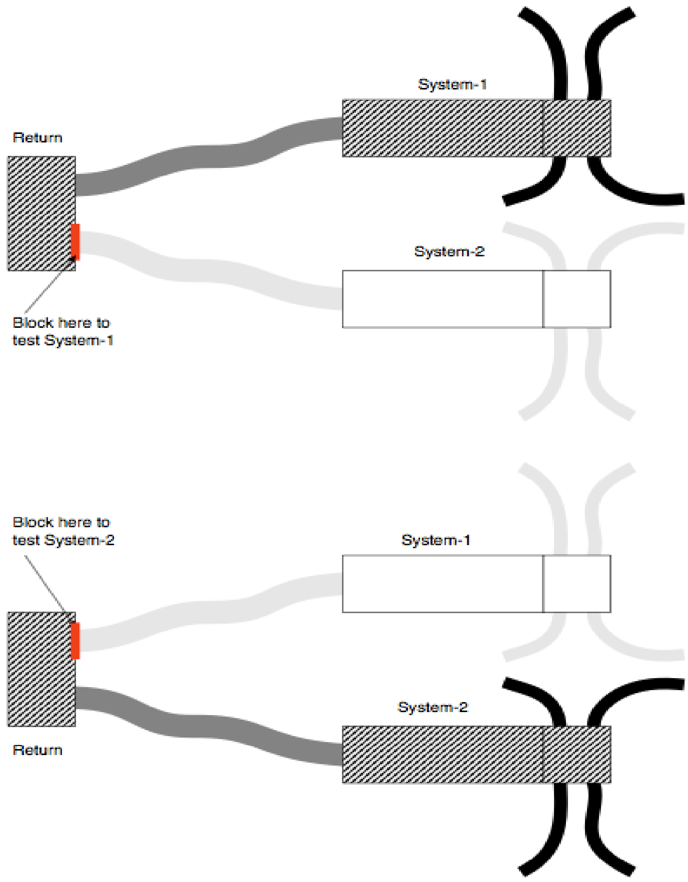
Duct Leakage Testing for Multiple Duct Systems With Common Return Ducts

If there are two or more duct systems in a building that are tied together at a common return duct, then each duct system should be tested separately, including the shared portion of the return duct system in each test. Under this scenario, the portions of the second duct system that is not being tested must be completely isolated from the portions of the ducts that are being tested, so the leakage from second duct system does not affect the leakage rate from the side that is being tested. Note that multiple dwelling units may not share ducted returns per CMC 311.4.

Figure 4-3: Two Duct Systems with a Common Return Duct represents the systems that are attached to a shared return boot or remote return plenum. In this case, the point in the return system that needs to be blocked off is readily accessible through the return grille.

The "duct leakage averaging," where both systems are tested together as though it is one large system and divided by the combined tonnage to get the target leakage, may not be used as it allows a duct system with more than 5 percent leakage to pass if the leakage of the combined system is 5 percent or less.

Figure 4-3: Two Duct Systems with a Common Return Duct



Source: California Energy Commission

Air Filtration

Please refer to Chapter 4.4.1.14 of the 2022 Single-family Residential Compliance Manual.

Air Filter Pressure Drop

Please refer to Chapter 4.4.1.14.1 of the 2022 Single-family Residential Compliance Manual.

Air Filter Particle Removal Efficiency Requirements – MERV 13

Please refer to Chapter 4.4.1.14.2 of the 2022 Single-family Residential Compliance Manual.

Air Filter Requirements for Space-Conditioning Systems

Reference: Section 150.0(m)12B

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 V 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   Equation 4.4 1

Comply with Energy Code Tables 150.0-B and C, 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 Section 150.0(m)13 requirement for ECC-verified fan efficacy and airflow rate but requires instead ECC-Verification of the return duct design.

Air Filter Requirements for Ventilation Systems

Please refer to Chapter 4.4.1.14.4 of the 2022 Single-family Residential Compliance Manual.

Filter Access and Filter Grille Sticker – Design Airflow and Pressure Drop

Please refer to Chapter 4.4.1.14.5 of the 2022 Single-family Residential Compliance Manual.

Air Filter Selection

Please refer to Chapter 4.4.1.14.6 of the 2022 Single-family Residential Compliance Manual.

Preventing Bypass

Please refer to Chapter 4.4.1.14.7 of the 2022 Single-family Residential Compliance Manual.

Forced-Air System Duct Sizing, Airflow Rate, and Fan Efficacy

Reference: Section 150.0(m)13

Adequate airflow is critical for cooling equipment efficiency. Further, it is important to maintain adequate airflow without expending excessive fan power.

Section150.0(m)13 requires system airflow and watt draw to be ECC-verified. See RA3.3 for the applicable ECC-verification procedures.

Forced-air systems that provide cooling must comply with either the airflow rate and fan efficacy verification, or may comply with the return duct design specifications given in Tables 150.0-B and C.

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, 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 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.
  - 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.

The methods for measuring the air-handling unit watt draw are described in RA3.3. Three acceptable apparatuses are:

- A portable watt meter.
- An analog utility revenue meter.
- A digital utility revenue meter.

Note: 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.

There are three acceptable methods for determining compliance with the system airflow requirement. They are described in 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 requires use of a HSPP or PSPP (Section 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) as shown in RA3.3.

The HSPP or PSPP simplifies cooling coil airflow measurement when using devices/procedures that depend on supply plenum pressure measurements.

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 shall not exceed 30 feet 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 degrees of bend. To use this method, the designer and installer must provide return system sizing that meets the appropriate criteria in Energy Code Table 150.0-B and C.

Airflow and Fan Efficacy Testing Versus Return Duct Sizing

Please refer to Chapter 4.4.1.16 of the 2022 Single-family Residential Compliance Manual.

Return Duct Sizing Example

Please refer to Chapter 4.4.1.17 of the 2022 Single-family Residential Compliance Manual.

Zonally Controlled Central Forced-Air Heating and Cooling Systems

The primary purpose of zoning HVAC systems 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 house with room location, position of the sun, and occupancy. For example, it is common for two-story homes to be too hot on the second floor in summer and winter. Zoning has the capability of diverting more of the HVAC capacity to the area with the increased load. Another common example is a home with a significant area of west-facing and east-facing windows. In the summer, the east rooms overheat in the morning, and the west rooms overheat in the afternoon. Providing the most agreeable temperature to all the zones aids comfort and with proper equipment selection and design execution can save energy.

The typical way zone systems operate is when the temperature of any zone deviates from the zone thermostat setpoint, the zone control opens the damper, and the HVAC system is triggered to operate in the appropriate mode (heating or cooling). Adding zoning to single speed systems is problematic because if only one damper opens, the air handler will not be able to deliver all its air to that zone due to pressure restrictions, and blower motor energy use will likely increase. The reduced airflow also lowers the sensible efficiency of heat pumps and air conditioners, and elevated duct pressures can increase leakage.

Bypass ducts and dampers that connect the supply plenum to the return plenum are sometimes used in single speed zoned systems to maintain airflow through the blower, but they significantly compromise heat pump heating and air conditioner cooling efficiency. For example, in cooling mode the lower airflow will cause the indoor coil (evaporator) to be much colder. The compressor will not be able to deliver its maximum capacity and condensation on the coil may even freeze, blocking all airflow. For these reasons, compliance calculations penalize bypass ducts.

Section 150.1(c)13 of the standards prohibits the use of bypass ducts prescriptively. They may be used but compliance software will adjust simulated energy usage due to the reduced airflow.

A better alternative to bypass dampers for single-speed zoned systems is to provide a "dump zone" that does not include a zone damper, and to carefully design the duct system. The ducts with zone dampers can be oversized such that the system can deliver the required 350 cfm per ton and meet efficacy requirements (0.45 W/cfm for furnaces and air conditioners and 0.58 W/cfm for heat pumps). §150.0(m)13C requires that zonally controlled forced-air cooling systems be demonstrated to meet these efficacy requirements "in every zonal control mode", meaning with only the damper in the smallest zone open.

Exception 1 to §150.0(m)13C allows airflow and fan efficacy to be tested in all zonal control modes if a variable speed compressor with controls that vary fan speed subject to the number of zones is installed. However, this exception also allows these systems to operate at maximum speed with all zones calling for conditioning. All major HVAC system manufacturers offer products that can vary fan speed in accordance with the number of zones calling. These systems deliver the greatest efficiency and quality.

Zonally Controlled Cooling Systems Compliance

Zoning Credit for Heating System

Compliance software allows for a "heating zonal control credit" if sleeping and living areas are separately zonally controlled. Non-closeable opening areas between living and sleeping zones must be less than 40 ft^2 and each zone must have a return air register. This credit applies only to furnaces, not heat pumps. Separate systems may be used to earn this credit.

If an air conditioner is installed that uses the furnace air handler to distribute heat, then the air handler and zonally controlled duct system must pass the efficacy testing described below. If tested airflow is lower than 350 cfm, then the heating credit for zoning referred to above will be adjusted based on the reduced cooling airflow.

Zoning with Air Conditioners and Heat Pumps

Recent studies have verified that zonally controlled cooling systems with or without bypass dampers using a single air handler usually do not meet the airflow and fan efficacy (AF/FE) requirements when fewer than all zones are calling. The resulting energy usage of the system can be greater than the benefit of having zonal control. Note that the energy usage adjustments in compliance software only applies to cooling systems, though it should also apply to heat pump heating systems because they are similarly affected by reduced airflow.

If zoning is accomplished by using two or more separate systems instead of one air handler with zone dampers, the software applies the most LSC energy-consuming system to both zones. Thus, it is unwise to install multiple heat pump systems that include an excessive amount of strip heat in any of the air handlers.

If the system is modeled by performance compliance software as a zoned system with a single-speed compressor, the airflow defaults to 150 CFM/ton. Because the standard house is assumed to have an airflow of 350 CFM/ton, there is an adjustment made to the compliance calculation unless the designer specifies a value of 350 CFM/ton or higher. Entering a value between 150 and 350 CFM/ton will result in changes in the simulated energy usage but the airflow must be ECC-verified. It is extremely important that the energy consultant model airflow and fan efficacy values that are reasonable and can be verified by an ECC-Rater. Otherwise, the system will fail verification, and the compliance calculations will have to be revised to include an airflow that is equivalent to the value that is measured by the ECC-Rater. For these reasons, energy consultants should coordinate with the HVAC designer before registering the certificate of compliance. For example,

- A home is to be built with a heat pump with a single-speed compressor, connected to a system with two zones and bypass ducts. From experience, the HVAC contractor knows that it will not be possible to meet the 350 CFM/ton requirement, but 275 CFM/ton is likely. 275 CFM/ton must be verified in all control modes.
- The energy consultant models the system in the proposed house with 275 CFM/ton and 0.45 W/CFM fan efficacy (0.45 W/cfm is standard for a gas furnace and 0.58 W/cfm for a heat pump). Because the standard house assumes 350 CFM/ton, there are adjustments made to simulated energy usage that must be made up by including other better-than-

standard features in the performance compliance input, but the changes in simulated energy usage are not as large as it would be with a default airflow of 150 CFM/ton.

- The home is built, and the system is verified to have an airflow of 287 CFM/ton with one zone calling and 372 CFM/ton with both zones calling. With one zone calling the fan energy is measured to be 165 Watts and an efficacy of 0.575 W/cfm is calculated. The system meets both the 350 CFM/ton total airflow and 0.58 W/cfm requirement when operated with one zone open.
- If this same home was to be built with a multispeed compressor, it would be tested only with all zones calling, and the target airflow would be no less than the mandatory 350 CFM/ton. Compliance credit can be achieved by modeling airflows greater than the mandatory CFM/ton and/or fan efficacies less than the mandatory watts/CFM.

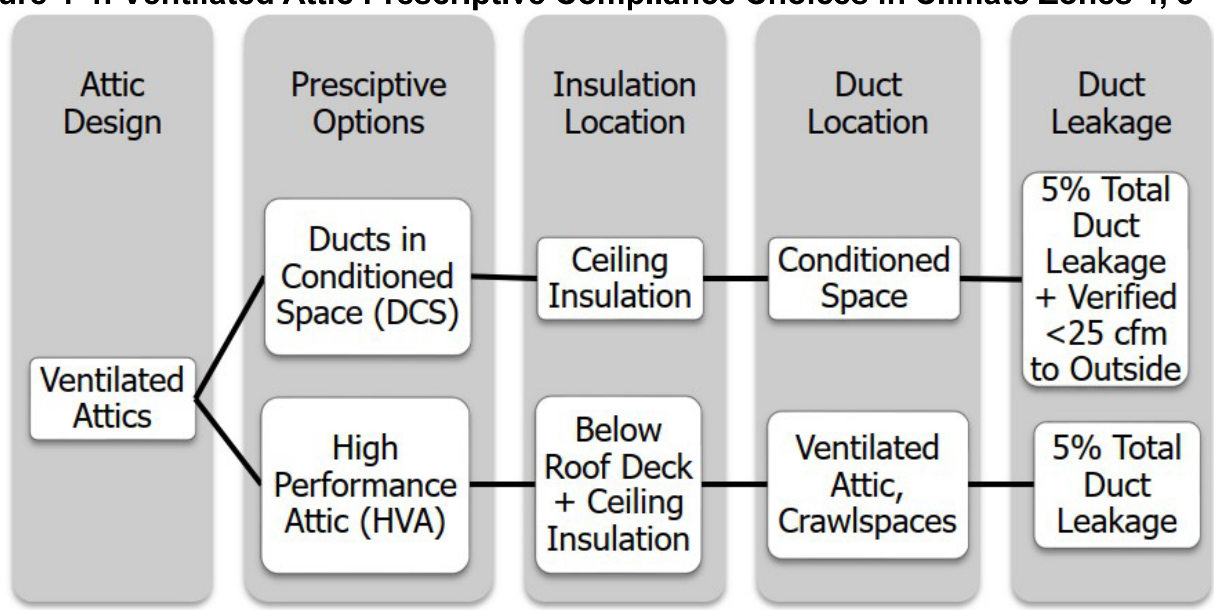
Indoor Air Quality and Mechanical Ventilation

Please refer to Chapter 4.4.1.20 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements for Air Distribution System Ducts, Plenums, and Fans

The Energy Code is designed to offer flexibility to the builders and designers of residential newly constructed buildings in achieving the intended energy efficiency targets. As such, several options are offered for achieving one of two design objectives related to improving energy performance of homes built with ventilated attics in Climate Zones 4, and 8 – 16, as shown in Figure 4-2: Ventilated Attic Prescriptive Compliance Choices in Climate Zones 4, 8 – 16.

Figure 4-4: Ventilated Attic Prescriptive Compliance Choices in Climate Zones 4, 8 – 16



Source: California Energy Commission

A high-performance attic (HPA) implements measures that minimize temperature difference 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, R-8 duct insulation, and 5 percent total duct leakage of the nominal air handler airflow. These requirements and approaches to meet the requirements are explained in Chapter 3 of this manual.

Ducts in conditioned space (DCS) is achieved when the ducts and air handler(s) are within the thermal envelope and air barrier of the building. This DCS option requires field verification to meet the prescriptive requirement. The following sections describe the duct related requirements for DCS.

Duct Location

Reference: §150.1(c)9

A typical residential construction practice in California is to place ducts and associated air handling equipment in the attic. When meeting the prescriptive requirements, there are two options for where this equipment can be located:

- If meeting the prescriptive requirements for a high-performance attic (HPA) as explained above, the duct system and air handlers of HVAC systems are allowed to be located in the attic.
- If meeting the prescriptive requirements for ducts in conditioned space (DCS) as explained above, the duct system and air handlers of HVAC systems must be located in entirely conditioned space, which includes a joist cavity between conditioned floors, or in a sealed cavity below attic insulation. For dwelling units with attics, the duct system and air handlers of HVAC systems shall be located below the ceiling separating the occupiable space from the attic.

If the DCS requirements are to be met, additional requirements apply:

- Air handlers containing a combustion component should be direct-vent (sealed combustion chambers) and shall not use air from conditioned space as combustion air. Other types of combustion heating systems are possible given the system installer adheres to the combustion air requirements found in Chapter 7 of the California Mechanical Code.
- Duct leakage to outside needs to be confirmed by field verification and diagnostic testing in accordance with RA3.1.4.3.8.
- Ducts are insulated to a level required in Table 150.1-A.

Figure 4-5: Checklist for Prescriptive Requirement − Option C DCS (§ 150.1(c)1)

§150.1(c)1
Option C

- ☐ Vented attic
- ☐ R30 or R38 ceiling insulation (climate zone specific)
- ☐ R6 ducts (climate zone specific)
- ☐ Radiant Barrier
- ☐ Verified ducts in conditioned space

Source: California Energy Commission

The checklist in Figure 4-3: Checklist for Prescriptive Requirement – Option C DCS (§ 150.1(c)1) lists all the requirements for complying prescriptively using a DCS strategy. It is not enough to locate ducts in conditioned space, the insulation must also meet prescriptive values. If a building is not able to meet all of the requirements in this checklist, it must use the performance approach or Option B from Section 150.1(c).1. Refer to Chapter 3 for more information on these options.

There are several methods of achieving the goal of DCS including:

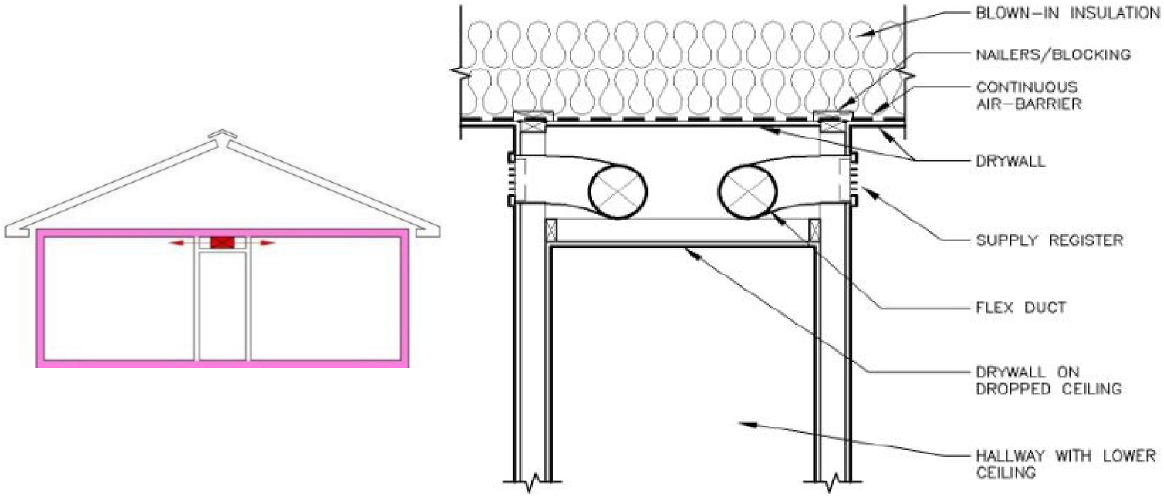
- Vented Attic, Dropped Ceiling,
- Vented Attic, Conditioned Plenum Space, and,
- Vented Attic, Open Web Floor Truss.

An overview of the strategies, related benefits, challenges, and potential solutions to those challenges are outlined below.

Vented Attic, Dropped Ceiling

This strategy places ducts within the thermal envelope without affecting the standard construction of the attic space. This strategy works well in linear plans where rooms branch out from a central hallway with a dropped ceiling.

Figure 4-6: Ducts in Conditioned Space Using a Dropped Ceiling



Source: www.ductsinside.org/

Figure 4-7: Ducts Routed Through a Dropped Ceiling

Source: BIRA Energy

Benefits of selecting this strategy include the following:

- Attic ventilation remains the same as standard practice.
- This strategy does not affect attic assembly or insulation; there are no changes to truss design.
- The strategy works with simple and linear designs with rooms off the main hallway but can also work with more complex plans.
- The strategy can be integrated into architectural accents.

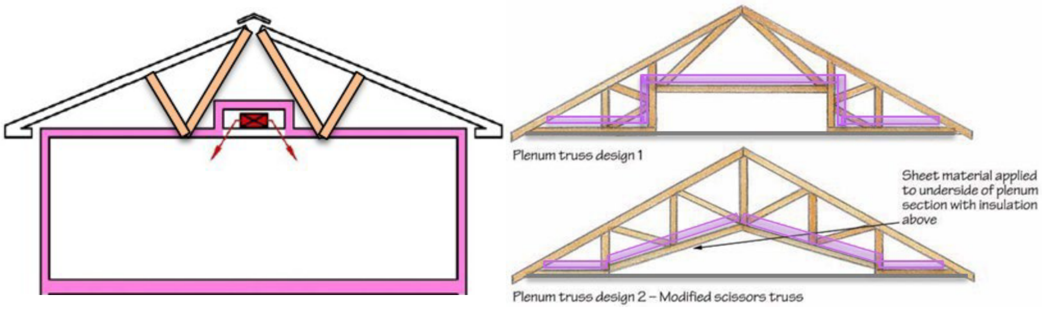
There are challenges associated with this strategy as outlined below, but they can be overcome with good design and installation practices.

- Air handler location – there may not be sufficient space (height, width) in the dropped ceiling to accommodate the air handler. In this case, the air handler would need to be installed in a separate closet within the thermal boundary of the home.
- Coordination needed between trades – installation of the ducts and air handlers and with isolating and sealing the dropped ceiling requires coordination between different trades (HVAC installer, drywall, framing, and electrical contractors) to ensure thermal integrity of the dropped ceiling.

Vented Attic, Conditioned Plenum Space

A conditioned plenum is created when a space within the attic is sealed off and insulated from the rest of the attic. To use this design option, a builder can specify two types of modified trusses: either scissor trusses or a truss configuration that creates a plenum box. Another way to create a conditioned plenum does not involve modified trusses, but rather creates the space by framing, sealing and insulating the plenum space above the ceiling plane.

Figure 4-8: Plenum Truss Design Example



Source: www.ductsinside.org

Similar to a dropped ceiling, this design is easier with a linear plan that allows the conditioned space in the attic to cover a central "spine" throughout the floor plan that can reach all spaces in need of supply registers. This design option allows for ducts in the attic space and does not affect aesthetics of the home.

Benefits of selecting this strategy include the following:

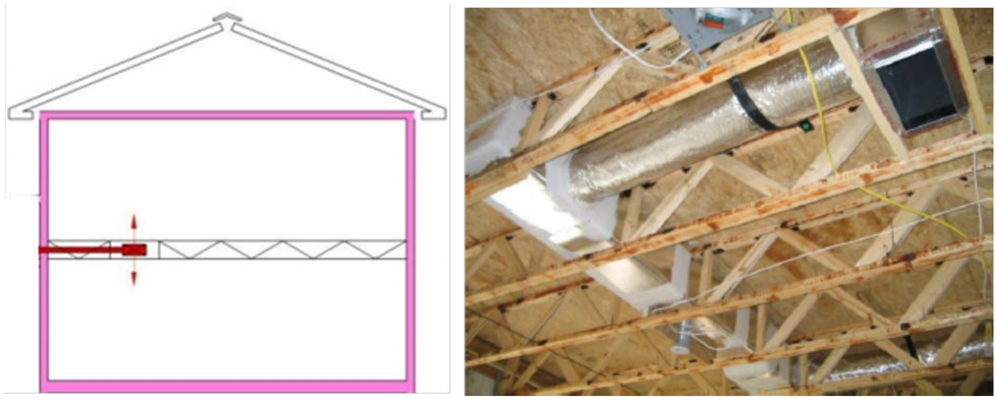
- Vented attic space, same as standard construction.
- Aesthetically less disruptive than a dropped ceiling.
- Works with simple and linear designs with rooms off main hallway.

There are challenges associated with this strategy as outlined below, but they can be overcome with good design and installation practices.

- Need to seal the plenum from attic – as with most of the DCS strategies, it is important that care and attention are provided to air-sealing the plenum space from the attic space.
- May require modified trusses, in which case manufacturers need to be provided with specifications that can be met.

Vented Attic, Open Web Floor Truss

Figure 4-9: Open Web Floor Truss Example



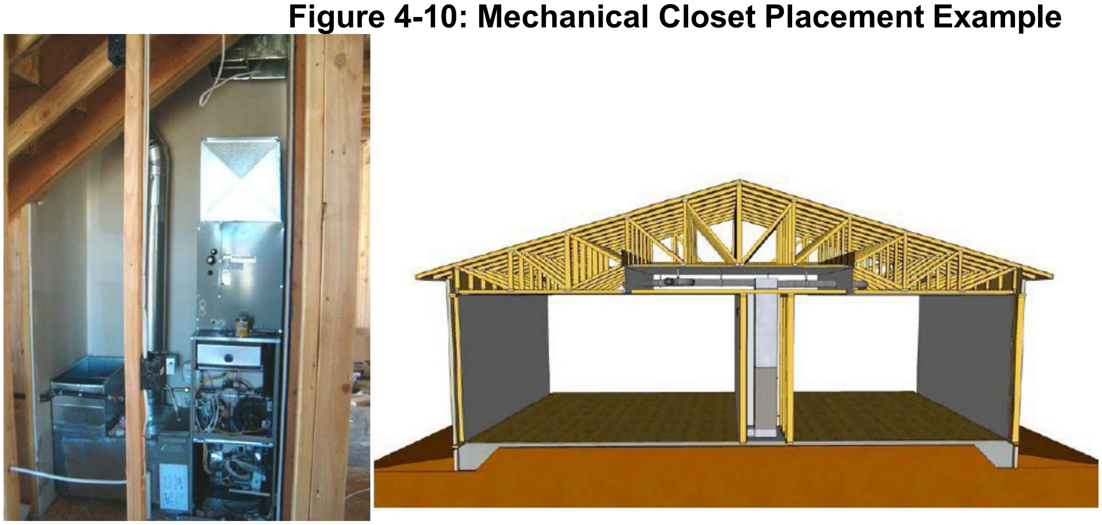
Source: www.ductsinside.org

This option can work for two-story construction and makes use of the space between floors to house ducts. Open-web floor trusses are uncommon in residential construction but are available from several floor joist manufacturers. The depth of floor joists may need to be increased to create a large enough space for supply ducts. The increased joist depth may affect interior details and wall heights. Because of the size constraints from using the floor truss, there is a need to preserve construction quality and prevent undesirable construction practices such as forcing 14-inch ducts into 12-inch joist spaces. Another option is to use alternatives to wire helix plastic flexible ducts that take up less space. Coordination between the architect and the HVAC engineer and/or contractor is needed to ensure that ducts are correctly sized and truss depths are appropriately selected.

Using the area between floors to house ducts prescribes that supply registers be at the floor or lower wall in the second story and the ceiling or upper wall in the first story.

Mechanical Closet and Placement of Sealed Combustion Furnace

Figure 4-10: Mechanical Closet Placement Example



Source: IBACOS 2013

As part of the requirement for moving the duct system and air handler into a conditioned space, construction of a mechanical closet is necessary with some DCS strategies. For example, if ducts are placed in dropped ceiling space but there is not enough room to accommodate the air handler in that space, the mechanical closet could be placed inside the thermal boundary of the building. A conditioned plenum could provide enough space for ducts and equipment; in which case, a mechanical closet may not be needed.

One potential location for a mechanical closet is within the garage or other normally unconditioned spaces. In such instances, the air handler must be located within a specially built closet that is insulated to the same level as the exterior of the house so that the closet is not a part of the unconditioned space. Combustion air for the air handler must be taken directly from the outside through a direct vent to the outside.

Duct Insulation

Reference: Section 150.1(c)9

All ducts shall be insulated to a minimum installed level as specified by Table 150.1- A, which requires either R-6 or R-8 depending on the climate zone and whether Option B or Option C is chosen for roof/ceiling Insulation. The prescriptive duct insulation requirement can be opted out by using the performance approach and trading off increased energy usage against some other features.

Central Fan-Integrated (CFI) Ventilation

Please refer to Chapter 4.4.2.3 of the 2022 Single-family Residential Compliance Manual.

Compliance Options for Air Distribution System Ducts, Plenums, and Fans

Please refer to Chapter 4.4.3 of the 2022 Single-family Residential Compliance Manual.

System Airflow and Fan Efficacy

A performance compliance credit is available for ECC verification of the installation of a high-efficiency air handler and duct system that performs better than the applicable mandatory requirements for minimum system airflow (CFM/ton) and maximum system fan efficacy (W/CFM). The performance compliance method 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 fan efficacy of each system using the procedure in RA3.3 and show that it is equal or less than what was proposed in the compliance software analysis.

The fan efficacy and airflow must also be verified by an ECC-Rater.

Duct Location

There are three ways to achieve credit for favorable duct location when using the performance compliance method:

- Credit is available if no more than 12 linear feet (LF) of duct are outside the conditioned space and the user chooses the high-performance attic (HPA) as explained in Chapter 3. This total must include the air handler and plenum lengths. This credit results in a reduction of duct surface area in the computer compliance programs. This option requires certification by the installer and field verification by an ECC-Rater.
- The second alternative applies when 100 percent of the ducts are located in conditioned space and the user chooses high-performance attic (HPA) as explained in Chapter 3. 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 an ECC-Rater.

- Credit for a high-efficiency duct design is available. This option requires field verification of the duct design layout drawing(s) by an ECC-Rater. Verified duct design, when required, will be included in the ECC Required Verification list on the certificate of compliance (CF1R). This approach provides energy savings credits for having shorter duct runs, fewer ducts, ducts in beneficial locations of ductwork, and other benefits of a well-designed duct system. This credit is available regardless of whether a high-performance attic (HPA) or ducts in conditioned space (DCS) option is chosen, as explained in Chapter 3.

There is no compliance credit provided for choosing a heating system such as a wall furnace, floor heater, or room heater, even though those systems typically have no ducts. For these cases, the standard design in the compliance calculation uses the same type of system and has no ducts. However, other systems, such as hydronic heating systems with a central heater or boiler and multiple terminal units, are considered central HVAC systems that are compared to a ducted system in the standard design. If the hydronic system has no ducts, there may be a significant energy credit through the performance method.

Duct Insulation

Please refer to Chapter 4.4.3.3 of the 2022 Single-family Residential Compliance Manual.

Diagnostic Duct Location, Surface Area, and R-value

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 must enter the design characteristics of all ducts that are not within the conditioned space. The information required as 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 outperforms 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 ECC-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 CF2R form and verified by an ECC-Rater on the CF3R. Details of this compliance option are described in the *Residential Alternative Calculation Method (ACM) Reference Manual*, and verification procedures are described in RA3.1.

Buried and Deeply Buried Ducts

Please refer to Chapter 4.4.3.5 of the 2022 Single-family Residential Compliance Manual.

Ducts in Attics with Radiant Barriers

Installation of a radiant barrier in the attic increases the duct efficiency by lowering attic summer temperatures. Compliance credit for radiant barriers is available in cases where the prescriptive standard does not require radiant barriers and requires listing of the radiant barrier in the special features and modeling assumptions to aid the local enforcement agency's inspections. Compliance credit for a radiant barrier does not require ECC-Rater verification.

Radiant barrier must be installed with the appropriate clearance and/or air gap as specified by the manufacturer. Insulation products installed in direct contact with the radiant barrier may negatively affect the performance of the radiant barrier. When a

credit is taken for radiant barrier, an improperly installed radiant barrier assembly will require revision of the CF1R compliance document to remove the energy compliance credit taken.

Duct Installation Standards

Please refer to Chapter 4.4.4 of the 2022 Single-family Residential Compliance Manual.

Tapes and Clamps

Please refer to Chapter 4.4.4.1 of the 2022 Single-family Residential Compliance Manual.

All Joints Must Be Mechanically Fastened

Please refer to Chapter 4.4.4.2 of the 2022 Single-family Residential Compliance Manual.

All Joints Must Be Made Airtight

Please refer to Chapter 4.4.4.3 of the 2022 Single-family Residential Compliance Manual.

Controls

Thermostats

Automatic setback thermostats can add comfort and convenience to a home. Occupants can wake up to a warm house in the winter and come home to a cool house in the summer without using unnecessary energy. See Heating System Controls and Cooling System Controls for more details.

Example 4-1

Question:

Am I exempt from the requirement for a thermostat if I have a gravity wall heater or any of the equipment types listed in the exception to §110.2(c)?

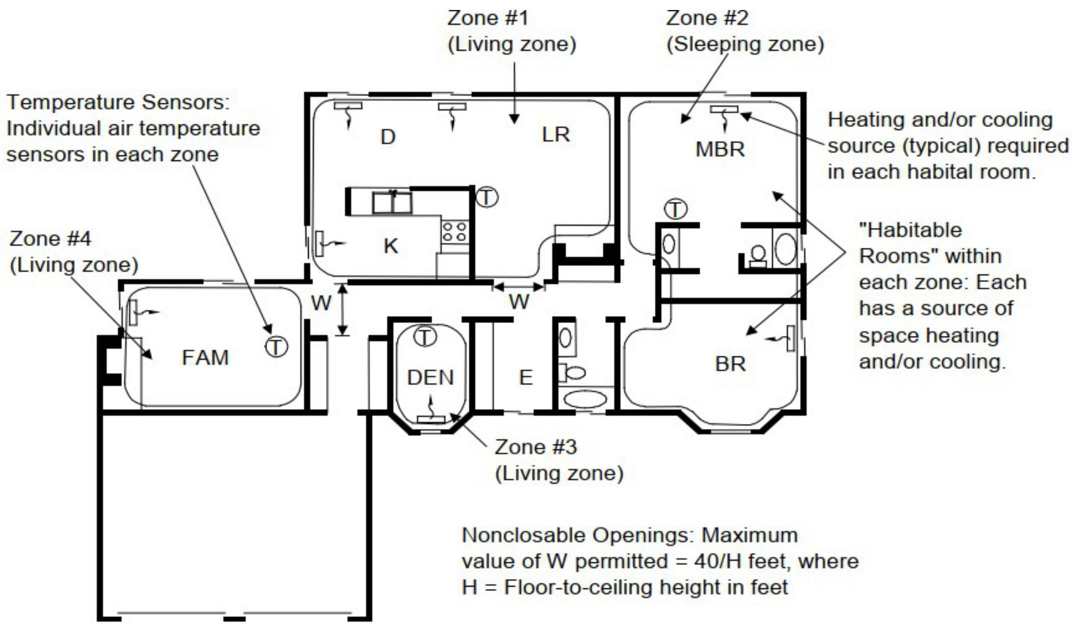
Answer:

Yes.

Zonal Control for Compliance Credit

An energy compliance credit is provided for zoned heating systems, which save energy by providing selective conditioning for only the occupied areas of a house. A house 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 area zones in the daytime and the living area zones at night. (See Figure 4-9: Zonal Control Example)

Figure 4-11: Zonal Control Example



Source: Richard Heath & Associates/Pacific Gas and Electric Company

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:

- **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.
- **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.
- **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.
- **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:

- Each zone must be served by a return air register located entirely within the zone. Return air dampers are not required.
- Supply air dampers must be manufactured and installed so that when they are closed, there is no measurable airflow at the registers.

- The system must be designed to operate within the equipment manufacturer's specifications.
- 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

As with cooling systems, zonally-controlled heat pump or furnace systems must be ECC verified to confirm they meet the mandatory fan efficacy and airflow requirements. Single-speed systems and variable-speed systems that do not have integrated controls must test in all zonal control modes. Variable-speed systems that utilize integrated controls that vary fan speed with respect to the number of zones calling for air may do these tests with the compressor on high speed and all zones calling for cooling.

Example 4-2

Question:

In defining the living and sleeping zones for a home with a zonally controlled HVAC system, can laundry rooms and bathrooms (which are not habitable spaces) be included on whichever zone they are most suited to geographically (for example, a bathroom located near bedrooms)?

Answer:

Yes. For computer modeling, include the square footage of any not habitable or indirectly conditioned spaces with the closest zone.

Example 4-3

Question:

I have two HVAC systems and want to take zonal control credit. Can the return air grilles for both zones be located next to each other in the 5 ft. wide by 9 ft. high hallway (in the same zone)?

Answer:

No. Because of the need to prevent mixing of air between the conditioned zone and the unconditioned zone, it is necessary to (1) have the return air for each zone within that zone, and (2) limit any noncloseable openings between the two zones to 40 ft² or less. Unless these criteria and the other criteria listed in this chapter can be met, credit for a zonally controlled system cannot be taken.

Example 4-4

Question:

Can a gas-vented fireplace be used for zonal control heating, and qualify for the zonal control credit?

Answer:

Gas-vented fireplaces that meet zonal control requirements may qualify for the zonal control credit.

Example 4-5

Question:

Does a gas-vented fireplace with a handheld remote thermostat meet the thermostat requirement for the two-zone modeling credit?

Answer:

Yes, as long as the thermostat has manual "on" to start, automatic setback capability, and temperature preset capability, it does not have to be permanently wall-mounted.

Indoor Air Quality and Mechanical Ventilation

Please refer to Chapter 4.6 of the 2022 Single-family Residential Compliance Manual.

Continuous Mechanical Ventilation for Indoor Air Quality

ASHRAE *Standard 62.2–Ventilation for Acceptable Indoor Air Quality in Residential Buildings* recognizes the need for controlled mechanical outdoor air supply in homes that are built tight for efficient space conditioning. Infiltration, or uncontrolled air leakage through the building, is highest during winter and lowest in mild weather, and too inconsistent to rely on for air exchange.

California's 2008 Energy Code adopted Standard 62.2-2007 with exceptions, and the 2013 Energy Code began requiring ECC field verification of airflow rates of residential indoor-outdoor (I-O) ventilation systems installed to meet this requirement. The 2025 Energy Code incorporates updated versions of Standard 62.2 and extends its requirements to multifamily and high-rise residential buildings.

Standard 62.2 requires two residential mechanical ventilation functions:

- Local exhaust fans in bathrooms and kitchens to remove most occupant-generated moisture and odors where and when they are generated.
- Whole-dwelling ventilation systems to automatically ensure an adequate amount of I-O air exchange year-round, regardless of window operation.

It also discusses the need for tightening building envelopes and preventing habitable spaces from drawing air from polluted spaces such as garages, attics, crawlspaces, adjacent dwellings, and other sources of outdoor air pollution.

Since the Energy Code requirement for mechanical ventilation is a continuous electrical end use in new homes, fan efficacy (in W/cfm fan flow) is one factor to consider when selecting a ventilation system.

Types of Mechanical Ventilation Systems

There are three basic ways to meet the whole-dwelling ventilation requirement.

- Exhaust-only systems remove indoor air and create some degree of negative indoor pressure (depressurization) that induces air infiltration of the building envelope through the paths of least resistance.
- Supply-only systems filter outdoor air from a known location before delivering it to a home; this creates some degree of positive pressure (pressurization) that can serve to both prevent infiltration and buffer against depressurization.
- Balanced ventilation systems use an exhaust fan and a supply fan that move approximately the same amount of air at the same time; these opposite airflows have little effect on indoor pressure, and cannot prevent the forces of wind, stack effect, and other fans from pressurizing or depressurizing a home.

Indoor pressures cannot be avoided. In fact, the tighter and more energy-efficient the building envelope, the higher indoor pressures can and will be. Airflow requires both a driving force and a pathway. Regardless of the degree of indoor pressure, infiltration cannot occur unless there are leakage sites or designated pathways for air to flow.

The building science principle "Build Tight, Ventilate Right" acknowledges that energy efficient homes require tight building envelopes that make it possible for a continuous low-cfm ventilation system to control indoor-outdoor air exchange.

Balanced systems do not create indoor pressure or neutralize indoor pressure. The advantage of a balanced mechanical ventilation system is the ability to incorporate an engineered heat exchanger core that passively transfers thermal energy between the outgoing exhaust airstream and incoming supply airstream. This reduces the cost of heating and cooling the incoming supply ventilation air.

However, balanced heat or energy recovery ventilation (HRV, ERV) systems cannot recover heat from air that infiltrates the home and bypasses the system's core.

The remainder of this section describes minimum requirements for residential mechanical ventilation, which can be readily exceeded or improved upon by:

- Using local exhaust fans as needed to remove moisture and odors.
- Using source control to minimize air pollutants within the building.
- Operating the whole-dwelling fan continuously to minimize volatile organic compound (VOC) levels.

As residential buildings are tightened to improve energy performance, the dilution of indoor air through natural ventilation and infiltration has been reduced. As a result, the importance of controlling indoor pollutants and moisture generated and volatile organic compounds (VOCs) in homes has increased.

Energy Commission sponsored field research revealed that indoor concentrations of pollutants such as formaldehyde are higher than expected, and that many occupants do not open windows regularly for ventilation.

The Energy Code includes mandatory requirements for local mechanical exhaust and whole-dwelling unit mechanical ventilation to improve indoor air quality (IAQ) in homes and MERV 13 air filtration requirements for ventilation systems. As specified by §150.0(o), dwelling units must meet the requirements of ASHRAE Standard 62.2- 2019 including Addenda v and d (ASHRAE 62.2), subject to the amendments specified in Section 150.0(o)1. A copy of this version of ASHRAE 62.2 may be obtained at https://store.accuristech.com/ashrae/standards/california-energy-commission-adopted-version-of-ansi-ashrae-standard-62-2-2019?product_id=2033702.

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 dwelling unit mechanical ventilation, as well as local exhaust ventilation at known sources of pollutants or moisture, such as kitchens, bathrooms, and laundries. The California Air Resources Board (CARB) provides guidance for reducing indoor air pollution in homes by selecting low-VOC building materials, finishes, and furnishings. For more information, see the CARB Indoor Air Quality Guidelines at https://ww2.arb.ca.gov/our-work/topics/indoor-air-quality-exposure.

This section covers mandatory requirements for mechanical ventilation of homes, the process of compliance and enforcement, including ECC-Verifications, and requirements specified by ASHRAE 62.2 as amended in the Energy Code.

Compliance with the whole-dwelling unit ventilation airflow specified in ASHRAE 62.2 is required in new dwelling units, in new dwelling units that are additions to an existing building except for junior accessory dwelling units, and in additions to existing dwelling units that increase the conditioned floor area of the existing dwelling unit by more than 1,000 square feet. Alterations to components of existing buildings that previously met any requirements of ASHRAE 62.2 must continue to meet requirements upon completion of the alteration(s).

The key requirements for most newly constructed buildings are summarized below:

- A whole-dwelling unit mechanical ventilation system shall be provided. Typical solutions are described in the Typical Solutions for Single-Family Dwelling Unit Ventilation section below. The airflow rate provided by the system shall be confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in RA3.7.
- Kitchens and bathrooms must have local exhaust systems vented to outdoors.
- Clothes dryer exhaust shall be vented to outdoors.

Additional indoor air quality design requirements include:

- Ventilation air shall come from outdoors and shall not be transferred from adjacent dwelling units, garages, unconditioned attics, or crawl spaces.
- Ventilation system controls shall be labeled, and the homeowner shall be provided with instructions on how to operate the system.
- Combustion appliances shall be properly vented to outdoors and exhaust systems shall be designed to prevent back drafting.
- Walls and openings between the house and attached garage shall be sealed or gasketed to prevent air exchange between the house and garage.
- Habitable rooms shall have operable windows with a free opening area of at least 4 percent of the floor area.
- Mechanical systems including space conditioning systems that supply air to habitable spaces shall have a MERV 13 or better filter and be designed to accommodate the air filter's rated pressure drop at the designed airflow rate.

- Dedicated outdoor air inlets that are part of the ventilation system design shall be located away from known sources of outdoor contaminants.
- A carbon monoxide alarm shall be installed in each dwelling unit in accordance with the National Fire Protection Association (NFPA) Standard 720.
- Air-moving equipment used to meet the whole-dwelling unit ventilation requirement and local exhaust requirement shall be rated for airflow and sound:
    - Whole-dwelling unit ventilation and continuously operating local exhaust fans must be rated at a maximum of 1.0 sone.
    - Demand-controlled local exhaust fans must be rated at a maximum of 3.0 sones.
    - Kitchen exhaust fans must be rated at a maximum of 3.0 sones at one or more airflow settings greater than or equal to 100 CFM.
    - Remotely located air-moving equipment (mounted outside habitable spaces) are exempt from the sound requirements provided there is at least 4 feet of ductwork between the remote fan and interior grille.

Compliance and Enforcement

Compliance with ASHRAE 62.2 requirements must be verified by the enforcement agency, except for the following requirements that must be ECC verified in accordance with the procedures in Residential Appendix RA3.7:

- Whole-dwelling unit ventilation airflow rate.
- Home Ventilating Institute (HVI) or Association of Home Appliance Manufacturers (AHAM) ratings for kitchen local mechanical exhaust fan airflow or capture efficiency, and sound.

All applicable certificates of compliance, installation, and verification must be registered with an approved ECC-Provider.

Title 24 Part 6 amendments to ASHRAE 62.2 do not require a blower door measurement when calculating the dwelling unit mechanical ventilation rate (Qfan). Instead, the Qfan calculation applies a default infiltration leakage rate of 2 ACH50 (air changes per hour at 50 Pascals). Blower door measurement of actual dwelling unit enclosure leakage is required only when performance compliance modeling uses an infiltration leakage rate less than 2 ACH50 - which requires ECC-Verification of enclosure leakage for energy compliance and for determining Qfan.

If a central heating/cooling system air-handler fan is used to ventilate the dwelling (central fan-integrated ventilation, also known as CFI ventilation), the air-handler must be less than or equal to the mandatory fan efficacy criteria. This requires the installer to perform the test given in Reference Appendix RA3.3 and an ECC-Rater to verify the efficacy (W/CFM) of the central air-handler fan.

Certificate of Compliance Reporting Requirements

When using the prescriptive compliance approach, the mechanical ventilation rate (Qfan) must be calculated using the applicable equations in Energy Code Section 150.0(o)1, also shown in Typical Solutions for Single-Family Dwelling Unit Ventilation below. The value for Qfan must be reported on the CF1R. When using the performance compliance approach, the compliance model automatically calculates Qfan based on inputs for conditioned floor area, number of bedrooms, and climate zone, and uses the Qfan ventilation airflow value when calculating the building energy use. The performance certificate of compliance (CF1R-PRF-01) will report the following parameters for the whole- dwelling unit ventilation system:

- 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 only to HRV or ERV systems.
- For CFI systems—ECC-Verification of air handler fan efficacy is required.

The installed dwelling unit ventilation system must conform to the performance requirements on the CF1R.

The local enforcement agency may require additional information/documentation describing the ventilation systems be submitted along with the CF1R at plan check.

Certificates of Installation and Verification Reporting Requirements

The builder/installer must complete two certificates of installation (CF2R-MCH-27 and CF2R-MCH-32) for the dwelling. The ECC-Rater must complete a certificate of verification (CF3R-MCH-27) for the dwelling.

CF2R-MCH-27

The following information must be provided on the CF2R-MCH-27 for each ventilation fan/system in the dwelling that will require ECC-Verification.

For dwelling unit ventilation systems:

- System type, name, and location.
- Control type.
- Minimum required continuous airflow rate.
- Ventilation fan or system manufacturer, and model number.
- Energy Commission certification number for variable system/control (if any).

For kitchen exhaust ventilation systems:

- Type of exhaust fan control (intermittent, demand-controlled, or continuous).
- Type of exhaust fan (range hood, over-the-range microwave, downdraft, other).
- Required airflow or capture efficiency.
- Manufacturer name and model number.

CF3R-MCH-27

Please refer to Chapter 4.6.3.2.3 of the 2022 Single-family Residential Compliance Manual.

Typical Solutions for Single-Family Dwelling Unit Ventilation

Please refer to Chapter 4.6.4 of the 2022 Single-family Residential Compliance Manual.

Exhaust Ventilation

Please refer to Chapter 4.6.4.1 of the 2022 Single-family Residential Compliance Manual.

Supply Ventilation

Please refer to Chapter 4.6.4.2 of the 2022 Single-family Residential Compliance Manual.

Central Fan-Integrated (CFI) Ventilation

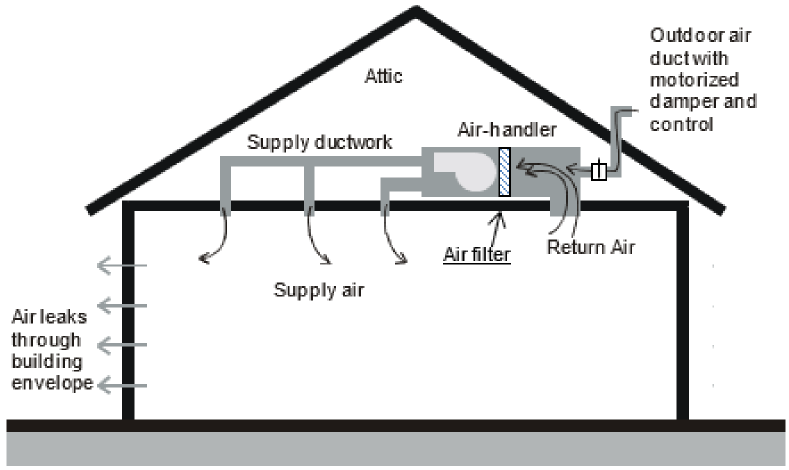
A central fan integrated (CFI) ventilation system is a configuration where the ventilation ductwork is connected to the space conditioning duct system, to enable distribution of ventilation air to the dwelling unit when the space conditioning system air handler is operating. This strategy mixes the outdoor 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. CFI ventilation systems are considered intermittent mechanical ventilation systems and must be certified to the Energy Commission as capable of meeting the minimum whole-dwelling unit ventilation requirements of Section 150.0(o).

A listing of certified CFI ventilation systems is posted at https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment.

The Energy Code includes the following requirements specific to CFI ventilation systems:

- Continuous Operation is Prohibited – The continuous operation of a space conditioning air handler is prohibited in providing whole-dwelling unit ventilation.
- 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.
- 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.
- 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 4-12: Central Fan-Integrated (CFI) Ventilation Example



Source: California Energy Commission

Section 150.0(m)12 requires that outside air be filtered using MERV 13 (or greater) 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. 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 where the outside air enters the return plenum of the central fan.

When considering system design and ECC verification compliance for CFI ventilation systems, it is important to distinguish between the central forced-air system fan total airflow and the much smaller outdoor ventilation airflow rate. Both of these airflows must be verified by an ECC-Rater. Figure 4-10: Central Fan-Integrated (CFI) Ventilation Example. The total airflow through the air handler is the sum of the return airflow and the ventilation airflow. CFI ventilation systems, devices, and controls may be approved for use for compliance with the ECC field verification requirements for whole- dwelling unit mechanical ventilation in accordance with RA3.7.4.2.

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 is required to have controlled motorized dampers that open only when outdoor air ventilation is required and close when outdoor air ventilation is not required. These dampers may be closed during duct leakage testing. See RA3.1.4.3 for duct leakage verification and diagnostic test protocols.

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.

Balanced Ventilation

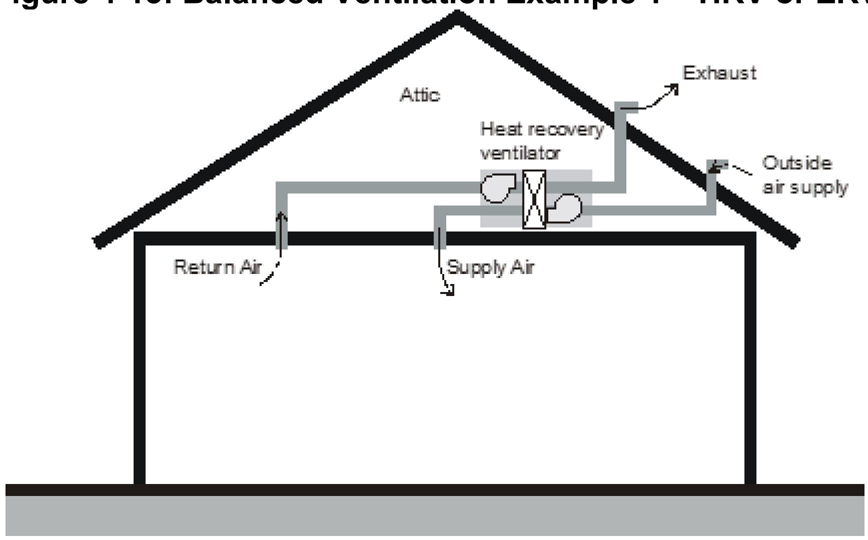
Balanced systems use an exhaust fan and a supply fan to move approximately the same volume of air into and out of a dwelling unit. To be considered a balanced ventilation system, the total supply airflow and the total exhaust airflow from all fans must be within 20 percent of each other. For determining compliance, the average of the supply and exhaust airflows is equal to the balanced system airflow rate. (Refer to RA3.7.4.1.2.)

A balanced system may include an indoor-outdoor air heat exchanger. This is called a Heat Recovery Ventilator (HRV). Another balanced system type that also exchanges moisture (humidity) is called an Energy Recovery Ventilator (ERV). These systems indirectly or directly temper incoming air with outgoing air, which reduces the thermal effect of ventilation on heating and cooling loads, but the dual fans also increase electrical energy use. They are most practical for use in tightly sealed houses and in multifamily units where exhaust type systems have difficulty drawing adequate outside air due to limited exterior wall area. Fault Indicator Displays (FID) are prescriptively required for HRV and ERV systems serving individual dwelling units with ECC-rater verification per Joint Reference Appendix JA17. An HRV or ERV without an FID may be used via the performance compliance method, but will receive less compliance credit than an HRV/ERV equipped with an FID.

Section 150.0(m)12 requires that outside air be filtered using MERV 13 (or greater) air filters. The filters must be accessible to facilitate replacement. An example of a heat recovery ventilator is shown in Figure 4-11: Balanced Ventilation Example 1 – HRV or ERV.

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

Figure 4-13: Balanced Ventilation Example 1 – HRV or ERV

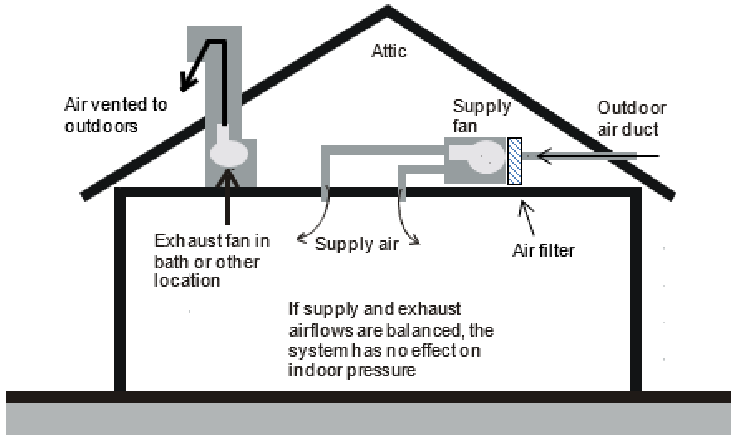


If supply and exhaust airflows are balanced, the system has no effect on indoor pressure

Source: California Energy Commission

Another balanced system configuration uses a stand-alone supply fan coupled with a stand-alone exhaust fan, both wired to a common switch or control to ensure they operate simultaneously. The controls must make it possible to adjust the speed of the fans for balancing the airflows within 20 percent. An example is shown in Figure 4-12: Balanced Ventilation Example 2 – Separate Supply and Exhaust Fan.

Figure 4-14: Balanced Ventilation Example 2 – Separate Supply and Exhaust Fan



Source: California Energy Commission

Source: California Energy Commission

Whole-Dwelling Unit Ventilation Airflow Measurement

Residential Appendix RA3.7.4 provides direction for field measurement of supply, exhaust, and balanced ventilation system types. These measurement procedures are applicable for ventilation systems that operate at a specific airflow rate or systems that are controlled to operate intermittently at a fixed speed (averaged over any three-hour period), according to a fixed schedule that is verifiable by an ECC-Rater on site. (Refer to ASHRAE 62.2 Section 4.5.1 Short Term Average Ventilation.)

Variable or intermittent operation that complies with ASHRAE 62.2 Sections 4.5.2 and 4.5.3 complies with the dwelling unit mechanical ventilation requirements by use of varying ventilation airflow rates based on calculations of relative exposure as specified in ASHRAE 62.2 Normative Appendix C. These calculation procedures provide the basis for "smart" ventilation controls implemented by use of digital controls that rely on the manufacturer's product-specific algorithms or software. Any ventilation system models that use these complex ventilation system controls in a ventilation product designed to be used to comply with Standards Section 150.0(o) must submit an application to the Energy Commission to have the ventilation technology approved. These manufacturers are expected to provide with their applications evidence that the system will perform to provide the required dwelling unit mechanical ventilation. The manufacturers are also expected to provide a method that could be used by an ECC-Rater to verify that an installed system is operating as designed.

Listings of systems approved by the Energy Commission are located at https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment.

Dwelling Unit Ventilation Rate

Please refer to Chapter 4.6.6 of the 2022 Single-family Residential Compliance Manual.

Total Ventilation Rate (Qtot)

The total ventilation rate is the combined volume of ventilation air provided by infiltration and the mechanical ventilation provided from fans, as follows:

$$Q_{tot} = 0.03A_{Floor} + 7.5(N_{br} + 1)$$

Where,

- Q_tot = total required ventilation rate (CFM)
- A_floor = conditioned floor area (ft^2)
- N_br = number of bedrooms (not less than one)

Infiltration Rate (Qinf)

Please refer to Chapter 4.6.6.2 of the 2022 Single-family Residential Compliance Manual.

Required Mechanical Ventilation Rate (Qfan)

The required mechanical ventilation rate, Qfan is the total outside airflow required to be supplied to (or total indoor air required to be exhausted from) the building by fans. For balanced ventilation system, the average of the supply and exhaust airflows must be greater than or equal to Qfan.

Qfan is calculated using the equation below, which uses the values for Qtot and Qinf determined above. The equation below accounts for reduced exterior wall leakage area in attached units (e.g., townhomes and duplexes). It also accounts for the differences in ventilation effectiveness of balanced systems compared to exhaust/supply (unbalanced) systems due to varying dwelling infiltration leakage rates. If Qfan is less than 10 CFM, then no fan is required.

$$Q_{fan} = Q_{tot} - \varphi \times (Q_{inf} \times A_{ext})$$

Where,

- Q_{tot} = total required ventilation rate (CFM)
- Q_{inf}= effective annual average infiltration rate (CFM)
- φ = 1 for balanced ventilation systems or $\frac{Q_{inf}}{Q_{tot}}$ for other system types
- A_{ext} = 1 for single-family detached homes. For attached dwelling units not sharing ceilings or floors with other dwelling units, occupiable spaces, public garages, or commercial spaces (e.g., duplexes and townhomes), A_{ext} is the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to total envelope surface area.

Example 4-6: Required Ventilation

Question:

What is the required continuous ventilation rate for a three-bedroom, 1,800 ft² 2-story townhouse located in climate zone 8 that has 9-foot ceilings, and where 25% of the exterior wall surface area adjoins another unit? Ventilation is provided by a bathroom exhaust fan. No extraordinary measures have been taken to seal the building.

Answer:

Equation 4-1 yields a total ventilation rate of 84 CFM.

$$Qtot = 0.03A_{floor} + 7.5(N_{br} + 1) = 0.03(1800) + 7.5(3 + 1) = 84 \text{ CFM}$$

The volume is 1,800 x 9 = 16,200 ft^3. Solving for Equation 4-2 results in a leakage rate of 540 CFM.

$QQ_{50} = VVVVVV\ xx\ 2\ AAAAAA50/60 = 16{,}200\ xx\ \frac{2}{60} = 540\ AACCCC$

Using Equation 4-3:

$QQ_{iiiii} = 0.052\ xx\ QQ_{50}\ xx\ wwwwww\ xx\ (\frac{AA}{AA_{rr}})^{zz} = 0.052\ xx\ 540\ xx\ 0.36\ xx\ (\frac{18}{8.2})^{0.4} = 14\ AACCCC$

The mechanical ventilation system must move 82 CFM.

$$Q_{fan} = Q_{tot} - \varphi \times (Q_{inf} \times A_{ext})$$

= 84 – (14/84)(14 x (1-0.25)) = 82 CFM

Due to the reduction in infiltration resulting from reduced exterior wall area and to the use of an exhaust fan instead of a balanced system, the effective infiltration credit is only 2 CFM.

Example 4-7

Question:

The two-story house I am building in Climate Zone 12 has a floor area of 2,240 ft² and four bedrooms. I am using an HRV that delivers 80 CFM of outdoor air and exhausts 90 cfm of indoor air. My calculations for required mechanical ventilation rate (Qfan) come out to 86 CFM. Can I use this system?

Answer:

No. For balanced systems, the supply and exhaust airflows can be averaged, and in this case, they average 85 CFM, which is slightly less than the required 86 CFM.

The nominal rating of a fan can be different than what it actually delivers when installed and connected to ductwork, so designers should always include a safety margin when sizing equipment. The length and size of ducting should be used to calculate the pressure drop. This is why dwelling unit ventilation rates must be verified by an ECC-Rater.

Example 4-8

Question:

A 2,300 ft² house has exhaust fans running continuously in two bathrooms, providing a total exhaust flow rate of 90 CFM, but the requirement is 98 CFM. What are the options for providing the additional 8 CFM?

Answer:

Option 1: The required additional CFM could be provided either by increasing the size of either or both exhaust fans such that the combined airflow exceeds 98 CFM.

Option 2: Another solution would be to use a balanced system, which may reduce the airflow requirement to below 90 CFM. Adding another 8 CFM fan is not an acceptable solution.

Example 4-9

Question:

A CFI system is connected to the return air plenum of a furnace such that when operating, 10% of the air supplied by the furnace is outdoor air. The CFI control limits furnace fan operation to 30 minutes of every hour. If the house requires 100 CFM of continuous ventilation air, what volume of air must the furnace deliver?

Answer:

Since the furnace operates half the time, the volume of outside air delivered when it is operating must be 2 x 100 = 200 CFM. Therefore, the furnace must be able to deliver 200/0.1 = 2,000 CFM.

Example 4-10

Question:

Can an exhaust fan be used to supplement ventilation air provided by a CFI system?

Answer:

Yes. In the example above, if an exhaust fan is operated continuously to deliver 50 CFM, then the volume of air required of the CFI system is reduced to 100 CFM, or an average of 50 CFM over the hour such that the sum of ventilation air delivered averages 100 CFM. A 1,000 CFM furnace providing 10% outside air could be used in this case. Even though such a combined ventilation system is partially balanced, it would not qualify as a balanced system in the calculation of Qfan.

Example 4-11

Question:

I want to provide controls that disable the ventilation system so it does not bring in outside air during the hottest two hours of the day, and the calculations show I need 80 CFM continuous. How large must my fan be?

Answer:

If the average rate over three hours is 80 CFM and the fan only operates one hour, then it must be capable of delivering 3 x 80 = 240 CFM. ASHRAE 62.2 does not allow averaging ventilation over more than a three-hour period.

Control and Operation

Please refer to Chapter 4.6.6.4 of the 2022 Single-family Residential Compliance Manual.

Whole-Dwelling Unit Mechanical Ventilation Energy Consumption

For builders using the performance compliance approach, the energy use of whole-dwelling unit ventilation fans is factored into the compliance of the proposed building. Proposed designs with lower fan efficacy, higher W/CFM, than the energy usage in the standard design will be adjusted and proposed designs with higher fan efficacy will get a compliance credit. Whole-dwelling unit ventilation airflow rate is also a factor in the performance approach. Proposed designs exceeding the standard design ventilation airflow rate, higher CFM than the standard, will see an adjustment in energy usage due to the additional fan energy. In most cases the standard design will match the proposed design ventilation rate and compliance will be neutral for airflow rate. However, the standard design will only match the proposed design airflow rate up to a limit and additional airflow will count against the proposed design energy budget. More information on the standard design ventilation fan efficacy and airflow rate limit can be found in the *Residential ACM Reference Manual*. For balanced heat recovery or energy recovery ventilators (H/ERVs), the HVI rated heat recovery efficiency can help offset higher fan energy use for balanced ventilation systems.

The fan efficacy of the central air handler used for a CFI ventilation system must conform to the same fan watt draw (W/CFM) limit as for cooling systems in all climate zones as verified by an ECC-Rater in accordance with the diagnostic test protocols given in RA3.3. The RA3.3 verification of CFI systems determines the W/CFM of the total central system airflow, not the W/CFM of the ventilation airflow.

The Energy Code does not regulate the energy use of ventilation fans installed for other purposes, such as local exhaust.

Central Fan-Integrated Ventilation Systems – Watt Draw

Please refer to Chapter 4.6.7.1 of the 2022 Single-family Residential Compliance Manual.

Other Whole-Dwelling Unit Ventilation Systems – Watt Draw

Using the prescriptive or performance compliance approach, the maximum mandatory fan efficacy for HRVs and ERVs is 1.0 W/CFM. This must be ECC verified in accordance with RA3.7.4.4. For balanced systems without heat recovery, exhaust, or supply ventilation fans there are no mandatory or prescriptive fan efficacy requirements.

When using the performance compliance approach, the airflow rate and fan watt draw of the fan must be entered into the compliance software. Values for airflow and fan W/CFM information may be available from the HVI directory at https://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. When fan energy is listed as CFM/W instead of W/CFM, it is necessary to invert the value to provide W/CFM as input to the compliance software (for example: 4 CFM/ W = 1/4 W/CFM = 0.25 W/CFM).

Dwelling unit ventilation is not compliance neutral and performance compliance will be affected by the proposed design W/CFM, ventilation airflow rate, and heat recovery if present. Installation of designs exceeding the standard design W/CFM or ventilation rate will receive adjusted energy usage in building model simulations. More information on the standard design ventilation fan W/CFM and airflow rate can be found in the *Residential ACM Reference Manual*.

If an H/ERV is specified, the heat recovery efficiency of the proposed system must be entered into the compliance software so that the heat recovery effect can be accounted for in the compliance simulation. Many factors affect the benefit of heat recovery on ventilation, like climate zone and building design, but in general heat recovery will increase building compliance.

Local Mechanical Exhaust

Please refer to Chapter 4.6.8 of the 2022 Single-family Residential Compliance Manual.

Demand-Controlled (Intermittent) Local Exhaust

The Energy Code requires that local exhaust fans be designed to be operated by the occupant. This usually means that a wall switch or some other control is accessible and obvious. 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. They can use ceiling-mounted exhaust fans or may use a 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. Kitchens can have range hood exhaust fans, down-draft exhausts, ceiling- or wall-mounted exhaust fans, or pickups for remote-mounted inline exhaust fans. Generally, HRV and ERV manufacturers do not allow exhaust ducting from the kitchen because of the presence of heat, moisture, grease, and particulates that should not enter the heat exchange core. Building codes require kitchen exhaust fans to be connected to metal ductwork for fire safety.

Example 4-12: Ducting Kitchen Exhaust to the Outdoors

Question:

How do I know what kind of duct I need to use? 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 is generally a smooth metal duct that is sized to match the outlet of the ventilation device. It is often a six-inch or seven-inch-round duct, or the range hood may have a rectangular discharge. If it is rectangular, the fan will typically have a rectangular-to-round adapter included. Always use a terminal device on the roof or wall that is sized to be at least as large as the duct. Try to minimize the number of elbows used.

Example 4-13

Question:

How do I know what the requirements are in my area?

Answer:

Ask your code enforcement agency for that information. Some enforcement agencies will accept metal flex; some will not.

Control and Operation for Intermittent Local Exhaust

The choice of control is left to the designer. It 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. New control strategies continue to come to the market. The only requirement is that there is a control.

Title 24, Part 11 may specify additional requirements for the control and operation of intermittent local exhaust.

Ventilation Rate for Demand-Controlled Local Exhaust

Cooking is a regularly occurring activity inside a home that causes indoor pollution. The most effective method of 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 incorporated a metric for local exhaust called capture efficiency. Capture efficiency is defined as the fraction of emitted tracer gas that is directly exhausted by a range hood.

To adequately capture the moisture, particulates, and other products of cooking and/or combustion in kitchens, the Energy Code requires minimum ventilation rates or capture efficiencies in Table 4-9: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0 -E) and Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0). Only in kitchens that are enclosed, 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 requirements of ASHRAE Standard 62.2.

Table 4-9: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0 -E)

Application	Airflow
Enclosed Kitchen	• Vented range hood (including appliance-range hood combinations): capture efficiency or airflow rate specified in Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0). • Other kitchen exhaust fans, including downdraft: 300 CFM (150 L/s)
Non-Enclosed Kitchen	• Vented range hood (including appliance-range hood combinations): capture efficiency or airflow rate specified in Table 4-10. • Other kitchen exhaust fans, including downdraft: 300 CFM (150 L/s)
Bathroom	• 50 CFM (25 L/s)

Source: California Energy Commission

Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0-G)

Dwelling Unit Floor Area (ft^2)	Hood Over Electric Range	Hood Over 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: California Energy Commission

The Energy Code requires 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 noise level of 3 sones or less. Verification must be in accordance with the procedures in RA3.7.4.3. Range hoods that have a minimum airflow setting exceeding 400 CFM are exempt from the noise requirement.

Ratings for Local Exhaust Fans are listed at the following web pages:

- Home Ventilating Institute (HVI) at https://www.hvi.org/hvi-certified-products-directory/
- Association of Home Appliance Manufacturers (AHAM) at https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification

ASHRAE Standard 62.2 limits exhaust airflow when atmospherically vented combustion appliances are located inside the pressure boundary. This is particularly important to observe when large range hoods are installed. Refer to Combustion and Solid-Fuel Burning Appliances below for more information.

Example 4-14: Ceiling or Wall Exhaust vs Demand-Controlled Range Hood in an Enclosed Kitchen

Question:

I am building a house with 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?

Answer:

If a range hood exhaust is not used, either a minimum 300 CFM demand-controlled local ventilation exhaust airflow or a minimum 5 ACH continuous local ventilation exhaust airflow is required. The kitchen volume is 12 ft. x 14 ft. x 10 ft. = 1,680 ft^3. Five air changes requires 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. Otherwise, a vented range hood fan that provides at least the required minimum air flow in Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0) according to the dwelling unit size and the type of range is required.

Continuous Local Exhaust

Please refer to Chapter 4.6.8.2 of the 2022 Single-family Residential Compliance Manual.

Other Requirements (Section 6 of ASHRAE 62.2)

Adjacent Spaces and Transfer Air

Please refer to Chapter 4.6.9.1 of the 2022 Single-family Residential Compliance Manual.

Instructions and Labeling

Please refer to Chapter 4.6.9.2 of the 2022 Single-family Residential Compliance Manual.

Clothes Dryers

Please refer to Chapter 4.6.9.3 of the 2022 Single-family Residential Compliance Manual.

Combustion and Solid-Fuel Burning Appliances

Please refer to Chapter 4.6.9.4 of the 2022 Single-family Residential Compliance Manual.

Garages

Please refer to Chapter 4.6.9.5 of the 2022 Single-family Residential Compliance Manual.

Ventilation Opening Area

Please refer to Chapter 4.6.9.6 of the 2022 Single-family Residential Compliance Manual.

Habitable Spaces

Please refer to Chapter 4.6.9.7 of the 2022 Single-family Residential Compliance Manual.

Minimum Filtration

Please refer to Chapter 4.6.9.8 of the 2022 Single-family Residential Compliance Manual.

Air Inlets

Please refer to Chapter 4.6.9.9 of the 2022 Single-family Residential Compliance Manual.

Air-Moving Equipment (Section 7 of ASHRAE 62.2)

Please refer to Chapter 4.6.10 of the 2022 Single-family Residential Compliance Manual.

Selection and Installation

Please refer to Chapter 4.6.10.1 of the 2022 Single-family Residential Compliance Manual.

Sound Ratings for Fans

Please refer to Chapter 4.6.10.2 of the 2022 Single-family Residential Compliance Manual.

Airflow Measurements and Airflow Ratings

Please refer to Chapter 4.6.10.3 of the 2022 Single-family Residential Compliance Manual.

Exhaust Ducts

Please refer to Chapter 4.6.10.4 of the 2022 Single-family Residential Compliance Manual.

Supply Ducts

Please refer to Chapter 4.6.10.5 of the 2022 Single-family Residential Compliance Manual.

Alternative Systems

Hydronic Heating Systems

Please refer to Chapter 4.7.1 of the 2022 Single-family Residential Compliance Manual.

Mandatory Requirements

Please refer to Chapter 4.7.1.1 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements

Please refer to Chapter 4.7.1.2 of the 2022 Single-family Residential Compliance Manual.

Performance Compliance Options

Credit for choosing a hydronic heating system is possible using the performance compliance method. The standard design is assumed to have a heat pump in all climate zones. In all cases, the system is of minimum efficiency rating with a ducted air distribution system.

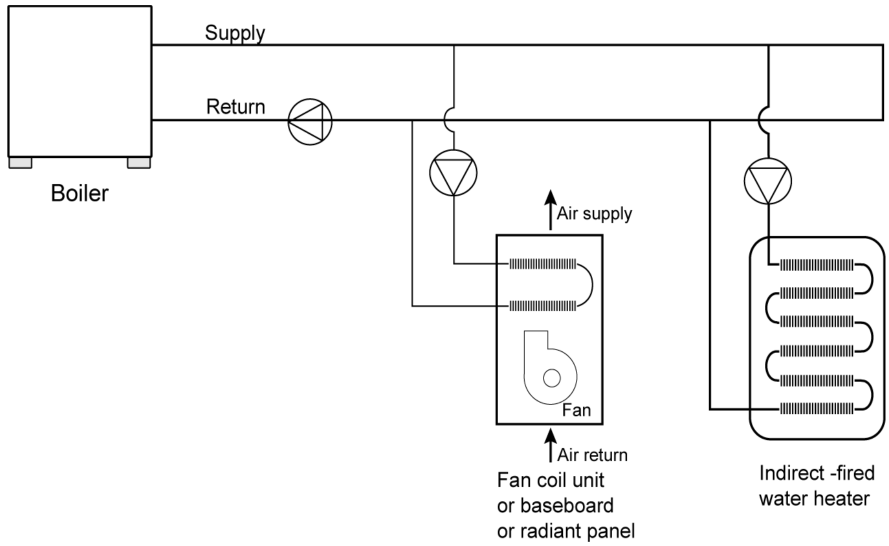
Therefore, hydronic systems without ducts can take credit for avoiding duct leakage. In addition, minimizing the amount of pipe outside conditioned space will provide some savings. Hydronic heating and cooling compliance calculations are described in the *Residential ACM Manual*.

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 another compliance option that is possible when using the performance compliance 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), heat pump, 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 4-15: 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 heat source 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 performance 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 HSPF2 rating is calculated. These calculations are performed automatically by the compliance software.

Radiant Floor System

Please refer to Chapter 4.7.2 of the 2022 Single-family Residential Compliance Manual.

Evaporative Cooling

Evaporative coolers cool a building by passing outdoor air through a wetted evaporative medium (direct evaporative cooler), by indirect cooling through a nonporous heat exchanger separating evaporatively cooled secondary air from outdoor air, or by a system that combines an indirect heat exchanger with a downstream direct evaporative process. Direct evaporative cooling is not allowed for compliance. The indirect and indirect-direct systems offer generally lower supply air temperatures with less moisture introduced to the indoor space. For the Energy Code, performance credit is allowed only for indirect and indirect-direct evaporative cooling systems. All coolers receiving credits within the *Residential ACM Manual* must be listed in the Energy Commission's Title 20 Evaporative Cooler appliance database at https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.

Evaporative coolers may be used with any compliance approach. In the prescriptive compliance approach, all evaporative coolers are treated as a minimum efficiency 14.3 SEER2 air conditioner.

In the performance compliance approach, the compliance software uses an hourly model based on unit effectiveness, supply airflow, and power to determine the magnitude of the credit based on climate conditions and unit sizing relative to the loads. Typical cooling budget credits are 20-30 percent, depending upon these factors.

The evaporative cooling system must meet the following requirements to receive credit based on the hourly performance method described above. Indirect and indirect-direct coolers not meeting these criteria, shall be modeled as a minimum efficiency (14.3 SEER2) central air conditioner.

- The equipment manufacturer shall certify to the Energy Commission that water use does not exceed 7.5 gallons per ton hour based on the Title 20 Appliance Efficiency Regulations testing criteria.
- Equipment shall be permanently installed (no window or portable units).
- Installation shall provide for automatic relief of supply air from the house with maximum air velocity through the relief dampers not exceeding 800 feet per minute (at the Title 20 rated airflow). Pressure relief dampers and ductwork shall be distributed to provide adequate airflow through all habitable rooms. For installations with an attic, ceiling dampers shall be installed to relieve air into the attic and then outside through attic vents. For installations without an attic, sidewall relief dampers are acceptable.
- To minimize water consumption, bleed systems are not allowed.
- A water quality management system (either "pump down" or conductivity sensor) is required. "Pump down" systems can either be integral to the evaporative cooler or they can be accessories that operate on a timed interval. The time interval between pumps shall be set to a minimum of 6 hours of cooler operation. Longer intervals are encouraged if local water quality allows. Automatic systems that use conductivity sensors provide the best water efficiency compared to a timed pump down system. These sensors monitor the water quality and don't unnecessarily drain the water based on elapsed time.
- Automatic thermostats are required. Manual on/off controls are not allowed.
- If the evaporative cooler duct system is shared with a heating and/or cooling system, the installed duct system shall employ backdraft dampers at the evaporative cooler supply.
- The installing contractor must provide a winter closure device that substantially blocks outdoor air from entering the indoor space.
- The size of the water inlet connection at the evaporative cooler shall not exceed 3/8 inch.
- Unless prohibited by local code, the sump overflow line shall not be directly connected to a drain and shall terminate in a location that is normally visible to the building occupants.

Example 4-15

Question:

How are applications with vapor compression cooling systems and evaporative cooling systems handled?

Answer:

In situations where evaporative cooling system(s) and vapor compression system(s) are installed in a house, the size of the evaporative cooler will dictate the magnitude of the credit. The performance approach will ensure that an evaporative cooler sized to meet most of the cooling loads will generate a higher credit than one sized to meet a fraction of the design cooling load.

Example 4-16

Question:

How do you model multiple evaporative coolers on one house?

Answer:

In situations with multiple evaporative coolers, effectiveness inputs should be averaged, and airflow and power inputs should be totaled. Performance characteristics of each piece of equipment should be listed on the compliance forms.

Ground-Source Heat Pumps

Table 4-11: Standards for Ground Water-Source and Ground-Source Heat Pumps

Appliance	Rating Condition	Minimum Standard
Ground water-source heat pumps (cooling)	59º F entering water temperature	16.2 EER
Ground water-source heat pumps (heating)	50º F entering water temperature	3.6 COP
Ground-source heat pumps (cooling)	77º F entering brine temperature	13.4 EER
Ground-source heat pumps (heating)	32º F entering brine temperature	3.1 COP

Source: Section 1605.3 of the California Appliance Efficiency Regulations

A geothermal or ground-source heat pump uses the earth as a source of energy when heating the home and as a heat sink for energy when cooling. Some systems pump water from an aquifer in the ground and return the water to the ground after exchanging heat with the water. A few systems use refrigerant directly in a loop of piping buried in the ground. Those heat pumps that either use a water loop or pump water from an aquifer have efficiency test methods that are accepted by the Energy Commission.

The mandatory minimum efficiencies for ground water-source heat pumps shown in Table 4-11: Standards for Ground Water-Source and Ground-Source Heat Pumps are certified to the Energy Commission by the manufacturer and are expressed in terms of coefficient of performance (COP) for heating and EER for cooling.

Verify that the system will meet local code conditions before choosing this type of system to comply with the Energy Code.

Solar Space Heating

Please refer to Chapter 4.7.5 of the 2022 Single-family Residential Compliance Manual.

Wood Space Heating

Please refer to Chapter 4.7.6 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Approach

Please refer to Chapter 4.7.6.1 of the 2022 Single-family Residential Compliance Manual.

Performance Approach

Please refer to Chapter 4.7.6.2 of the 2022 Single-family Residential Compliance Manual.

Wood Heater Qualification Criteria

Please refer to Chapter 4.7.6.3 of the 2022 Single-family Residential Compliance Manual.

Gas Appliances

Please refer to Chapter 4.7.7 of the 2022 Single-family Residential Compliance Manual.

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 (EER2).

If credit is taken for a high EER2, field verification by an ECC-Rater is required. Other ECC verified measures are also required, including duct sealing, airflow, fan efficacy, and refrigerant charge or fault indicator display.

Besides the ECC-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 CF2R compliance form.

Variable Capacity Heat Pump Systems

Several manufacturers offer variable capacity 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.

Compliance with ductless VCHP systems requires that all indoor units be located entirely in conditioned space with wall-mounted thermostats in zones over 150 square feet and air flow to all habitable spaces. Refrigerant charge verification is also required.

Ducted VCHP systems do not need to meet the mandatory duct system sealing and leakage (Section 150.0(m)11) and fan airflow rate and fan efficacy testing (Section 150.0(m)13). However, there are requirements to verify that VCHP system indoor unit ducts are located entirely in conditioned space, that ducted indoor units are low-static certified, and additional requirements for this compliance option listed below. The list of low-static ducted VCHP system certified to the Energy Commission including the manufacturer's product documentation can be found at https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/ducted-vchp.

Additional verification requirements apply depending on the system type, see below.

- 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

Ventilation Cooling

Please refer to Chapter 4.7.10 of the 2022 Single-family Residential Compliance Manual.

Whole-House Fans

Please refer to Chapter 4.7.10.1 of the 2022 Single-family Residential Compliance Manual.

Central Fan Ventilation Cooling Systems

Please refer to Chapter 4.7.10.2 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements

Please refer to Chapter 4.7.10.3 of the 2022 Single-family Residential Compliance Manual.

Eligibility Criteria for Whole-House Fans

Please refer to Chapter 4.7.10.3.1 of the 2022 Single-family Residential Compliance Manual.

Refrigerant Charge

Refrigerant Charge Verification

This section summarizes the procedures for verifying refrigerant charge for heat pumps and air-conditioning systems as required in 150.1(c)7A and specified in RA3.2.

Overview

The refrigerant charge in all split-system heat pumps and air conditioners undergoes a final adjustment at installation. This refrigerant charge adjustment of heat pumps in all Climate Zones and split-system air conditioners in climate zones 2 and 8 – 15 must be verified to ensure proper performance. Important factors that affect performance include the amount of refrigerant in the system (the charge) and the proper functioning of the metering device. Energy efficiency suffers if the refrigerant charge is either too low or too high and if the metering device (thermostatic expansion valves (TXV) or electronic expansion valves (EXV)) is not functioning properly. In addition to a loss of efficiency and capacity, errors in these areas can lead to premature compressor failure.

To help avoid these problems, the prescriptive standards require that heat pump systems be correctly installed and field-verified in all climate zones. This installation and field-verification is required for air conditioners in climate zones 2 and 8 – 15. Refrigerant charge verification is also required for air conditioners in any climate zone when chosen as a compliance feature using the performance compliance approach.

The requirement to verify the refrigerant charge after installation does not apply to new packaged systems, where the installer certifies the package system came factory-charged and did not alter the system in any way that would affect the refrigerant level. The ECC-Rater does not verify this method of RCV but may review that the CF2R accurately documented the packaged system. Airflow and other requirements must still be verified.

The prescriptive standards regarding verification of refrigerant charge do apply to altered package systems in all climate zones.

There are two methods of verifying that the charge level is appropriate: 1) testing the charge level, and 2) weighing-in of refrigerant. Installers must confirm that the charge level is correct and ECC-Raters must independently verify the charge.

Example 4-17: "DIY" HVAC Installation

Question:

Does a "do-it-yourself" (DIY) split system require refrigerant charge verification?

Answer:

Yes, for multiple reasons that may appear to conflict with the manufacturer's claims about easy, leak-proof installation. Installation of a space conditioning appliance (other than a plug-in room appliance) requires a building permit. It also requires wall penetrations and sturdy mounting to support the indoor fan-coil unit. New HVAC systems require load calculations. If the new system is replacing an old system (an alteration), then removal of the old system requires refrigerant recovery by a technician that holds an EPA 608 Type II or Universal certificate.

Even though the DIY system is charged at the factory, it must be altered by connecting the indoor unit(s), outdoor unit, and the charged line set at the home to complete the installation. This disqualifies it from the Exception to Section 150.1(c)7A.

The appropriate RCV protocol is the weigh-in method. This allows the installer and rater to document the installation and certify that no refrigerant adjustment was necessary.

Charge Test

Verification of proper refrigerant charge must occur after the HVAC contractor has installed the system in accordance with the manufacturer’s specifications, which may include nominally evacuating and charging the system. The standard procedure requires properly calibrated digital refrigerant gauges, thermocouples, and digital thermometers. Multiple systems in a home that require verification must be verified individually. For a heat pump, refrigerant charge verification can only be done with the system operating in cooling mode.

In a typical home HVAC 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 temperature-dependent. This is why heat pumps can only be tested in cooling mode.

A note about flammable refrigerants: Residential HVAC equipment has typically contained R-22, R-410A, or R-408A, which are not flammable but have high global warming potential (GWP) characteristics. Low-GWP refrigerants such as R-454B, R-32 and R-1234yf, are appearing on the market and are classified in the ASHRAE Safety Group A2L for "Slight Flammability."

This presents a safety concern that requires personnel to consider the size of any enclosed workspace and availability of ventilation or refrigerant detection. A series of fact sheets, articles, and guidance materials may be found on the AHRI Safe Refrigerant Transition Task Force webpage at https://www.ahrinet.org/safe-refrigerant-task-force.

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.

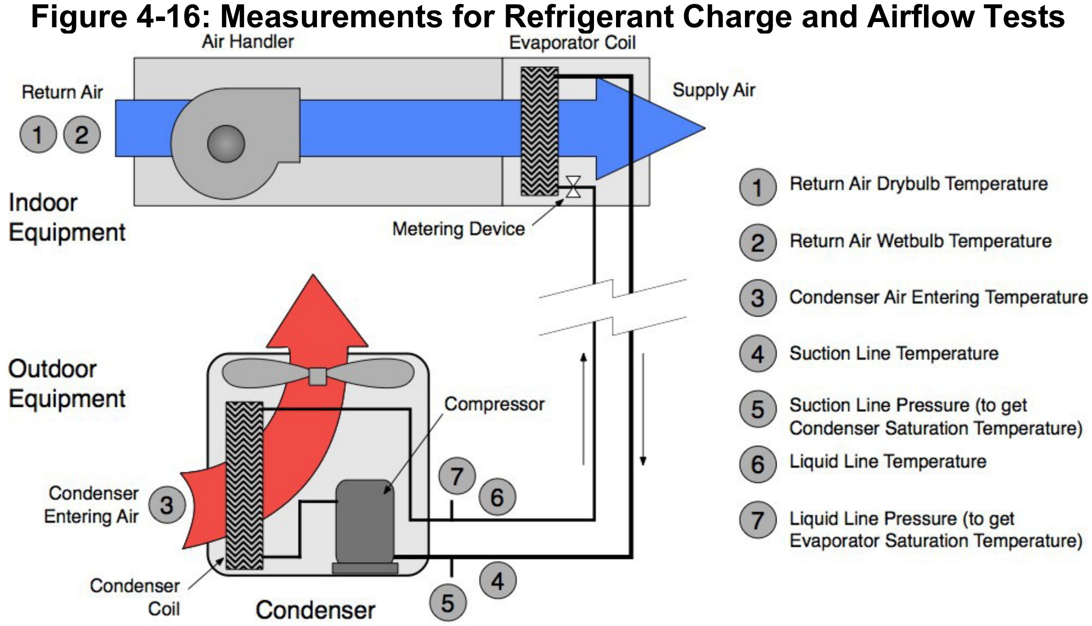
If an altered system does not meet the minimum airflow requirements, remedial steps are required to increase system airflow. More airflow is generally better for systems with air conditioning. Not only does this allow proper refrigerant charge to be verified, but it improves the overall performance of the system. When possible, 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 case (RA3.3.3.1.5). When this option is used, verification by sample groups is not allowed. Minimum airflow is critical to proper heat pump and air-conditioner operation. Reducing airflow reduces 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 minimum airflows of 300 and 350 CFM/ton are lower than the desired airflow for most systems, which is usually 400 CFM/ton and higher.

Standard Charge Verification Procedure (RA3.2.2)

The first step is to confirm that the outdoor conditions are warm enough to conduct the test, and warm enough for the system to run properly, typically at least 50°F. Turn on the system and let it run for at least 15 minutes to stabilize temperatures and pressures. While the system is stabilizing, the ECC-Rater or the installer may attach the instruments needed to take the measurements.

Figure 4-16: Measurements for Refrigerant Charge and Airflow Tests



Source: California Energy Commission

The following measurements shall be taken by the technician or ECC-Rater, when applicable.

- 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 4-14: Measurements for Refrigerant Charge and Airflow Tests). See Figure RA 3.2-1 for more information on the placement of the MAH.

- 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 4-14: Measurements for Refrigerant Charge and Airflow Tests). 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.

- 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 4-14: Measurements for Refrigerant Charge and Airflow Tests)
- The second measurement determines the saturation temperature of the refrigerant in the evaporator coil. (See Point 5 in Figure 4-14: Measurements for Refrigerant Charge and Airflow Tests)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:

- 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 Figure 4-14: Measurements for Refrigerant Charge and Airflow Tests)
- 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 4-14: Measurements for Refrigerant Charge and Airflow Tests)

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.

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 (TSuction, db) minus the evaporator saturation temperature (TEvaporator, 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 ECC-Raters add or remove refrigerant on systems that they are verifying.

Subcooling Verification Method (RA3.2.2.6.2)

Please refer to Chapter 4.8.1.5 of the 2022 Single-family Residential Compliance Manual.

Weigh-In Charging Procedure (RA3.2.3)

When the conditions are not conducive to conducting a charge test, a Weigh-In Charge Verification must be completed. This may only be performed by the installer, and it must be verified by the ECC-Rater either by simultaneous observation or by using the standard method when conditions permit.

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 ECC-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 installing technician may perform any kind of weigh-in procedure. The ECC-Rater may only verify compliance of the weigh-in method if the installer performed a weighed-in verification (with rater observation) and the system is incompatible with the standard procedure (e.g., ductless mini-split system).

Per RA 3.2.3.1.5, the weigh-in procedure shall be performed in accordance with all manufacturer specifications. The HVAC Installer shall document and confirm the following, and certify on the Certificate of Installation that the manufacturer's specifications for these procedures have been met.

- Liquid line filter drier has been installed if required per outdoor condensing unit manufacturer's instructions, and installed with the proper orientation with respect to refrigerant flow.
- If refrigerant line connections require welding, the system is braised with dry nitrogen in the lines and indoor coil.
- In all cases where the equipment manufacturer's instructions call for checking for gas leaks with vacuum, the system is evacuated to 500 microns or less and, when isolated, rises no more than 300 microns over five minutes.
- In all cases where the equipment manufacturer's instructions call for checking for gas leaks with nitrogen gas, the system is pressurized to the manufacturer's specified pressure and if the pressure cannot be maintained, leaks shall be located and fixed.
- The calculated weight adjustment for lineset length is based on the length and diameter of the lineset.
- The calculated weight adjustment for coil size is based on equipment manufacturer's instructions.

- The actual total weight adjustment is equal to the sum of the calculated weight adjustments for lineset and coil size.
- The calculated and actual total weights of refrigerant in the system are recorded on or near the nameplate label, in indelible ink or other permanent means.

These requirements shall also be verified through ECC-Rater on-site observation, and per RA 3.2.3.2, the ECC-Rater shall observe and confirm, and document on a Certificate of Verification:

- The calculated weight adjustment for lineset length was based on the length and diameter of the lineset.
- The calculated weight adjustment for coil size was based on the equipment manufacturer's instructions.
- The actual charge adjustment was equal to the sum of the calculated weight adjustments for lineset and coil size.
- The calculated and actual total weights of refrigerant in the system were recorded on or near the nameplate label, in indelible ink or other permanent means.
- One of the following:
    - In all cases where the equipment manufacturer's instructions call for checking for gas leaks with vacuum, the system is evacuated to 500 microns or less and, when isolated, rises no more than 300 microns over five minutes.
    - In all cases where the equipment manufacturer's instructions call for checking for gas leaks with nitrogen gas, the system was pressurized to the manufacturer's specified pressure and if the pressure could not be maintained, leaks were located and fixed.
    - Confirm that no fittings (other than the fitting to the compressor) are compression or flare fittings.

General Requirements

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 Energy Commission. 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 ECC-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 ECC-Rater observation procedure is specified by the Energy Code.

ECC-Verification Procedures

When required by the CF1R, ECC-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 ECC-Rater and the installer except that the tolerances for passing the superheat and subcooling tests are less stringent for the ECC-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:

- When the weigh-in method is used.
- 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 ECC-Rater will perform the verification only after the installer has charged the system according to manufacturer's specifications.

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 ECC-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 Section RA3.2.3 may also be used for air conditioners or heat pumps in cooling mode 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 air conditioners or heat pumps in cooling mode, and only for units equipped with variable metering devices, which include TXV and 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 of Section RA3.2.2 remain the same and must be completed when using the winter charge setup.

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 an ECC-Rater must verify the correct charge; however, an exception to §150.1(c)7Aic provides for an alternative third-party ECC 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, an ECC-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:

- Use the RA3.2.3.1 Installer Weigh-In Charging Procedure to demonstrate compliance and install an occupant-controlled smart thermostat (OCST)**.**
- 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 an ECC-Rater determines later, when the outside temperature is 55 degrees F or above, that correction is necessary as described in Residential Appendix RA 2.4.4. The installer must also provide written notice to the homeowner and enforcement agency that the charge has not yet been verified.

Compliance and Enforcement

Please refer to Chapter 2 of the 2025 Single-family Residential Compliance Manual.

Design-Phase Documentation

The initial compliance documentation consists of the certificate of compliance (CF1R). It lists the features that the house needs for compliance with the prescriptive or performance compliance requirements.

For the prescriptive compliance approach, the required features are based on the Prescriptive Component Package, shown in Tables 150.1-A and 150.1-B.

For the performance compliance approach, the required features are based on a set of features that the designer has documented to result in a level of efficiency at least as good as the prescriptive standard design for single-family houses and townhouses. The calculations for documenting this performance are done using the approved performance compliance software at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency. The calculation approach is described in the *Residential ACM Reference Manual.*

The performance compliance approach provides maximum design flexibility. It also allows compliance credit for special additional features to be quantified.

The CF1R lists special features for which compliance credit was taken using the performance compliance approach. These features require additional visual verification by the enforcement agency to ensure proper installation. Some require field verification and diagnostic testing by an ECC-Rater. These will be listed separately on the CF1R under the following headings. For the purposes of this manual, only HVAC-related features are listed below.

Special Features Not Requiring ECC-Rater verification:

- Ducts in a basement
- Ducts in a crawlspace
- Ducts in an attic with a radiant barrier

- Hydronic heating and system design details
- Gas-fired absorption cooling
- Zonal control
- Ductless wall heaters

Special features requiring ECC-Rater verification:

- Duct sealing
- Verified duct design – for reduced duct surface area and ducts in conditioned space
- Low-leakage ducts in conditioned space
- Low-leakage air handlers
- Verification of return duct design
- Verification of air filter device design
- Verification of bypass duct prohibition
- Refrigerant charge verification
- Verified system airflow
- Air handler fan watt draw
- High energy efficiency ratio (EER2)
- Verified seasonal energy efficiency ratio (SEER2)
- Heating seasonal performance factor (HSPF2)
- Heat pump - rated heating capacity
- Continuous whole-dwelling unit mechanical ventilation airflow for IAQ
- Intermittent dwelling unit mechanical ventilation airflow for IAQ
- Kitchen exhaust fan verification for IAQ (Local Mechanical Exhaust)
- Whole-house fan (WHF) airflow and fan efficacy
- Central fan ventilation cooling system (CFVCS)
- Variable capacity heat pump (VCHP)

HRV or ERV fan efficacy and fault indicator display (FID)

Information summarizing measures requiring field verification and diagnostic testing is presented in Table RA2-1. The field verification and diagnostic testing protocols that must be followed to qualify for compliance credit are described in RA3.

Registration of the CF1R with an approved ECC Provider is required. The building owner or the person responsible for the design must submit the CF1R to an ECC Data Registry for retention according to the procedures described in Section 10-103 and RA2. Registration ensures that the project follows the appropriate verification process, provides tracking, and provides electronic access to authentic documentation.

Construction-Phase Documentation

During construction, the general contractor or specialty subcontractors must complete all applicable CF2Rs for the building design special features specified on the CF1R.

Registration of the CF2R is required. The licensed contractor responsible for the installation must submit the CF2R information that applies to the installation to an ECC-Provider Data registry using procedures described in Section 10-103 and RA2. CF2R documents corresponding to the list of special features requiring ECC-Rater verification in Design-Phase Documentation are required.

Field Verification and Diagnostic Testing

When the CF1R and CF2Rs require ECC verification, an ECC-Rater must visit the site to perform the tests necessary to complete the applicable heating and cooling system certificates of verification (CF3R). A CF3R is available for each special feature requiring ECC-Rater verification given in Section 4.9.1.

Field verification for nonmandatory features is necessary only when performance credit is taken for the measure. Some field verifications are mandatory in all homes unless they are exempted in the Energy Code by specific exceptions.

Registration of the CF3R is required. The ECC-Rater must submit the field verification and diagnostic testing information to the ECC Data Registry as described in Chapter 2. For additional details describing ECC-Verification and the registration procedure, refer to RA2.

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Water Heating Requirements

Overview

Please refer to Chapter 5.1 of the *2022 Single-family Residential Compliance Manual*.

What's New for 2025

This section summarizes changes to the requirements for residential water heating for the 2025 Energy Codes.

Mandatory Requirements

- Heat pump water heaters installed so that inlet air is outdoor air must have backup heat if the compressor cut-off temperature is above the local Heating Winter Median of Extremes (Section 110.3(c)7A).
- Ventilation is required when installing a heat pump water heater (Section 110.3(c)7B).
- Pool and/or spa heating systems must be sized appropriately for newly constructed single-family buildings with heated swimming pools and spas (Section 110.4(c)).
- Heat pump pool heaters with supplementary heaters shall have controls installed to ensure that the supplementary heater does not operate when the heating load can be met by the heat pump alone (Section 110.4(d)).

Prescriptive Requirements

Water heating equipment is required to be a heat pump water heater or a solar water heating system with electric backup and minimum 70% solar fraction in all climate zones (Section 150.1(c)8).

At a Glance

Table 5-1: Overview of Water Heating Requirements in the Energy Code and Chapter 5 provides an overview of the location of the water heating requirements in the 2025 Energy Codes by construction and building type.

Table 5-1: Overview of Water Heating Requirements in the Energy Code and Chapter 5

Type	Mandatory Requirements Standards Section	Prescriptive Requirements Manual Section	Prescriptive Requirements Standards Section	Prescriptive Requirements Manual Section	Performance Requirements Standards Section	Performance Requirements Manual Section
Single-family dwelling	Section 110.3; Section 150.0(j) Section 150.0(n)	Mandatory Requirements for Water Heating	Section 150.1(c)8	Prescriptive Requirements for Water Heating	Section 150.1(b)	Performance Approach Compliance for Water Heating

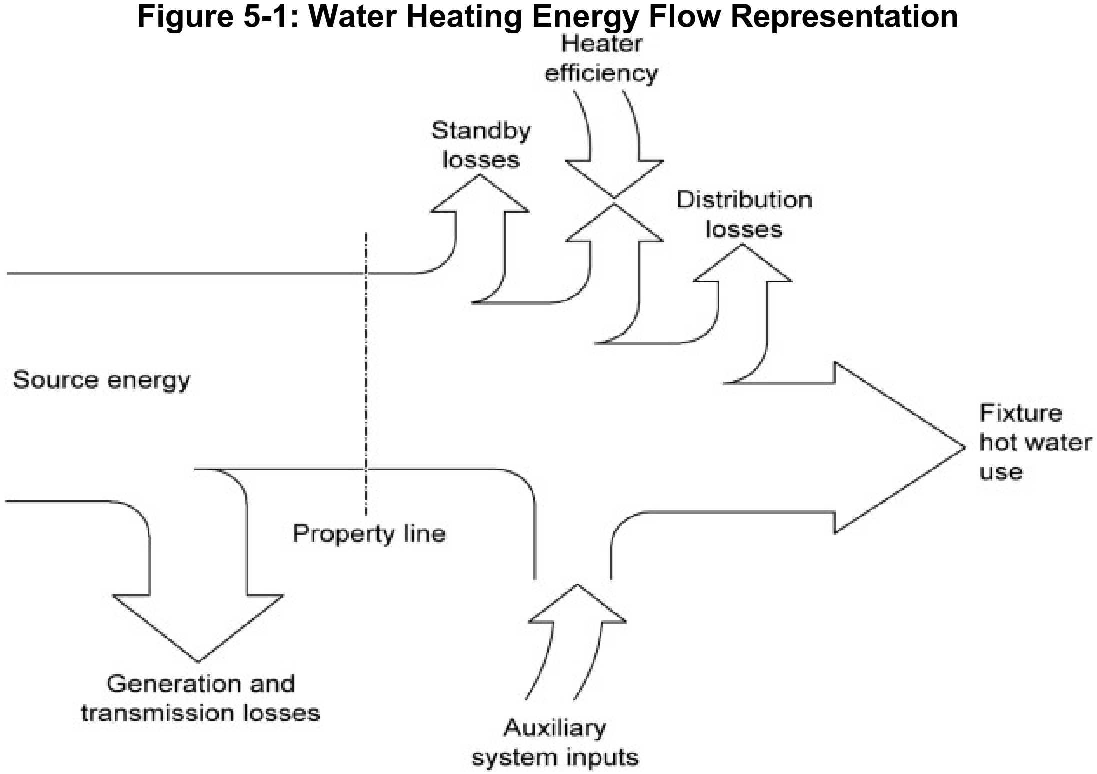
Addition	Section 110.3; Section 150.0(j) Section 150.0(n)	Mandatory Requirements for Water Heating, Chapter 9	Section 150.2(a)1D	Prescriptive Requirement s for Water Heating	Section 150.2(a)2	Performanc e Approach Compliance for Water Heating
Alteratio n	Section 110.3; Section 150.0(j)	Mandatory Requirements for Water Heating, Chapter 9	Section 150.2(b)1H	Prescriptive Requirement s for Water Heating	Section 150.2(b)2	Performanc e Approach Compliance for Water Heating

Source: California Energy Commission

Water Heating Energy

Total energy use associated with water heating consists of the end use, heater inefficiencies, standby loss, and distribution system inefficiencies. Figure 5-1: Water Heating Energy Flow Representation below shows the energy flows that constitute water heating energy usage.

Figure 5-1: Water Heating Energy Flow Representation



Source: California Energy Commission

Hot water drawn at the end use points (for example, faucets, showers, and so forth) represents the useful energy consumed. In most cases, hot water that is actually used represents the largest fraction of water heating energy use, 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 single-family home may be as much as 30 percent of the total energy used for water heating. However, distribution losses in single-family homes with compact hot water distribution systems may be lower than 10 percent of total water heating energy use. An important consideration for any water heating system is the recovery load (that is, end use plus distribution losses) of the water heating unit minus any contribution from auxiliary heat inputs, such as a solar thermal system.

Residential Water Heating Equipment

There are several types of residential water heaters described below. The most common water heaters in single-family homes are storage (heat pump water heater, propane, natural gas, or electric resistance) or instantaneous water heaters (propane, natural gas, or electric resistance).

To comply with the Energy Codes using either the prescriptive or performance approach, the water heater must meet the federal and/or the California Appliance Efficiency Regulations (California Code of Regulations (CCR) Title 20).

Instantaneous Water Heaters

Please refer to Chapter 5.2.1 of the *2022 Single-family Residential Compliance Manual*.

Storage Water Heater

Please refer to Chapter 5.2.2.1 of the *2022 Single-family Residential Compliance Manual*.

Heat Pump Water Heaters

A heat pump water heater (HPWH) is an electric water heater that works like an air conditioner in reverse. It uses the refrigeration process 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. Some models entering the market use larger compressors to avoid the need for resistance elements.

The performance of HPWHs depends both on storage water temperature and inlet air temperature. Buildings in warm and cold climate zones, and different installation locations such as a garage or well vented outdoor closet, all have an impact on performance and must be considered. If the HPWH is installed in a confined water heater closet, carefully follow manufacturer instructions on the use of ducting to discharge exhaust air out of the closet. Without ducting, a confined closet can result in overcooling of the air, significantly diminishing HPWH performance.

HPWHs are most efficient in warmer climates, but even in cold climate zones such as climate zone 16, HPWHs still use only half as much electricity as conventional electric resistance water heaters. 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.

The Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification was developed to address critical performance and comfort issues of HPWH in colder climates. Tiers are incorporated into this specification recognizing variations in product performance and configuration. An HPWH that meets the NEEA Advanced Water Heater Specification performs significantly better in real world conditions, and an HPWH that meets the NEEA Tier 3 or higher can be used to meet the prescriptive requirement for newly constructed buildings, addition, and alteration.

The list of qualified NEEA HPWH products can be found at https://neea.org/img/documents/qualified-products-list.pdf

Joint Appendix (JA) 13 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 heating 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, https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/ja13.

Example 5-2: HPWH Compliance Credits

Question:

Are there any additional compliance credits available for unitary HPWHs?

Answer:

NEEA Tier 3 and Tier 4 rated HPWHs are available in the performance compliance software and provide compliance credit compared to the standard design HPWH. Additionally, with the approval of JA13, there is now credit within the performance compliance software for HPWHs that are JA13-certified and provide the Basic Load Up demand management functionality. This credit varies with climate zone. Note that a mixing valve must be installed to ensure safe hot water delivery.

Air-to-Water Heat Pumps with Water Heating Capability (Three Function Heat Pumps)

Air-to-water heat pumps provide space heating and cooling output via hydronic delivery. Some models also provide a water heating function, enabling the use of a single outdoor heat pump unit to serve indoor heating, indoor cooling, and domestic hot water production. For this reason, these AWHP systems are often referred to as "three function heat pumps" (TFHPs). This type of system can be attractive for all-electric retrofits, as no new breaker space or service upgrades are required..

Residential-Duty Commercial Water Heater

Please refer to Chapter 5.2.2.4 of the *2022 Single-family Residential Compliance Manual*.

Hot Water Supply Boiler

Please refer to Chapter 5.2.2.5 of the *2022 Single-family Residential Compliance Manual*.

Water Heater Maintenance

Please refer to Chapter 5.2.3 of the *2022 Single-family Residential Compliance Manual*.

Maintenance of Instantaneous Water Heaters

Please refer to Chapter 5.2.3.1 of the *2022 Single-family Residential Compliance Manual*.

Maintenance of Storage Water Heaters

Please refer to Chapter 5.2.3.2 of the *2022 Single-family Residential Compliance Manual*.

Drain Water Heat Recovery Devices

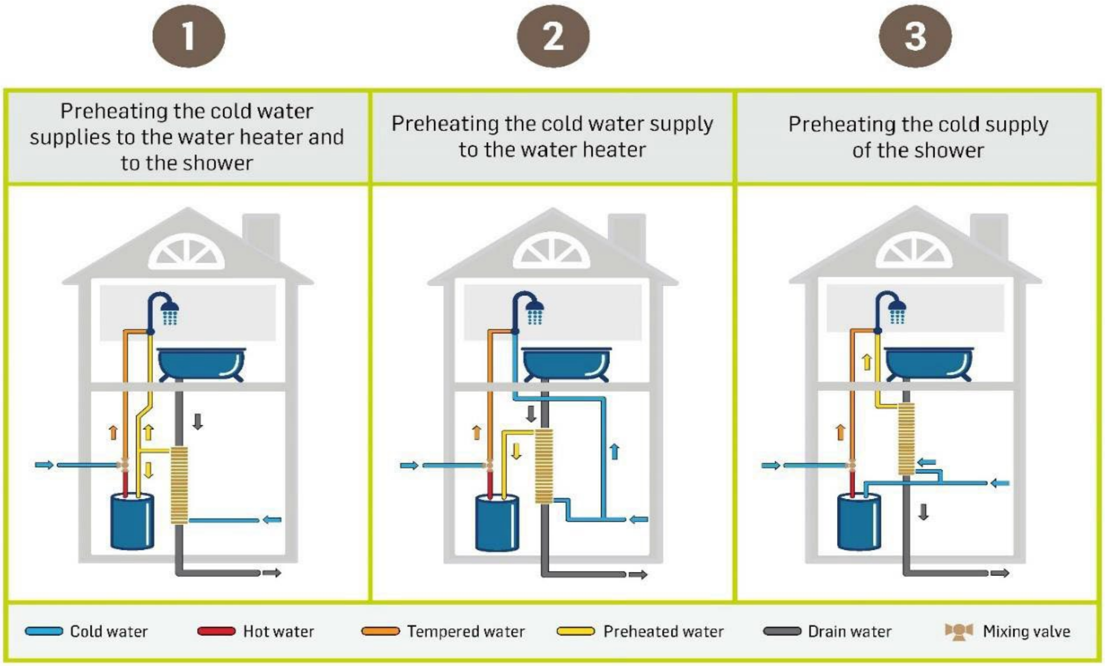
Drain water heat recovery (DWHR) is a technology that captures shower waste heat from the drain line. DWHR devices are counter flow heat exchangers, with cold water entering the building on one side of the device and hot drain water exiting the building on the other.

DWHR is a component of an alternative prescriptive path. It is also a compliance option for other water heating applications. DWHR technologies are most prevalent and perform best in cold climates in applications with large water heating loads and colder inlet water temperatures. California, being a generally milder climate, will show somewhat diminished performance relative to the preferred applications.

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 5-2: The Three Plumbing Configurations of DWHR Installation (From Left to Right: Equal Flow, Unequal Flow – Water Heater, Unequal Flow Fixture) schematically shows the three installation configurations. The energy harvested from a DWHR device is maximized in an equal flow configuration. They are sold in both vertical design configurations, as shown in Figure 5-2: The Three Plumbing Configurations of DWHR Installation (From Left to Right: Equal Flow, Unequal Flow – Water Heater, Unequal Flow Fixture), 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 ECC-Verified and meet the Reference Appendix RA4.4.21 requirements.

Figure 5-2: The Three Plumbing Configurations of DWHR Installation (From Left to Right: Equal Flow, Unequal Flow – Water Heater, Unequal Flow Fixture)



Source: California Energy Commission

Mandatory Requirements for Water Heating

Equipment Certification

Please refer to Chapter 5.3.1 of the *2022 Single-family Residential Compliance Manual*.

Equipment Efficiency

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 heaters, or gallon per minute for instantaneous water heaters. The efficiency requirements for the most common consumer water heaters are given in Table 5-2: Minimum Federal UEF Requirements for Consumer Water Heaters below. The efficiency requirements for the residential-duty commercial water heaters are given in Table 5-3: Minimum Federal Uniform Energy Factor Requirements for Residential-Duty Commercial Water Heaters below.

The Energy Commission has developed a water heater efficiency guide to allow quick lookup of the minimum efficiency of the most common types and sizes of water heaters. These guides can be found at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/online-resource-center/water.

Table 5-2: Minimum Federal UEF Requirements for Consumer Water Heaters

Product class	Rated storage volume	Draw pattern	UEF
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	Very Small	0.3456 – (0.0020 × Vr)

Product class	Rated storage volume	Draw pattern	UEF
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	Low	0.5982 − (0.0019 × Vr)
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	Medium	0.6483 − (0.0017 × Vr)
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	High	0.6920 − (0.0013 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	Very Small	0.6470 − (0.0006 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	Low	0.7689 − (0.0005 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	Medium	0.7897 − (0.0004 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	High	0.8072 − (0.0003 × Vr)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Very Small	0.8808 − (0.0008 × Vr)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Low	0.9254 − (0.0003 × Vr)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Medium	0.9307 − (0.0002 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	Very Small	1.9236 − (0.0011 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	Low	2.0440 − (0.0011 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	Medium	2.1171 − (0.0011 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	High	2.2418 − (0.0011 × Vr)
Instantaneous Gas-fired Water	<2 gal and >50,000 Btu/h	Very Small	0.8

Product class	Rated storage volume	Draw pattern	UEF
Heater			
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h	Low/Medium/High	0.81
Instantaneous Electric Water Heater	<2 gal	Very Small/Low/Medium	0.91
Instantaneous Electric Water Heater	<2 gal	High	0.92
Grid-Enabled Water Heater	>75 gal	Very Small	1.0136 − (0.0028 × Vr)
Grid-Enabled Water Heater	>75 gal	Low	0.9984 − (0.0014 × Vr)
Grid-Enabled Water Heater	>75 gal	Medium	0.9853 − (0.0010 × Vr)
Grid-Enabled Water Heater	>75 gal	High	0.9720 − (0.0007 × Vr)

Source: U.S. Department of Energy

Table 5-3: Minimum Federal Uniform Energy Factor Requirements for Residential-Duty Commercial Water Heaters

Product class	Specifications	Draw pattern	UEF
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	Very Small	0.2674 − (0.0009 × Vr)
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	Low	0.5362 − (0.0012 × Vr)
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	Medium	0.6002 − (0.0011 × Vr)
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	High	0.6597 − (0.0009 × Vr)

Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	Very Small	0.2932 − (0.0015 × Vr)
Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	Low	0.5596 − (0.0018 × Vr)
Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	Medium	0.6194 − (0.0016 × Vr)
Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	High	0.6740 − (0.0013 × Vr)
Electric Instantaneous	>12 kW and ≤58.6 kW and ≤2 gal	All draw pattern	0.80

Source: California Energy Commission, *Title 20 Appliance Efficiency Regulations* (2014)

Storage Tank Insulation

Please refer to Chapter 5.3.3 of the *2022 Single-family Residential Compliance Manual*.

Isolation Valves

Reference: Section 110.3(c)6

All newly installed instantaneous water heaters (minimum input of 6.8 kBTU/hr) shall 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 heater that has integrated drain ports for servicing are acceptable to meet the requirements of Section 110.3(c)6 and will not require additional isolation valves.

Heat Pump Water Heaters (Air-Source)

Backup Heat

Reference: Section 110.3(c)7A

An air-source heat pump water heater (HPWH) transfers heat from the surrounding air to the water inside a storage tank using a heat pump cycle. This relies on the heat content of the surrounding air being sufficient to produce high-temperature refrigerant at the compressor outlet.

HPWH design and refrigerant type affect how low the ambient temperature can be while still extracting sufficient heat from the surrounding air by this process. Below this minimum ambient temperature, the compressor is disabled, as it is no longer able to operate efficiently and begins to suffer rapid wear.

If the inlet air is unconditioned, there is a higher likelihood of the HPWH experiencing ambient temperature conditions below the compressor cutout temperature. If that occurs and backup heat is not provided, then the HPWH will be unable to generate hot water.

In general, most R-134a based HPWH systems can only operate down to an ambient temperature of 40 °F, while most R-744 (CO_2) based HPWH systems can operate down to temperatures below 0 °F. For R-134a-based systems, the inclusion of backup heat is critical to provide adequate hot water. Most of California typically experiences winter temperatures below 40°F, and hot water demand is typically higher in the winter season.

However, if a HPWH is able to operate below the local Winter Median of Extremes, then the HPWH will always provide sufficient heat to generate hot water except in rare and brief extreme winter weather events.

Therefore, backup heat must be provided if unconditioned air is supplied to the inlet heat pump and the compressor cutout temperature is above the Winter Median of Extremes for the closest location listed in Table 2-3 from Reference Joint Appendix JA2. Backup Heat may be internal or external to the HPWH and may be gas or electric resistance.

Example 5-3: HPWH Backup Heat

I am installing a R-134a HPWH in Davis, CA. How do I determine if backup heat is needed for my HPWH?

Answer:

Check manufacturer documentation or contact the manufacturer to obtain the compressor cutout temperature.

Assuming that their response is 40 °F, look up the Heating Winter Median of Extremes for closest city in Table 2-3 from Reference Appendix JA2. Davis, CA itself is listed in the table with a Heating Winter Median of Extremes of 24 °F.

As 40 °F is greater than 24 °F, the HPWH installation must be fitted with backup heat.

Example 5-4: HPWHs with Built-In Backup Heat

The HPWH specified in the design is a consumer-sized integrated HPWH and includes electric resistance elements built into the tank from the manufacturer. Does this count for backup heat?

Answer:

Yes. In these consumer-sized integrated systems, the electrical resistance elements are set up to turn on when the HPWH is not able to meet the load demand, or the supply air temperature is too low, and will provide heat for how water.

Ventilation

Reference: Section 110.3(c)7B

If the thermal resource of the air is not replenished through ventilation, the heat content and temperature of the ambient air will decrease until compressor cutout temperature is reached and the HPWH is unable to operate (see commentary for Section 110.3(c)7A).

Section 110.3(c)7B requires a minimum level of ventilation for HPWHs, regardless of building type and installation location. This can be provided in one of four ways:

- Installation without ducts in a large room.
- Installation without ducts in a smaller room that is vented.

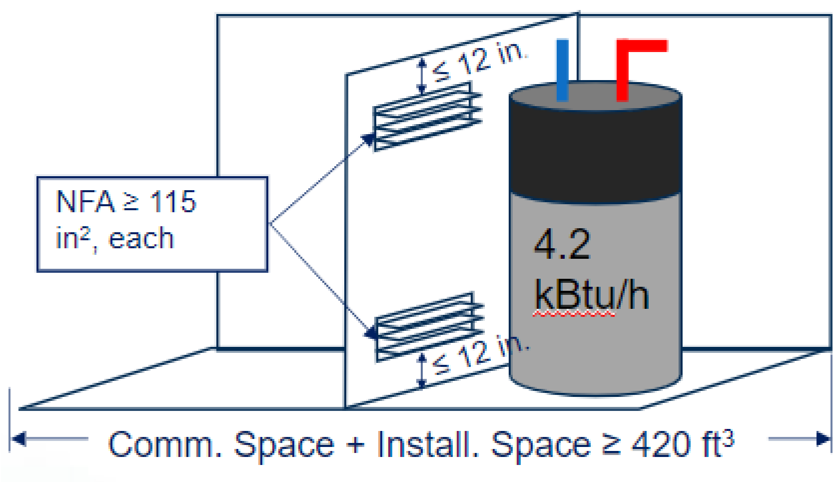
- Installation with ducts in any size room.
- Installation using a method not covered above that is supported by the manufacturer.

Selection of ventilation method will depend on the building design and situation, but it is up to the designer and installer. Detail for each method is discussed in the sections below.

It is important to note that HPWHs installed indoors impact the heating loads. The heat used to produce hot water with the compressor comes from the indoor air and therefore from the heating system in winter. This load should be considered when sizing heating equipment.

Figure 5-3: HPWH and Louvered Openings provides an example of a HPWH complying with Section 110.3(c)7B3.

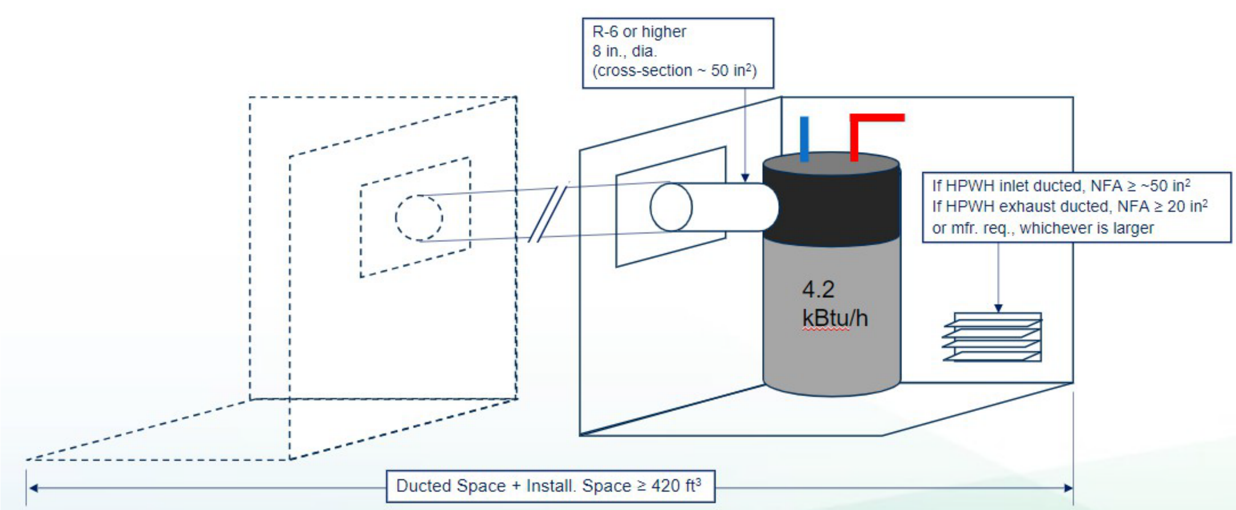
Figure 5-3: HPWH and Louvered Openings



Source: California Energy Commission

Figure 5-4: HPWH and Ducted Exhaust provides an example of a HPWH complying with Section 110.3(c)7B4.

Figure 5-4: HPWH and Ducted Exhaust



Source: California Energy Commission

Example 5-5: HPWHs Ventilation Method Selection

Question:

A consumer-sized integrated HPWH has been specified for installation. How do I determine the appropriate ventilation method and ventilation requirements?

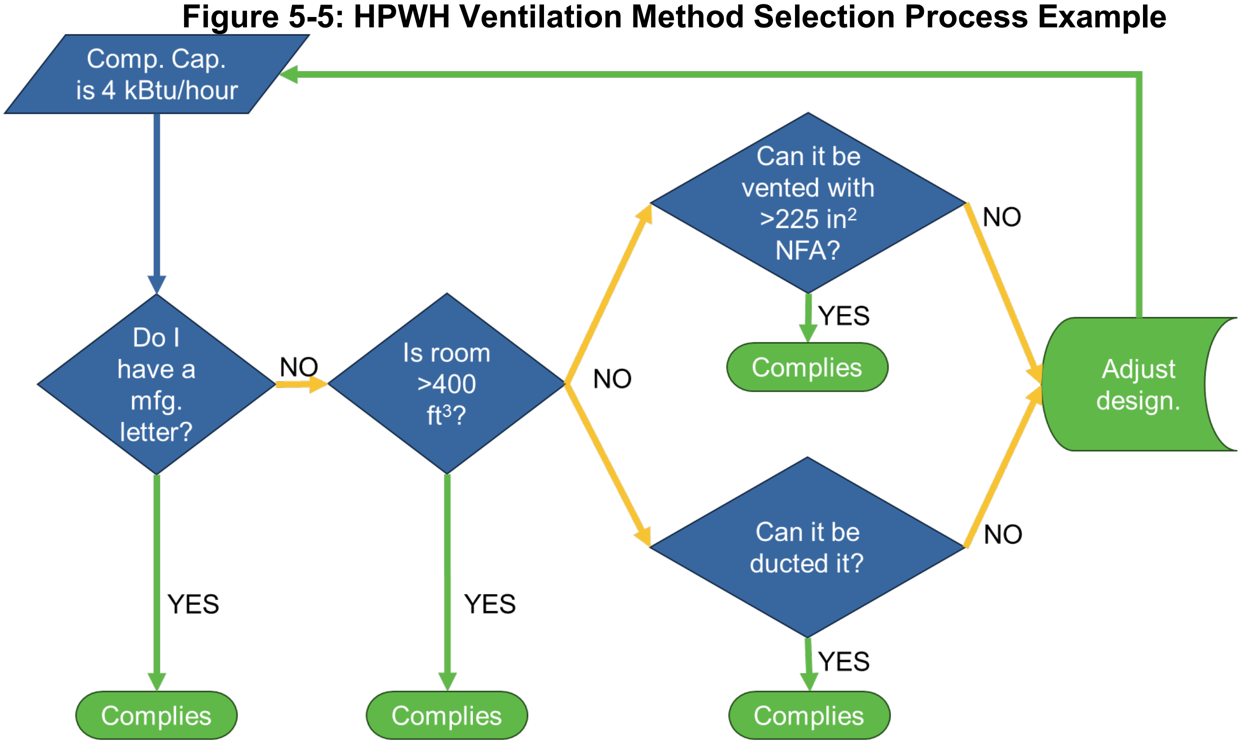
Answer:

The first step is to determine the compressor capacity. This can be obtained from manufacturer documentation or by contacting the manufacturer and requesting it. Most consumer-sized integrated HPWHs currently on the market have a compressor capacity of approximately 4 kBtu/hour, which will be used to continue this example.

This value is used to determine the minimum ventilation characteristics for each ventilation method. In all cases, if the installation manual specifies a minimum ventilation characteristic that is larger than required by code, then the manufacturer specified minimum must be used.

The flow chart below shows an example decision process for a HPWH with 4 kBtu/hour compressor capacity. This example assumes that the installation manual specifies the same requirements or less, making the minimums in the chart the mandatory minimums.

Figure 5-5: HPWH Ventilation Method Selection Process Example



Source: California Energy Commission

The process begins with checking whether the planned ventilation method is covered by code or is novel and requires a manufacturer letter. If a letter is needed and obtained, then the system complies. It is highly recommended to include the manufacturer letter with plan documents for reference by inspectors and in documentation provided to the building owner.

If a manufacturer letter is not required or obtained, then ventilation must be obtained by one of the other three covered methods. The simplest is the large room volume method. In this example, the minimum room volume would be 400 cubic feet.

If 400 cubic feet is not available or not provided by the design, then either the installation space must be vented with 225 square inches of net free area (NFA) or the HPWH must be ducted. There are additional requirements for these two methods which must also be met.

Example 5-6: HPWHs Ventilation Method Priority

Question:

I am installing a consumer-sized integrated HPWH in a garage with more volume than required by both Section 110.3(c)7B and the installation manual, but I want to duct the unit anyway. Is this still allowed?

Answer:

Yes. Each of the four methods for providing ventilation to HPWHs in Section 110.3(c)7B are independently valid methods and the availability or feasibility of one does not cause it to supersede the others.

Manufacturer Provided Ventilation Method

If the manufacturer provides a ventilation installation method that provides at least the same performance as the other ventilation methods, such method may be used. If no such method is provided, use of another method in Section 110.3(c)7B is required.

Installation in an Unvented Room

If the HPWH is to be installed without ducting in an unvented room, that room must have a volume equal to the greater of 100 cubic feet per kBtu per hour of compressor capacity or the minimum volume provided by the manufacturer for installation in an unvented room, whichever is greater.

Example 5-7: Determining Unvented Room Size

Question:

My consumer-sized integrated HPWH has a compressor capacity of 4 kBtu per hour. The manufacturer installation manual specifies a minimum room volume of 350 cubic feet. What is the minimum room volume required to meet the ventilation requirements of Section 110.3(c)7B?

Answer:

The minimum room volume per Section 110.3(c)7Bii is calculated using the compressor capacity:

4 kBtu per hour x 100 cu. ft. per kBtu per hour = 400 cu. ft.

This is larger than the manufacturer requirement of 350 cu. ft. Therefore, the minimum room volume required to meet the ventilation requirements of Section 110.3(c)7B is 400 cu. ft.

Installation with Ventilation

If the HPWH is to be installed without ducting in a vented room, that room’s openings for ventilation must meet the following requirements:

- Vent directly to a neighboring space that meets the minimum volume requirement for an install in an unvented room without ducts, minus the volume of the HPWH installation space.
- Ventilation openings must consist of a single layer of fixed flat slat louvers or grilles, with a total minimum NFA the larger of 125 square inches plus 25 square inches per kBtu per hour of compressor capacity, or the minimum provided by the manufacturer for this method.
- Ventilation openings must be either fully louvered doors or two openings of equal area, one in the upper half of the enclosure and one in the bottom half of the enclosure. The top of the upper opening must be 12 inches or less from the enclosure top and the bottom of the lower vent must be 12 inches or less from the enclosure bottom.

Example 5-8: Determining Required Ventilation Net Free Area

Question:

My consumer-sized integrated HPWH has a compressor capacity of 4 kBtu per hour. The manufacturer installation manual for a small closet install does not specify a minimum net free area (NFA), and just says the closet needs a "fully louvered door." What is the minimum NFA required to meet the ventilation requirements of Section 110.3(c)7B?

Answer:

The minimum NFA per Section 110.3(c)7Biii is calculated using the compressor capacity:

4 kBtu per hour x 25 sq. in. per kBtu per hour + 125 sq. in. = 225 sq. in.

If the installation manual does not specify a minimum NFA, the manufacturer may still have a requirement in other documentation or installer training. Contact the manufacturer for this information.

Example 5-9: Determining Net Free Area of a Vent

Question:

I wish to use a fully louvered door to vent the closet my HPWH will be installed in. How do I determine the NFA of a louvered door?

Answer:

Net free area is the total area of a vent through which air can freely flow. This can be obtained from either the door manufacturer or by direct measurement. For direct measurement, measure the width of the louvers and the thickness of the louver gap at its narrowest point and count the number of louver gaps. Multiply these three values together to obtain the NFA of the louvered door.

For example, a louvered door has louvers that are 26 inches wide. The gap between the louvers is 3/16ths of an inch at the narrowest point. There are 53 louver gaps.

26 x 0.1875 x 53 = 258.375 sq. in.

Example 5-10: Determining Net Free Area of a Vent

Question:

My client wants to use chevron louvers instead of flat slats. Is there a way for chevron louvers to comply?

Answer:

No. Chevron louvers resist the flow of air due to thermal buoyancy. Only fixed position flat slat louvers may be used.

Installation with Ducting

The HPWH may also be ducted. Section 110.3(c)7Biv requires the following when ducting a HPWH:

- The volume of the space joined to the installation space, plus the volume of the installation space via ducts, must meet the minimum volume of Section 110.3(c)7Bii.
- All duct connections and building penetrations must be sealed.
- Exhaust air ducts and all ducts which cross pressure boundaries must be insulated to minimum of R-6.
- Where only the HPWH inlet or outlet is ducted, the installation space must be vented. These vents must be permanent openings consisting of a single layer of fixed flat slat louvers or grilles in the bottom half of the room, and/or a door undercut.
- For ducted inlet, a minimum NFA equal to the cross-sectional area of the duct.
- For ducted exhaust, a minimum NFA the larger of 20 square inches or the minimum NFA provided by the manufacturer for this method.
- Where the inlet and outlet ducts both terminate within the same pressure boundary, airflow from the termination points shall be diverted away from each other.

It is important to note that ducting only the inlet or exhaust across the pressure boundary could increase heating and cooling load and interfere with balanced ventilation systems. This should be considered when specifying HPWH location and ventilation method.

High-Efficiency Electric Ready for Gas Water Heater

Reference: Section 150.0(n)

To facilitate future installations of HPWH, the Energy Codes contain the following mandatory requirements for gas or propane water heaters. When a gas or propane water heater is installed, the building must be made electric ready to minimize future retrofit costs when gas appliances are replaced with electric appliances. Dedicated space for a future HPWH, and wiring is required to be run to the designated location. Space must also be reserved at the electric panel to serve a future heat pump water heater, and a condensate drain must be installed

These requirements are for newly constructed buildings and additions (if a water heater is installed in the added floor area), and they are not applicable to alterations. Moreover, these requirements are not applicable when installing an electric water heater.

- A dedicated 125-volt (V) electrical receptacle that is within 3 feet of the water heater and accessible to the water heater with no obstructions, and be connected to a three conductor, branch circuit rated at 30 amps minimum. In addition, the unused conductor must be labeled and electrically isolated and have a reserved circuit breaker space.

- A condensate drain that is no more than 2 inches higher than the base of the installed water heater and allows natural draining without pump assistance

These requirements make it easier for someone to retrofit HPWH in the future. Wiring during initial construction stage is much less costly than trying to retrofit it later.

Electrical Receptacle

The goal of this requirement is to allow easy installation of HPWH when the existing gas water heater needs to be replaced. HPWH typically requires a 240-volt circuit, and this requirement allows an electrician to easily convert the 120-volt circuit to a 240-volt circuit.

The electrical receptacle must be installed with 3 feet from the water heater. It should be connected to a dedicated circuit with a branch circuit rated at 30 amps minimum. The ends of the unused conductor must be labeled as "spare" and be electrically isolated. A reserved single-pole circuit breaker space must be placed in the electrical panel next to the circuit breaker for the branch circuit and labeled with the words "Future 240V Use."

Condensate Drain

Please refer to Chapter 5.3.5.2 of the *2022 Single-family Residential Compliance Manual*.

Mandatory Requirements for Hot Water Distribution Systems

Pipe Insulation for All Buildings

Please refer to Chapter 5.3.6.1 of the *2022 Single-family Residential Compliance Manual*.

Insulation Protection

Please refer to Chapter 5.3.6.2 of the *2022 Single-family Residential Compliance Manual*.

Prescriptive Requirements for Water Heating

Single Dwelling Units

Reference: Section 150.1(c)8

There are three options to comply with the prescriptive water heating requirements for newly constructed single dwelling units. For all three options, the water heater must comply with the mandatory requirements for water heaters. (See Mandatory Requirements for Water Heating.) If a recirculation distribution system is installed, only demand recirculation systems with manual control pumps are allowed. The three options are described below.

- Install a single 240-volt heat pump water heater. The storage tank shall be located in the garage or conditioned space. In addition, the building must comply with the following:
    - A compact hot water distribution design meeting the Basic Compact Design in climate zones 1 and 16.
    - A, ECC-verified drain water heat recovery system in climate zone 16.

- Install a single 240 volt heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher.[1] For climate zone 16, the storage tank must be located in the garage or conditioned space and install a drain water heat recovery system that meets field verification described in Appendix RA3.6.9.
- A solar water-heating system with electric backup that meets the installation criteria specified in Reference Residential Appendix RA4.4.20 and with a minimum annual solar savings fraction of 0.7.

In climate zones 1 and 16, then one or more additional building features must be installed as shown above. These features require consideration at the start of the design process and must be coordinated with several players including the designer, general contractor, sub-contractor, and ECC Rater.

For more information on ECC-verified compact hot water distribution design, see Compact Hot Water Distribution System – Basic Credit and ECC-Verified Compact Hot Water Distribution System – Expanded Credit. ECC-verified compact hot water distribution designs are included in Option 1 described above.

For more information on ECC-verified drain water heat recovery system requirements, see Drain Water Heat Recovery System of this chapter. The Reference Appendix contains the requirements for the proper installation of the system (see RA4.4.21). An ECC-verified drain water heat recovery system is included in Options 1 and 2 described above.

Unless one of the three exceptions can be claimed, any other water heating system that differs from the three options described above does not meet the prescriptive requirements but can be installed using the performance approach as described in Performance Approach Compliance for Water Heating. The three Exceptions are:

- An electric water heater with point-of-use distribution (RA4.4.5) is allowed in new dwelling units of up to 500 ft2 conditioned floor area
- For new dwelling units with 1 or fewer bedrooms, a 120V HPWH may be used instead of a 240V HPWH.

For additions, the prescriptive requirements apply only if a water heater is being installed as part of the addition. In those cases, the prescriptive requirements would apply only to the space that is added, not the entire building.

For alterations where an existing water heater is being replaced, the water heater must meet the mandatory equipment efficiency requirements. Pipe insulation requirements do not apply to inaccessible piping. See Chapter 9 for a more detailed explanation for the water heating alteration requirements.

Example 5-11: Alterations

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[1] The list of qualified product list of NEEA HPWH may be found here: https://neea.org/img/documents/qualified-products-list.pdf

Question:

If my house has an electric-resistance water heater and I plan to upgrade my water heater, do I need to install a gas instantaneous or gas storage water heater?

Answer:

No, because the existing water heater is an electric water heater, then a consumer electric water heater that meets the requirements of California's Appliance Efficiency Regulations or appropriate federal requirements can replace the existing water heater. If installing new piping to the water heater, then you will need to comply with the mandatory pipe insulation requirements for newly installed piping and any accessible existing piping. See Pipe Insulation for All Buildings for more information on pipe insulation requirement and Chapter 9 for more information on alterations.

Example 5-12: Additions

Question:

I am building an addition to my home that will be a self-contained apartment. Do I need to comply with the prescriptive water heater requirements?

Answer:

If the addition will include a water heater, or if it will be connected to the existing hot water distribution system to supply hot water to the apartment, then you must comply with the standards either through the prescriptive or performance path. If taking the performance approach, you can install any type of water heater as long as it 1) meets the requirements of California's Appliance Efficiency Regulations and 2) does not exceed the water heating energy budget for the self-contained building. If you were adding only an additional room with hot water and not a self-contained dwelling, then the water heating budget would be based on the existing building plus addition. (See Performance Approach Compliance for Water Heating.)

Example 5-13: Heat Pump Water Heaters

Question:

For a new home, can I install an electric heat pump water heater? Do I have to perform calculations to show compliance?

Answer:

Yes, electric heat pump water heaters (HPWHs) can be used for both prescriptive and performance compliance. Calculation is not necessary using the prescriptive compliance path. There are 2 prescriptive options for HPWH. Option 2 is the simplest option, which requires the installation of a NEEA Tier 3 or higher HPWH in the garage or conditioned space. For climate zones 2 – 15, no additional requirement is needed for compliance. For climate zones 1 and 16, compact hot water distribution and/or a drain water heat recovery system are also required, depending on the climate zone. For more details, see Single Dwelling Units above.

For performance compliance, the characteristic of the HPWH must be modeled, such as rated UEF or make and model of the HPWH if it is NEEA rated.

Example 5-14: Drain Water Heat Recovery

Question:

I'm in the schematic design phase for a single-family home. I intend to include drain water heat recovery in my design and to follow the prescriptive path. What are the primary design issues I should consider?

Answer:

If you follow the prescriptive path, drain water heat recovery is required in climate zones 1 and 16.

For all other water heater types, you could follow the performance path and obtain compliance credit within an energy model calculation. In any case, the initial design issues are related to the selection of an appropriate drain water heat recovery model (i.e. horizontal or vertical type, minimum rated effectiveness, and diameter and length), and designing the layout of the system.

If your residence is single story, then a horizontally rated unit is required. If your residence has multiple stories, then the unit can be horizontally or vertically rated. In any case, the required minimum rated effectiveness is 42 percent.

The diameter of the unit should match the diameter of the drainpipe. Added length improves effectiveness but requires more space.

In terms of the system layout, the unit must recover heat from at least the master bathroom shower and must at least transfer that heat back, either to all the respective showers or the water heater. To maximize savings, place the unit in a drain line that serves all the showers and pipe the preheated water to the cold side of all shower mixing valves and the make-up water inlet of the water heater. This is known as an equal flow configuration (see Figure 5-2: The Three Plumbing Configurations of DWHR Installation (From Left to Right: Equal Flow, Unequal Flow – Water Heater, Unequal Flow Fixture)), since the preheated water flow rate will match the drain water flow rate.

Demand Recirculation Control

Please refer to Chapter 5.4.1.1 of the *2022 Single-family Residential Compliance Manual*.

Performance Approach Compliance for Water Heating

Energy Budget Calculation

The performance method allows for modeling alternative water heater and distribution system combinations, which would impact the amount of compliance credits received for the system the performance of a heat pump water heater in most climate zones. In addition to a heat pump water heater, a compact hot water distribution system is required in climate zone 1 and 16 and a drain water heat recovery device also is required in climate zone 16. The water heating energy budget in climate zones 3, 4, 13, or 14, is based on the performance of a gas instantaneous water heater. Both gas and electric water heaters used in the standard design meet the minimum requirements in California's *Title 20 Appliance Efficiency Regulations* Section 1605.1(f) for federally regulated appliances

The computer performance approach allows for the modeling of water heating system performance by taking into account building characteristics, climate, system type, efficiency, and fuel type. The standard design water heating budget is defined by the corresponding prescriptive requirements. The performance method allows for modeling alternative water heater and distribution system combinations. Some of these options will offer compliance credits, and others will result in penalties.

Systems Serving a Single Dwelling Unit

In the case of single 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 with a standard distribution system for gas water heaters, or a HPWH with compact distribution system and drain water heat recovery for electric water heaters. Adding multiple water heaters to a single-family design will generally result in an adjustment to the compliance credits in the water heating budget that must be offset elsewhere in the total energy budget.

A standard distribution system serving a single dwelling unit does not incorporate a pump for hot water recirculation and does not take credit for any additional DHW design features. All mandatory pipe insulation requirements must be met, such as insulating all hot water pipes. Alternative distribution systems are compared to the standard design case by using distribution system multipliers (DSMs), which effectively rate alternative options.

Table 5-4: Applicability of Distribution Systems Options Within a Dwelling Unit 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 represent an energy credit, while distribution systems with a multiplier greater than 1 will affect the energy usage simulated in the compliance software. For example, pipe Insulation with ECC Inspection Required (PIC-H) has a multiplier of 0.8. That means that it is modeled at 20 percent less distribution loss than the standard distribution system. For more information or installation requirements on any of the systems, refer to Distribution Systems.

Table 5-4: Applicability of Distribution Systems Options Within a Dwelling Unit

Distribution System Types	Assigned Distribution System Multiplier	Systems Serving a Single Dwelling Unit
No ECC-Verification Required Trunk and Branch -Standard (STD)	1.0	Yes
No ECC-Verification Required Compact Design – Basic (CHWDS)	0.7	Yes
No ECC-Verification Required Parallel Piping (PP)	1.1	Yes
No ECC-Verification Required Point of Use (POU)	0.3	Yes

Distribution System Types	Assigned Distribution System Multiplier	Systems Serving a Single Dwelling Unit
No ECC-Verification Required Recirculation: Non-Demand Control Options (R-ND)	9.8	Yes
No ECC-Verification Required Recirculation with Manual Demand Control (R-Dman)	1.75	Yes
No ECC-Verification Required Recirculation with Motion Sensor Demand Control (R-DAuto)	2.6	Yes
ECC-Verification Required Pipe Insulation (PIC-H)	0.85	Yes
ICC Verification Required Parallel Piping with 5' maximum length (PP-H)	1	Yes
ICC Verification Required Compact Design - Expanded (CHWDS-H)	0.3 – 0.7[2]	Yes
ICC Verification Required Recirculation with Manual Demand Control (R-Drmc-H)	1.6	Yes
ICC Verification Required Recirculation with Motion Sensor Demand Control (RDRsc-H)	2.4	Yes

Source: California Energy Commission

Treatment of Water Heater Efficiency

Please refer to Chapter 5.5.3 of the *2022 Single-family Residential Compliance Manual*.

Compliance Issues

Please refer to Chapter 5.5.4 of the *2022 Single-family Residential Compliance Manual*.

Distribution Systems

Types of Water Heating Distribution Systems

Please refer to Chapter 5.6.1 of the *2022 Single-family Residential Compliance Manual*.

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[2] The multiplier for the Compact Design – Expanded credit varies depending on the home's floorplan and water heater location. See Section 5.6.2.4 for more information.

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. For systems designed for single-family buildings, the system will resemble one of the system types described below under dwelling unit distribution systems. The installation of a hot water distribution system that does not meet all the installation guidelines discussed in this compliance manual and in the Reference Appendix RA3 and RA4 must either (a) have the deficiencies corrected, or (b) use the performance approach and compensate for the adjustments to the compliance credits. In all cases, the locations of the water heaters and fixtures should be given consideration at the beginning of building design. By minimizing the length of distribution piping, energy use, water waste, wait time for hot water and construction cost can all be reduced.

Systems Serving a Single Dwelling Unit

Standard Distribution System (Trunk-and-Branch and Mini-manifold Configurations)

Please refer to Chapter 5.6.2.1 of the *2022 Single-family Residential Compliance Manual*.

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 feet between the water heater and the manifold. With the advent of mini-manifolds, the central parallel piping system can now accommodate multiple mini-manifolds in lieu of the single central manifold, provided that a) the sum of the piping length from the water heater to all the mini- manifolds is less than 15 feet and b) all piping downstream of the mini-manifolds is nominally ½ inch or smaller.

Installation Criteria and Guidelines

All applicable mandatory measures must be met. Piping between the water heater and the manifold must be insulated, and all branch piping past the framing member from the manifold must be insulated. Piping from the manifold cannot run up to the attic and then down to points of use on the first floor. The intent of a good parallel piping design is to minimize the volume of water entrained in piping between the water heater and the end-use points, with a focus on reducing the length of the 3/4-inch or 1-inch line from the water heater to the manifold(s). To encourage reducing the pipe length between the water heater and manifold, there is a distribution system compliance credit for installations that are ECC-verified to have no more than 5 feet of piping between the water heater and the manifold(s). The manifold feeds hot water use points with 3/8 or 1/2 inch PEX tubing. (Check with enforcement agencies on the use of 3/8-inch piping in the event that it is prohibited without engineering approval.) The adopted requirements for installation guidelines are included in RA3 and RA4.

Point of Use

Please refer to Chapter 5.6.2.3 of the *2022 Single-family Residential Compliance Manual*.

Compact Hot Water Distribution System – Basic Credit and ECC-Verified Compact Hot Water Distribution System – Expanded Credit

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 is typical in standard homes. Through this process, energy and water will be saved, and homeowners will experience reduced hot water waiting times. This compliance option is applicable only to new single-family home.

Installed hot water distribution systems are often much larger than needed in terms of excessive pipe length and oversized pipe diameter. A design consideration that often is overlooked is the location of the water heater relative to hot water use points. Figure 5-6: "Common" Production Home House Layout below shows a common production home layout with the water heater in the corner of the garage and hot water use points in each corner of the house.

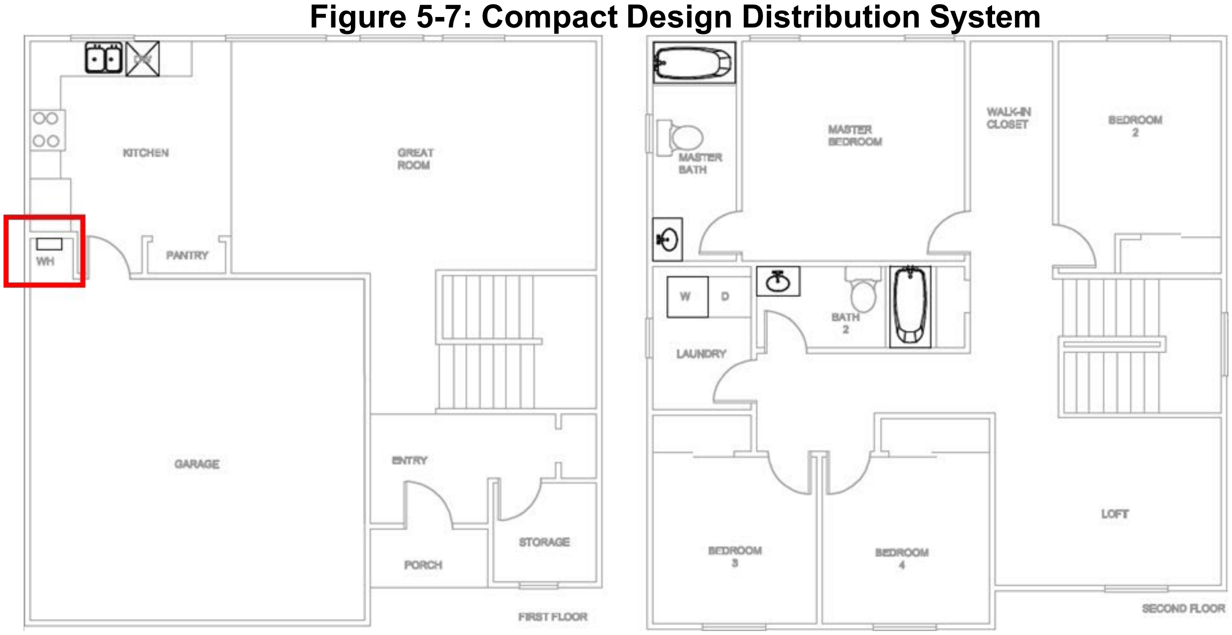
A more effective hot water distribution system design is shown in Figure 5-7: Compact Design Distribution System. In the figure, the location of the water heater is near the kitchen, bathrooms and laundry area. The location of hot water use points plays an integral role in achieving the benefits associated with a compact distribution system design.

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 ECC-Verification, while Expanded Credit requires field verification by an ECC-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. 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), then 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 ECC-verification requirements that must be met.

Figure 5-6: "Common" Production Home House Layout

Source: 2019 CASE Initiative: Compact Hot Water Distribution

Figure 5-7: Compact Design Distribution System



Source: 2019 CASE Initiative: Compact Hot Water Distribution

Weighted Distance Calculation Method

Please refer to Chapter 5.6.2.4.1 of the *2022 Single-family Residential Compliance Manual*.

Qualification Distance Method

The Qualification Distance is a function of conditioned floor area (CFA), number of stories, and number of installed water heaters. The Qualification Distance for systems with multiple water heaters is identified by using the equation for the appropriate distribution system (recirculation or non-recirculation), and dividing by the number of water heaters installed as shown in the Equation below:

Qualification Distance = (a + b * CFA) / n

Where:

a, b = Qualification distance coefficients (unitless), see RA 4.6 Table 4.4.6-2,

CFA = Conditioned floor area of the dwelling unit (ft^2), and

n = Number of water heaters in the dwelling unit (unitless)

Drain Water Heat Recovery System

A drain water heat recovery system recovers heat that would otherwise be lost down the drain during showers, and transfers that heat back to the water heater, shower mixing valve, or both. These systems can help users comply with the water heating requirements in the Energy Codes using either the prescriptive or performance approach. To use these systems to comply with Energy Codes, the design and installation must be ECC-verified and meet the Reference Appendix RA4.4.21 requirements.

Recirculation System – Non-Demand Control Options

Please refer to Chapter 5.6.2.6 of the *2022 Single-family Residential Compliance Manual*.

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). Push button control is preferred from a performance perspective, since it eliminates "false signals" for pump operation that an occupancy sensor could generate. The adopted requirements for installation guidelines are included in Reference Appendices RA3 and RA4.

Installation Criteria

All criteria listed for continuous recirculation systems apply. Piping in a recirculation system cannot be run up to the attic and then down to points of use on the first floor.

Pump start-up must be provided by a push button or occupancy sensor. Pump shutoff must be provided by a temperature sensing device that shuts off the pump when the temperature sensor detects no more than 10 degree rise above the initial temperature of water in the pipe or when the temperature reaches 102 degrees F. Moreover, the controls shall limit the maximum pump run time to five minutes or less.

Push buttons and sensors must be installed in all locations at least 20 feet from the water heater (measured along the hot water piping) with a sink, shower, or tub, with the exception of the laundry room.

Plans must include a wiring/circuit diagram for the pump and timer/temperature- sensing device and specify whether the control system is manual (push button or flow switch) or other control means, such as an occupancy sensor.

Combined Hydronic Systems

Please refer to Chapter 5.7 of the *2022 Single-family Residential Compliance Manual*.

Solar Water Heating

Please refer to Chapter 5.9 of the *2022 Single-family Residential Compliance Manual*.

Solar Or Recovered Energy in State Buildings

Section 110.3(c)5

Please refer to Chapter 5.9.1 of the *2022 Single-family Residential Compliance Manual*.

Solar-Ready Buildings Requirements

Reference: Section 150.0(r) and Section 110.10

Please refer to Chapter 5.9.1.1 of the *2022 Single-family Residential Compliance Manual*.

Swimming Pool and Spa Heating

Swimming Pool and Spa Types

Please refer to Chapter 5.10.1 of the *2022 Single-family Residential Compliance Manual*.

Mandatory Requirements for Pools and Spas

Reference: Section 110.4, Section 110.5

Before any pool or spa heating system or equipment may be installed, the manufacturer must certify to the Energy Commission that the system or equipment complies with Section 110.4 and Section 110.5. The requirements include minimum heating efficiency according to the *Appliance Efficiency Regulations*, an on-off switch outside the heater, permanent and weatherproof operating instructions, no continuous pilot light and minimum pool heating system sizing requirements.

Pool and spa heaters may not have continuously burning pilot lights.

Certification Requirements

A pool heater for a pool, spa, or pool and spa combination shall only be installed if the manufacturer has certified that it meets the following requirements:

- Efficiency: The equipment must meet state or federal appliance efficiency standards as specified in Section 110.1.
- On-Off Switch: The heater must have an easily accessible on-off switch on the outside, allowing the heater to be turned off without changing the thermostat setting.

Rating and instructions: The heater must have a permanent, readable, and weatherproof plate or card that shows the energy efficiency rating and provides instructions for efficient operation.

Installation Requirements

Reference: Section 110.4 (b)

Heating equipment installed to heat pool and/or spa water shall be selected from equipment meeting the standards shown in Table 5-5: Heating Equipment Standards.

Table 5-5: Heating Equipment Standards

Heating Energy Source	Standard
Electric Resistance	UL 1261
Gas-fired	ANSI Z21.56/CSA 4.7a
Heat Pump	AHRI 1160 and one of the following: CSA C22.2 No. 236, UL 1995, or UL/CSA 60335-2-40
Solar	ICC/APSP 902/SRCC 400 for solar pool heaters, ICC 901/SRCC 100 for solar collectors

Source: California Energy Commission

If a pool and/or spa does not currently use solar heating collectors, piping shall be installed to accommodate future installation. Contractors can choose one of three options:

- Leave at least 18 inches of vertical or horizontal pipe between the filter and heater.
- Plumb separate suction and return lines dedicated to future solar heating.
- Install built-up or built-in connections for future piping to solar heating (e.g., a capped-off tee fitting between the filter and heater).

Outdoor pools and/or spas with gas or electric heaters shall have a cover installed. The cover should be fitted and installed during the final inspection. All pool systems shall be installed with the following:

- Directional inlets to adequately mix the pool water.
- A permanent time switch or similar permanent control mechanism to control the circulation system, allowing the pump to run during off-peak periods and for the minimum time necessary to maintain water quality as required by public health standards.

Pool and/or spa heating systems or equipment for single family buildings must meet one of the following sizing requirements:

- A solar pool heating system with a solar collector surface area that is equivalent to at least 60 percent of the pool and/or spa surface area.
- A heat pump pool heater as the primary heating system that meets the HPPH manufacturer's sizing specifications, as specified in Reference Joint Appendix JA16.3. The supplementary heater can be of any energy source. If the HPPH manufacturer's specifications do not include information on HPPH sizing, follow the steps found in JA16.3
- A heating system that derives at least 60 percent of the annual heating energy from on-site renewable energy or on-site recovered energy.

- A combination of a solar pool heating system and heat pump pool heater without any additional supplementary heater; or
- A pool heating system determined by the Executive Director to use no more energy that the systems specified in items above.

There are five allowable exceptions to the heating source sizing requirements as listed below:

- Portable electric spas compliant with California's Appliance Efficiency Regulations (Title 20).
- Alterations to existing pools and/or spas with existing heating systems or equipment.
- A pool and/or spa that is heated solely by a solar pool heating system without any backup heater.
- Heating systems which are used exclusively for permanent spa applications in existing buildings with gas availability.
- Heating systems which are used exclusively for permanent spa applications where there is inadequate Solar Access Roof Area (SARA) as specified in Section 150.1(c)14 for a solar pool heating system to be installed.

Example 5-15

Question:

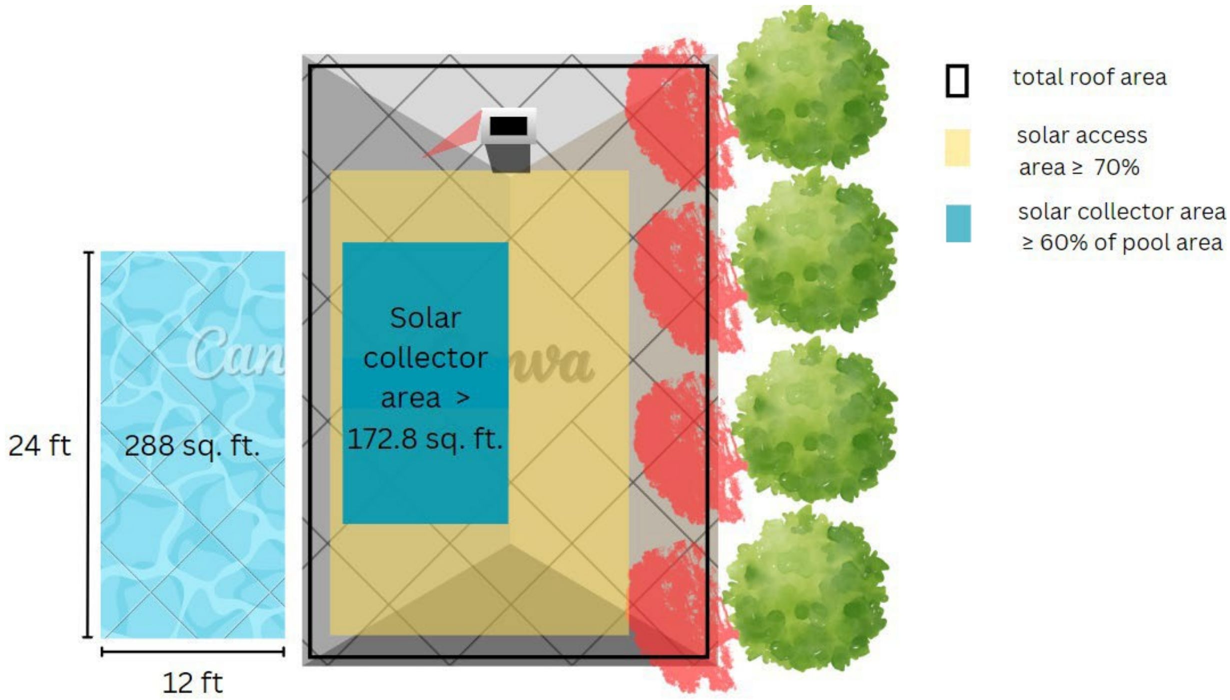
I am designing a residential swimming pool with a surface area of 288 square feet for a single family home. If I want to use a gas heater as a backup to solar, what would be the sizing requirements of my solar pool heating system?

Answer:

If you plan to use a gas heater as a backup, the solar pool heating system must have a solar collector surface area that is at least 60% of the pool's surface area. For a pool with a surface area of 288 square feet, the calculation is as follows: $288 \text{ ft}^2 \times 0.60 = 172.8 \text{ ft}^2$

You need to install a solar pool heating system with a collector surface area of at least 172.8 square feet.

Figure 5-8: Example Home for Solar Pool Heating



Source:

Additionally, you will need to determine the SARA for your building to ensure you have sufficient space for the solar collectors. This includes:

- Assessing Planned Obstructions: Identify any trees, structures, or other potential obstructions that could shade the solar collectors and reduce their efficiency. This assessment should cover the current situation as well as future landscaping plans. For steep slope roofs, only shading from permanent obstructions outside the dwelling (such as trees, hills, and adjacent structures) is considered. For low slope roofs, all obstructions, including those part of the building design, are considered.
- Determining Annual Solar Roof Access: Calculate the annual solar access for the roof area where the solar collectors will be installed. This involves considering shading patterns throughout the year to ensure that the collectors receive adequate sunlight.

If the roof area has less than 70% annual solar access due to shading or other obstructions, it may not be suitable for a solar pool heating system as per the regulations.

Example 5-15

Question:

I am installing a portable electric spa, the type that is factory built and delivered on a truck. Do I need to comply with the heating source sizing requirements outlined in Title 24?

Answer:

Your portable electric spa is excepted from the T24 pool heating sizing requirements. The portable electric spa must meet the minimum efficiency and cover requirements in Title 20 (20 CCR Section 1605.3(g)(7)).

Pool Pump Requirements

Reference: Section 150.0(p)1

For maximum energy efficiency, pool filtration should be operated at the lowest possible flow rate for a period that provides sufficient water turnover for clarity and sanitation. Auxiliary pool loads that require high flow rates, such as spas, pool cleaners, and water features, should be operated separately from the filtration to allow the filtration flow rate to be kept to a minimum.

All dedicated-purpose pool pumps and replacement motors must be listed in the Energy Commission's directory of certified equipment.

Dedicated-purpose pool pumps must comply with the standards in 20 CCR Section 1605.1(g)(7) of the Appliance Efficiency Regulations.

Replacement dedicated-purpose pool pump motors must comply with the standards in 20 CCR Section 1605.3 of the Appliance Efficiency Regulations.

The pool filtration flow rate may not be greater than the rate needed to turn over the pool water volume in 6 hours or 36 gallon per minute (gpm), whichever is greater. This means that for pools of less than 13,000 gallons, the pump must be sized to have a flow rate of less than 36 gpm, and for pools of greater than 13,000 gallons, the pump must be sized using the following equation:

$$MMMMMM\ FFFFFFFF\ RRMMRRRR\ (gggggg) = \frac{PPFFFFFF\ VVFFFFVVggRR\ (ggMMFFFFFFgggg)}{360\ ggmmggVVRRRRgg}$$

These are maximum flow rates. Lower flow rates and longer filtration times are encouraged and will result in added energy savings. All pool pumps sold in California must be tested and listed with the CEC according to the *Appliance Efficiency Regulations*. The pool pump must be chosen such that the flow rate calculated by the system curve is less than the 6-hour turnover rate. The following equation is used to calculate the system curve. The coefficient included in the equation is dependent on the capacity of the pool.

$$HH = CC \times FF^2$$

Where,

- H = The total system head in feet of water
- F = The flow rate in gallons per minute (gpm)
- C =0.0167 for pools less than or equal to 17,000 gallons, or 0.0082 for pools greater than 17,000 gallons

Pool Pump Controls

Pool controls are a critical element of energy efficient pool design. Modern pool controls allow for auxiliary loads such as cleaning systems, solar heating, and temporary water features without compromising energy savings.

Pool Pipe, Filter, and Valve Requirements

Please refer to Chapter 5.10.2.3 of the *2022 Single-family Residential Compliance Manual*.

Compliance and Enforcement

Please refer to Chapter 5.11 of the *2022 Single-family Residential Compliance Manual*.

Design Review

Please refer to Chapter 5.11.1 of the *2022 Single-family Residential Compliance Manual*.

Field Inspection

Please refer to Chapter 5.11.2 of the *2022 Single-family Residential Compliance Manual*.

ECC Field Verification and/or Diagnostic Testing

Single Family

ECC-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. For all of the cases where ECC-verification is required, the ECC-Rater must verify that the eligibility requirements in RA3.6 for the specific system are met.

In addition, ECC-verified drain water heat recovery is an option for prescriptive compliance and as a compliance credit for the performance approach.

Glossary/Reference

General Glossary/Reference for Water Heating

Please refer to Chapter 5.12.1 of the *2022 Single-family Residential Compliance Manual2022 Single-family Residential Compliance Manual*.

General Glossary/Reference for Swimming Pool and Spa

Relevant terms are defined in Reference Joint Appendix JA1. The following are terms that are either not defined in JA1 or expansions to the Appendix I definitions.

- Flow rate is the volume of water flowing through the filtration system in a given time, usually measured in gallons per minute.
- Nameplate power is the motor horsepower (hp) listed on the nameplate and the horsepower by which a pump is typically sold.
- Pool pumps usually come with a leaf strainer before the impeller. The pumps contain an impeller to accelerate the water through the housing. The motors for residential pumps are included in the pump purchase but can be replaced separately. The pumps increase the "head" and "flow" of the water. Head is necessary to move fluid through pipes, drains, and inlets, push water through filters and heaters, and project it through fountains and jets. Flow is the movement of the water used to maintain efficient filtering, heating, and sanitation for the pool.
- Return refers to the water in the filtration system returning to the pool. The return lines or return side, relative to the pump, can also be defined as the pressure lines or the pressure side of the pump. Water in the returns is delivered back to the pool at the pool inlets.
- Service factor indicates the percentage above nameplate horsepower at which a pump motor may operate continuously when full-rated voltage is applied and ambient

temperature does not exceed the motor rating. Full-rated pool motor service factors can be as high as 1.65. A 1.5 hp pump with a 1.65 service factor produces 2.475 hp (total hp) at the maximum service factor point.

- Suction created by the pump is how the pool water gets from the skimmers and drains to the filtration system. The suction side and suction lines refer to the vacuum side of the pump. It is at negative atmospheric pressure relative to the pool surface.
- Total dynamic head (TDH) refers to the sum of all the friction losses and pressure drops in the filtration system from the pools drains and skimmers to the returns. It is a measure of the system's total pressure drop and is given in units of either psi or feet of water column (sometimes referred to as "feet" or "feet of head").
- Total motor power or T-hp refers to the product of the nameplate power and the service factor of a motor used on a pool pump.
- Turnover is the act of filtering one volume of the pool.
- Turnover time (also called turnover rate) is the time required to circulate the entire volume of water in the pool or spa through the filter. For example, a turnover time of 6 hours means an entire volume of water equal to that of the pool will be passed through a filter system in six hours.

$$TTVVTTggFFTTRRTT\ TTmmggRR = \frac{VVFFFFVVggRR\ FFoo\ RRhRR\ ggFFFFFF}{FFFFFFFF\ RRMMRRRR}$$

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Residential Lighting

Overview

Please refer to Chapter 6.1 of the *2022 Single-family Residential Compliance Manual*.

Scope

Please refer to Chapter 6.1.2 of the *2022 Single-family Residential Compliance Manual*.

Related Resources

The California Energy Commission and others prepare educational resources with information about residential lighting. The Energy Commission's online resources can be found at the Energy Code Support Center at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/energy-code-support-center.

Luminaire Requirements

A luminaire, also known as a light fixture, is defined by §100.1 as a complete lighting unit consisting of a light source, such as a lamp or lamps, and the parts that distribute the light, position and protect the light source, and connect it to the power supply.

A lamp is a light bulb or similar separable lighting component. It is defined by §100.1 as an electrical appliance that produces optical radiation for visual illumination, with a base to provide an electrical connection between the lamp and a luminaire, and to be installed into a luminaire. The definition clarifies that a lamp is not a luminaire and is not an LED retrofit kit designed to replace components of a luminaire.

The 2025 Energy Code for residential lighting requires all installed luminaires and light sources to comply with the requirements of Reference Joint Appendix JA8 (aka JA8).

The installed luminaires are permanently installed lighting as defined in §100.1 as luminaires that are affixed to land. Examples of permanently installed lighting include:

- 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.

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, refrigerated cases, vending machines, food preparation equipment, and scientific and industrial equipment.

The following are not required to be certified and marked as required by JA8 (Section 150.0(k):

- Lighting integral to exhaust fans, kitchen range hoods, bath vanity mirrors, and garage door openers. Ceiling fan light kits that are subject to DOE's Appliance and Equipment Standards Program.
- Navigation lighting rated less than 5 watts, such as night lights, step lights, and path lights.
- Lighting with an efficacy of 45 lumens per watt or greater and located inside drawers, cabinetry, and linen closets.
- LED light sources that are installed outdoors.
- Inseparable solid-state lighting (SSL) luminaires containing colored light sources for decorative lighting purpose.
- 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.

There are luminaires that must use JA8-certified light sources or lamps (See Residential Luminaires – Reference Joint Appendix JA8 Certified Light Sources), recessed downlight luminaires in ceilings (See Recessed Downlight Luminaires in Ceilings), and luminaires that are not required to be certified for meeting JA8.

Residential Luminaires – Reference Joint Appendix JA8 Certified Light Sources

Luminaires not listed in Luminaire Requirements must have an integral light source or removable lamp that meets the performance requirements of JA8. The requirements in JA8 ensure that new lighting technologies, like LEDs, provide energy-efficient light, while also maintaining performance characteristics that customers expect. In addition to setting minimum efficacy requirements, 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. Changeable lamps, such as those in screw-base luminaires, must also be certified to the Energy Commission.

Luminaires and lamps certified to the Energy Commission must be labeled with JA8-2025 or JA8-2025-E on the product. The JA8-2025-E marking indicates that the lamp product or the LED light engine product has been certified for passing the federal test at elevated temperature. This test ensures that the light source is appropriate for elevated temperature applications such as installation in enclosed or recessed luminaires.

Luminaires that can be classified as high luminous efficacy by meeting the requirements of JA8 include:

- LED luminaires with integral light sources that are JA8-certified.
- Ceiling recessed downlight luminaires with JA8-certified light sources (the luminaire must not contain screw-based lamp sockets).
- Low-voltage pin-based luminaires with JA8-certified lamps.

Almost any luminaire can be classified as high luminous efficacy if it 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 at https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx or an advanced search at https://cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx.

Recessed Downlight Luminaires in Ceilings

In addition to the luminaire efficacy requirements, there are several additional requirements for residential downlight luminaires that are mounted in ceilings.

Figure 6-1: Recessed Downlight Luminaires in Ceiling

Source: Image Courtesy of Lutron Electronics Co., Inc.

Recessed downlight luminaires are limited to specific light sources and lamp types. Recessed downlight luminaires must not contain screw-based lamps and the light source must be marked with "JA8-2025-E" showing meeting the elevated temperature requirement.

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 also meet all the following performance requirements:

- Have a label that certifies the luminaire is airtight with air leakage less than 2.0 cubic feet per minute (cfm) at 75 Pascals when tested in accordance with ASTM E283 (exhaust fan housings with integral light are not required to be certified airtight); and
- 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; and
- Meet the clearance and installation requirements of California Electrical Code Article 410.116 for recessed luminaires which requires the following:

- A recessed luminaire that is not identified for contact with insulation, non-Type IC, shall have all recessed parts spaced not less than 1/2 inch from combustible materials. The points of support and the trim finishing off the openings in the ceiling shall be permitted to be in contact with combustible materials.
- A recessed luminaire that is identified for contact with insulation, Type IC, shall 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 shall not be installed above a recessed luminaire or within 3 inches of the recessed luminaire'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.

Installers 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, they must meet all other requirements for recessed luminaires.

Figure 6-2: Recessed Luminaire with an IC Housing (left); Recessed Luminaire with Non-IC Housing (right)

Source: Image Courtesy of Lutron Electronics Co., Inc.

Enclosed Luminaires and Recessed Luminaires Other than Ceiling Recessed Downlight Luminaires

Lamps and other separable light sources in enclosed luminaires and recessed luminaires (other than ceiling-recessed downlights) must be in compliance with the federal time-to-failure test requirement specified in Joint Appendix JA8.5 and as mentioned in Chapter 7. The JA8-compliant lamps and light sources must be marked with “JA8-2025-E” to signify that they are suitable to be installed in an enclosed or recessed luminaire.

Navigation Lighting – Night Lights, Step Lights and Path Lights

Navigation lighting such as night lights, step lights, and path lights must either:

- Be rated to consume no more than 4 watts; or
- Comply with luminaire efficacy requirements in §150.0(k)1A.

Lighting in Drawers, Cabinets, and Linen Closets

Luminaires or light sources internal to drawers, cabinets, and linen closets must either:

- Have an efficacy of 45 lumens per watt or greater or
- Comply with luminaire efficacy requirements in §150.0(k)1A.

Example 6-1: 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 residential lighting requirement for screw-based luminaires?

Answer

If the LED lamp is JA8-certified and marked JA8-2025 or JA8-2025-E, then it meets the residential lighting requirement for screw-based luminaires in Energy Code §150.0(k)1B.

If the luminaire is a recessed luminaire in a ceiling, it would not comply since recessed luminaires cannot contain a screw base socket.

Example 6-2: Color-tunable and dim-to-warm luminaires installed in residential buildings

Question

Can color-tunable luminaires and dim-to-warm luminaires be certified to meet JA8 specifications?

Answer

JA8 includes color characteristic specifications for light sources.

The JA8 specifications require all light sources to be capable of providing color temperature (correlated color temperature, CCT) of 4000 Kelvin (K) or less.

JA8 also require light sources to provide color rendering index (CRI) of 90 or higher and R9 of 50 or higher. LED lamps regulated by the Title 20 Appliance Efficiency Regulations must have a CRI of 82 or higher.

If the color-tunable luminaire or dim-to-warm luminaire can provide a CCT of 4000k or less and provide CRI that meets these requirements, it meets the color characteristic criteria.

If all requirements of JA8 are met, including the color characteristic requirements, these light sources can be certified to meet JA8.

Example 6-3: Fade-in lighting

Question

I would like to use lighting with an aesthetic fade-in feature in my design. JA8 has a start time requirement. Are fade-in lights able to qualify as high efficacy?

Answer

Aesthetic fade-in lights are acceptable under Title 24. The test procedure for start time measures "[t]he time between the application of power to the device and the point where the light output reaches 98% of the lamp's initial plateau." The "initial plateau" is "[t]he point at which the average increase in the light output over time levels out(reduces in slope)."

For light sources with a fade-in feature, the light output intentionally follows a programmed fade-in curve to increase light output gradually. Because the light output must level out, the initial plateau for these light sources is the point in time at which there is perceived light output and the perceived light increase begins to follow the programmed fade-in curve. The programmed fade-in curve is expected to be continuously increasing as a function of time.

This allows fade-in lighting to qualify as high efficacy.

Example 6-4: 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 luminaire efficacy requirements for permanently installed lighting.

Example 6-5: Kitchen alterations

Question

I am designing a residential kitchen lighting system with six 12W LED recessed downlights and four 24W LED tape lights for under cabinet lighting. How many watts of incandescent or halogen luminaires can be installed?

Answer

There are no wattage limitations for residential lighting. However, all luminaires must meet the luminaire efficacy requirements in §150.0(k)1A of the Energy Code. Incandescent and halogen light sources may not be able to meet the requirements of JA8, thus may not be able to be installed for Energy Code compliance.

Example 6-6: Night lights

Question

Where are night lights permitted to be installed in residential buildings?

Answer

There are no location restrictions in the Energy Code. Permanently installed night lights and night lights integral to installed luminaires can be installed anywhere in single family buildings, or other residential spaces.

Blank Electrical Boxes

Please refer to Chapter 6.2.8 of the *2022 Single-family Residential Compliance Manual*.

Indoor Lighting Control Requirements

Lighting controls are an important part of the Energy Code because they can produce energy savings for the owners and users of the spaces. Lighting Control Requirements in Accordance with Room and Luminaire Types

All lighting controls must comply with the mandatory requirements of §110.9. Following are general control requirements that apply for the room type and for the luminaire type.

Readily Accessible Manual Controls

A wall-mounted controls must be installed to manually turned on and off all permanently installed luminaires, and the wall-mounted controls must be "readily accessible”. “Readily accessible” – as defined in §100.1 - means capable of being reached quickly for operation, repair, or inspection without requiring climbing or removing obstacles, or resorting to access equipment.

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, where a dimmer or vacancy sensor has been installed to comply with §150.0(k), the following requirements must be met:

- No controls shall bypass the dimmer, occupancy sensor, or vacancy sensor function.
- The dimmer or vacancy sensor must comply with the applicable requirements of §110.9(b).

Controls Permitted – 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 §150.0(k)2 if it provides the functionality of the specified controls in accordance with §110.9, and the physical controls specified in §150.0(k)2A. No controls shall bypass control functions of a dimmer, occupant sensor, or vacancy sensor where the dimmer or sensor has been installed to comply with Section 150.0(k)2.

Exhaust Fan Integrated Lighting

Integrated lighting in an exhaust fan must be controlled independently from the fan to comply with Section 150.0(k)2G.

Lighting in Drawers and Cabinets

Undercabinet lighting, undershelf lighting, and interior lighting of display cabinets must be controlled independently from ceiling-installed lighting such that one can be turned on without turning on the other to comply with Section 150.0(k)2G.

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.

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.

Automatic-off Controls – Vacancy Sensors or Occupancy Sensors

The following residential spaces are required to have at least one installed luminaire in the space to be controlled by an occupancy or vacancy sensor providing automatic-off functionality:

- Bathrooms
- Garages
- Laundry Rooms
- Utility Rooms
- Walk-in Closets

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 to comply with Section 150.0(k)2F.

The following are not required for meeting the dimming controls requirements:

- Ceiling fans may provide control of integrated lighting via a remote control.
- Lighting integral to kitchen range hoods and bathroom exhaust fans.
- 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 with automatic off controls that is internal to drawers and cabinetry with opaque fronts or doors.

Note that when a forward phase-cut dimmers is installed to control LED light sources, the dimmer is required to be rated as NEMA SSL 7A. A NEMA SSL 7A-compliant dimmer ensures a flicker-free operation when the LED luminaire is dimmed. The dimmer/light source compatibility information is usually included on dimmer cut sheets or dimmer product packaging.

Example 6-7: 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 day. When less light is needed, the homeowner can reduce the light intensity with a dimmer to save energy.

Lighting Control Functionality

Please refer to Chapter 6.3.1 of the *2022 Single-family Residential Compliance Manual*.

Residential Outdoor Lighting Requirements

Outdoor lighting permanently mounted to a residential building or to other buildings on the same lot are subject to the outdoor lighting requirements. This includes lighting for patios, entrances, balconies, and porches.

Outdoor lighting not permanently attached to a building on a single-family site, such as decorative landscape lighting, is not regulated by the residential lighting requirements. LED lighting and controls such as a time clock or photocontrol will save energy and ensure that lighting is not accidentally left on during daylight hours.

Outdoor Luminaires

Outdoor LED luminaires and LED light sources installed outdoors are not required to comply with Joint Appendix JA8.

Outdoor Lighting Controls

Outdoor lighting must be controlled by a manual ON and OFF control switch and one of the following automatic controls in accordance with 150.0(k)3:

- A photocell and a motion sensor; or
- A photocell and an automatic time switch control; or
- An astronomical time clock control.

Any override that keeps the above automatic controls to "ON" must return to automatic control operations within six hours.

As alternative to the above mentioned controls (manual on and off control and the automatic controls), an EMCS can be used to control outdoor lighting, provided that the EMCS can provide the control functionalities - including the override - of the above mentioned controls.

Internally Illuminated Address Signs

Please refer to Chapter 6.4.3 of the *2022 Single-family Residential Compliance Manual*.

Example 6-8: Outdoor lighting: glare control

Question

Are there luminaire cutoff requirements for residential outdoor luminaires?

Answer

There are no luminaire cutoff requirements for residential outdoor lighting. Even though not required for most residential outdoor lighting, luminaires that limit uplight are usually more efficient at providing lighting in the required area, allowing a lower wattage luminaire to be used. Backlight, uplight, and glare requirements also reduce stray light and glare problems which can cause visual discomfort.

Example 6-9: Outdoor lighting: landscape lighting

Question

I would like to install low-voltage landscape lighting in my yard. Are these required to be controlled by a motion sensor and photocontrol?

Answer

No. The lighting requirements only apply to lighting that is attached to a building or structure. However, using photocontrols or astronomical time clock controls can save energy by ensuring that landscape lighting is not left on during daylight hours.

Residential Garages

Please refer to Chapter 6.5 of the *2022 Single-family Residential Compliance Manual*.

Additions and Alterations

Additions must meet the same requirements as newly constructed buildings. Because the residential lighting requirements are mandatory, lighting in residential additions must meet all applicable requirements of §150.0(k).

For residential alterations, any new or altered lighting systems must meet all applicable requirements of §150.0(k). Existing luminaires, controls, and lighting systems that are not altered may stay as is.

Where existing screw base sockets are present in ceiling-recessed luminaires, removal of these sockets is not required provided that new JA8 compliant trim kits or lamps designed for use with recessed downlights or luminaires are installed.

Compliance Documentation

Please refer to Chapter 6.7 of the *2022 Single-family Residential Compliance Manual*.

Certificate of Installation (C2FR-LTG)

The certificate of installation for lighting is the CF2R-LTG.

Person Responsible to Submit the Certificate of Installation

The individual responsible for constructing and installing the residential lighting project (Title 24 California Code of Regulations, Part 1, §10-103(a)3) must submit the certificate of installation. This individual must be eligible under Division 3 of the Business and Professions Code to accept responsibility for the installed lighting system. This individual must ensure the installed lighting system complies with the applicable lighting requirements before signing the certificate.

Number of Certificates of Installation Required

A residential lighting project may require more than one certificate to be submitted. If one qualified person accepts responsibility for the installation of an entire lighting project, one certificate is needed. If one qualified person installs the lighting controls and another installs the luminaires, each person will need to submit a separate certificate.

A certificate must be submitted to the responsible code enforcement agency for any residential lighting project that is regulated by the Energy Code, whether that project includes installation of a single luminaire or installation of lighting for an entire building.

The responsible person or contractor installing permanently installed lighting must complete and sign the certificate. The responsible person or installer verifies whether high luminous efficacy lighting and the required controls (i.e., vacancy sensors, dimmer switches) were installed.

Registration

Registration is required for projects that require Energy Code Compliance (ECC) field verification (see Title 20 California Code of Regulations §1670 et seq.). When registration is required, the certificates must be submitted electronically to an approved ECC-Provider data registry for registration and retention.

Registration requirements are in Chapter 2. Lighting measures do not require ECC-Verification.

For Building Officials

Please refer to Chapter 6.8 of the *2022 Single-family Residential Compliance Manual*.

Plans

Please refer to Chapter 6.8.1 of the *2022 Single-family Residential Compliance Manual*.

Compliance Documentation

Confirm that all required compliance documentation is included with the plans.

Certificate of Installation

The certificate of installation (CF2R-LTG) is the primary compliance document for residential lighting. There will be one or more CF2R-LTG forms submitted for each project. Confirm all lighting systems and lighting controls in the project are covered by a CF2R-LTG. Confirm all CF2R-LTG forms are registered if the project requires ECC field verification and diagnostic testing. (ECC-Verification is not required for residential lighting, but registration is required if any project measures do require ECC-Verification.)

Lighting Schedule

Builders must submit a lighting schedule to homeowners or occupants at the time of occupancy. This schedule should describe all installed interior luminaires and lamps. A draft schedule should be included for the plan check. In addition to a list of installed lighting systems, provided documentation should include necessary system information for regular operations and maintenance.

For Manufacturers – Certification to the Energy Commission

The following are guidelines for manufacturers to ensure their lighting products meet residential lighting requirements of the Energy Standards:

Light source products (luminaires, lamps, and light sources) that are required to comply with Reference Joint Appendix JA8 shall be marked with JA8-2025 or JA8-2025-E.

For lighting control and light source products to be certified to the Energy Commission (as defined in §100.1), the manufacturer must comply with the requirements of certification. Certification can be done on the Energy Commission's Certifications Packets webpage which is https://www.energy.ca.gov/files/certification-packets-appliances. The procedures include filling out a certification packet and submitting a declaration of compliance, executed under penalty of perjury of the laws of California, that the regulated product meets the requirements.

Building departments, builders, installers, lighting designers, and specifiers are advised to use the MAEDBS database to verify that a regulated product has been certified to the Energy Commission by the manufacturer.

Luminaires do not need to be shipped with a JA8-certified lamp by manufacturers.

Luminaires, Lamps, and Other Light Sources Complying with JA8 and JA10

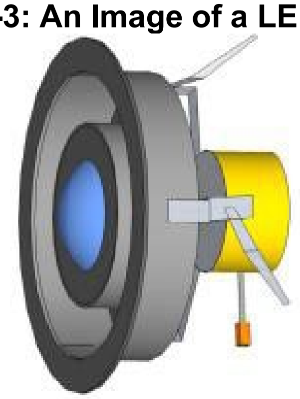
Joint Appendix JA8, "Qualification Requirements for High Luminous Efficacy Light

Sources," is a technical specification with requirements for luminaires, lamps, and light sources. JA8 specifies the performance requirements that light sources must meet, and the testing procedures that must be used to measure the performance metrics.

The elevated temperature life test requirement is optional as stated in JA8.5, and is required only for light source products intended for installation in enclosed or recessed luminaires. Light sources that have passed the "time to failure " portion of the federal test procedures specified in Appendix BB to Subpart B of 10 CFR 430 (2018) with a rated life of 15,000 hours or greater when the ambient temperature for the test is maintained at 45 °C ± 5°C tolerance or at a manufacturer-selected temperature higher than 45 °C with ± 5°C tolerance, can be marked with JA8-2025-E.

LED trim kit products like the one shown in Figure 6-3 do not need to be tested for the "time to failure" test procedure or marked with JA8-2025-E; however, they are still required to comply with JA8 and be marked with JA-8-2025.

Figure 6-3: An Image of a LED Trim Kit



Source: California Energy Commission

Joint Appendix JA10, "Test Method for Measuring Flicker of Lighting Systems and Reporting Requirements," is a supplement to the reduced flicker operation requirement of JA8. JA10 describes the test method to measure the flickering of light from the lighting system. The test involves using signal processing to remove high frequency components and quantifies flicker as a percent amplitude modulation below a given cut- off frequency.

Marking Designation, and Product Data Required for JA8-Certified Luminaires, Lamps and Light Sources

JA8-certified products, including luminaires, lamps, and light sources, must be marked as meeting the requirement of Section JA8.5.

Table 6-1: Elevated Temperature Test Requirements for Certified JA8 Luminaires, Lamps and Light Sources shows different marking designations depending on the light source type.

Table 6-2: Data to be Submitted to the California Energy Commission to Meet JA8.6 shows the required data to be submitted to the Energy Commission for JA8 certification and for meeting JA8.6.

Table 6-1: Elevated Temperature Test Requirements for Certified JA8 Luminaires, Lamps and Light Sources

Light Source Type	Marking Designation	Testing Notes for Meeting the Lumen Maintenance and Rated Life Requirements
Lamps and light sources installed in enclosed or recessed luminaires	JA8-2025-E	Light sources must pass the "time to failure" portion of the DOE Standards test procedures in order for the light source to be marked with "JA8-2022-E".
Ceiling recessed downlight luminaires	JA8-2025	No elevated temperature test is required.
3.Light sources other than #1 and #2.	JA8-2025	No elevated temperature test is required.

Source: California Energy Commission

Table 6-2: Data to be Submitted to the California Energy Commission to Meet JA8.6

METRIC	JA8 REQUIREMENTS
Light source type	LED, OLED, , HID, Others (certifier to identify)
Product type	Omnidirectional lamp, Directional lamp, Decorative lamp, LED light engine, Inseparable SSL luminaire, T20 lamp, Others (certifier to identify such as tape light)

Lab accredited by NVLAP or accreditation body operating in accordance with ISO/IEC 17011	Yes
Initial luminous efficacy	≥ 45 lumens/W
Power factor at full rated power	≥ 0.90
Start time	≤ 0.5 sec
Correlated color temperature (CCT)	≤ 4000 K
Color rendering index (CRI)	≥ 90 for all products other than T20 lamps, or ≥ 82 for T20 lamps
Color rendering R9 (red)	≥ 50 for all products other than T20 lamps
Ambient or elevated temperature	Ambient or Elevated
Minimum dimming level	≤ 10%
Dimming control compatibility	At least one type (Forward Phase cut control, reverse phase cut, powerline carrier, digital, 0-10 VDC) must be listed in order to be certified for meeting JA8.
NEMA SSL 7A compatible?	If compatible with forward phase cut dimmer control, "Yes." If not, "NA."
FLICKER:	--
See JA10 Table 10-1 for flicker data requirements and permissible answers	< 30% for frequencies ≤ 200 Hz at 100% light output
See JA10 Table 10-1 for flicker data requirements and permissible answers	< 30% for frequencies ≤ 200 Hz at 20% light output
	--
AUDIBLE NOISE: 100% light output	≤ 24 Dba
AUDIBLE NOISE: 20% light output	≤ 24 Dba
MARKING:	--
Marked in accordance with JA8.5	(Marked as) "JA8-2025", or "JA8-2025-E"

Source: California Energy Commission

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Solar Photovoltaic and Battery Energy Storage Systems

Solar Photovoltaic and Battery Energy Storage Systems Overview

Chapter 7 describes the compliance requirements for solar photovoltaic systems (PV), battery energy storage systems (BESS), and solar and energy storage system readiness for newly constructed single-family residential buildings.

The prescriptive Solar PV requirement sets the standard design budget for the performance compliance method. To comply with the prescriptive requirements, all newly constructed single-family buildings must have a Solar PV installed unless the building qualifies for an exception specified in Section 150.1(c)14. Homes that qualify for an exception to not be required to comply with the PV system requirements are still subject to mandatory measures for solar readiness. The intent of the solar readiness requirement is to reserve a penetration-free and shade-free portion of the roof for the potential future installation of a solar energy system, plan for a pathway for connecting the components of the system, and install a main electrical service panel that will enable a future system.

Installation of a battery energy storage system is a compliance option, and this chapter describes the qualification requirements for this compliance option. New single-family homes have mandatory requirements for being ready for the future installation of BESS if one is not installed. The BESS ready requirements ensure that electrical infrastructure is in place and sized appropriately for the potential future installation of battery energy storage system.

For information about solar water heating system requirements, please see Chapter 5.

What's New for 2025

Mandatory measures (Section 150.0(s))

- Revise BESS ready requirements to apply only for all newly constructed single-family buildings with one or two dwelling units that have electrical service greater than 125 amps.
- Clarify that BESS ready requirements do not apply if a BESS is installed .

Prescriptive and Performance Compliance (150.1(c)14)

- Introduce solar access roof area (SARA) multipliers that are used for steep-sloped and low-sloped roofs to determine the Solar PV size in kW for a given square foot area of SARA roof space.

Prescriptive Requirements for Photovoltaic System

Photovoltaic System Size

To comply with the prescriptive requirements, all newly constructed single-family buildings are required to have a Solar PV system installed unless the building qualifies for an exception. The minimum qualifying size of the Solar PV system is based on the conditioned floor area (CFA) and the number of dwelling units as specified by the following equation.

$$\text{Required } kW_{PV} = \frac{(CFA \times A)}{1000} + (N_{DU} \times B)$$

WHERE:

kW_{PV} = kWdc size of the Solar PV

CFA = Conditioned floor area

N_{DU} = Number of dwelling units

A = CFA adjustment factor from Table 7- 1: CFA and Dwelling Adjustment

B = Dwelling unit adjustment factor from Table 7- 1: CFA and Dwelling Adjustment

Table 7- 1: CFA and Dwelling Adjustment

Climate Zone	Factor A – CFA Adjustment Factor	Factor B - Dwelling Units Adjustment Factor
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

Example 7-1: Prescriptive Requirements for Solar PV for two different Climate Zones

Question:

How do I calculate the size of the required Solar PV system for a 2,000 sq ft single family home in Climate Zone 10? How do I compare the results to the same home in Climate Zone 15?

Answer:

$$\text{CZ10}\ kkkk_{pppp} = \frac{2{,}000\ ssRRssss\ \times 0.627}{1000} + 1\ \times 1.41$$

$$kkkk_{pppp} = 2.66\ kkkk$$

$$\text{CZ15}\ kkkk_{pppp} = \frac{2{,}000\ ssRRssss\ \times 1.56}{1000} + 1\ \times 1.47$$

$$kkkk_{pppp} = 4.59\ kkkk$$

In this example, we see the effects of the Adjustment factor “A” and the Dwelling Unit Factor “B”. The A Factor for climate zone 15 is over twice the A Factor for climate zone 10. As a result, the Solar PV system size required for the home in climate zone 15 is larger than the identical single family home in climate zone 10. The B Factor has a larger impact as the number of dwelling units increases, such as for multifamily buildings.

Exceptions to Solar PV Requirements

Solar Access Roof Area (SARA) is the roof area that has ample annual solar access and is available for installation of solar PV. It includes the area of the building’s roof, covered parking areas, carports, and all other newly constructed structures that are capable of structurally supporting a Solar PV as specified by Title 24, Part 2, Section 1511.2.

SARA does not include any roof area with less than 70 percent annual solar access. Annual solar access is the ratio of solar insolation including shading divided by the solar insolation without shading.

SARA also excludes any roof area that is not available due to state building code requirements, such as HVAC equipment setback and access (on low sloped roofs only) and fire setback and access pathways for Solar PV. Occupied roof areas are also specifically excluded from SARA but must be defined consistent with California Building Code (CBC) Section 503.1.4.

Some local building codes or ordinances require the roof to be used for specific purposes, such as for “living roofs.” Areas of the roof that are required to be used for specific purposes can be removed from the SARA if the CEC’s Executive Director has approved the SARA removal for the specific local code/ordinance. The enforcement agency must apply to the CEC for that approval.

Fire Code Regulations Applying to Residential Solar PV

Under regulations developed by the Office of the State Fire Marshal, the 2025 version of Parts 2, 2.5, and 9 of Title 24 include requirements for the installation of rooftop solar photovoltaic systems. These regulations cover the marking, location of DC conductors, and access and pathways for photovoltaic systems. They apply to residential and nonresidential buildings regulated by all Parts of Title 24, California Building Standards Code. Provided below is a brief summary of the fire code requirements for residential buildings.

Solar PV arrays shall not have dimensions in either axis greater than 150 feet. To provide adequate firefighter access, residential buildings shall provide two pathways from the lowest roof edge to the ridge, which are not less than 36 inches wide, for each roof plane with a photovoltaic array. Solar PV arrays shall not be located higher than 18 inches or 36 inches below the ridge depending on the roof area covered by the Solar PV array. Builders shall refer directly to the relevant sections of the California Residential Code (Title 24, Part 2.5, Sections R324.3, and R324.6) for requirements. The California Department of Forestry and Fire Protection – Office of the State Fire Marshal (CAL FIRE-OSFM), local fire departments (FD), and the solar photovoltaic industry developed a Solar Photovoltaic Installation Guideline to increase public safety for all structures equipped with solar photovoltaic systems. The intent of this guideline is to provide the solar PV industry with information that will aid in designing, building, and installing Solar PV to meet the objectives of both the solar PV industry and the requirements set forth in the California Fire Code.

The entire Solar Photovoltaic Installation Guideline can be accessed at

http://opr.ca.gov/docs/20190226-Solar_Permitting_Guidebook_4th_Edition.pdf.

Solar Access Roof Area

The Solar PV size requirement for a home is normally established by Equation 150.1-C (see Equation 7.1 above). However, when there is limited Solar Access Roof Area (SARA), the Solar PV size requirement may be reduced based on the SARA determined for the home. Once the SARA is determined, it is multiplied by 18 W/sq ft for steep-sloped roofs or by 14 W/sq ft for low-sloped roofs to determine the SARA-based Solar PV requirement. The lower of the two Solar PV calculation methods (SARA and Equation 150.1-C) shall determine the size of Solar PV required for the home.

There are five allowable exceptions to the prescriptive Solar PV requirements as shown below.

Exception 1: For steep slope roofs, SARA shall not consider roof areas with a northernly azimuth that lies between 300 degrees and 90 degrees from true north. Whenever any individual roof area has a SARA that is less than 80 contiguous square feet, no PV system is required for that individual roof area.

Exception 2: No Solar PV is required when the minimum Solar PV is less than 1.8 kWdc for the home as calculated by the prescriptive equation or the SARA-based calculation.

Exception 3: If the building is in an area that receives large amounts of snow, and the enforcement agency determines it isn't possible for the Solar PV system, including panels, modules, components, supports, and attachments to the roof structure, to meet the snow load requirements of Ch. 7 in the American Society of Civil Engineers (ASCE) Standard 7- 16, no Solar PV is required.

Exception 4: For buildings that are approved by the local planning department prior to January 1, 2020 with mandatory conditions for approval:

- Shading from roof designs and configurations for steep-sloped roofs, which are required by the mandatory conditions for approval, shall be considered for determining the annual solar access.
- Roof areas, that are not allowed by the mandatory conditions for approval to have Solar PVs, shall not be excluded from the SARA.

Exception 5: Solar PV sizes determined using equation 150.1-C may be reduced by 25 percent if the Solar PV is installed in combination with a battery energy storage system. The battery energy storage system shall meet the qualification requirements specified in Joint Appendix JA12 and have a minimum compliance cycling capacity of 7.5 kWh as defined in Joint Appendix JA12. Manufacturers limit the amount of capacity that the battery can charge and discharge; this is called usable capacity. When commissioned, batteries can be set to establish a reserve level amount of the usable capacity that will be set and not be available for daily cycling for the purpose of load shifting, maximized solar self-utilization, and grid-harmonization. The remainder of the battery capacity that is commissioned to be available for daily cycling for compliance purposes is the compliance cycling capacity.

Example 7-2: Detached Building

Question:

Does a newly constructed building of U or R occupancy that does not contain dwelling units (like a pool house, rec room, or an art studio) on a residential lot need to meet the Solar PV requirements in Energy Code Section 150.1?

Answer:

Yes. A conditioned, newly constructed building classified as U building occupancy on a residential lot needs to meet the Solar PV requirements in Section 150.1(c)14 of the Energy Code. Using the prescriptive method, the annual Solar PV electrical output Equation 150.1-C allows for an input of zero for the number of dwelling units in this case.

Example 7-3

Question:

If a home that is located in Climate Zone 13 has a conditioned floor area of 1,410 sq ft and a SARA of 310 sq ft, what is the required Solar PV size?

Answer:

The SARA that is available is 310 sq ft and the SARA multiplier is 18 W/sq ft based on the slope of the roof. The Solar PV possible on this size roof is:

$$kkkk_{pppp} = 310\ ssRRssss \times 18 \frac{kk}{ssRRssss} = 5{,}580 kk$$

$$kkkk_{pppp} = 5.58\ kkkk$$

Next, calculate the prescriptively required Solar PV size using Equation 150.1-C:

$$kkkk_{pppp} = \frac{1{,}410\ ssRRssss\ \times 0.894}{1000} + 1 \times 1.510$$

$$kkkk_{pppp} = 2.77\ kkkk$$

The required Solar PV size is 2.77 kW because it's the smaller of the two calculations.

Example 7-4

Question:

Suppose that a mature tree exists in the front yard to the south of the SARA and a solar shading report shows that the square footage of roof space with at least 70% annual solar access is 133 sq ft, as shown below. Determine the required size of the Solar PV.

Answer:

The required Solar PV based on SARA is:

$$kkkk_{pppp} = 133\ ssRRssss \times 18 \frac{kk}{ssRRssss} = 2{,}394 kk$$

$$kkkk_{pppp} = 2.4\ kkkk$$

This value is lower than the prescriptive calculation of 2.77 kW using Equation 150.1-C. Therefore, the required size of the Solar PV is 2.4 kW. Note that if the solar shading report gave a usable SARA of < 80 square feet, no Solar PV would be required using Exception 1.

Joint Appendix 11 (JA11)

The installed Solar PV must meet the applicable requirements specified in JA11.

System Orientation

For prescriptive path compliance, a Solar PV with module pitches greater than 2:12, or 10 degrees, must be installed with an azimuth between 90 to 300 degrees measured clockwise from true north. Module pitches less than 10 degrees (low-slope) can be installed in any orientation since the azimuth of low-slope modules has an insignificant impact on array performance.

When using the performance approach, the array may be faced in any azimuth, including True north; however, the more the azimuth deviates from the optimum azimuth of south to southwest, the worse the system performs, resulting in a larger Solar PV size needed to achieve compliance. It is best to orient the panels as close to south to southwest as possible to maximize the system performance with the smallest Solar PV size.

To use the California Flexible Installation 1 (CFI1) simplified modeling option in the performance method, the Solar PV array must be installed with an azimuth range between 150 to 270 degrees from true north, with all modules at the same tilt as the roof for pitches up to 7:12. Solar PV arrays must have 98% annual solar access in order to use the CFI1 or CFI2 method; if the location of the Solar PV array(s) cannot meet the 98 annual solar access criteria, then the detailed method must be used. The detailed method uses the actual azimuth, tilt, and annual solar access for simulating energy production.

When the CFI2 option is selected in the performance calculation, the Solar PV array must be installed with an azimuth range between 105 and 300 degrees from true north, with all modules at the same tilt as the roof for pitches up to 7:12. Note, when selecting CFI2, the performance of the proposed system is reduced by approximately 10 percent.

Shading

Shading from obstructions must be limited to meet the prescriptive requirements. For prescriptive compliance and for performance compliance using CFI1 or CFI2, if the Solar PV does not qualify for Exception 1 described above, then the weighted average annual solar access by panel count shall be at least 98 percent. Any obstruction located north of the array does not need to be considered. 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 Solar PV.
- 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 shall 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 feet from the nearest point of the array.

Example 7-5: Shading

Question:

What would be the impact of shading on the Solar PV sizing requirement?

Answer:

Prescriptively, the weighted average annual solar access as measured by an approved solar assessment tool must be at least 98 percent by panel count. Under the performance path, there is no minimum requirement for annual solar access, however the increase in shading (lower annual solar access) will necessitate a larger Solar PV size to meet the same long-term system cost (LSC) budget as a smaller unshaded Solar PV.

Solar Access Verification

A solar assessment tool that is approved by the Executive Director must be used to demonstrate the shading conditions of the Solar PV or when claiming an exception based on limited amount of solar access. The list of solar assessment tools that have been approved by the Energy Commission for use as specified in JA11.4.1 are provided at the Energy Commission website, https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/solar-assessment-tools.

The installer must also provide documentation that demonstrates the actual shading condition of the installed Solar PV using an approved solar assessment tool. Documentation includes satellite, drone, or other digital images used in the solar assessment that clearly show that the installed system matches the system modeled by the solar assessment tool.

Remote Monitoring Capability

All Solar PV systems are required, as specified in JA11.5.1, to have a web portal and a mobile device application that enables the building owner, manager or occupants to monitor the performance of their Solar PV to identify, report and correct performance issues with the panels, inverters, shading and other issues that may impact the performance of the Solar PV. At a minimum, the occupants must have access to the following information:

JA11.5.1 Remote Monitoring Capability

The Solar PV shall have a web-based portal and a mobile device application that at a minimum

provide the building owner, manager, or dwelling occupants access to the following information:

(a) The nominal kW rating of the Solar PV.

(b) Number of Solar PV modules and the nominal watt rating of each module.

(c) Hourly (or 15-minute interval), daily, monthly, and annual kWh production in numeric and graphic formats.

(d) Running total of daily kWh production.

(e) Daily kW peak power production.

(f) Current kW production of the entire Solar PV.

Example 7-6: 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 to the homeowner's internet, through ethernet and/or wireless connection. Others use independent cellular connections. For cellular, the data should be updated to the monitoring portal periodically as allowed by the cellular plan.

Additional Requirements

In addition to the requirements above, the Solar PV must also meet the following requirements in JA11:

- Interconnection Requirements: All inverters in the Solar PV must comply with the CPUC Electric Tariff Rule 21, which governs CPUC-jurisdictional interconnections for all net energy metering (NEM) and net billing tariff (NBT) customers. Rule 21 requires that inverters have certain capabilities to ensure proper operation of the electrical grid as renewables are interconnected. Information about the CPUC's Rule 21 can be found at: https://www.cpuc.ca.gov/rule21/ .
- Certificates and Availability: The Solar PV installer shall certify on the Certificate of Installation that all provisions of JA11 are met and provide a solar assessment report meeting one of the following conditions:
    - A satellite, drone, or other digital image used in the solar assessment report must be created and dated after the Solar PV is installed.

- If the satellite, drone, or other digital image used in the solar assessment report is dated before the Solar PV is installed, additional on-site pictures must be attached to clearly show that the installed system matches the system modeled in the solar assessment report.

The Certificate of Installation shall be available on the building site for inspections.

Enforcement Agency Responsibilities: The local enforcement agency shall verify that the Certificate of Installation is valid complete and correct, and uploaded into an Energy Commission approved registry.

Performance Approach Compliance for Photovoltaic System

Energy Budget Calculation

The computer performance approach allows for the modeling of the Solar PV performance by considering Solar PV size, climate, panel azimuths and tilts, inverter efficiency, and shading characteristics. The standard design Solar PV size is determined by the modeled annual electrical consumption of the mixed-fuel proposed design building, regardless of the actual fuel type of the proposed design building. The performance method allows for modeling different Solar PV sizes, solar thermal systems, more energy efficiency measures, battery storage system and other demand response measures.

Substituting Solar PV for building energy efficiency measures is not possible because Solar PV has no impact on the Efficiency LSC compliance metric. However, a more efficient building design can enable a building to comply using a smaller solar system. Given the substantial value of Solar PVs, it's unlikely to design a home where a Solar PV is not required.

Example 7-7: Efficiency Tradeoff

Question:

Does the performance path allow tradeoffs between a Solar PV that is coupled with a battery storage system and energy efficiency measures? How about a standalone battery storage system?

Answer:

When the Solar PV is coupled with at least a 5 kWh compliance cycling capacity battery storage system, the performance path will allow a portion of the available credit to be used for efficiency measure tradeoffs; this is a modest credit that can be used to achieve compliance in buildings that have marginal difficulty achieving compliance. No compliance credit can be used for efficiency measure tradeoffs when a standalone battery energy storage system is installed.

Example 7-8: Solar Thermal System

Question:

Does a solar thermal water heating system still qualify for compliance credit in the performance path?

Answer:

Yes, although a solar water heating system cannot serve as a substitution for the prescriptively required Solar PV, it can still be installed for optional compliance credit in the performance path. Solar water heating systems are modeled along with the remainder of water heating and distribution systems as part of the Efficiency LSC compliance, and can be used for efficiency measures tradeoff, or installing a smaller Solar PV. The requirements for solar thermal water heating systems are described in Chapter 5, Water Heating Requirements.

Community Shared Solar Electric Generation and Storage Systems

Photovoltaic System Size

The 2019 Energy Code first allowed the possibility for the requirement for photovoltaics on the site of the residential building to be fully or partially offset by Community Shared Solar Electric Generation. Community Shared Solar Electric Generation means solar electric generation, battery storage or other renewable electric generation that is provided as part of a community or neighborhood program that is approved to share the generation resources it develops with individual homes to demonstrate compliance with the Energy Code. Also, batteries installed in combination with photovoltaics on the building site can be fully or partially offset by Community Shared Battery Storage Systems. Community Shared Solar Electric Generation Systems and Community Shared Battery Storage Systems could be installed in combination or separately. Such systems are hereinafter referred to just as Community Solar Electric Generation Systems.

Entities who wish to serve as administrators of a proposed Community Solar Electric Generation System must apply to the Energy Commission for approval. The application process involves demonstrating compliance with all of the requirements specified in Section 10-115 of the Energy Code. If approved, Energy Commission approved compliance software will be modified to enable users to take compliance credit for buildings served by that Energy Commission approved Community Solar Electric Generation System.

Any entity may apply to serve as administrator of a proposed Community Shared Solar Electric Generation System, including but not limited to utilities, builders, solar companies, or local governments. The administrator is responsible for ensuring that the criteria for approval are met throughout (at least) a twenty-year period for each building that participates in the Community Solar Electric Generation System. The administrator is accountable to builders, building owners, enforcement agencies, the Energy Commission, and other parties who relied on these systems for offset of full or partial compliance with the Energy Code. Records demonstrating compliance with the criteria must be maintained over that period, with access to those records provided to any entity approved by the Energy Commission.

Enforcement Agency

The Community Shared Solar Electric Generation System must exist and be available for enforcement agency review early in the permitting process, and shall not delay the enforcement agency review and approval of the building that it will serve. All documentation required to demonstrate compliance for the building and the compliance offset from the Community Shared Solar Electric Generation System shall be completed and submitted to the enforcement agency with the permit application. The enforcement agency must have facilitated access to the Community Shared Solar Generation System to verify the validity and accuracy of compliance documentation.

Energy Performance and Minimum Community Shared Solar PV and Battery Storage Size

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 batteries, which would otherwise be required for the building to comply with the Energy Code.

The compliance software will determine a minimum kW size that represents the portion of the community solar resource dedicated to the building, based on the characteristics of the Community Shared Solar Electric Generation System resources, including Solar PV component performance characteristics, azimuth and tilt, inverter type, and fixed or tracking panel mounting.

Participating Building Energy Savings and Bill Reduction Benefits

A specific share of the Community Shared Solar Generation System, determined to comply with the energy performance requirement discussed above, must be dedicated on an ongoing basis to the building. The energy savings benefits dedicated to the building shall be provided in one of the following ways:

1. Actual reductions in the energy consumption of the building;
2. Energy reduction credits that will result in virtual reductions in the building's energy consumption that is subject to energy bill payments; or
3. Payments to the building that will have an equivalent effect as energy bill reductions.

For all three options mentioned above, the reduction in energy bills resulting from the share of the Community Shared Solar Generation System dedicated to the building shall be greater than the cost that is charged to the building to obtain that share of the Community Shared Solar Generation System.

Durability, Participation, and Building Opt-Out

Durability. The Community Shared Solar Generation System must be designed and installed to provide the energy savings benefits to the participating building for a period not less than 20 years.

Participation and Opt-out. Buildings using community shared solar and/or battery storage systems to comply with Section 150.1(a)3 must participate in the Community Shared Solar Generation System for at least 20 years, regardless of who owns or occupies the building, unless the building owner discontinues participation in the Community Shared Solar Generation System and causes installation and interconnection of an on-site solar electric generation system that meets or exceeds the requirements of the Energy Code, which were in effect at the time that the builder applied for the original building permit for the participating building.

Compliance Documentation. The Administrator shall maintain record(s) of the compliance documentation that determined the requirements for the on-site solar electric generation system and/or battery storage system to comply with the standards in effect at the time the builder applied for the original building permit, and which establishes participants' obligations to meet the Opt-Out Requirements.

Additionality

The Community Shared Solar Generation System must provide the benefits exclusively to the participating building. Those benefits shall in no way be 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) shall be served primarily by renewable resources developed specifically for the community solar electric generation system.

Other renewable resources may be used for each participating building if the building is permitted before the renewable resources developed for the program start operating, or after they cease operating.

For each renewable resource developed to serve participating buildings, bundled Renewable Energy Credits (RECs), which satisfy the criteria of Portfolio Content Category 1, shall be retired and tracked in the Western Renewable Energy Generation Information System (WREGIS) on behalf of program participants to ensure they will not be allocated to or used for any other mandatory or voluntary renewable electricity program requirement or claim.

Excess generation from renewable resources may be used to serve other loads but must be isolated from the generation serving participating buildings. This is not considered a violation of Section 10-115(a)5C, the Additionality requirement above.

Location

The community shared solar electric generation system must be located on a distribution system of the load serving entity providing service to the participating buildings. The distribution system shall have an electrical voltage less than 100kV.

Size

The community shared solar electric generation system must not be served by any individual source larger than 20 MW.

Example 7-9

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 Energy Performance and Minimum Community Shared Solar PV and Battery Storage Size.

Answer:

Examples would include:

- Actual reductions in the energy consumption of the building. This could be accomplished by locating the Solar PVs for several houses on a carport on common land in a subdivision, and direct wiring the unique Solar 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 or Net Billing requirements, the common land that is hosting the Solar PVs on the carport would have to be adjacent to (could be directly across a street) the houses that are being served by the Solar PV. 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, for which a renewable resource is paid for through shares purchased for each home. Energy bill credits that reduce monthly electricity bills would be allocated based on the home's shares. 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 that would result from one of the two options above: This could be accomplished by builders installing Solar PVs on other properties they own to offset the compliance requirement for onsite Solar PVs on homes they build. The homes would pay for a share of the Solar PVs on the other properties. The builders would be obligated to make an ongoing cash payment to the homes for the home's share of the electricity generation achieved by the Solar PVs on the other properties. The share of the ownership of the Solar PVs on the other properties and the corresponding sharing of the electricity generation achieved by the Solar PVs 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 Solar PVs 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 7-10

Question:

Explain the cost requirements in the last sentence of the Participating Building Energy Savings and Bill Reduction Benefits section above regarding the reduction in energy bills resulting from the building's participation in the Community Shared Solar Generation System dedicated to the building being required to be greater than the cost that is charged to the building to participate in the Community Shared Solar Generation System.

Answer:

Regardless of the three options chosen above, it must be cost effective for the home to participate in a community shared solar electric generation system program. The participating home will pay for charges to participate in the program, and will receive either energy consumption reductions, energy bill credits, or cash payments for the electricity that is generated by the participating home's share of the community shared solar electric generation system resource. The value of the reductions, credits, or cash payments to the participating home must exceed the home's charges to participate in the program.

Battery Energy Storage System

The primary function of the battery energy storage system (BESS) is daily cycling for the purpose of load shifting, maximized solar self-utilization, and grid-harmonization.For the purpose of the Energy Code, grid harmonization is defined as strategies and measures that harmonize customer owned distributed energy resource assets with the grid to maximize self-utilization of solar PV array output, and limit grid exports to periods beneficial to the grid and the ratepayer. This is done by charging the battery from the Solar PV when there is limited electrical load at the building and excess Solar PV generation, that would otherwise be exported directly to the grid in midday when the grid already has plenty of utility-owned Solar PV, and the value of customer-owned generation has low value to the grid. By charging the battery with that excess Solar PV generation, the battery can load shift by discharging to the building load in the late afternoon and early evening hours, when there is much less utility-owned Solar PV generation available and loads at the house and on the grid are peaking for the day, and when the customer-owned generation has much higher value to the grid.BESS is available as a compliance credit in the performance compliance method, either coupled with an on-site Solar PV or as a standalone system if the building does not have on-site Solar PV due to an exception or being part of an Energy Commission approved community solar program. BESS is also a criterion of Exception 5 of the prescriptive Solar PV requirements in section 150.1(c). In all cases, the BESS must meet all applicable requirements in Joint Appendix JA12 and be self-certified to the Energy Commission by the manufacturer as a qualified product.

A Solar PV size can be specified with the performance approach based on a user-defined target LSC and a coupled BESS with an appropriate battery control strategy and compliance cycling capacity. This is a cost-effective strategy for meeting lower target LSCs, that may be required by reach codes, with a smaller, grid harmonized Solar PV. BESScontrol strategies are described below.

The list of qualified JA12 products can be found here, https://solarequipment.energy.ca.gov/Home/Index

For the Energy Code purposes, the JA12 compliant BESS must have Y(2025) in the JA12 column.

Minimum System Performance Requirements

JA12 specifies that the BESS must meet or exceed the following specifications for performance approach:

- Usable capacity of at least 5 kWh.
- Energy capacity retention of 70 percent of nameplate capacity after 4,000 cycles covered by a warranty, or 70 percent of nameplate capacity under a 10-year warranty.

And the following specifications for prescriptive approach:

- The single AC-to-AC charge-discharge cycle (round-trip) efficiency of the BESS must be at least 80 percent.

Controls Requirements

BESS that remain in backup mode indefinitely bring no grid benefits. The JA12 requirements are designed to ensure that the BESS remains in an active control mode and prevent the BESS from remaining in the backup mode indefinitely. These requirements also enable the BESS to receive the latest firmware, software, control strategy, and other important updates.

The following requirements apply to all control strategies, including Basic Control, TOU Control, and Advanced Demand Flexibility Control, described in Controls Strategies below:

- The BESS shall have the capability of being remotely programmed to change the charge and discharge periods.
- During charging, when combined with an on-site solar photovoltaic system, the BESS shall first charge from an on-site photovoltaic system when the photovoltaic system production is greater than the on-site electrical load. The BESS also may charge from the grid during off-peak TOU hours of the day if allowed by the load serving entity. In anticipation of severe weather, Public Safety Power Shutoff events, or demand response signal, the BESS may charge from the grid at any time if allowed by the load serving entity.
- During discharge, the BESS shall be programmed to first meet the electrical load of the property. If during the discharge period the electrical load of the property is less than the maximum discharge rate, the BESS shall have the capability to discharge electricity into the grid upon receipt of a demand flexibility signal from the Load serving entity or a third-party aggregator.
- The BESS shall operate in one of the control strategies specified in Controls Strategies except during a power interruption, when it may switch to backup mode. If the BESS switches to backup power mode during a power interruption, upon restoration of power the BESS shall immediately revert to the previously programmed JA12 control strategy. The device must have the feature that would enable export to be built in at the time of installation. It can be in the off mode and be turned on later with a remote signal.
- At the time of inspection, the BESS shall be installed to meet one of the following control strategies. The BESS also shall have the capability to remotely switch to any of the control strategies.
- At the time of inspection, the BESS will be commissioned with a compliance cycling capacity that will be specified on the Certificate of Compliance. If at any time during operation, the capacity of the BESS that is available for daily cycling drops below the level of the compliance cycling capacity as a result of changes in the reserve level, the BESS shall automatically reset back to the compliance cycling capacity level after 72 hours. This reset requirement does not apply to reserve level changes that are controlled by a load serving entity or the California Independent System Operator, third-party aggregator, or manufacturer due to severe weather or Public Safety Power Shutoff events. At the conclusion of the severe weather or Public Safety Power Shutoff event, the BESS shall return to the compliance cycling capacity.

Control Strategies

JA12 includes four control strategies that are designed to encourage load shifting to harmonize the onsite PV system with the grid and deliver benefits to the environment, building owner and building occupants. Installation of battery energy storage systems increase self-utilization of PV array output, and reduce exports of excess generation to the grid. The installed BESS can follow any of the following control strategies. However, the compliance software will only simulate “Time of Use” control strategy.

Basic Control: When combined with an on-site Solar PV, to qualify for the Basic Control, the battery storage system shall be installed to only allow charging from an on-site Solar PV when the Solar PV production is greater than the on-site electrical load. The battery storage system shall discharge to the building load when the Solar PV production is less than the on-site electrical load.

Time-of-Use (TOU) Control: Designed to match load shifting with utility TOU rates. This control strategy generally results in a greater compliance credit than the Basic Control. When combined with an on-site Solar PV, BESS shall discharge during the highest priced TOU hours of the day. The operation schedule shall be preprogrammed from factory, updated remotely, or commissioned during the installation/commissioning of the system. At a minimum, the system shall be capable of programming three separate seasonal TOU schedules, such as spring, summer, and winter.

Advanced Demand Flexibility Control: Designed to bring the maximum value to the Solar PV generation by placing the charge/discharge functions of the BESS under the control of a load serving entity or a third-party aggregator. This control strategy allows discharging to the grid upon receiving a demand response signal from a grid operator. When combined with an on-site Solar PV, to qualify for the Advanced Demand Flexibility Control, the BESS shall be programmed by default as Basic Control or TOU control as described above. The BESS control shall meet the demand flexibility control requirements specified in Section 110.12(a). Additionally, the BESS shall have the capability to change the charging and discharging periods in response to signals from the local utility or a third-party aggregator

Controls for Separate Battery Systems: When installed separate from (not in combination with) an on-site solar photovoltaic system, including when the building is served by a community Solar PV, to qualify for the compliance credit, the battery storage system shall be programmed by default to:

- Start Charging from the grid during the lowest priced TOU hours of the day and start discharging during the highest priced TOU hours of the day, or
- Meet all the demand response control requirements specified in Section 110.12(a) and shall have the capability to change the charging and discharging periods in response to signals from the load serving entity or a third-party aggregator.

Alternative Control Approved by the Executive Director: The Executive Director may approve alternative control strategies that demonstrate equal or greater benefits to those strategies specified in JA12. To qualify for Alternative Control, the BESS shall be operated in a manner that increases self-utilization of the photovoltaic array output, responds to utility rates, responds to demand response signals, minimizes greenhouse gas emissions from buildings, and/or implements other strategies that achieve equal or greater benefits than those specified in JA12.2.3. The application to the Executive Director for the alternative control option shall be accompanied with clear and easy to implement algorithms for incorporation into the compliance software for compliance credit calculations.

Safety Requirements

The BESS shall be tested in accordance with the applicable requirements specified in UL 1973 and UL 9540. Inverters used with BESS shall be tested in accordance with the applicable requirements in UL 1741 and UL 1741 Supplement SA, or UL1741 Supplement SB.

Enforcement Agency

The local enforcement agency shall verify that all Certificate of Installations are valid. The BESS shall be verified as a model certified to the Energy Commission as qualified for credit as a BESS. In addition, the enforcement agency shall verify that the BESS is commissioned and operational with one of the controls specified in Controls Strategies above. The control strategy at system installation and commissioning and final inspection by the enforcement agency shall be the control strategy and the compliance cycling capacity that was specified in the Certificate of Compliance. The enforcement agency cannot enforce a particular control strategy after the BESS is installed and inspected. As a result, BESS can be operated with any JA12 control strategy, but the performance compliance software will only simulate time of use control strategy.

Certification Documentation Requirements

A specification sheet information showing usable capacity, compliance cycling capacity, roundtrip efficiency and an identification as a field assembled or integrated BESS shall be submitted to the Energy Commission for JA12 certification. In addition, a document showing the software operation of cycling control strategy, and a document or training materials describing the programming of the permanent 72 hour reset requirement during the commissioning of the BESS as specified in JA12.3.3.1(e) and JA12.3.3.1(e)(4), respectively shall be submitted to the Energy Commission for JA12 certification.

Fire Code Regulations Applying to Residential Battery Energy Storage Systems

Section 1207 of the California Fire Code (CFC) establishes requirements for energy storage systems. Requirements include that BESS shall be listed and labeled for use in accordance with UL 9540. Individual units shall be separated from each other by at least 3 feet except where smaller separation distances are documented to be adequate based on large-scale fire testing complying with Section 1206.1.5.

Allowable locations for BESS include:

- Detached garages and detached accessory structures.
- Attached garages meeting CFC requirements
- Outdoors or on the exterior side of exterior walls located not less than 3 feet (914 mm) from doors and windows directly entering the dwelling unit.
- Enclosed utility closets, basements, storage or utility spaces within dwelling units with finished or noncombustible walls and ceilings. Walls and ceilings of unfinished wood-framed construction shall be provided with not less than 5 /8-inch Type X gypsum wallboard

BESS shall not be installed in sleeping rooms, closets, spaces opening directly into sleeping rooms or habitable spaces of dwelling units.

Example 7-11: Battery Storage Credit

Question:

Can you explain the BESS credit requirements and how to comply with them?

Answer:

The performance path allows a compliance credit for:

- A BESS with a compliance cycling capacity of at least 5 kWh, with the capability to be programmed for a certain compliance cycling capacity, programmed for basic, time-of-use, or advanced demand flexibility control, and is coupled with a Solar PV, or
- A standalone BESS separate from on-site Solar PV with control requirements meeting JA12.3.3.2.4.

Compliance will allow a portion of available credit for a BESS combined with solar PV system to be used to meet the Efficiency LSC energy budget, with the rest of the credit being available for improving the Total LSC score. This "self-utilization" credit can be used to achieve compliance in buildings that are marginally out of compliance with the Efficiency LSC energy budget. The "self-utilization" credit is not available for stand-alone BESS.

BESS manufacturers must self-certify to the Commission that the BESS meets the requirements of JA12. These include minimum performance requirements, communication requirements, control requirements, safety requirements, and interconnection requirements, among others as mentioned in JA12.5, that must be complied with and certified to the Commission. The self-certification form may be downloaded from the Commission's website.

The following form must be used if a battery storage system or energy storage system is a system that has a single model number and contains both battery and inverter components:

https://www.energy.ca.gov/media/8219

For field assembled energy storage systems, the following form must be used:

https://www.energy.ca.gov/media/2247

Example 7-12: Battery Storage Credit

Question:

When batteries are used there is a loss of energy associated with round trip charging and discharging, resulting in lower generated kWh. Why does the Commission provide a compliance credit for a BESS that is coupled with a Solar PV if there is a loss of energy?

Answer:

BESS stores the Solar PV generated power in the middle of the day when the solar resources are generally plentiful and electricity prices are low. The systems then discharges the stored energy later in the day, during the peak hours when solar resources are diminished, and electricity prices are high. BESS have a limited charge/discharge (round trip efficiency) loss of 5 to 15 percent, depending on the type of battery and the inverter efficiencies. A compliance credit is available because of the major electricity cost differential between mid-day and peak-hours rates. This differential is greater than the battery charge/discharge loss.

To calculate the compliance credit of a BESS coupled with a Solar PV, the Energy Commission's compliance software, on an hourly basis, accounts for the Solar PV generation, losses, energy storage's compliance cycling capacity, charge and discharge rates, cost of electricity, house loads, and hourly exports. Similar calculations are also performed to calculate the benefits of storage for CO_2 emissions.

Only BESS complying with JA12 requirements are eligible for compliance credit. The requirements ensure the BESS remains in a dynamic mode allowing residents to take advantage of variable electricity costs associated with charge and discharge periods throughout the day. Static batteries that remain mostly in backup mode have little to no value for load shifting.

Example 7-13: Battery Storage TOU schedule

Question:

How will control requirement be enforced for customers that are not on a TOU schedule? How about customers on TOU rate but want to be in Basic Control?

Answer:

The BESS's cycling capacity must comply with JA12.3.3.1(e) whether the local utility does or does not currently have a TOU schedule. If the local utility currently does not have a TOU schedule, to comply with JA12.2.3, the BESS must perform a system check on 1 May and 1 November. A customer can set the control strategy to Basic Control if a TOU rate is not available for the customer. However, this strategy will reduce the benefits of the battery storage for both the customer and the grid, and therefore is not recommended. Load serving entities are expected to switch to TOU rates over time.

Solar Ready Overview

The solar-ready provisions are mandatory for single-family residences without a Solar PV located in subdivisions of 10 or more residences. Often, these residences do not have a Solar PV due to an exception to the prescriptive Solar PV requirements in Section 150.1(c)14.

Solar readiness requires that a portion of the roof or overhang of the building is reserved as a solar zone where solar panels can be installed in the future at the owner's discretion. The area must comply with access, pathway, ventilation, and spacing regulations specified in the California Residential Code (Title 24, Part 2.5, Section R324.3) and other local jurisdictional requirements.

The solar zone must also adhere to size and azimuth requirements (Section 110.10(b)1A - Section 110.10(b)2). It must be free from solar obstructions , such as vents, chimneys, architectural features and roof mounted equipment. The solar zone must be clearly indicated on construction documents, which must also include structural design loads of the roof. This documentation is required so that at the time of a future solar PV installation, the structural design loads of the roof at the time the building was permitted are know. The Energy Code does not require estimating the structural loads of possible future solar equipment. (Section 110.10(b)3 - (Section 110.10(b)4).

Also, all buildings that comply by designating a solar zone must indicate on construction documents a location reserved for inverters and metering equipment and a pathway reserved for routing of conduit from the solar zone plan for connecting a future Solar PV system. Alternatively, construction documents can indicate a pathway for routing of plumbing from the solar zone to a solar water-heating system (SWH) (Section 110.10(c)1, Section 110.10(c)2). In addition, the main electrical service panel shall have a minimum busbar rating of 200 amps, and shall have a reserved space to allow for the installation of a double pole circuit breaker for a future solar electric installation (Section 110.10(e)).

There are six allowable exceptions to the solar zone area requirements that reduce or remove the need to reserve a portion of the roof area as a solar zone. (Section 110.10(b)1A, Exception

1-6) These exceptions allow alternate efficiency measures instead of establishment of a solar zone, so the requirements for zone shading, azimuth, design load, interconnection pathways, owner documentation, and electric service panel do not apply.

California Fire Code Solar Access Requirements

Please see discussion in the Fire Code Regulations Applying to Residential Solar PV section.

Battery Energy Storage System Ready Overview

All newly constructed single-family residences with one or two dwelling units, which have electrical service greater than 125 amps, must be BESS ready to facilitate the future installation of a battery system. Dwelling units with 125 amp panels or less are not required to install electrical infrastructure to be battery ready. This may exclude smaller Accessory Dwelling Units (ADUs). BESS ready requirements do not apply if a BESS is actually installed. The following requirements must be met to be BESS ready:

1. Either a. or b. (or both) shall be provided:
   a. BESS ready interconnection equipment with a minimum backed-up capacity of 60 amps and a minimum of four BESS-supplied branch circuits specified in Section 150.0(s)2; or
   b. A dedicated 1" minimum raceway from the main service to a subpanel that supplies the branch circuits specified in Section 150.0(s)2. The subpanel must be labeled "Subpanel shall include all backed-up load circuits." All branch circuits are permitted to be supplied by the main service panel prior to the installation of a BESS.
2. A minimum of four branch circuits shall be identified and have their source of supply collocated at the subpanel specified in1.b. above to be supplied by the BESS. At least one circuit must supply the refrigerator. One lighting circuit must be located near the primary egress. At least one circuit shall supply a sleeping room receptacle outlet. Other circuits may serve any purpose.
3. The main panelboard shall have a minimum busbar rating of 225 amps.
4. Sufficient space shall be reserved to allow future installation of a system isolation equipment/transfer switch within 3 feet of the main panelboard. Raceways shall be installed between the panelboard and the system isolation equipment transfer switch location to allow the connection of a backup power source.

Compliance and Enforcement

When a building permit application is submitted to the enforcement agency, the applicant also submits plans and energy compliance documentation. This section describes the forms and procedures for documenting compliance with the solar ready requirements of the Energy Code. The following discussion is addressed to the designer preparing construction and compliance documents, and to the enforcement agency plan checkers who are examining those documents for compliance with the standards.

There are five certificate of installation forms associated with the low-rise residential solar photovoltaic system, battery storage systems and solar-ready requirements:

- The following forms are required for newly constructed single family residential projects to document that the solar and battery storage systems (where applicable) that were installed to match the Certificate of Compliance (CF1R).CF2R-PVB-01-E: Certificate of Installation: Photovoltaic Systems

- CF2R-PVB-02-E: Certificate of Installation: Battery Storage Systems

The following forms are required for single family residential projects to document compliance with solar-ready requirements. Solar readiness compliance is required when a single family residential project is not required to install solar PV by meeting an exception.

- CF2R-SRA-01-E: Certificate of Installation: Solar Readiness

  This form documents what was installed to comply with the solar-ready requirements, including any equipment installed to qualify for one of the solar zone exceptions.

- CF2R-SRA-02-E: Certificate of Installation: Minimum Solar Zone Area Worksheet

  This form is required when buildings comply with the solar-ready requirement by including a solar zone.

- CF2R-STH-01-E: Certificate of Installation: Solar Water Heating System

  This form is required when a solar water- heating system is required to comply with the Energy Code. It would be required when solar readiness requirements are met by installing a solar water heating system .

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Performance Method

Performance Method Overview

This chapter explains the performance method of complying with the *Building Energy Efficiency Standards* (Energy Code). The performance method provides maximum flexibility to trade off the energy performance of different building components to achieve compliance. For new construction, the energy budget is expressed in terms of the long-term system cost (LSC) and source energy. Energy Commission approved compliance software calculate total source energy for the proposed building and compares it to the total source energy budget of a standard design building. Approved compliance software also calculate an efficiency LSC for the proposed building and compares it to the efficiency LSC budget of a standard design building. The efficiency LSC includes LSC energy for space-conditioning, water heating and mechanical ventilation. Finally approved compliance software calculate the total LSC for the proposed building and compares it to the total LSC of a standard design building. The total LSC includes efficiency LSC and LSC from photovoltaic systems, battery energy storage systems, lighting, demand flexibility and other plug loads.

The standard efficiency includes water heating, space heating, space cooling, indoor air quality (IAQ) fan energy, and solar generation. Energy use from lighting and appliances is not eligible to be traded off.

The Energy Commission approved compliance software programs calculate space-conditioning and water-heating energy use in accordance with a set of rules.

Modeling capabilities are in the *Residential Alternative Calculation Method (ACM) Reference Manual*. All approved software programs use the California simulation engine to simulate the energy use, and the same report generator to create the certificate of compliance (CF1R), as the public domain program, California Building Energy Code Compliance - Residential (CBECC-Res). Approved software vendors have can create their own user interface, documentation, and additional forms. Each approved program is required to have a compliance supplement with information on how to use the software.

A discussion of performance method for additions and alterations is in Chapter 9.

What's New for 2022

- LSC and source energy metrics used for compliance.
- Photovoltaic performance procedures (See Chapter 7).

Compliance Basics

Compliance Process

Reference: Section 10-109, Single-family ACM Reference Manual

Any approved compliance software may be used to show compliance with the Energy Code using the performance method. The following steps are an outline of the typical compliance software procedure:

- Collect all necessary data on each component.

- For the building envelope, the area of each fenestration, wall, door, roof, ceiling, and floor is needed. For each component, the applicable energy characteristics needs to be defined including U-factor, solar heat gain coefficient (SHGC), solar reflectance, and thermal mass values.
- For HVAC systems, the equipment type and efficiency are required. For hydronic space heating, the specific water heater type and efficiency are required. For fan-forced air conditioning systems, the location and amount of insulation on the duct system are needed.
- For DHW systems, the water heater type, number, efficiency, and area served are required, along with the information about the hot water distribution system. Additional information will be required for features such as solar thermal systems and drain water heat recovery devices. More information is in Chapter 5.
- For PV systems, size and location information--such as roof slope and orientation-- are required. Battery storage capacity and control information must be described if battery storage is proposed. Refer to Chapter 7 for more information.

- Enter the basic building envelope data such as square footage, number of stories, occupancy type, and climate zone. Define each opaque surface with the orientation, area, and thermal performance properties. Add the doors and fenestration associated with each opaque surface, including any fixed shading such as overhangs and side fins. Enter the data of the equipment and distribution systems for the space conditioning and water-heating systems. The input values and assumptions must correspond to the information on the final approved plan set, and the inputs must be at least as energy efficient as the relevant mandatory measures. (Software compliance programs may not automatically check for compliance with mandatory measures.)
- Launch a computer simulation to calculate the source energy, efficiency LSC, and total LSC of the standard design and the proposed design.

For additions and alterations, compliance is based on LSC energy, and not the source energy criteria that is used for newly constructed buildings. In existing buildings, where the values of installed features are unknown, default values may be used based on the year of the construction. Refer to Table 8-1: Standard Design for an Altered Component, at the end of this chapter. The proposed design complies if all mandatory measures are met and the total LSC energy use is the same as or less than the standard design LSC energy budget.

When creating a computer input file, use the space provided for the project title information to concisely describe the building being modeled. User-designated names should be clear and internally consistent with other orientations and/or surfaces being analyzed. Title names and explanatory comments should assist in the compliance and enforcement processes.

Defining the Standard Design Efficiency

Approved compliance software programs automatically calculate the standard design efficiency based on data entered for the proposed building.

The program defines the standard building by modifying the geometry of the proposed building and inserting the features of Table 150.1-A of the Energy Standards. Details on how the proposed and standard design energy budget are established can be found in the *Residential ACM Reference Manual*.

Note the details of how the standard design efficiency is determined. Deviations from the prescriptive requirements will be reflected in the compliance margin. For example, if the prescriptive requirements from Table 150.1-A include a heat pump space heating system, and the proposed building is modeled with a central gas furnace, it will significantly increase the heating source energy in the energy usage simulated by the compliance software.

The standard design assumes the same total conditioned floor area and volume as the proposed design and the same gross exterior wall area as the proposed design, except that the wall area in each of the four cardinal orientations is divided equally. The standard design uses the same roof/ceiling area, raised floor area, slab-on-grade area, and perimeter as the proposed design, but uses the standard insulation R-values from Table 150.1-A of the Energy Code.

The standard design includes all features of the prescriptive compliance tables, including quality installation of insulation, walls with the prescriptive U-factor, below- deck roof insulation or radiant barrier, and a solar PV system.

Total fenestration area in the standard design is equal to that in the proposed design if the fenestration area in the proposed design is less than or equal to 20 percent of the conditioned floor area (CFA), Otherwise, the fenestration area is equal to 20 percent of the CFA. Fenestration area in the standard design is evenly distributed among the four cardinal orientations. SHGC and U-factors in the standard design are the same as those listed in the prescriptive tables, with no overhangs.

The standard design includes minimum efficiency heating and cooling equipment, as well as the minimum duct insulation R-value required for Option B from Table 150.1- A of the Energy Code. Ducts are assumed to be sealed as required by §150.0(m).

The standard design also assumes correct refrigerant charge as required by §150.1(c)7A**.**

For water-heating systems that serve dwelling units, the standard design is a NEEA Tier 3 heat pump water heater with a uniform energy factor equal to 2.0, and the distribution system meets all mandatory requirements specified in §150.0.

Standard Reports

For consistency and ease of enforcement, the way building features are reported by compliance software programs is standardized. Energy Commission-approved compliance software programs produce compliance reports in a standard format.

The principal report is the certificate of compliance (CF1R-PRF-01-E).

The CF1R-PRF-01-E includes two feature summary sections, one for required special features and modeling assumptions, and a second for features requiring Energy Code Compliance (ECC) field verification and/or diagnostic testing. These sections provide a general overview during compliance verification by the local enforcement agency and the ECC-Rater. Items in the special features and modeling assumptions section indicate that if such features or assumptions used for compliance are not installed, the building would not comply, and they call for special consideration by the local enforcement agency. Items in the ECC-Verification section rely on diagnostic testing and verification by an approved ECC-Rater to ensure proper field installation. Diagnostic testing and verification by ECC-Raters is separate from local enforcement agency inspections.

Professional Judgement

Please refer to Chapter 8.3.3 of the *2022 Single-family Residential Compliance Manual*.

Subdivisions and Master Plans

Please refer to Chapter 8.4 of the *2022 Single-family Residential Compliance Manual*.

Individual Building Approach

Please refer to Chapter 8.4.1 of the *2022 Single-family Residential Compliance Manual*.

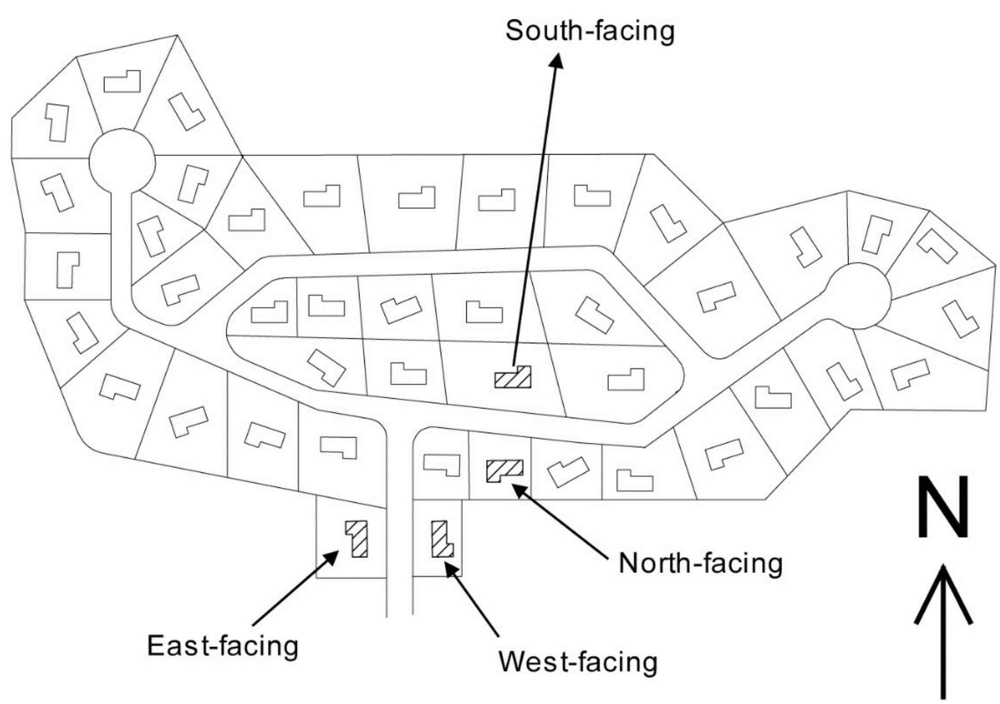
Multiple Orientation Alternative: No Orientation Restrictions

Section 150.1(b)

The performance method may be used to demonstrate that a building plan complies regardless of its orientation within the same climate zone. To ensure compliance in any orientation, the annual energy consumption must be calculated using all four cardinal orientations (a single CF1R with results for north, east, south, and west).

The building must have the identical efficiency measures and levels, and comply with the energy budget in all orientations. Cardinal compliance can be used to show compliance for a reversed floor plan.

Figure 8-1: Subdivisions and Master Plans Compliance Option



Source: California Energy Commission

For compliance, submit certificate of compliance documentation of the energy budgets for each of the four orientations to the enforcement agency. Only one CF1R compliance document that shows compliance for all four orientations is required to be submitted to the enforcement agency for each unique or reverse plan.

Master plans that use the multiple orientation alternative must establish a connection to the CF1R in the ECC registry. For the multiple orientation compliance approach in a master plan subdivision, the required documentation for each dwelling unit should be a multiple orientation master plan certificate of compliance (CF1R), a dwelling-specific certificate of installation (CF2R), and a dwelling-specific certificate of verification (CF3R).

HVAC Issues

No Cooling Installed

When a building has no cooling system, the software simulates a hypothetical system with the characteristics required by Table 150.1-A as if a cooling system were installed.

Wood Heat

Please refer to Chapter 8.5.2 of the *2022 Single-family Residential Compliance Manual*.

Multiple HVAC Systems

Please refer to Chapter 8.5.3 of the *2022 Single-family Residential Compliance Manual*.

ECC-Verified Efficiency

When higher than minimum efficiency is modeled, a ECC Rater must verify the efficiency. This includes:

- Seasonal Energy Efficiency Ratio 2 (SEER2)
- Energy Efficiency Ratio 2 (EER2)
- Combined Energy Efficiency Ratio (CEER)
- Heating Seasonal Performance Factor 2 (HSPF2)

Existing + Addition + Alteration Approach

Please refer to Chapter 8.5.5 of the *2022 Single-family Residential Compliance Manual*.

Table 8-1: Standard Design for an Altered Component

Altered Component	Standard Design Without Third Party Verification of Existing Conditions Shall be Based On	Standard Design With Third Party Verification of Existing Conditions Shall be Based On
Ceiling Insulation, Wall Insulation, and Raised-floor Insulation	The requirements of Sections 150.0(a), (c), and (d)	The existing insulation R-value

Fenestration	The U-factor of 0.40 and SHGC value of 0.35. The glass area shall be the glass area of the existing building.	If the proposed U-factor is ≤ 0.40 and SHGC value is ≤ 0.35, the standard design shall be based on the existing U-factor and SHGC values as verified. Otherwise, the standard design shall be based on the U-factor of 0.40 and SHGC value of 0.35. The glass area shall be the glass area of the existing building.
Window Film	The U-factor of 0.40 and SHGC value of 0.35.	The existing fenestration in the alteration shall be based on Table 110.6-A and Table 110.6-B.
Doors	The U-factor of 0.20. The door area shall be the door area of the existing building.	If the proposed U-factor is < 0.20, the standard design shall be based on the existing U-factor value as verified. Otherwise, the standard design shall be based on the U-factor of 0.20. The door area shall be the door area of the existing building.
Space-Heating and Space-Cooling Equipment	TABLE 150.1-A for equipment efficiency requirements; Section 150.2(b)1C for entirely new or complete replacement systems; Section 150.2(b)1F for refrigerant charge verification requirements.	The existing efficiency levels.
Air Distribution System – Duct Sealing	The requirements of Sections 150.2(b)1D and 150.2(b)1E	The requirements of Sections 150.2(b)1D and 150.2(b)1E
Air Distribution System – Duct Insulation	The proposed efficiency levels.	The existing efficiency levels.
Water Heating Systems	The requirements of Section 150.2(b)1Hii	The existing efficiency level.
Roofing Products	The requirements of Section 150.2(b)1I.	The requirements of Section 150.2(b)1I
All Other Measures	The proposed efficiency levels.	The existing efficiency levels.

SOURCE: California Energy Commission Energy Code Table 150.2-D

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Additions, Alterations, and Repairs

Overview

This chapter covers key aspects of how the 2025 Building Energy Efficiency Standards (Energy Code) apply to the construction of additions and/or alterations to an existing residential building. As explained below, the Energy Code does not apply to building repairs.

The chapter is organized as follows:

- Section 9.1 – Introduction. Highlights the applicable standards definitions for additions, alterations, and repairs and provides several examples of each.
- Section 9.2 – What's New in the 2025 Energy Code. Highlights of the requirements and compliance options in the 2025 Energy Code.
- Section 9.3 – Compliance Approaches. An overview of prescriptive and performance compliance options.
- Section 9.4 – Prescriptive Approach and Mandatory Requirements. Detailed information on prescriptive compliance methods for additions and alterations, including how mandatory requirements apply.
- Section 9.5 – Performance Approach. An explanation of computer simulation of compliance for building additions, including existing + addition + alterations.

When additions and alterations include changes to the building envelope, mechanical systems, and/or water heating systems, a certificate of compliance form (CF1R) must be completed and submitted with the building permit application:

- If complying prescriptively, CF1R-ADD-01-E and/or CF1R-ALT-02-E, CF1R-ADD-02-E, or CF1R-ALT-05-E forms are used.
- For the performance approach, compliance software produces a CF1R-PRF-01-E. (See Appendix A for a list of forms.)

Changes to HVAC systems will likely include one or more features that require Energy Code Compliance (ECC) field verification and diagnostic testing. If ECC-Verification is required, the certificate of compliance must be completed and registered online with an approved ECC provider using the provider's website.

Refer to Chapter 2 for information about document registration and refer to Residential Appendix RA2 for more information about ECC-Verifications.

For a list of appropriate compliance documents refer to Appendix A of this manual.

Additions

An *addition* is any change to an existing building that increases both conditioned floor area and conditioned volume (including conditioning a previously unconditioned space). See Section 100.1.

Examples of an addition include:

- Adding a conditioned sunroom or other living space to an existing house.
- Converting a garage or other existing unheated space into living space.
- Enclosing and conditioning an existing patio area.
- Obtaining a permit to legalize an existing, conditioned space that was previously added to a residential building without a permit.
- Adding a bay window that extends from floor to ceiling, thereby increasing both floor area and volume.

Alterations

An *alteration* is any change to a water-heating system, space-conditioning system, lighting system, or envelope of a building that is not an addition. See Section 100.1.

Examples of alterations include:

- Adding insulation to an existing ceiling, exterior roof, exterior wall, or raised floor that is over a crawl space, garage, or unheated basement.
- Replacing or installing a new finish surface to an existing roof (reroofing) and replacing either portions of or the entire roof assembly.
- Replacing existing fenestration or adding fenestration area (for example, windows, glazed doors, dynamic glazing, or skylights) to an existing building.
- Replacing an existing skylight or increasing the skylight area of an existing roof over existing conditioned space.
- Constructing an entirely new roof over an existing conditioned space.
- Adding a loft within the conditioned volume of an existing home.

  Replacing an existing space heating system or adding a space heating system to existing conditioned space (furnace, wall heater, heat pump, or radiant floor).
- Adding heating to unconditioned space is considered an addition, not an alteration, when it increases both the conditioned floor area and conditioned volume of the building.
- Replacing an existing space cooling system or adding a space cooling system to existing conditioned space (for example, a central air conditioner or heat pump).
- Extending or replacing an existing duct system or adding an entirely new duct system.
- Replacing the existing water heater or adding water heaters and/or hot water piping.
- Replacing existing hardwired lighting or adding new hardwired lighting fixtures.
- Adding window film.

Repairs

Please refer to Chapter 9.1.3 of the *2022 Single-family Residential Compliance Manual*.

Example 9-1

Question:

A sunspace addition is designed with no mechanical heating or cooling and a glass sliding door separating it from all existing conditioned space. This design is approved by the enforcement agency as uninhabitable or unimproved space. Under what conditions will the Energy Code apply to this addition?

Figure 9-1: Unconditioned Sunspace

Source: California Energy Commission

Answer:

The mechanical and envelope requirements of the Energy Code do not apply if the space is not directly or indirectly conditioned, which is demonstrated by the air and thermal barrier between the added sunspace and the existing conditioned space. This space, therefore, is unconditioned as defined in Section 100.1; however, per Section 100.0(c)2, the sunspace must still comply with the applicable lighting requirements of Section 150.0(k). The sunspace is unconditioned if:

- The new space is not provided with heating or cooling
- All openings between the new space and the existing house can be closed off with weather-stripped doors and windows or
- The addition is not indirectly conditioned space (defined in Section 100.1 under CONDITIONED SPACE, INDIRECTLY).

A building official may require a sunspace to be conditioned if it appears to be habitable space, in which case the Energy Code applies.

Example 9-2

Question:

An existing duplex is remodeled, which includes only the installation of new faucets and bathroom lighting. Does the Energy Code apply?

Answer:

Yes, this remodel is considered an alteration. However, due to the limited scope of work and since no new conditioned space is being created, the remodel must comply only with the applicable mandatory requirements described in Section 110.1 for appliances and Section 150.0(k) for residential lighting.

Example 9-3

Question:

An existing house is remodeled by adding floor area but not increasing the volume of the house (adding a loft in an area in the house with a vaulted ceiling). As part of this remodel, some windows are replaced, and two windows are being added. Several exterior walls are being opened to install new wiring. What requirements will apply?

Answer:

Since floor area is added but not conditioned volume, this is an alteration and not an addition. It must comply with the Energy Code using either the prescriptive method or performance method and meet all the applicable mandatory requirements. To comply prescriptively, the new and replacement windows must meet the maximum U-factor and solar heat gain coefficient (SHGC) requirements of Section 150.2(b)1A and B. Newly installed and replacement windows must also comply with the mandatory requirements for caulking/sealing around windows per Section 110.7.Alternatively, the performance approach may be used to demonstrate compliance for the entire house, even if individual windows fail to meet the prescriptive requirements, if the building meets all applicable mandatory requirements. At this time, since the exterior walls are exposed or open, this allows the opportunity to insulate the walls and contribute the energy efficiency of the building. Such upgrades are unlikely to contribute to the compliance of the building without third party verification of existing conditions.

What's New for 2025

The 2025 Energy Code includes updates to the mandatory, prescriptive, and performance requirements for additions and alterations. This section highlights the key changes from the 2022 Energy Code. Note that prescriptive compliance requirements may be higher than mandatory requirements.

Building Envelope

- For additions and alterations, the prescriptive maximum U-factor requirements for windows reduced from 0.30 to 0.27 in climate zones 1 – 5, 11 – 14, and 16; climate zones 6 – 10 and 15 remain at 0.30 U-factor. For homes 500 square feet or less, the U-factor requirement remains at 0.30 in climate zone 5. In climate zone 15 an SHGC of 0.23 is allowed.
- Option C for roof insulation provides a prescriptive path for cathedral ceilings. The required cavity R-value for all climate zones is R-38. A radiant barrier is not prescriptively required for cathedral ceilings.

Space Conditioning System

- In addition to the requirements in 150.0(h)5, in additions and alterations where airflow is NOT field verified to be at least 350 cfm/ton, maximum capacity limits are provided in Tables 150.2-A and B that depend on the relative sizes of the calculated heating design load (HL) and cooling design load (CL), the type of space conditioning system, and the duct sizing (Section 150.2(a)1E).
- When doing load calculations for additions, the envelope leakage specified in the load calculation shall be no greater than the values shown in Table 150.2-C ("average" for many load calculation software tools). If leakage is established through field verification and

diagnostic testing, the tested envelope leakage value may be used in the load calculations (Section 150.2(a)1E).

- Block loads (the total load for all rooms combined that are served by the central equipment) may be used for the purpose of system sizing for additions (Section 150.0(h)5).
- The Energy Budget for additions is expressed in terms of Long-term System Cost (LSC) (Section 150.2(a)2).
- Refrigerant charge verification is required for heat pumps in all Climate Zones. Refrigerant charge verification is required for air conditioners in climate zones 2 and 8 – 15.

Water Heating

There are new mandatory requirements for air-source heat pump water heaters. These requirements are discussed in detail in Chapter 5 and summarized below.

- Heat pump water heaters installed so that inlet air is outdoor air must have backup heat if the compressor cutout temperature is above the local Heating Winter Median of Extremes (Section 110.3(c)7A).
- Ventilation is required when installing a heat pump water heater (Section 110.3(c)7B).

Compliance Approaches

Please refer to Chapter 9.3 of the *2022 Single-family Residential Compliance Manual*.

Additions

Regardless of the compliance approach selected, the following exceptions apply:

- Additions of ≤ 300 ft^2 do not require a cool roof product (if required by Section 150.1(c)11) to be installed.
- Whole-house fan (or ventilation cooling) does not apply to additions of 1,000 ft^2 or less (if otherwise required by Section 150.1(c)12).
- Existing space conditioning systems that are extended to provide conditioning to an addition are required (mandatory) to meet duct insulation and duct leakage requirements specified in Section 150.2(b)1Di and 150.2(b)1Dii (Section 150.2(a) Exception 4).
- Indoor air quality (IAQ) requirements (Section 150.0(o)1C, D, or F) do not apply to additions of 1,000 ft^2 or less that are not a new dwelling unit that is not a Junior Accessory Dwelling Unit.
- Photovoltaic (PV) requirements do not apply to additions or alterations.

Addition Alone

In this compliance scenario, the addition alone is modeled using compliance software, and the existing building is not modeled. This approach can work well when the existing building is not undergoing alterations, and the permitted work scope covers only the addition.

- Advantages: Little information about the existing building is needed (conditioned floor area, number of bedrooms) because it is not modeled.
- Disadvantages: Some prescriptive allowances for additions do not apply to the addition-alone compliance approach. For example, a 400 ft2 addition has a 30 percent fenestration area limit if complying using existing + addition, while only 20 percent is allowed when

complying as an addition alone. Also, with this approach, alterations to the existing building that improve its energy performance cannot be used to "trade-off" requirements for the addition

Existing + Addition + Alteration

In this compliance scenario, the entire building undergoes the compliance analysis, and unaltered building components are not required to be brought into compliance.

- Advantages: This approach offers the most flexibility by modeling improvements to the existing building. The energy budget provides more generous fenestration allowances for prescriptive compliance. Note: There is no requirement to make alterations to the existing building using this approach.
- Disadvantages: Plans and data for the existing building are needed, increasing the time and complexity of the calculations.

Existing + Addition as Newly Constructed Building

In this compliance scenario, modeling the existing building and the addition as if they were a newly constructed building. This approach is used when changes to the existing building are extensive. Demonstrating compliance can be difficult because all existing features must be brought up to current code.

Additions and Alterations Combined

Prescriptive Approach

When a single-family building project that includes an addition and alterations uses the prescriptive approach to compliance, all prescriptive requirements must be met. The addition complies with the CF1R-ADD-01-E prescriptive certificate of compliance.

Alterations to the existing building must also meet prescriptive requirements and be documented by a CF1R-ALT-02-E prescriptive certificate of compliance for alterations.

Performance Approach

Please refer to Chapter 9.3.2.2 of the *2022 Single-family Residential Compliance Manual*.

Alterations Only

Prescriptive

Alterations may comply prescriptively by meeting all applicable requirements in

Section 150.2(b), which are explained further in Prescriptive Approach and Mandatory Requirements. Several prescriptive alteration requirements or exceptions are specific to conditions such as building climate zone.

It is important to note that every applicable prescriptive requirement must be met; otherwise, the building must comply using the performance approach. However, if one or more proposed alterations do not comply prescriptively, other alterations must exceed prescriptive requirements for the project to comply based on the performance approach.

Under the prescriptive approach to alterations, the CF1R-ALT-02-E prescriptive certificate of compliance is completed and submitted with the permit application. If any mandatory or prescriptive features require ECC-Verification (see Chapter 2, ECC Field Verification and

Diagnostic Testing), the certificate of compliance must be completed and registered online with an ECC-Provider (see Chapter 2, Compliance Documentation) before being submitted to the enforcement agency.

Performance

Alterations may comply using the performance approach by meeting the requirements in Section 150.2(b)2. This is explained in Performance Approach. The main options are:

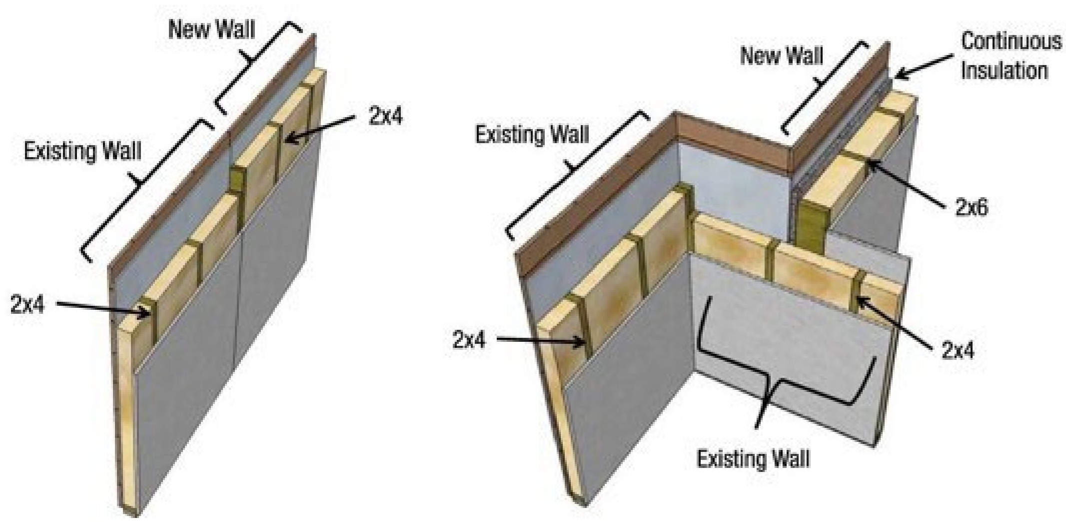
- Existing plus alterations: If multiple components or systems are being altered or if the proposed modification(s) exceed prescriptive requirements, then the existing + alterations performance approach can be used to make trade-offs.
- Compliance without third-party verification: This option allows alterations to comply without third-party inspection to verify existing conditions being altered.
- Compliance with third-party verification: This option allows for alterations to comply only with third-party inspection to verify existing conditions being altered.
- Existing plus alterations as a newly constructed building: This option is the most difficult.

Wall Exceptions to Continuous Insulation

Wall Extension

When an addition is built with a connection to an existing wood-framed wall, an extension to an existing wood-framed wall (Figure 9-2: Wall Extension to the Left and not a Wall Extension to the Right) is allowed to retain the existing dimensions (Section 150.2(a)1Ai or 150.2(a)1Biii).This exception will typically apply to only one or two walls of an addition. Prescriptive compliance for the walls that meet the criteria will require R-15 cavity insulation if the existing framing is 2x4 or R-21 cavity insulation if the existing framing is 2x6 for the extended wall(s). The energy budget for performance compliance will match the prescriptive requirements.

Figure 9-2: Wall Extension to the Left and not a Wall Extension to the Right



Source: California Energy Commission

Existing Wall with Siding

Please refer to Chapter 9.3.4.2 of the *2022 Single-family Residential Compliance Manual*.

Accessory Dwelling Units

California Government Code Section 65852.2 defines accessory dwelling units as an attached or detached residential dwelling unit which provides complete independent living facilities for one or more persons. An ADU shall include permanent provisions for living, sleeping, eating, cooking, and sanitation on the same parcel as the single-family dwelling is situated.

The Energy Code does not include a definition of Accessory Dwelling Unit. The Energy Code defines a junior accessory dwelling unit (JADU) which is a dwelling unit that is no more than 500 square feet in size and contained entirely within an existing or newly constructed single-family building A JADU includes a kitchen, a separate entrance from the main entrance to the building, and an interior entry to the main living area. A JADU may include separate sanitation facilities, or may share sanitation facilities with the existing single-family building.

State legislation effective since January 1, 2017 has given more flexibility to build ADUs, sometimes called "granny" or "in-law" units. For compliance, an ADU may be an addition, a newly constructed building, an alteration, or entirely within existing conditioned space. See Figure 9-3: ADU Type Newly Constructed Detached from Existing Home through Figure 9-10: ADU Type Alteration to Existing Detached Conditioned CFA to determine the compliance requirements.

Energy code compliance for Accessory Dwelling Units, with a few exceptions, only pertains to where and how conditioned space is altered or added. For the purposes of Energy code, a single-family residential building is an Occupancy Group (per CBC) R-3 building or a U-building on a residential site. According to Section 100.0 of the Energy Code, an ADU that is a newly constructed building triggers the mandatory and prescriptive/performance requirements of sections 150.0 and section 150.1, respectively. For all intents and purposes, it is considered a new single-family home and energy code does not confer any special category or requirements due to the fact that it is an ADU per Government Code. If an ADU is created as a part of an addition or alteration, then Section 150.2 requirements apply within the definitions and scope of additions or alterations.

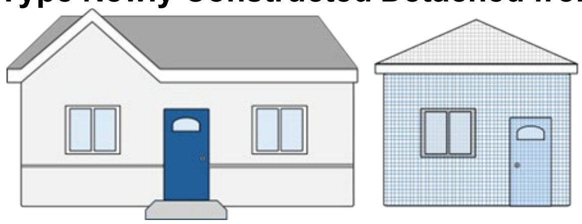
ADU compliance requirements are based on the associated Energy Code classification as either an addition or alteration to an existing residence or as a new building, as shown in Figure 9-3: ADU Type Newly Constructed Detached from Existing Home through Figure 9-10: ADU Type Alteration to Existing Detached Conditioned CFA. An ADU may comply using any of the prescriptive or performance method options available for other residential additions or new buildings plus meeting applicable mandatory requirements.

- If the ADU shares common walls with the existing dwelling unit and is newly constructed, some or all of the walls may be wall extensions (see Wall Exceptions to Continuous Insulation).
- If the ADU is converting an existing unconditioned structure into conditioned space, an exception to the prescriptive requirement for continuous insulation is available for walls where existing exterior siding (or cladding) is not removed.
- If the ADU shares common walls with an existing single-family residential building and is converting an attached unconditioned space into conditioned space, the existing walls of the

new ADU may meet an exception to the requirement for continuous insulation if exterior siding is not removed.

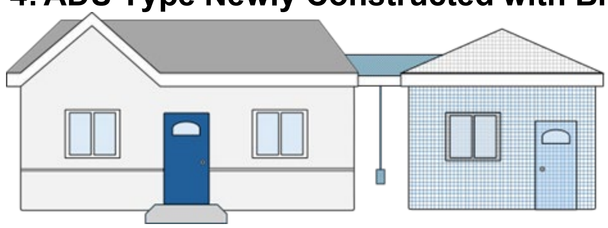
- If the ADU shares no common walls and is a new detached structure, this is a newly constructed residential building.
- If an ADU is created within existing conditioned space with a combination of existing, altered, and new components, then the project is an Alteration.
- If an ADU is created by adding off of an existing unconditioned space, such as building a second story over an existing detached garage building, the project is an Addition.

Figure 9-3: ADU Type Newly Constructed Detached from Existing Home



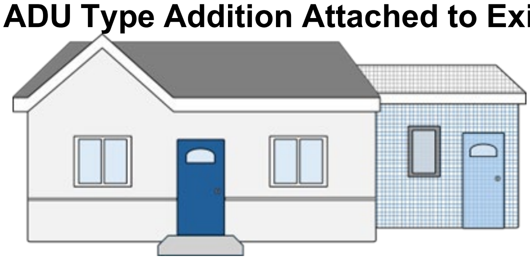
Source: California Energy Commission

Figure 9-4: ADU Type Newly Constructed with Breezeway



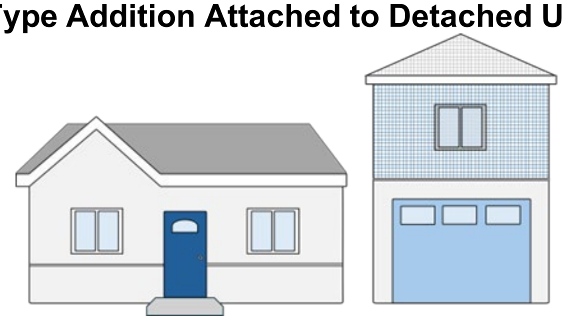
Source: California Energy Commission

Figure 9-5: ADU Type Addition Attached to Existing Home



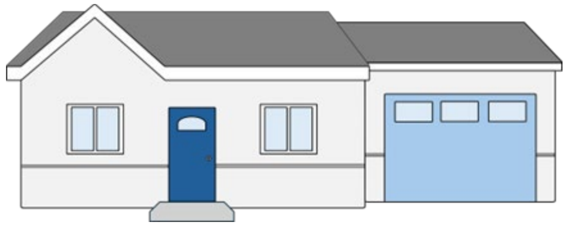
Source: California Energy Commission

Figure 9-6: ADU Type Addition Attached to Detached Unconditioned CFA



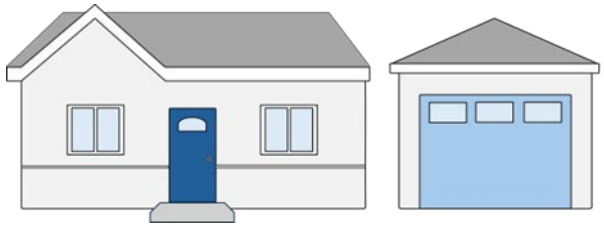
Source: California Energy Commission

Figure 9-7: ADU Type Addition Converting Attached Unconditioned CFA to Conditioned CFA



Source: California Energy Commission

Figure 9-8: ADU Type Addition Converting Detached Unconditioned CFA to Conditioned CFA



Source: California Energy Commission

Figure 9-9: ADU Type Alteration to Existing Attached Conditioned CFA

Source: California Energy Commission

Figure 9-10: ADU Type Alteration to Existing Detached Conditioned CFA

Source: California Energy Commission

HVAC

When adding an attached ADU to an existing home, the Mechanical Code does not allow return air from one dwelling unit to be discharged into another dwelling unit through a shared heating or cooling system (CMC 311.4). Systems without ducts are an option.

A system serving an ADU must have its own thermostat. Heating systems must be capable of maintaining 68 °F at a point three feet above the floor and two feet from the exterior walls in habitable rooms. Heating and cooling load calculations will need to be provided per Title 24, Part 6, Section 150.2(a)1E to verify that any existing and/or new system is properly sized. For additions, per section 150.2(a)1E, the envelope leakage specified in the load calculation shall be no greater than the values shown in Table 150.2-C. There is an exception to this requirement if leakage is established through field verification and diagnostic testing following procedures specified in Reference Residential Appendix RA3.8, the tested envelope leakage value may be used in the load calculations and no disclosure is required. Any addition that adds a new dwelling unit must meet all applicable IAQ ventilation requirements of Sections 150.0(o)1C, except for additions that are JADUs (defined above). A detached ADU must meet all applicable IAQ ventilation requirements of Sections 150.0(o)1C. An attached ADU must also meet all requirements if the dwelling units do not share a floor or ceiling. The whole house ventilation airflow is to be based on the square footage of the new dwelling unit.

Local exhaust for bathrooms and kitchens is required for any addition. See Table 9-6: HVAC Requirements for Prescriptive Additions for a more detailed summary of prescriptive HVAC system requirements for additions.

Photovoltaics (PV)

Solar electricity generated by photovoltaics (PV) is not required if the ADU is an addition. PV is required for detached, newly constructed ADUs.

Example 9-4

An existing single-story residence has a 600 ft² attached unconditioned storage room that the owner plans to turn into an accessory dwelling unit. The existing uninsulated walls have 2x6 wood framing, and the owner plans to keep the existing exterior siding. For prescriptive compliance, what wall insulation is required in the proposed ADU?

Answer:

The proposed ADU is considered an addition for Title 24, Part 6. The existing 2x6 walls can be insulated with R-21 cavity insulation (Section 150.2(a)1Bvi) for prescriptive compliance. Continuous insulation is not required for these walls.

Example 9-5

Question:

Can the ADU in the previous example get energy compliance credit using ECC-Verification of existing conditions for performance method compliance?

Answer:

No. Existing walls in newly conditioned spaces are considered "new" for the purposes of the Energy Code since the walls enclose the building envelope around newly conditioned space. ECC-Verification of existing conditions is only applicable to "altered" components, which would not apply to parts of the building envelope that do not enclose existing conditioned space.

Example 9-6

Question:

In the ADU in the previous example, is solar electricity generated by PV required for prescriptive or performance method compliance?

Answer:

No, PV is not required for Title 24 energy compliance for additions using any compliance approach.

Example 9-7

Question:

The existing residence in the previous example has a ducted forced-air furnace with a central return and enough heating capacity to heat the existing residence and the new ADU. The proposed alteration is to extend the existing ductwork to serve the ADU. Is this allowed for code compliance?

Answer:

No. The California Mechanical Code does not allow return air from an existing forced-air system to be discharged into another dwelling unit through the heating or cooling system. Therefore, the existing ducted furnace may not serve the existing home and the proposed ADU.

Example 9-7a

Question:

When modeling a conversion of an existing garage to an accessory dwelling unit (ADU), and also making an addition to the existing house, can this be modeled together using the existing plus addition plus alteration approach?

Answer:

Yes. In this scenario, the existing home, addition, and ADU must be modeled as separate zones.

Example 9-7b

Question:

When converting existing conditioned space, like a conditioned basement, into an ADU or junior ADU, is this an addition?

Answer:

No. This is considered an alteration. Energy Code requirements may be triggered if altering a component which is covered by the Energy Code. Some examples of alterations that are covered by the Energy Code are newly installed water heaters or mini-split HVAC systems, lighting upgrades, changes to the building envelope, etc.

Example 9-8a

Question:

A new 1200 square feet (sq. ft.) detached garage is being proposed in climate zone 15. It is being proposed as conditioned space. There is not external shading to the roof. Do Prescriptive Solar PV requirements apply to this building?

Answer:

Yes. Per equation 150.1-C, the project is prescriptively assessed 1.87 kW of PV. [(1200 sq. ft. X 1.560)/1000 + (0 DU’s x 1.47)= 1.87 kW. The project will require solar PV unless compliance can be achieved without PV using the Performance path. Exception 2 does not apply since this calculation exceeds 1.8 kW.

Example 9-8b

Question:

A newly constructed detached duplex of ADUs is being constructed in climate zone 1. The roof is fully exposed. The total conditioned floor area is 500 square feet (250 square feet for each ADU). Does this project prescriptively require PV?

Answer:

Yes. Per equation 150.1-C, the project is prescriptively assessed 2.86 kW of PV. [(500 sq. ft. X 0.793)/1000 + (2 DU's x 1.27)= 2.86 kW. The code specifies that this equation is assessed on the building, and not on the dwelling units in that building individually. The project will require solar PV unless compliance can be achieved without PV using the Performance path. Exception 2 does not apply since this calculation exceeds 1.8 kW.

Example 9-8c

Question:

A newly constructed detached duplex of ADUs is being constructed in climate zone 1. The total conditioned floor area is 500 sq. ft. (250 sq. ft. For each ADU). The low-sloped roof is shaded by nearby trees and combined with fire clearances, has a remaining Solar Access Roof Area of 125 sq. ft. Does this project prescriptively require PV?

Answer:

No. Per equation 150.1-C, the project is prescriptively assessed 2.94 kW of PV. [(500 sq. ft. X 0.793)/1000 + (2 DU's x 1.27)= 2.94 kW. The Solar Access Roof Area is assessed 1.75 kW (125 sq. ft. X 14 W/sq. ft.). The PV requirement assessed under section 150.1(c)14 is the smaller of the assessment using Equation 150.1-C and the SARA assessment, which is 1.75. Exception 2 applies since this calculation is less than 1.8 kW.

Example 9-9

Question:

An ADU is being created out of an existing detached 400 sq. ft. garage. What Prescriptive Indoor Air Quality fan requirements apply to the project?

Answer:

Only if the project qualifies as a Junior Accessory Dwelling unit., Section 150.2(a)1C indicates that IAQ fan requirements do not Prescriptively apply. Section 150.2(c) does require mechanical ventilation for "New dwelling units that are additions to an existing building," regardless of added floor area.

Prescriptive Approach and Mandatory Requirements

The prescriptive requirements apply to additions in the same way they apply to new buildings and must be documented on the certificate of compliance.

Except as noted, all applicable prescriptive requirements for additions must be met when using the prescriptive approach. Otherwise, the building must comply using the performance approach.

For prescriptive additions, a certificate of compliance (CF1R-ADD-01-E, CF1R-ADD-02-E, or CF1R-NCB-01-E) form must be completed and submitted for permit. If any mandatory or prescriptive features require ECC-Verification or testing or both, the certificate of compliance for the project must be completed and registered online using an ECC-Provider's residential data registry before submittal to the enforcement agency. Refer to Chapter 2 Design Phase and Chapter 2 ECC Field Verification and Diagnostic Testing.

Prescriptive Additions

There are three prescriptive paths available for additions based on the total conditioned floor area (CFA) of the addition. The total CFA of the addition may include floor areas representing several physically separate additions to the building under the same permit. Table 9-1: Envelope Roof/Ceiling Requirements for Prescriptive Additions through Table 9-6: QII Requirements for Prescriptive Additions summarize the key features of the prescriptive envelope requirements for the three prescriptive addition options in Section 150.2(a)1.

The prescriptive requirements for additions are listed in Section 150.2(a)1. Unless noted below, the newly constructed building prescriptive requirements contained in Section 150.1(c) also apply.

Additions (all sizes)

- Extensions of existing wood-framed walls (Figure 9-2: Wall Extension to the Left and not a Wall Extension to the Right) may retain the dimensions of the existing walls and require the following cavity insulation:
  - In 2x4 wood-framed walls, insulation shall be R-15.
  - In 2x6 or greater wood-framed walls, insulation shall be R-21.
- Existing wood-framed walls, where existing exterior siding (or cladding) will not be removed, do not need continuous insulation, and require only cavity insulation:
  - In 2x4 wood-framed walls, insulation shall be R-15.
  - In 2x6 or greater wood-framed walls, insulation shall be R-21.
- Ceiling insulation of R-38 in Climate Zones 1,2,4 and 8-16, or R-30 in climate zones 3 and 5 – 7. For cathedral ceilings, R-38 is required in all climate zones.
- Radiant barrier in climate zones 2 – 15.
- The prescriptive maximum U-factor requirement for windows is 0.27 in climate zones 1 – 5, 11 – 14, and 16. For climate zones 6 – 10 and 15 the U-factor requirement is 0.30. For homes 500 ft^2 or less, the U-factor requirement is 0.3 in climate zone 5.

Additions ≤ 400 square feet:

- Total glazing area up to 75 ft2 or 30 percent of the conditioned floor area, whichever is greater.
- QII does not apply.
- Rafter roof insulation of R-22.

Additions > 400 square feet and ≤ 700 square feetft2:

- Total glazing area up to 120 ft2 or 25 percent of the conditioned floor area.
- Total glazing area maximum for west-facing glazing is 60 ft2 or 5 percent in Climate Zones 2, 4, and 6-15.

- QII does not apply.
- Rafter roof insulation of R-22.

Additions > 700 square feet:

- Total glazing area up to 175 ft2 or 20 percent of the conditioned floor area, whichever is greater.
- Total glazing area maximum for west-facing glazing is 70 ft^2 or 5 percent in Climate Zones 2, 4, and 6-15.
- Alterations that add fenestration area of shall have a Maximum SHGC value of 0.23 in Climate Zone 15
- QII applies to the addition.
- When an addition is an existing unconditioned space converted to conditioned space, the QII requirements do not include:
    - Window and door header insulation.
    - Air sealing if the existing air barrier is not removed or replaced.

Example 9-8

Question:

I am retrofitting an existing home that includes an 800 square foot addition. Part of this addition includes converting a 400 square foot unconditioned garage to conditioned space and adding a 400 square foot bedroom above the garage. If complying prescriptively, is QII required for this addition?

Answer:

Yes. Because this addition, including the conversion of the garage, is greater than 700 ft2, QII is prescriptively required. If the existing walls of the garage are remaining and the exterior cladding is not being removed, the QII insulation requirements for window and door headers in the garage walls and QII air-sealing requirements are not required. For all new walls and walls that are being replaced, all aspects of QII must be met. If the performance method is used for compliance, the QII requirements can be traded off with other efficiency features to meet compliance. The prescriptive wall insulation requirements for existing wood framed walls in the garage are R-15 in 2x4 framing and R-21 in 2x6 framing.

Example 9-9:

Question

A small addition of 75 square feet is planned for a house in climate zone 7. An existing porch is being enclosed by extending the existing 2x4 wood-framed walls. The existing heating and air-conditioning system will serve the new conditioned space, including an extension of less than 25 linear feet of new ducts. The contractor wants to follow the prescriptive requirements. What requirements apply?

Answer:

Because the addition is smaller than 400 ft^2, the total fenestration area is limited to a maximum of 75 ft^2, and west-facing fenestration area is limited to 60 ft^2. The fenestration must meet the prescriptive U-factor and SHGC requirements of Table 150.1- A, which are a maximum U-factor of 0.30 and a maximum SHGC of 0.23 in Climate Zone 7.

In climate zone 7, for an addition of this size, insulation requirements are R-30 ceiling insulation with radiant barrier in a ventilated attic, and R-19 floor insulation. The new 2x4 walls that are extensions of existing walls (Figure 9-1: Unconditioned Sunspace), require only R-15 cavity insulation. Any walls that are not extensions must have a maximum 0.065 U-factor. This can be achieved with a 2x4 wood-framed wall with R-15 cavity and R-4 continuous insulation. Since the addition is less than 300 ft2 there is no cool roof requirement.

Since existing heating and cooling equipment is used, that equipment does not have to meet the mandatory equipment efficiency requirements. Duct sealing requirements apply regardless of the length of ductwork extended to serve the addition. The existing duct system must be sealed and tested to have no more than 10 percent total leakage or 7 percent leakage to outside. Duct insulation requirements apply to any new ducts, which is R-6.0 minimum in unconditioned space, and the duct system must be sealed (Exception 4 to Section 150.2(a)). All other applicable mandatory requirements in Section 150.0(m) must be met.

Example 9-10

Question:

If I remove a window from the existing house and reuse this window in an addition to that house, does the relocated window have to meet the prescriptive requirements?

Answer:

Yes, if using prescriptive compliance, in which case the relocated window must be treated as a new window and must meet the U-factor and SHGC requirements of Section 150.1(c)3. If you use this existing window in the addition, you must use the actual or default U-factor and SHGC of the window in showing compliance. Therefore, meeting the prescriptive requirements may not be possible, and performance compliance may be the only option. Section

Relocated windows must also meet the maximum area-weighted average U-factor in

Section 150.0(q) with the Exception of up to 10 ft² or 0.5 percent of conditioned floor area, whichever is greater.

Example 9-11 Question:

For an addition alone, do the refrigerant charge requirements in Section 150.1(c)7A and fan airflow and watt draw measurements in Section 150.0(m)13 need to be met for existing air conditioners serving an addition?

Answer:

If existing equipment is used to serve the addition, the refrigerant charge, airflow, and watt draw requirements do not need to be met as specified by Exception 3 to Section 150.2(a). However, if the existing duct system is extended to serve the addition it must meet the duct insulation requirements and duct sealing requirements must be met (Exception 4 to

Section 150.2(a)). New ducts in unconditioned space also shall meet the prescriptive duct insulation requirements per Section 150.2(b)1Di.

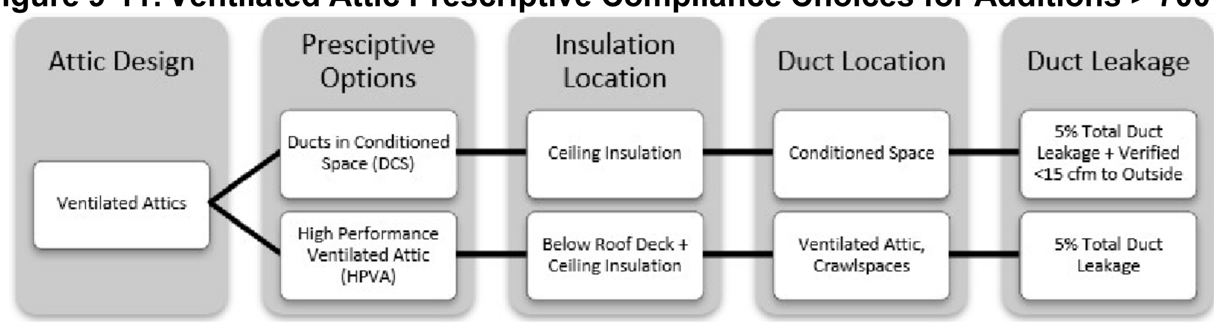
If a new system is installed to serve the addition, it must meet all the requirements for space conditioning in a new home which includes prescriptive refrigerant charge verification in all climate zones for heat pumps and in climate zones 2 and 8 – 15 for air conditioners. Additionally, mandatory fan airflow and watt draw testing in all climate zones.

Table 9-1: Envelope Roof/Ceiling Requirements for Prescriptive Additions

Component	Additions ≤ 400 ft^2	Additions > 400 and ≤700 ft^2	Additions > 700 ft$_2$
Roof/Ceiling Insulation	Ventilated attics in CZ 1, 2, 4, 8-16: R-38 Ventilated attics CZ 3, 5-7: R-30 Cathedral Ceilings in all CZ R-38	Same as ≤ 400 ft^2	Option B or C [C = require ducts and air handler to be in conditioned space] (see Table 9-3 below).
Roof Products (Cool Roof)	Steep Slope (≥2:12): CZ10-15: Reflectance = 0.20 and Emittance = 0.75; or SRI = 16 Low-Sloped (<2:12): CZ` 13&15: Reflectance = 0.63 and Emittance = 0.75; or SRI = 75 Exception: Additions ≤ 300 ft^2 exempt from cool roof requirements	Same as ≤ 400 ft^2	Steep-Sloped (≥2:12): CZ10-15: Reflectance = 0.20 and Emittance = 0.75; or SRI = 16 Low-Sloped (<2:12) CZ 13&15: Reflectance = 0.63 and Emittance = 0.75; or SRI = 75
Radiant barrier above attic	CZ 2-15: Radiant barrier above attic spaces. Does not apply to cathedral ceilings	Same as ≤ 400 ft^2	CZ 2-15: Radiant barrier above attic spaces except when complying with Option B (see Section 150.1(c)2)

Source: California Energy Commission

Figure 9-11: Ventilated Attic Prescriptive Compliance Choices for Additions > 700 ft^2



Source: California Energy Commission

Table 9-2: Roof and Ceiling Requirements for Prescriptive Additions

Component	Option B	Option C
Roof Deck Insulation	Below-deck insulation CZ 4, 8-16: R-19	No roof deck insulation required
Radiant Barrier	CZ 2-3, 5-7	CZ 2-15 vented attics
Roofing	Tile roof or other product with an air space	Tile roof or other product with an air space

Component	Option B	Option C
Ceiling Insulation	CZ 1, 2, 4, 8-16: R-38 CZ 3, 5-7: R-30	CZ 2-7,: R-30 CZ 1, 8-16: R-38 Cathedral Ceilings: R-38
Duct and Air Handler Location	Attic	Conditioned space

Source: California Energy Commission

Table 9-3: Envelope Door and Glazing Requirements for Prescriptive Additions

Component	Additions ≤ 400 ft²	Additions > 400 and ≤700 ft²	Additions > 700 ft²
Allowable total glazing area	Up to 75 ft² or 30% of conditioned floor area, whichever is greater	Up to 120 ft² or 25% of conditioned floor area, whichever is greater	Up to 175 ft² or 20% of conditioned floor area, whichever is greater
Allowable west-facing glazing area: CZ 2, 4, 6-15	Up to 60 ft²	Up to 60 ft2	The greater of 70 ft² or 5% of conditioned floor area in CZ 2, 4, 6-15
Glazing U-factor & SHGC[1]	CZs 1-4, 11-14 & 16: U=0.27 CZs 5-10 & 15: U = 0.30 CZ 2, 4 & 6-15: SHGC = 0.23	CZs 1-4, 11-14 & 16: U = 0.27 CZs 6-10 & 15: U = 0.30 CZ 5: U = 0.30 (≤500ft²) or 0.27 (>500ft²) CZ 2, 4 & 6-15: SHGC = 0.23	CZs 1-5, 11-14 & 16: U = 0.27 CZs 6-10 & 15: U = 0.30 CZ 2, 4 & 6-15: SHGC = 0.23
Opaque door U-factor	U = 0.20	U = 0.20	U = 0.20

1. See Section 150.0(q) and 150.1(c)3 for new and replaced window and skylight exceptions.

Source: California Energy Commission

Table 9-4: Envelope Wall/Floor Insulation Requirements for Prescriptive Additions

Component	Additions ≤ 400 ft²	Additions > 400 and ≤700 ft2	Additions > 700 ft2
Exterior framed wall[1] insulation	CZ 1-5, 8-16: U = 0.048 CZ 6-7: U = 0.065	Same as ≤ 400 ft2	Same as ≤ 400 ft2
Extension of existing wood-framed wall Or Existing wood-framed wall with exterior siding (or cladding) to remain	R-15 in 2x4 wood framing R-21 in 2x6 wood framing	Same as ≤ 400 ft2	Same as ≤ 400 ft2
Raised floor[1] insulation	All CZs: R-19 or U = 0.037	Same as ≤ 400 ft2	Same as ≤ 400 ft2
Slab floor[1] perimeter insulation	CZ 1-15: No requirement CZ16: R-7 or F = 0.58	Same as ≤ 400 ft2	Same as ≤ 400 ft2

1. See Table 150.1-A and 150.1-B for requirements for non-framed walls including mass walls

2. R-values refer to wood framing, and U-factors refer to metal framing.

Source: California Energy Commission

Table 9-5: QII Requirements for Prescriptive Additions

Component	Additions ≤ 400 ft²	Additions > 400 and ≤700 ft²	Additions > 700 ft²
New structure	No requirement	Same as ≤ 400 ft²	All CZs: Required (Does not apply to any altered spaces)
Converting unconditioned to conditioned space	No requirement	Same as ≤ 400 ft²	Same as above except: Window and door header insulation Air sealing if the existing air barrier is not removed or replaced

Source: California Energy Commission

Table 9-6: HVAC Requirements for Prescriptive Additions

Component	Additions ≤ 400 ft²	Additions > 400 and ≤700 ft	Additions > 700 ft²
Ventilation cooling[1] (whole-house fan)	No Requirement	Same requirements as ≤400 ft²	Additions ≤ 1000 ft² – no requirement Additions > 1,000 ft2: CZ 8-14 - Required
Adding new space conditioning system(s)	All prescriptive requirements	Same requirements as ≤400 ft²	All except requirement for ducts in conditioned space[2]
Replacing existing space conditioning system(s)	All prescriptive requirements	Same requirements as ≤400 ft²	All except requirement for ducts in conditioned space[2]
Adding all new complete duct system(s)	All prescriptive requirements	Same requirements as ≤400 ft²	All except requirement for ducts in conditioned space[2]
Extending existing duct system(s)	All duct insulation, duct system sealing, and ECC verification	Same requirements as ≤400 ft²	All duct insulation, duct system sealing, and ECC verification, Except requirements for ducts in conditioned space[2]

1. (Note: also, mandatory mechanical ventilation per ASHRAE 62.2 with ECC-Verification for additions > 1,000 ft²)

2. For more information about ducts in conditioned space, see Section 3.5.3.5.

Source: California Energy Commission

Water Heating System

If an addition increases the number of water heaters serving a dwelling unit, the addition can comply prescriptively if one of the conditions contained in Section 150.2(a)1Di-iv are met. If a heat pump water heater is being installed, there are mandatory requirements for venting the HPWH.

Alterations – Prescriptive/Mandatory Requirements

This section provides a road map and a few relevant summaries that identify the requirements unique to alterations. Envelope, mechanical, and water-heating system alterations 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 of approved compliance software is the alternative. This section describes the mandatory requirements for single-family residential buildings as they apply to additions and alterations. More information on the mandatory requirements can be found in Chapters 3, 4, 5, and 6. Note: Mandatory requirements are not incorporated explicitly as such but rather as requirements under both the Prescriptive and Performance pathways.

Residential lighting alterations need to meet applicable mandatory requirements. There are no prescriptive lighting requirements in residential buildings.

Although alterations must meet many of the same prescriptive requirements for newly constructed buildings and additions, there are several exceptions or special allowances for certain types of alterations.

Envelope Alterations

This section summarizes the requirements for many typical residential envelope alterations.

Table 9-7: Single-family Alterations Summary of Mandatory and Prescriptive Requirements

Envelope Alteration Type	Applicable Mandatory Requirements[1]	Summary of Relevant Prescriptive Requirements[2]	Exception(s) to the Prescriptive Requirements
Altered Ceiling	Ceiling w/ attic and roof rafters: R-19, U=0.054 Section 110.8/Exception to Section 150.0(a)2	R-49 (U=0.20) attic insulation: CZ 1-4, 6, 8-16 Recessed can lights covered with insulation to the same depth as the rest of the ceiling: CZ 1-4, 8-16 Air sealing: CZ 2,4,8-16 Min. attic ventilation: all CZs Section 150.2(b)1J	R-38 existing attic insulation. Asbestos or knob and tube wiring in the attic. Attic space is shared with another dwelling unit which does not have an altered ceiling. The above conditions exempt a project from all the prescriptive requirements. Other exceptions apply to individual requirements.

Altered rafter roof	R-19, U=0.054 Section 110.8/Exception to Section 150.0(a)2	N/A	N/A
Adding exterior framed wall insulation	In 2x4 framing: R-15, U=0.095 In 2x6 framing: R-21, U=0.069 Exception: 2x4 framing already insulated to R-11 (u-0.110) or greater per Section 150.0(c)1	N/A	N/A
Mass or Masonry walls above grade	Section See requirements under Table 150.1-A for Mass Walls	Meet 150.1(c) and Table 150.1-A CZ 1-15 Interior R-13 (U 0.077) Exterior R-8 (U0.125) CZ 16 Interior R-17 (U 0.059) Exterior R-13 (U 0.077	N/A
Mass or Masonry walls below grade	See requirements under Table 150.1-A for Mass Walls	Meet 150.1(c) and Table 150.1-A CZ 1-15 Interior R-13 (U 0.077) CZ 1-13 Exterior R-5 (U 0.20) CZ 14-15 R-10 (U 0.10) CZ 16 Interior R-15 (U 0.067) Exterior R-19 (U 0.053	N/A
Replacing > 50% of existing steep-sloped (≥2:12) roof surface, including adding a new surface	Section 110.8(i)	Cool Roof Requirements CZ 4, 8 - 15: Aged Solar Reflectance ≥0.20	(a) Building has ≥ R-38 ceiling insulation. (b) Building has a radiant barrier per

layer on top of existing exterior surface		and Thermal Emittance ≥0.75; or SRI ≥16 Section 150.2(b)1Ii	Section 150.1(c)2 (not over spaced sheathing). In CZ 2, 4, 9, 10, 12, & 14 no ducts in attic. >≥R-2.0 insulation above roof deck Roof area covered by building integrated PV or solar thermal panels. Roof constructions with a weight ≥25 lbs/ft^2.
Adding raised floor insulation	R-19 or equivalent U-factor Exception: Floors over controlled ventilation or unvented crawlspaces per Section 150.0(d)	N/A	N/A
Adding or replacing skylight[3]	Weighted average U-factor ≤0.40 Exception 1: Up to 20 ft^2 or 0.5% of conditioned floor area, whichever is greater, is exempt from the U-factor requirement of Section 150.0(q) Exception 3 to Section 150.0(q): Fenestration installed in buildings meeting Part 7 of the CBC CA WUI Code, where the building is located in Fire Hazard Severity	Must not exceed 20% total (all CZs) and 5% west fenestration area (CZ 2, 4, 6-15) with a U-factor of ≤ 0.27 in CZs 1-5, 11-14, 16 and ≤ 0.30 in CZs 6-10, 15); in CZ2, 4 & 6-15: SHGC ≤ 0.23 Section 150.2(b)1A	Section Replacement fenestration and skylights up to 16 ft^2 need not meet total fenestration and west-facing area requirements per Section 150.2(b)1A Exception 2. Replacement skylights must meet U-factor max 0.40 and SHGC max 0.30

	Zones or WUI Fire Areas.		
Replacing vertical fenestration[3] (altered glazing)	Weighted average U-factor ≤0.40 Exception 1: Up to 10 ft^2 or 0.5% of conditioned floor area, whichever is greater, is exempt from the U-factor Exception 3 to Section 150.0(q): Fenestration installed in buildings meeting Part 7 of the CBC CA WUI Code, where the building is located in Fire Hazard Severity Zones or WUI Fire Areas.	Must not exceed 20% total (all CZs) and 5% west fenestration area (CZ 2, 4, 6-15) with a U-factor of ≤ 0.27 in CZs 1-5, 11-14, 16 and ≤ 0.30 in CZs 6-10, 15: SHGC ≤ 0.23 Section 150.2(b)1A	Section Up to 75 sq. ft. with U factor of max 0.40 in CZ 1-16 and max SHGC of 0.35 in CZ 2, 4, and 6 through 15
Adding vertical fenestration[3] (new glazing) and greenhouse	Weighted average U-factor ≤0.40 Exception 1: Up to 10 ft^2 or 0.5% of conditioned floor area, whichever is greater, is exempt from the U-factor requirement of Section 150.0(q) Exception 2 to Section 150.0(q): For dual-glazed greenhouse or garden windows, up to 30 square feet of fenestration ara is not required to comply with the maximum U-factor requirement Exception 3 to Section 150.0(q):	Must not exceed 20% total (all CZs) and 5% west fenestration area (CZ 2, 4, 6-15) with a U-factor of ≤ 0.27 in CZs 1-5, 11-14, 16 and ≤ 0.30 in CZs 6-10, 15; in CZs 2, 4 & 6-15: SHGC =≤ 0.23 Section 150.2(b)1A	Added fenestration and skylights up to 16 ft^2 need not meet total fenestration and west-facing area requirements per Section 150.2(b)1A Exception 2.

	Fenestration installed in buildings meeting Part 7 of the CBC CA WUI Code, where the building is located in Fire Hazard Severity Zones or WUI Fire Areas.		

Alterations must comply with all applicable mandatory measures in Section 110.0 and Section 150.0 of the Energy Standards as explained in Chapters 3, 4, 5 and 6 of this manual, except as

1. Noted in Section 150.2(b).
2. Several prescriptive measures are climate zone (CZ) specific.
3. Replacement fenestration may include fenestration that is located in the same existing wall or roof in which the same or larger area of existing fenestration is being removed. This is labeled as “altered.” Any new fenestration area that increases the total net area of fenestration in any existing wall or roof is labeled as “new.”

Source: California Energy Commission

Replacing the Roof Surface or Roof Sheathing (Partial or Entire Replacement)
Please refer to Chapter 9.4.4.1 of the *2022 Single-family Residential Compliance Manual*.

Example 9-12

Question:

There is a Victorian building that has been converted into an office building and needs to have a shake roof replacement. This building has a vented unconditioned attic with the insulation on the ceiling. Would I need to meet Section 150.2(b)Hi?

Answer:

No, this section does not apply. The occupancy type has been changed to nonresidential. Since the Victorian building has a shake roof and is considered a steep-sloped roof,

Section 141.0(b)2Bib for nonresidential buildings would apply.

Example 9-13

Question:

What happens if I have a low-slope roof on most of the house but a steep-sloped roof on another portion? Do I have to meet two criteria for the new roofing products if using the Prescriptive approach?

Answer:

Yes. For roof replacements in climate zone 4 and 6 – 15, will need to meet the low-slope criteria for the areas with low slope when using the Prescriptive approach. The areas with the steep-slope roof will need to meet the steep-slope cool roof criteria for climate zones 4 and 8 – 15. Alternatively, you may use the Performance approach to evaluate other options.

Example 9-14

Question:

I am replacing my existing wood shake roof with asphalt shingles. Would this be considered a repair?

Answer:

No. A repair is defined as a reconstruction or renewal for maintenance of any component, system, or equipment of an existing building. A replacement of any component (i.e., roof-top), system, or equipment for which there are requirements in the Energy Code is considered an alteration and not a repair.

Example 9-15

Question:

If a radiant barrier is required for my addition, where does it need to be installed?

Answer:

The radiant barrier needs to be installed only on the underside of an attic roof assembly and the gable wall ends associated with the addition. See Residential Appendix 4.2.1

Example 9-16

Question:

I am considering reroofing my house. Under what conditions will I be required to put on a cool roof?

Answer:

Cool roof requirements are triggered when 50 percent or more of the roof area is being replaced. Prescriptive requirements are waived if one of the exceptions to Section 150.2(b)1H below applies:

Prescriptive Exceptions for Steep-Sloped Roofs

- Section Buildings have at least R-38 ceiling insulation.
- Buildings have an attic radiant barrier meeting the requirements of Section 150.1(c)2.
- Buildings have no ducts in the attic in climate zones 2, 4, 9, 10, 12, and 14.
- Buildings with R-2 or greater insulation above or below the roof deck.

Prescriptive Exceptions for Low-Sloped Roofs

- Aged solar reflectance and roof deck insulation R-value in Table 150.2-E are met. Alternatively, the building may show compliance using the performance approach.

Example 9-17

Question:

I am building a 450 ft² addition on my house. Do I have to meet cool roof requirements in the prescriptive package?

Answer:

Yes. Once the addition exceeds 300 ft2, if using prescriptive compliance is in a climate zone with a cool roof requirement, the roof must meet the requirements for the type of roof slope. To avoid the cool roof requirements for this addition, you may use the performance approach and trade-off against other energy efficiency features of the addition alone or the existing building by using the Existing + Addition + Alterations approach.

Example 9-18

Question:

When doing a full roof replacement on a steep slope roof in climate zone 12 with a new integrated photovoltaic roofing product which includes active photovoltaic components and inactive filler pieces that are visually identical, does the roofing product need comply with the Energy Code requirements in Section 150.2(b)1 for Prescriptive compliance?

Answer:

Yes. The roofing product must comply with the Energy Code and be rated by the Cool Roof Rating Council. Only the active photovoltaic area of the roof is exempt from these requirements.

Insulating Existing Roof/Ceilings

Rafter Roofs and Unvented Attics

When a roof/ceiling surface is altered, if the space between framing members becomes accessible, the ceiling/roof is considered altered. Rafter roofs have a mandatory requirement of at least R-19 (U 0.054) per the Exception to Section 150.0(a)2 insulation is prescriptively required if indicated for that climate zone above and beyond the mandatory requirement described above.

Vented Attics

Attic insulation and air sealing prescriptive requirements in vented attics apply when the ceiling above a conditioned space is altered or when an entirely new duct system is installed in the vented attic. A ceiling may be considered altered under various conditions including when the existing attic insulation is replaced, new attic insulation is added, or the ceiling plane is replaced.

Most single-family homes in California contain vented attics. On hot days, a typical vented attic is hotter than outside and if poorly ventilated the temperature difference between the attic and outdoors can be substantial. In homes with little or no attic insulation, this temperature difference can result in significant total heat gain or loss through the ceiling. High levels of attic insulation and an air barrier at the ceiling is an important approach to minimize those gains and losses and result in considerable energy savings.

A common circumstance that results in the disruption of existing attic insulation occurs when a new duct system is installed in a vented attic. At minimum, existing insulation is moved to access certain areas and then replaced. Sometimes, insulation is disturbed and left unfixed. In cases where penetrations are added to the ceiling layer for new registers, air sealing is critical to limit gains or losses to and from the home. By requiring insulation improvements and proper air sealing at duct replacement, vented attics are addressed as a system saving energy and improving comfort for the occupant.

When an attic is altered or a new duct system is installed when the ductwork and air handler are located in that attic, there are four primary sets of requirements that must be met as listed below.

- Air seal the ceiling between conditioned spaces and the unconditioned attic.
- Insulate the attic floor over any conditioned spaces to R-49.
- Insulate over all recessed can lighting fixtures. Any recessed can lighting fixtures not rated for insulation contact (IC-rated) must be replaced with IC-rated fixtures or have a fire rated cover installed over the attic side of the fixture to allow for insulation to be installed over the fixtures.
- Ensure attic ventilation meets California Residential Code requirements in Section R806.

An ECC Rater is not required to verify any of these prescriptive requirements. All requirements will be verified by an official from the building department.

The first three options above may or may not be required depending on climate zone and the existing attic insulation level. For projects that are subject to all or a portion of these requirements, the first step is to identify which requirements apply. Table 9-8: Altered Attic Requirements by Climate Zone below summarizes when these prescriptive requirements apply.

Table 9-8: Altered Attic Requirements by Climate Zone

Climate Zones	Building with < R-19 existing attic insulation	Building with ≥ R-19 existing attic insulation
5, 7	Attic ventilation only1	Attic ventilation only
6	R-49, attic ventilation	Attic ventilation only
1, 3	R-49, recessed cans, attic ventilation	Attic ventilation only
2, 4, 8-10	R-49, recessed cans & air sealing, attic ventilation	R-49, attic ventilation
11-16	R-49, recessed cans & air sealing, attic ventilation	R-49 & recessed cans, attic ventilation

1. Mandatory minimum R-19 insulation requirements still apply if the ceiling is being altered.

Source: California Energy Commission

If any of the following four conditions are met, the project is exempt from all of the four requirements:

- Existing attic insulation of R-38 or better.
- Alteration directly causes the disturbance of asbestos located in the ceiling, attic, or ductwork and remediation of asbestos is not being done as part of the scope of work.
- Knob and tube wiring located in the attic, which is not being removed as part of the scope of work.
- Altered attic space is shared with other dwelling units whose attic space is not considered altered.

If any of the exceptions are being claimed the existing conditions must be documented on the Certificate of Compliance which can be completed and signed by the homeowner, contractor, energy consultant, or any other party taking responsibility for the documentation. The existing conditions will be verified by the building official.

Below is additional detail on each of the four prescriptive requirements.

Air Sealing

In Climate Zones 2, 4, and 8 through 16, where existing attic insulation is less than R-19, all accessible areas of the attic floor between the attic and the conditioned space must be air sealed (see Table 9-9: Attic Air Sealing Requirements by Climate Zone). Homes with atmospherically vented space heating or water heating combustion appliances located inside the building pressure boundary are exempt from this requirement. This exception does not cover combustion appliances located in a vented attic, garage, or crawlspace.

Table 9-9: Attic Air Sealing Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
1, 3, 5-7	No requirement	No requirement
2, 4, 8-10	Yes	No requirement
11-16	Yes	No requirement

Source: California Energy Commission

Most air sealing can be completed with caulking or foam. Areas where large holes exist, such as at soffits and dropped ceilings, may require an air barrier to be installed if not already in place. Areas that present sources of air leakage that should be inspected when sealing the attic include:

- Soffits, dropped ceilings, and chases connected to conditioned space
- Gaps around chimneys and combustion venting
- Along the top plate
- Electric and plumbing penetrations
- Ceiling mounted duct boots
- Ceiling mounted exhaust fans and exhaust ducts
- Attic hatches
- Knee walls
- Recessed lighting fixtures

Recessed Can Lighting

In climate zones 1 – 4 and 8 – 16 any recessed can fixtures in the ceiling shall be covered with insulation to the same depth as the rest of the attic floor. Fixtures not rated for insulation contact must be replaced or retrofitted with a fire-proof cover that allows for insulation to be installed directly over the cover. Homes in climate zones 1 – 4 and 8 – 10 with existing attic insulation of R-19 or greater are exempt from this requirement. Table 9-10: Recessed Can Lighting Requirements by Climate Zone summarizes the recessed can lighting requirements by climate zone and existing insulation value.

Table 9-10: Recessed Can Lighting Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
5-7	No requirement	No requirement
1-4, 8-10	Yes	No requirement
11-16	Yes	Yes

Source: California Energy Commission

For recessed can fixtures to be directly covered with insulation the fixtures must be rated for Insulation Contact (IC). Fixtures that are IC rated usually have an Underwriters Laboratory (UL) sticker or stamp on the inside of the housing that says "IC" in some form. The lamp will likely need to be removed to properly view the housing. If the housing has slits or holes in it, it is not IC rated. If it cannot be determined whether a fixture is IC rated or not, it should be assumed that it is not. Recessed cans that are not IC rated present a serious fire hazard if they are surrounded by any flammable material because of the heat generated by the fixture. In these cases, the fixtures must be dammed to maintain separation between them and the attic insulation. This results in areas of the attic floor with minimal or no insulation where heat gains and losses are high, contributing to degraded insulation performance across the entire attic.

When present, older recessed can lighting can be a significant contributor to air leakage through a ceiling plane. Existing recessed cans typically are not airtight, and their perimeter can present a path for conditioned air to flow into the attic or unconditioned attic air to enter the conditioned space below. In addition to an IC rating, recessed can fixtures can also be rated to be "Airtight". This prescriptive standard does not require that existing fixtures be airtight. However, if existing recessed fixtures are being entirely replaced with new luminaires, the requirements of Section 150.0(k)1C must be met which requires the fixtures be certified as airtight with air leakage tested in accordance with ASTM E283 to be less than 2 cfm at 75 Pascals. Existing fixtures that are IC rated but not airtight can be retrofit with a retrofit trim kit which provides an airtight enclosure. Recessed cans that are not IC or AT rated may be replaced with IC rated housing units designed for retrofit applications.

In some cases, a fire-rated attic recessed light cover, shaped as domes or boxes, can be installed over the fixture allowing for insulation to be installed directly up to and over the cover. The recessed can fixture must have a thermal switch, which disconnects the electricity to the light if the temperature exceeds unsafe levels. The covers are to be installed over existing fixtures and sealed around the perimeter to the ceiling floor.

Products that act as dams for the can lighting but do not allow insulation to cover the area over the fixture are not acceptable for meeting these prescriptive requirements. If it cannot be determined whether the fixture has a thermal switch, assume that it is does not, and a fire-rated recessed light cover cannot be used.

Projects using the Performance compliance must meet the requirements specified in the CF1R-PERF.

Attic Insulation

Please refer to Chapter 9.4.4.2 of the *2022 Single-family Residential Compliance Manual*.

Attic Ventilation

When any work is conducted in an existing attic, ventilation is required to be reviewed and altered as necessary to ensure compliance with current code requirements per the California Building Code. Ventilation allows the natural flow of air that removes accumulated warm air and moisture from the attic. The relevant requirements that usually need to be addressed from Title 24, Part 2.5 Section R806 are listed below.

- A minimum net free ventilating area of 1/150 of the area of the attic space. This can be reduced down to 1/300th of the area of the attic if ventilation openings are equally distributed within 3 ft of ridgeline (or highest point) and in the bottom 1/3rd of the attic space.
- Ventilation openings shall be no smaller than 1/16" and no greater than 1/4".
- Ridge baffles should be installed when ceiling insulation is next to eave or soffit vents. The baffles should be placed at the top plate to direct ventilation air up and over the ceiling insulation. It is important to ensure the baffle extends sufficiently beyond the height of the ceiling insulation so as not to disturb the insulation.

Example 9-19

Question

I want to improve the performance of my existing vented attic and add attic insulation. The existing insulation is only about 3 inches deep. Is there a minimum insulation level that I must meet? Are there other requirements that apply to my project?

Answer:

For Prescriptive compliance, in climate zones 1 – 4, 6, and 8 – 16, a minimum of R-49 insulation shall be installed at the ceiling level or a weighted U-factor of 0.020 shall be achieved. In climate zones 5 and 7 only the mandatory minimum R-19 ceiling insulation must be met. Additionally, air sealing of all accessible areas between the attic and conditioned space is required in climate zones 2, 4, and 8 – 16 . The air sealing should be performed in accordance with Section 110.7. In climate zones 1 – 4 and 8 – 16 any existing recessed lights must be rated for insulation contact or retrofitted with a fire-proof cover that allows for insulation to be installed directly over the cover. In all climate zones, if attic ventilation does not meet California Building Code requirements it must be increased to meet current code. There are exceptions for various existing conditions.

Example 9-20

Question:

What if I have an atmospherically vented water heater inside a closet in my house?

Answer:

If space heating or water heating combustion appliances that are atmospherically vented are located inside the pressure boundary of the home, the project is exempt from the air sealing requirement. The other requirements still apply based on climate zone.

Example 9-21

Question:

What if my existing ceiling insulation is R-19?

Answer:

With an existing minimum insulation level of R-19, in climate zones 1, 3, and 5 – 7 none of the attic insulation, air sealing, or insulation covering recessed can requirements apply. In climate zones 2, 4, and 8 – 16 projects are only required to meet the insulation and attic ventilation requirements and are exempt from the air sealing and insulation covering recessed can requirements.

Example 9-22

Question:

What if my existing ceiling insulation is R-38?

Answer:

The project is exempt from all the prescriptive requirements.

Example 9-23

Question:

I am installing two new recessed can fixtures in my kitchen, do I have to meet the prescriptive attic insulation and air sealing requirements for an altered ceiling?

Answer:

No, this is a lighting alteration and does not constitute a ceiling alteration. The new recessed can fixtures must meet the requirements of Section 150.0(k).

Example 9-24

Question:

I am installing a new duct system in my vented attic, but I have asbestos insulation and knob and tube wiring, am I required to insulate and air seal my attic?

Answer:

No, the project is exempt from all the prescriptive requirements if either asbestos or knob and tube wiring is in the vented attic where work is being conducted. If asbestos abatement is occurring to remove asbestos on existing ductwork, and no other exceptions exist, then the prescriptive requirements still apply.

Fenestration and Doors

Replacement Fenestration

Please refer to Chapter 9.4.4.3 of the *2022 Single-family Residential Compliance Manual*.

New Fenestration in Alterations

Please refer to Chapter 9.4.4.3 of the *2022 Single-family Residential Compliance Manual*.

Greenhouse Windows

Greenhouse or garden windows are special windows that project from the façade of the building and are typically five-sided structures. An NFRC-rated U-factor for greenhouse windows is typically high and may not meet the mandatory requirements in Section 150.0(q) for the fenestration U-factor of 0.40.

To meet this mandatory requirement, greenhouse windows:

- Must have a maximum U-factor of 0.40 or better; or
- Must use the area-weighted average for all new and replacement fenestration with a combined mandatory maximum of 0.40 U-factor as per Section 150.0(q); or
- Must meet the Exception 1 to Section 150.0(q) for up to 10 ft2 or 0.5 percent of CFA, whichever is greater.
- Must meet the Exception 2 to Section 150.0(q) for buildings meeting Part 7 of the CBC, California WUI Code.

Exterior Doors

Please refer to Chapter 9.4.4.3 of the *2022 Single-family Residential Compliance Manual*.

Labeling, Certification, and Other Mandatory Requirements

Please refer to Chapter 9.4.4.3 of the *2022 Single-family Residential Compliance Manual*.

Example 9-25

Question:

An alteration in climate zone 12 is to move an existing 25 ft2 window to another location within the same existing wall. What prescriptive requirements does the relocated window need to meet?

Answer:

Removing glazing from an existing wall and reinserting up to the same area of glazing in a different opening is an alteration, covered by Section 150.2(b)1B. Exception 1 to Section 150.2(b)1B states that up to 75 ft2 of vertical replacement fenestration is allowed to meet a prescriptive requirement of 0.40 U-factor in all climate zones and 0.35 SHGC in climate zones 2, 4, and 6 – 15.

Example 9-26

Question:

For additions and alterations that include a greenhouse window (also known as garden window), how do I measure the fenestration area? What U-factor and SHGC requirements apply to a greenhouse window?

Answer:

The area of a greenhouse windows is the rough opening in the wall.

The default U-factor for greenhouse windows does not meet the mandatory maximum fenestration U-factor of 0.40 (there is no mandatory SHGC requirement). A metal-framed greenhouse window from Table 110.6-A has a 1.40 U-factor and the default SHGC from Table 110.6-B is 0.73 (for fixed, clear glass). By comparison, fenestration in prescriptive additions has to meet the prescriptive U-factor of 0.30 for all climate zones and an SHGC of 0.23 in all climate zones except 1, 3, 5, and 16, which have no SHGC requirement.

There are two options to meet the mandatory U-factor requirement: (1) up to 30 ft2 is exempt (Section 150.0[q], Exception 2), and (2) a weighted-average U-factor with other fenestration products is allowed.

For alterations, Exception 1 to Section 150.2(b) allows any dual-pane greenhouse window to meet the prescriptive U-factor requirement . This makes it possible for greenhouse windows to comply as part of a prescriptive alteration if there is no SHGC requirement (Climate Zones 1, 3, 5, and 16).

For climate zones with an SHGC requirement, if other windows are being altered, a weight-average SHGC may be calculated, or performance compliance is an option for achieving compliance. Compliance will likely depend on higher-than-average energy efficiency for some other components of the project to offset the poor performance of the greenhouse windows.

For other alternatives, see Chapter 3.

Example 9-27

Question:

An existing house in climate zone 12 has all single-pane windows. Most of the windows (300 ft2 total) will be replaced within existing openings. One existing 30 ft2 window is being replaced with a pair of 40 ft2 French doors. What requirements apply to this project?

Answer:

For prescriptive compliance, replacement fenestration (equal to or less than the area of existing windows in each wall being altered) and added fenestration area must meet the U-factor (0.30 in climate zones 6 – 10, 15 or 0.27 in climate zones 1 – 5, 11 – 14, 16) and SHGC (0.23 in climate zones 2, 4, 6 – 15) in Table 150.1-A. There are only 10 ft^2 of added fenestration, so the project meets Exception 1 to Section 150.2(b)1A and is not required to meet the prescriptive total glazing area requirement. All installed fenestration also must meet applicable mandatory requirements in Section 110.6.

For performance compliance:

- Using the Existing + Alterations approach *without* third-party verification, replacement fenestration that achieves the fenestration values in Table 150.2-D of the Energy Code is compared to those same values in the standard design. Replacement fenestration that does not reach these values is penalized.
- Using the Existing + Alterations approach *with* third-party verification, replacement fenestration that achieves the fenestration values in Table 150.2-D of the Energy Code is compared to Section Tables 110.6-A and 110.6-B default values for the existing fenestration condition. Replacement fenestration that does not reach these values is penalized.

Example 9-28

Question:

An existing building has all single-pane, metal-frame windows. A proposed remodel will replace all the windows; no other work is being done as part of the remodel. What applies?

Answer:

All replacement windows must meet the prescriptive requirements of Section 150.2(b)1B, and new fenestration must meet applicable mandatory requirements of Section 110.6, and 150.0.

If the prescriptive requirements cannot be met, the Existing + Alteration performance method can be used.

Example 9-29

Question:

An existing building has all single-pane, wood-framed windows. In addition to replacing more than 75 ft2 of window area, two double-pane, metal-frame greenhouse windows will be added. How should the greenhouse windows be shown to comply using the prescriptive standards?

Answer:

Greenhouse windows add conditioned volume but do not add conditioned floor area. There are three unique requirements (1) prescriptive SHGC, (2) prescriptive U-factor, and

(3) mandatory U-factor. Any dual-glazed greenhouse windows installed as part of an alteration must meet any SHGC requirements (0.23 or lower in climate zones 2, 4, 6 – 15, no requirement in other climate zones). While the prescriptive U-factor requirements do not apply (Section 150.2(b) Exception 1), all applicable mandatory requirements must be met. This includes Section 150.0(q), which requires a maximum weighted average U-factor of 0.40 or less. Exception 2 exempts up to 30 ft^2 from this requirement.

Water Heating Alterations

Please refer to Chapter 9.4.5 of the *2022 Single-family Residential Compliance Manual*.

Ventilation Requirements for Heat Pump Water Heater

Please refer to Chapter 9.4.5.1 of the *2022 Single-family Residential Compliance Manual*.

Trouble-shooting Water Heater Problems

If installing a recirculation system to reduce the long wait time for hot water, the only system type allowed in an alteration is a demand recirculation system with manual on/off controls. Any other alteration to the hot water distribution system, such as timer or temperature control recirculation systems, must be analyzed using the performance compliance approach to show that the energy use of the building has not been increased.

Another alternative is to install a natural gas or propane instantaneous (tankless) water heater closer to the fixtures having problems. Any other type of water heater may be installed as long as compliance is demonstrated using the performance compliance approach. When an additional water heater is installed as part of an addition, it must be a heat pump water heater meeting requirements 2 or 3 above. Additions 500 square feet or less may choose to install an electric water heater with point-of-use distribution per 150.2(a)1Diii

For more information on any of these requirements, see Chapter 5.

Example 9-30

Question:

I want to install a second water heater for an addition to a single-family home with an existing natural gas water heater. Does this comply?

Answer:

Yes, but it must be a heat pump water heater that complies with Section 150.2(a)1D. For small additions 500 square feet or less an electric water heater meeting certain conditions is also allowed. Otherwise, performance compliance may be used to demonstrate compliance.

Example 9-31

Question:

An existing 1,500 ft² single-family home is getting a 500 ft² addition. A new 50-gallon gas water heater will replace the existing water heating system. How do the water heating requirements apply?

Answer:

Because this is an alteration or replacement (Section 150.2[b]1H) of an existing water heating system, this proposed replacement meets the requirement of Section 150.2(b)1Hiiia.

For newly installed piping and existing accessible piping, all the applicable insulation requirements of Section 150.0(j)1 shall be met. If building energy compliance is achieved with the existing + addition + alterations calculation, the UEF or EF and other energy features of the altered water heating system are modeled in the performance method.

Example 9-32

Question:

An existing 2,000 ft² single-family house has one 50-gallon gas water heater, and a 600 ft² addition with a new instantaneous gas water heater is proposed. How does this comply?

Answer:

When there is an increase in the number of water heaters with an addition, the Energy Code allows addition-alone compliance in certain circumstances. An instantaneous gas water heater of 200,000 Btu/h or less is NOT one of those circumstances. A heat pump water heater must be used, or the performance method can allow for an alternate type of water heater. Compliance with applicable mandatory requirements is also needed.

The alternative to show compliance is by using the existing-plus-addition or whole- building compliance.

Example 9-33

Question:

An existing single-family home with one electric water heater has a 500 ft² addition with a 30-gallon electric water heater proposed. Does this comply with prescriptive addition requirements?

Answer:

Yes. When there is an increase in the number of water heaters with an addition, . Per 150.2(a)1Div, any electric resistance water heater for additions up to 500 ft2 is allowed.

Performance compliance may also be possible. The compliance software will adjust the simulated energy usage based on the use of electric resistance water heating.

Example 9-34: Alterations

Question:

If my house has an electric-resistance water heater and I plan to upgrade my water heater, do I need to install a gas instantaneous, gas storage water heater, or HPWH?

Answer

No, if the existing water heater is electric, then a consumer electric water heater that meets the requirements of California's Appliance Efficiency Regulations can replace the existing water heater. If installing new piping to the water heater, then you will need to comply with the mandatory pipe insulation requirements. See Chapter 5 for more information on pipe insulation requirement.

HVAC System Alterations

Please refer to Chapter 9.4.6 of the *2022 Single-family Residential Compliance Manual*.

Entirely New or Complete Replacement Space Conditioning Systems

A system installed in an existing dwelling as part of an alteration shall be considered entirely new when:

- 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 feet in length).

An entirely new or complete replacement must meet all applicable mandatory requirements and prescriptive requirements as described below (See Chapter 4 for details).

- Section 150.0(h)1-2: Cooling and heating load calculations.
- Section 150.0(h) 3: Outdoor condensing unit requirements.
- Section 150.0(h)4: Heating furnace temperature rise requirements.
- 150.0(h)5-9: System selection, defrost, supplemental heating, and third-party thermostat requirements
- Section 150.0(i): Setback thermostats or controlled by EMCS.
- Section 150.0(j)1-2: Pipe insulation.
- Section 150.0(m)1-10: Duct insulation, labeling, & damper requirements.
- Section 150.0(m)12: Air filtration requirements.
- Section 150.0(m)13: Static pressure probe, airflow, and fan efficacy requirements (or alternative return duct sizing as per Table 160.3-A and B).
- Section 150.1(c)7: Prescriptive refrigerant charge verification.
- Section 150.2(a)1E: Space-Conditioning Load Calculations and System Capacity.
- Section 150.2(b)1G: Electric resistance heating restrictions
- Table 150.2-A: Prescriptive duct insulation.

Altered Duct Systems

New ducts that are installed to replace or extend existing ducts must comply with the mandatory duct insulation, labeling and damper requirements of Section 150.0(m)1-10 (see Chapter 4 for details). When more than 25 feet of new ducts are installed, additional duct insulation and duct sealing and leakage testing requirements must be met, as described below.

New ducts installed in an unconditioned space must be insulated to a minimum R- value as described in Table 9-11: Duct Minimum R-Value.

Table 9-11: Duct Minimum R-Value

Climate Zone	3, 5 through 7	1, 2, 4, 8 through 16
Duct R-value	R-6	R-8

Source: California Energy Commission

The duct system must also be sealed by the installer and verified by an ECC-Rater as specified in RA3.1 (duct leakage test), regardless of whether the ducts are located in unconditioned space. The only exception is if the existing duct system contains asbestos.

- If the new ducts form an entirely new duct system, the measured duct leakage must be equal or less than 5 percent of the system airflow. The duct system must also meet the air filtration requirements, and the static pressure probe, airflow, and fan efficacy requirements (Section 150.0[m]12 and Section 150.0[m]13). If the air handler and ducts are located in a vented attic, then attic and air sealing requirements (Section 150.2[b]1J) apply, as described in Section 9.4.4.2. An entirely new duct system is having at least 75 percent of new duct material, and up to 25 percent of reused parts that must be accessible.
- If the new ducts (more than 25 feet installed) do not form an entirely new duct system, the measured duct leakage must be equal to or less than 10 percent of the system airflow, or the measured duct leakage to outside must be equal to or less than 7 percent of the system airflow. If it is not possible to meet either of these duct leakage targets (which must be performed first), then all accessible leaks must be sealed and verified through a visual inspection and a smoke test by an ECC-Rater.

Additionally, when altered ducts, air-handling units, cooling or heating coils, or plenums are located in a garage, the ducts must be the sealed by an ECC-Rater to a measured duct leakage of 6 percent or less of the system airflow. The alternative to this is having all accessible leaks located in the garage space sealed and verified through a visual inspection and a smoke test by an ECC-Rater. This requirement applies when any length of new ducts is installed (not limited to 25 feet of ducts).

When performing a visual inspection and smoke test, sampling is not allowed. The ECC-Rater must perform the inspection and test on every house. Some judgement is required in determining if ducts are accessible, where the local enforcement agency will have the final say when it is not immediately obvious.

Altered Space Conditioning Equipment

New space conditioning equipment that is installed, typically as equipment replacements, must comply with the applicable mandatory requirements for the new equipment (See Chapter 4 for details).

Load calculations are sensitive to the selection of the envelope infiltration rate. When doing load calculations for additions, the designer often has to estimate the envelope leakage. If this value is set too high, the system may end up oversized. Per the Energy Code, for additions, the infiltration rate used in load calculations cannot be greater than the values shown in Table 150.2-C ("average" for many load calculation software tools). However, if leakage is established through field verification and diagnostic testing (e.g., with a blower door test), the tested envelope leakage value may be used in the load calculations (Section 150.2(a)1E).

When used for the purpose of system sizing, for additions, block loads (the total load for all rooms combined that are served by the central equipment) may be used (Section 150.0(h)5).

In additions and alterations where airflow is field verified to be at least 350 cfm/ton, there is no limit on the maximum capacity of systems. Where airflow is NOT field verified to be at least 350 cfm/ton, maximum capacity limits are provided in Tables 150.2-A and B that depend on the relative sizes of the calculated heating design load (HL) and cooling design load (CL), the type of space conditioning system, and the duct sizing. These requirements are summarized in Table 9-12: Capacity Limits for Additions and Alterations below (which, for completeness, also shows the minimum capacity, as described in 150.0(h)5). In this table, "Heating Dominated" is defined as an application (building construction and local climate) where the heating load exceeds the cooling load by more than 12 kBtuh. "Cooling Dominated" is defined as an application where the cooling load exceeds the heating load by more than 12 kBtuh (Section 150.2(a)1E).

Table 9-12: Capacity Limits for Additions and Alterations

	Minimum Capacity	Maximum Capacity, when Airflow is NOT field verified to be at least 350 cfm/ton
Heat Pumps		
Heating Dominated	HC≥HL	No Limit on HC or CC
Cooling Dominated	HC≥HL	CC≤CL+6 and HC≤HL+12
Highly Cooling Dominated	HC≥HL	CC≤CL+6
Other:		
Cooling Only Sys	No Limit on CC	CC≤CL+6
Furnace / Heating Only Sys	HC defined in Man S	HC≤HL+6

(HC = Heating Capacity, HL = Heating Load, CC = Total Cooling Capacity, CL = Total Cooling Load)

Source: California Energy Commission

In addition to these limits, the capacity at lowest speed for variable or multi-speed systems must be no more than 80 percent of design load for:

- Heating only systems.
- Cooling only systems.
- Heat pump heating capacity when HL is greater than CL.

- Heat pump cooling capacity when CL is greater than HL.

In addition, altering space conditioning equipment triggers duct sealing and leakage testing, and other requirements as described below.

The duct system connected to the altered equipment must be sealed by the installer and verified by an ECC-Rater as specified in RA3.1 under any of the following conditions:

- An air handler is replaced.
- 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.

The measured duct leakage must be equal to or less than 10 percent of the system airflow, or the measured duct leakage to outside must be equal to or less than 7 percent of the system airflow. If it is not possible to meet either of these duct leakage targets (which must be performed first), then all accessible leaks must be sealed and verified through a visual inspection and a smoke test.

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 an ECC-Rater.
- Duct systems with a total less than 40 feet of duct; and
- Duct systems that contain asbestos. See Blueprint Issue 130, Q&A: Residential Duct Testing.

Additionally, when altered ducts, air-handling units, cooling or heating coils, or plenums are located in a garage, the ducts must be the sealed by an ECC-Rater to a measured duct leakage of 6 percent or less of the system airflow. The alternative to this is having all accessible leaks located in the garage space sealed and verified through a visual inspection and a smoke test by an ECC-Rater. This requirement applies when any length of new ducts is installed (not limited 25 feet of ducts).

When performing a visual inspection and smoke test, sampling is not allowed. The ECC-Rater must perform the inspection and test on every house. Some judgement is required in determining if ducts are accessible, where the local enforcement agency will have the final say when it is not immediately obvious.

When a refrigerant-containing component of an air conditioner in climate zones 2 and 8 – 15 or heat pump in all climate zones is replaced or installed in an existing house,

Section 150.2(b)1F requires a system to have refrigerant charge field verified (RCV) in accordance with all applicable procedures specified in RA3.2.2, or RA1. When RCV is required for compliance, the system must also comply with the minimum airflow of 250 cfm/ton for small duct high velocity systems and 300 cfm/ton for all other systems, according to the procedures specified in RA3.3.

For all climate zones, when an existing system has a refrigerant containing component added or replaced the thermostat must be upgraded to a digital setback type that meets Section 110.2(c).

If the space heating system is being replaced, the replacement system must not use electric resistance as the primary heat source unless one of the following exceptions is met:

- The existing system is electric resistance, and the replacement system is not ducted.
- The existing system is electric resistance, and a ducted space cooling system is not being replaced or installed.
- The existing system is electric resistance and located in climate zone 7 or 15.

Example 9-35

Question:

Do I have to seal the ducts if I replace the outdoor units in my house without changing the indoor unit?

Answer:

Yes. Replacing the outdoor unit (or indoor unit) by itself will trigger the duct sealing and verification requirement. The alteration requirements differ from newly constructed building requirements. (See Section 150.2[b]1Ei through iii for the requirements and exceptions.)

Example 9-36

Question:

I have an existing electric furnace and I'm adding a new bedroom. Can I extend the existing ducts to the new room and use the existing furnace?

Answer:

Yes. If ducts are extended (of any length) from an existing space-conditioning system, compliance requires meeting the mandatory duct requirements, and the additional prescriptive duct insulation and duct sealing and leakage testing requirements. The existing furnace must also have adequate heating capacity to meet California Building Code requirements for the additional space.

Example 9-37

Question:

I am adding a bedroom to a house that has a central forced-air natural gas furnace. I would like to heat the room with an electric resistance baseboard heater rather than extend the existing ductwork to reach the new space. Is this allowed?

Answer:

Not using prescriptive compliance. This is only possible if using performance compliance and the relatively high energy consumption of the electric resistance heater is made up by reductions from other energy efficiency features in the addition or in an accompanying alteration.

Example 9-38

Question:

My central gas furnace stopped working. If I get a new efficient unit rather than repair the existing one, what are the requirements?

Answer:

The furnace must meet minimum efficiency requirements, but all systems sold in California should already meet the minimum efficiency requirements. If the new system includes mechanical cooling, and the existing thermostat is not a setback thermostat, it must be replaced with a setback thermostat (Section 110.2(c)).

All new ducts must meet insulation and construction requirements. All existing and new ducts must be sealed and ECC-Verified, as specified Section 150.2(b)1E.

Prescriptively, the new heating unit must be natural gas fueled or a heat pump

Example 9-39

Question:

As part of an upgrade in an existing house, one of the ducts is being replaced because of deterioration of the insulation. What requirements apply to the replacement duct?

Answer:

This is an alteration to the space-conditioning system. If more than 25 feet of the duct is altered, the requirements of Section 150.2(b)1D trigger diagnostic testing and ECC-Verification of the duct system, as well as the prescriptive duct insulation requirements.

Example 9-40

Question:

An upflow air-handling unit with a furnace and air conditioning coil is located on a platform in the garage of an existing house. The platform is used as a return air plenum. The air-handling unit is being replaced, and the platform is being repositioned to the corner of the garage (three feet away from the current location). What requirements apply to this alteration?

Answer:

The mandatory requirements apply to this alteration. In particular, Section 150.0(m) prohibits raised platforms or building cavities from being used to convey conditioned air (including return air and supply air). When the platform is relocated, it is being altered, and the mandatory requirement applies. Ducts made from sheet metal, duct board, or flexible ducts must be installed to carry the return air to the replaced air handler.

Since the air handler is being replaced the prescriptive duct sealing requirements of

Section 150.2(b)1D and E, which apply to ducts in garage spaces, would require either 6 percent duct leakage or a visual inspection and smoke test.

Example 9-41

Question:

What is meant by the term "air handler"?

Answer:

The term "air handler" is used to identify the system component that provides the central system forced-air movement for the ducted heating or cooling space-conditioning system. The term "air handler" may be properly used to identify various types of central system forced-air-moving components that must meet the functional requirements for different types of space-conditioning systems. For instance, a "gas furnace" air handler includes a gas combustion heat exchanger and the central system fan, but does not include a direct expansion (DX) cooling coil; an "electric furnace" air handler has electric heating coils and the central system fan, but does not include a DX cooling coil; a "fan-coil unit" air handler for a split system heat pump has a DX cooling/heating coil and a central system fan; a "hydronic heat pump" air handler includes the air-side DX coil, compressor, water-cooled condenser, and the central system fan. There are other air handler configuration variations as well.

Example 9-42

Question:

I have a residential building that was constructed in the 1920s. It has a freestanding gas furnace, and I want to change it to an electric wall heater. Is this permitted?

Answer:

No. Section 150.2(b)1Cii states that the new space-conditioning system be limited to natural gas, liquefied petroleum gas, or the existing fuel type. The only electric option is a heat pump.

Example 9-43

Question:

I am replacing only my heat pump equipment. What requirements apply for my duct system?

Answer:

When a space conditioning system is altered duct sealing requirements are triggered. If the ducts are not being replaced, the existing duct system needs to be tested by the installer and an ECC-Rater to have no greater than 10% total leakage or 7% leakage to outside. If this leakage criteria cannot be met, a smoke test and visual verification may be conducted by an ECC-Rater to verify that all accessible ducts have bene sealed.

Example 9-44

Question:

What are the duct sealing requirements if am I replacing or adding 20 feet or more of ducts located in my garage?

Answer:

When replacing or adding any length of ducts in garage spaces or altering any space conditioning equipment in a garage (including air-handling units, cooling or heating coils, or plenums) duct sealing requirements apply. Ducts must be tested by the installer and an ECC-Rater to have leakage less than or equal to 6% of air handler airflow. If this leakage criteria cannot be met, a smoke test and visual verification may be conducted by an ECC-Rater to verify that all accessible ducts have bene sealed.

Example 9-45

Question:

I am replacing an existing ducted electric resistance furnace and am installing central A/C, can I install another electric resistance furnace?

Answer:

In climate zones 1 – 6, 8 – 14, and 16 no. When replacing an existing ducted electric resistance furnace in these climate zones, the only time another ducted electric resistance furnace can be installed is when ducted air conditioning is not being replaced or installed new. Otherwise, a heat pump or gas or propane heating system is required. In climate zones 7 and 15 an electric resistance furnace may be installed in this case.

Question:

What if I am replacing baseboard electric heating in addition to adding a central A/C system?

Answer:

When the replacement heating system is ductless, such as with baseboard heating, this is allowed whenever the existing system is electric resistance.

Mechanical Ventilation for Additions and Alterations

Please refer to Chapter 9.4.7 of the *2022 Single-family Residential Compliance Manual*.

Additions

Please refer to Chapter 9.4.7.1 of the *2022 Single-family Residential Compliance Manual*.

Alterations

Please refer to Chapter 9.4.7.2 of the *2022 Single-family Residential Compliance Manual*.

Lighting for Additions and Alterations

Highlights of the residential lighting requirements are listed below. All residential indoor and outdoor lighting requirements are mandatory. Details of the 2025 Energy Code residential lighting requirements can be found in Chapter 6.

- Luminaire (light fixture) requirements, see Section 150.0(k)1 and Chapter 6
- Recessed downlight luminaires in ceilings, see Section 150.0(k)1C and Chapter 6
- Indoor lighting control requirements, see Section 150.0(k)2 and Chapter 6
- Residential outdoor luminaires and lighting controls requirements, see Section 150.0(k)3 and Chapter 6
- Internally illuminated address sign requirements, see Section 150.0(k)4 and Chapter 6
- Residential garages , see Section 150.0(k)5 and Chapter 6

Altered lighting and any newly installed lighting equipment are required to comply with the residential lighting standards, which apply to permanently installed lighting and associated lighting controls.

Only the lighting equipment that is altered needs to comply with the Energy Code. Existing lighting equipment is not required to be replaced to comply.

Example 9-46

Question:

I am remodeling and renovating my whole home and putting in an entirely new indoor lighting system. How does the Energy Code apply to the new lighting system?

Answer:

When an entirely new lighting system is installed, it is treated like required for a newly constructed building. The new indoor lighting system must meet the lighting requirements in Section 150.0(k)1 and 150.0(k)2.

If the remodeling includes any lighting in garages with eight or more vehicles, there are also applicable requirements in Section 150.0(k)5.

Example 9-47

Question:

I am doing minor renovations to my kitchen that has six recessed incandescent cans, and I am adding a new luminaire over the sink. How does the Energy Code apply to the new luminaire and the altered luminaires in this case?

Answer:

The new luminaire and the altered luminaires must meet the luminaire efficacy requirements of Section 150.0(k)1. Where existing screw base sockets are present in ceiling-recessed luminaires, removal of these sockets is not required provided that new JA8 compliant trim kits or lamps designed for use with recessed downlights or luminaires are installed.

Example 9-48

Question:

In the kitchen above, I am replacing one of the recessed downlight luminaires. Must the new downlight luminaire be high luminous-efficacy?

Answer:

Yes, newly installed luminaires must be high luminous-efficacy and meet the requirements in Section 150.0(k)1. Screw-based sockets are not permitted for newly installed recessed downlight luminaires in ceilings.

Example 9-49

Question:

I am replacing my incandescent bath bar in the bathroom. Must the new luminaire meet the Energy Code requirements?

Answer:

The new luminaire is the altered component and must meet requirements in Section 150.0(k)1 including the high luminous-efficacy luminaires and the lighting controls requirements. The 2025 Energy Code now allows the installation of Joint Appendix JA8-compliant lamps in screw-based fixtures as a way to comply with the high luminous-efficacy lighting requirements as long as the luminaire is not a recessed downlight in ceiling. See Chapter 6.

Performance Approach

Performance: Addition Alone

Please refer to Chapter 9.5.1 of the *2022 Single-family Residential Compliance Manual*.

Performance Method: Additions and Existing + Addition + Alterations Approach

Please refer to Chapter 9.5.2 of the *2022 Single-family Residential Compliance Manual*.

Existing + Addition + Alterations Without Third-Party Verification

Please refer to Chapter 9.5.3 of the *2022 Single-family Residential Compliance Manual*.

Existing + Addition + Alterations with Third-Party Verification

Please refer to Chapter 9.5.4 of the *2022 Single-family Residential Compliance Manual*.

Existing + Addition + Alterations as Newly Constructed Buildings

Please refer to Chapter 9.5.5 of the *2022 Single-family Residential Compliance Manual*.

Summary of Modeling Rules

Please refer to Chapter 9.5.6 of the *2022 Single-family Residential Compliance Manual*.

Example 9-50

Question:

A 1,600 ft² house built in 1980 in Climate Zone 12 is being renovated as follows:

- A 500 ft² room will be added, including 120 ft² of new windows.
- A 200 ft² wall and 100 ft² of old window will be removed.
- Attic insulation in the existing house will be upgraded to R-38.
- The addition will be connected to the existing HVAC and duct system.

If the performance approach is used to demonstrate compliance, how does the compliance software establish the standard and proposed designs?

Answer:

Under the performance rules, the removed wall and window are not included in the energy model and have no effect. The standard design for the added conditioned floor area is set using the prescriptive requirements of Section 150.1(c). If the existing duct system is extended by 25 linear feet or more, the standard design assumes duct alterations with 10 percent duct leakage requirements.

The standard design assumptions for the existing house follow the rules summarized in

Section 150.2(b)2 and Table 150.2-D based on whether there is third-party verification of the existing conditions. Without third-party verification, upgraded energy components in the existing house are modeled as fixed assumptions that represent reasonably expected levels of efficiency for each altered component. If optional third-party verification is selected for the components in the existing house that are to be upgraded, the standard design assumes the existing conditions specified by the software user. These features must be verified before construction begins and before application of the permit.

The standard design assumptions for the 500 ft2 addition is based on the features of

Section 150.1(c), Table 150.1-A.

The existing space conditioning system, as defined by the software user, is modeled in both the standard and proposed design. The duct system is made up of new ducts as an extension of the existing ducts.

Example 9-51

Question:

For the 1980 house in the examples above, an operable single-pane metal window is replaced with a 0.55 U-factor window. Does this alteration result in a compliance credit? How about the case where the existing window is replaced with a window that has a U- factor of 0.35?

Answer:

Altered components that receive compliance credit must exceed the requirements of Table 150.2-D. Windows in the addition must have a U-factor of ≤ 0.30 and SHGC ≤ 0.23 to receive credit (climate zone 12). Replacement windows in the existing house must have a U-factor of ≤ 0.40 and SHGC ≤ 0.35 to receive credit.

Adjustments will be made to energy usage to reflect window replacement with a 0.55 U-factor. **Without** third-party verification of existing conditions, a 0.35 U-factor window replacement will receive a credit compared with a 0.40 U-factor standard design assumption for that window. **With** third-party verification of existing conditions, either window replacement will receive a credit as compared with a 1.28 U-factor standard design assumption for an operable single-pane metal existing window.

Although this example describes a window alteration, the same principles apply to other building systems, such as other building envelope components, as well as HVAC and water-heating equipment.

Example 9-52

Question:

An addition of 590 ft² is being added to a 2,389 ft² single-family house. How do you demonstrate compliance using the Existing + Addition + Alterations method?

Answer:

The steps are the following:

- Collect accurate envelope and mechanical information about the addition and existing building from scaled drawings (plans, sections, and elevations); determine what components, (HVAC, ducts, water heating, etc.) are being altered as part of the permitted scope of work.
- Enter the information about the addition and the existing building into the compliance software program, identifying each modeled feature as "existing," "altered," or "new." Proper identification of these inputs is critical to correctly and accurately determining compliance.
- Run the compliance software to determine if the proposed building TDV energy is equal or less than the standard design TDV energy.
- If the project does not comply, modify the energy features of the addition and/or the existing building until compliance is achieved.
- If features of the existing building are being modified, consider the option of verifying existing conditions. When using this option, this inspection by an ECC-Rater must be completed before construction begins and before the project registration (Step 6) can be completed.
- All projects that include energy features requiring ECC field verification and diagnostic testing, which represent almost all buildings under the 2022 Energy Code, must be registered online with an ECC-Provider as explained in Chapter 2 in order to obtain a valid CF1R to apply for a permit.
- Attach the registered CF1R to the permit application submittal.

Example 9-53

Question:

When using the existing-plus-addition performance approach, do the mandatory requirements, including airflow, watt draw measurement, etc. (Section 150.0[m]13) need to be met for space-conditioning equipment serving an addition? What about the prescriptive requirement for refrigerant charge verification (or one of the alternatives to Section 150.1[c]7)?

Answer:

If existing equipment is extended to serve the addition, these space conditioning requirements do not need to be met as specified by Exception 4 to Section 150.2(a). However, Exception 5 to Section 150.2(a) requires a duct system that is extended be sealed, tested, and ECC-verified according to Section 150.2(b)1D.

If an entirely new or complete replacement system is installed to serve the addition, it must meet the requirements of Section 150.2(b)1C. When the new equipment is designed to serve the existing house and the addition, it is an alteration and must meet the requirements of Section 150.2(b). The duct sealing, testing, and verification requirements of

Section 150.2(b)1E must also be met. Refrigerant charge verification is not a mandatory requirement. However, if the project is in Climate Zone 2 or 8-15 or if the HVAC system is a heat pump, the energy usage simulated in compliance software will be adjusted to if refrigerant charge verification is not modeled.

Example 9-54

Question:

When using the E+A+A performance method, can compliance credit be gained by sealing the existing ducts when it was not required for prescriptive compliance?

Answer:

No. Once the status of the ducts is "altered" the standard design assumes the duct

sealing is required.

Example 9-55

Question:

When using the existing-plus-addition performance compliance method, can credit be gained by installing a radiant barrier in the existing house attic?

Answer:

No. Once the attic/roof is "altered" the standard design becomes equivalent to Table

150.1-A or B

Example 9-56

Question:

I am adding a room to and altering an existing building in climate zone 12. I am upgrading an existing single-pane clear glass window with a U-factor of 1.2 and SHGC of

1.0 to a dual-pane window with a U-factor of 0.50 and SHGC of 0.45. Do I receive credit toward the addition compliance for installing this window?

Answer:

No. Without third-party verification of the existing building features, the energy usage simulated by compliance software will be adjusted since the window is not as efficient as defined by Section 150.1(c)3A, requiring a U-factor of 0.23 and maximum SHGC of 0.23 in Climate Zone 12. The penalty for the U-factor is based on the difference between 0.23 and 0.50 and for the SHGC is based on the difference between 0.23 and 0.45. If fenestration is installed that exceeds the performance of the values in Table 150.2-G, then credit is available.

Example 9-57

Question:

I am planning to install R-19 insulation in the attic of an existing house built in 1970. Can I use this added insulation as a credit for trading with the energy features of an addition?

Answer:

No. When insulation is added to an attic, it must comply with Section 150.0(a), which sets a mandatory minimum for attic insulation of R-38. Since R-38 is a mandatory minimum, a lower insulation cannot be installed.

Example 9-58

Question:

I am planning to install R-25 insulation in an uninsulated vaulted ceiling without an attic space in an existing house built in 1970. Can I use this added insulation as a credit for trading with the energy features of an addition?

Answer:

Only if you choose verified existing conditions. Once the roof is altered, the standard design becomes a cathedral ceiling meeting Option C of R-38. For Climate Zones 1 through 3 and 5 through 7, no below roof deck insulation is required under Option B and it's possible to get credit for insulating an uninsulated vaulted roof to R-25.

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Electric Ready Requirements

Overview

Please refer to Chapter 10.1 of the *2022 Single-family Residential Compliance Manual*.

What's New for 2025

Electric-readiness requirements in the 2025 Energy Code remain largely unchanged with only the removal of the 10 AWG copper wire requirement in section 150.0(n)1Ai to allow for flexibility in compliance. For information on battery energy storage ready requirements, please reference Chapter 7 of the 2025 Single-family Residential Compliance Manual.

Mandatory Requirements Section 150.0(n) and Section 160.0(t-v)

Electric readiness requires the following for the applicable gas appliances listed in Table 10-1: Summary of Electric Readiness Requirements.

Table 10-1: Summary of Electric Readiness Requirements summarizes the electrical capacity, panel, and other requirements for electric- readiness for each gas appliance installed in a new single family building. There are no electric ready requirements for additions or alterations. There are no performance or prescriptive electric ready requirements for single family buildings.

These requirements are for newly constructed buildings and are not applicable to additions or alterations. Moreover, these requirements are not applicable when electric equipment is installed.

Table 10-1: Summary of Electric Readiness Requirements

Gas or Propane Equipment Installed	Electrical Capacity requirements for new circuit (amps, volts)	Panel requirements	Other Requirements
Water heater Section 150.0(n)	1. If within 3 feet of the water heater, 125V, 20 amp receptacle with 120V/240V, 3-conductor wire, branch circuit rated at 30 amps minimum. Unused conductor shall be labeled and electrically isolated. OR 2. If more than 3 feet	1. Reserved space (labeled "For Future 240V use") for single pole circuit breaker adjacent to 125V, 20A circuit breaker. OR 2. Reserved space (labeled "For Future 240V use") for double pole circuit breaker	A designated space for a future HPWH (2.5 ft x 2.5 ft wide x 7 ft high) Condensate drain no more than 2 inches higher than the base of installed water heater to allow for natural drainage without pump assistance

	from the water heater240V, 30 amp dedicated circuit		
Furnace Section 150.0(t)	240V, 30 amp	Reserved space for double pole circuit breaker	n/a
Range Section 150.0(u)	240V, 50 amp	Reserved space for double pole circuit breaker	n/a
Clothes dryer Section 150.0(v)	240V, 30 amp	Reserved space for double pole circuit breaker	n/a

Source: California Energy Commission

Water Heater

Please refer to Chapter 10.3.1 of the *2022 Single-family Residential Compliance Manual*.

Designated Space

Please refer to Chapter 10.3.1.1 of the *2022 Single-family Residential Compliance Manual*.

Electrical Requirements

The goal of this requirement is to allow easy installation of a HPWH, which typically require a 240V circuit, when the existing gas water heater is replaced.

If the designated HPWH space is within 3 feet of the gas water heater, a dedicated 125- volt (V), 20 amp electrical receptacle shall be installed that is within 3 feet of the water heater and accessible to the water heater with no obstructions. The wiring to this dedicated receptacle shall be connected to a 120/240V, three conductor, branch circuit rated at 30 amps minimum. The ends of the unused conductor must be labeled as “spare” and be electrically isolated.

Additionally, a reserved single pole circuit breaker space must be placed in the electrical panel next to the circuit breaker for the branch circuit and labeled with the words “Future 240V Use.”

If the designated HPWH space is more than 3 feet from the gas water heater, a 240V branch circuit must be installed rated at a minimum of 30 amps with no obstructions, in addition to a dedicated space in the main service panel for a future double pole breaker that will serve the future HPWH. The dedicated space in the panels shall be identified as “Future 240V Use”. The circuit shall be dedicated to future electric replacement equipment and cannot be used for other appliances.

Condensate Drain

Please refer to Chapter 10.3.1.3 of the *2022 Single-family Residential Compliance Manual*.

Hot and Cold Water Supply

Please refer to Chapter 10.3.1.4 of the *2022 Single-family Residential Compliance Manual*.

Space Heater

Please refer to Chapter 10.3.2 of the *2022 Single-family Residential Compliance Manual*.

Cooktops

Please refer to Chapter 10.3.3 of the *2022 Single-family Residential Compliance Manual*.

Clothes Dryer

Please refer to Chapter 10.3.4 of the *2022 Single-family Residential Compliance Manual*.

Gas Uses not Covered by Electric Ready Requirements

Please refer to Chapter 10.3.5 of the *2022 Single-family Residential Compliance Manual*.

Compliance and Enforcement

This section describes compliance documentation and field verification requirements related to electric readiness. When a building permit application is submitted to the enforcement agency, the applicant also submits plans and energy compliance documentation.

Example 10-1 – HPWH Ready:

Question:

I am installing a propane water heater in a garage and the designated future HPWH location is in the same space, do I need to install a dedicated 125V, 20 amp electrical plug connected to a 3-conductor 10 AWG wire?

Answer:

Most modern efficient gas water heaters require 125V, 20 amp power to operate. The electric ready requirement is designed to easily convert the installed 120V electrical circuit to 240V, capable of powering a HPWH. If the installed gas water heater does not have an electrical connection, a dedicated 240V, 30 amp circuit can be provided at the designated HPWH location, along with dedicated space in the main panel for a double pole breaker. A 10 AWG wire is not required, but the branch circuit must be rated at 30 amps minimum.

Example 10-2 – HPWH Ready:

Question:

I am installing a split-system HPWH. The storage tank is in an interior closet and is separate from the compressor and evaporator, which is located outside, do I need to meet the electric ready requirements for water heating?

Answer:

No. If a HPWH is being installed, either split-system or integrated, the electric ready requirements do not apply. They only apply when a gas water heater is being installed.

Example 10-3 – HPWH Ready:

Question:

I am installing a 120V HPWH, do I need to meet the electric ready requirements for water heating?

Answer:

No. If a HPWH is being installed, regardless of the voltage, the electric ready requirements do not apply. They only apply when a gas water heater is being installed.

Example 10-4 – Electric Cooktop Ready:

Question:

If I am installing a gas range, do I need to meet the electric ready requirements for cooktops?

Answer:

Yes. Because your range includes a gas cooktop, the electric ready requirements need to be met.

Example 10-5 – Electric Clothes Dryer Ready:

Question:

If I am providing both gas piping and a dedicated electrical circuit for the potential for either a gas or electric dryer to be installed by the homeowner, do I need to meet the electric ready requirements at the dryer location?

Answer:

If you are installing a dedicated 240V, 30 amp or greater plug for an electric dryer, in addition to a gas stub-out for a gas dryer, you are meeting the electric ready requirements for clothes dryer.

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APPENDIX A: Compliance Documents

NOTE: For Documents and User Instructions, please visit our website at: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Table A- 1: Certificate of Compliance (CF1R) Documents

Title	Category	Document Description
CF1R-ADD-01-E	Additions	Prescriptive Additions Less Than 1,000 ft2
CF1R-ADD-02-E	Additions	Prescriptive Additions – That Do Not Require Field Verification
CF1R-ALT-01-E	Alterations	Prescriptive Alterations
CF1R-ALT-02-E	Alterations	Prescriptive Alterations HVAC
CF1R-ALT-05-E	Alterations	Prescriptive Alterations – That Do Not Require Field Verification
CF1R-ENV-02-E	Envelope	Area Weighted Average Calculation Worksheet
CF1R-ENV-03-E	Envelope	Solar Heat Gain Coefficient (SHGC) Worksheet
CF1R-ENV-04-E	Envelope	Solar Reflective Index (SRI) Worksheet
CF1R-ENV-05-E	Envelope	Alternative Default Fenestration Procedure (NA6) Worksheet
CF1R-ENV-06-E	Envelope	Interior and Exterior Insulation Layers Worksheet
CF1R-NCB-01-E	Newly Constructed Buildings	Prescriptive Newly Constructed Buildings and Additions Equal to or Greater Than 1,000 ft^2
CF1R-PRF-01-E	Performance	Residential Performance Compliance Method

Source: California Energy Commission

Table A- 2: Certificate of Installation (CF2R) Documents

Title	Category	Document Description
CF2R-ADD-02-E	Additions	Prescriptive Additions, That Do Not Require Field Verification
CF2R-ALT-05-E	Alterations	Prescriptive Alterations – That Do Not Require Field Verification
CF2R-ELC-01-E	Electrical	Electric Ready Requirements

Title	Category	Document Description
CF2R-ENV-01-E	Envelope	Fenestration Installation
CF2R-ENV-03-E	Envelope	Insulation Installation
CF2R-ENV-04-E	Envelope	Roofing - Radiant Barrier
CF2R-ENV-20-H	Envelope	Building Leakage Diagnostic Test
CF2R-ENV-21-H	Envelope	QII - Framing Stage
CF2R-ENV-22-H	Envelope	QII - Insulation Installation Stage
CF2R-LTG-01-E	Lighting	Lighting - Single Family Dwellings
CF2R-MCH-01a-E	Mechanical	Space Conditioning Systems-Performance
CF2R-MCH-01b-E	Mechanical	Space Conditioning Systems-Prescriptive Alterations
CF2R-MCH-01c-E	Mechanical	Space Conditioning Systems-Prescriptive NCB
CF2R-MCH-01d-E	Mechanical	Space Conditioning Systems-E+A+A
CF2R-MCH-02-E	Mechanical	Whole House Fan
CF2R-MCH-04-E	Mechanical	Evaporative Coolers
CF2R-MCH-20-H	Mechanical	Duct Leakage Test
CF2R-MCH-21-H	Mechanical	Duct Location Verification,
CF2R-MCH-22-H	Mechanical	Space Conditioning System Fan Efficacy
CF2R-MCH-23-H	Mechanical	Space Conditioning System Airflow Rate
CF2R-MCH-24-H	Mechanical	Enclosure Air Leakage Worksheet
CF2R-MCH-25-H	Mechanical	Refrigerant Charge Verification
CF2R-MCH-26-H	Mechanical	Rated Space Conditioning System Equipment Verification
CF2R-MCH-27-H	Mechanical	Indoor Air Quality and Mechanical Ventilation
CF2R-MCH-28-H	Mechanical	Return Duct Design and Air Filter Grille Device Sizing According to Tables 150.0-B or C
CF2R-MCH-29-H	Mechanical	Duct Surface Area Reduction; R-Value; Buried Ducts Compliance Credit
CF2R-MCH-30-E	Mechanical	Ventilation cooling compliance credit
CF2R-MCH-31-H	Mechanical	Whole House Fan
CF2R-MCH-32-H	Mechanical	Kitchen Ventilation

Title	Category	Document Description
CF2R-MCH-33-H	Mechanical	Variable Capacity Heat Pump Compliance Credit
CF2R-PLB-02-E	Plumbing (DHW)	Single Dwelling Unit Hot Water System Distribution
CF2R-PLB-03-E	Plumbing (DHW)	Pool and Spa Heating Systems
CF2R-PLB-22-H	Plumbing (DHW)	Verified Single Dwelling Unit Hot Water System Distribution
CF2R-PVB-01-E	Photovoltaics	Photovoltaic Systems
CF2R-PVB-02-E	Photovoltaics	Battery Storage Systems
CF2R-SRA-01-E	Solar Ready	Solar Ready Areas
CF2R-SRA-02-E	Solar Ready	Minimum Solar Zone Area Worksheet
CF2R-STH-01-E	Solar Thermal	Solar Water Heating Systems

Source: California Energy Commission

Table A- 3: Certificate of Verification (CF3R) Documents

Title	Category	Document Description
CF3R-ENV-20-H	Envelope	Building Leakage Diagnostic Test
CF3R-ENV-21-H	Envelope	QII - Framing Stage
CF3R-ENV-22-H	Envelope	QII – Insulation Installation Stage
C3R-EXC-20-H	Existing Conditions	Verification of Existing Conditions for Residential Alterations
CF3R-MCH-20-H	Mechanical	Duct Leakage Diagnostic Test
CF3R-MCH-21-H	Mechanical	Duct Location Verification
CF3R-MCH-22-H	Mechanical	Fan Efficacy
CF3R-MCH-23-H	Mechanical	Airflow Rate
CF3R-MCH-24-H	Mechanical	Enclosure Air Leakage Worksheet
CF3R-MCH-25-H	Mechanical	Refrigerant Charge Verification
CF3R-MCH-26-H	Mechanical	Rated Space Conditioning System Equipment Verification
CF3R-MCH-27-H	Mechanical	Indoor Air Quality and Mechanical Ventilation
CF3R-MCH-28-H	Mechanical	Return Duct Design and Air Filter Device Sizing According to Tables 150.0-B or C

Title	Category	Document Description
CF3R-MCH-29-H	Mechanical	Duct Surface Area Reduction; R-value; Buried Ducts Compliance Credit
CF3R-MCH-30-H	Mechanical	Ventilation cooling compliance credit
CF3R-MCH-31-H	Mechanical	Verified Whole House Fan
CF3R-MCH-32-H	Mechanical	Kitchen Ventilation
CF3R-MCH-33-H	Mechanical	Variable Capacity Heat Pump Compliance Credit
CF3R-PLB-22-H	Plumbing (DHW)	Verified Single Dwelling Unit Hot Water System Distribution

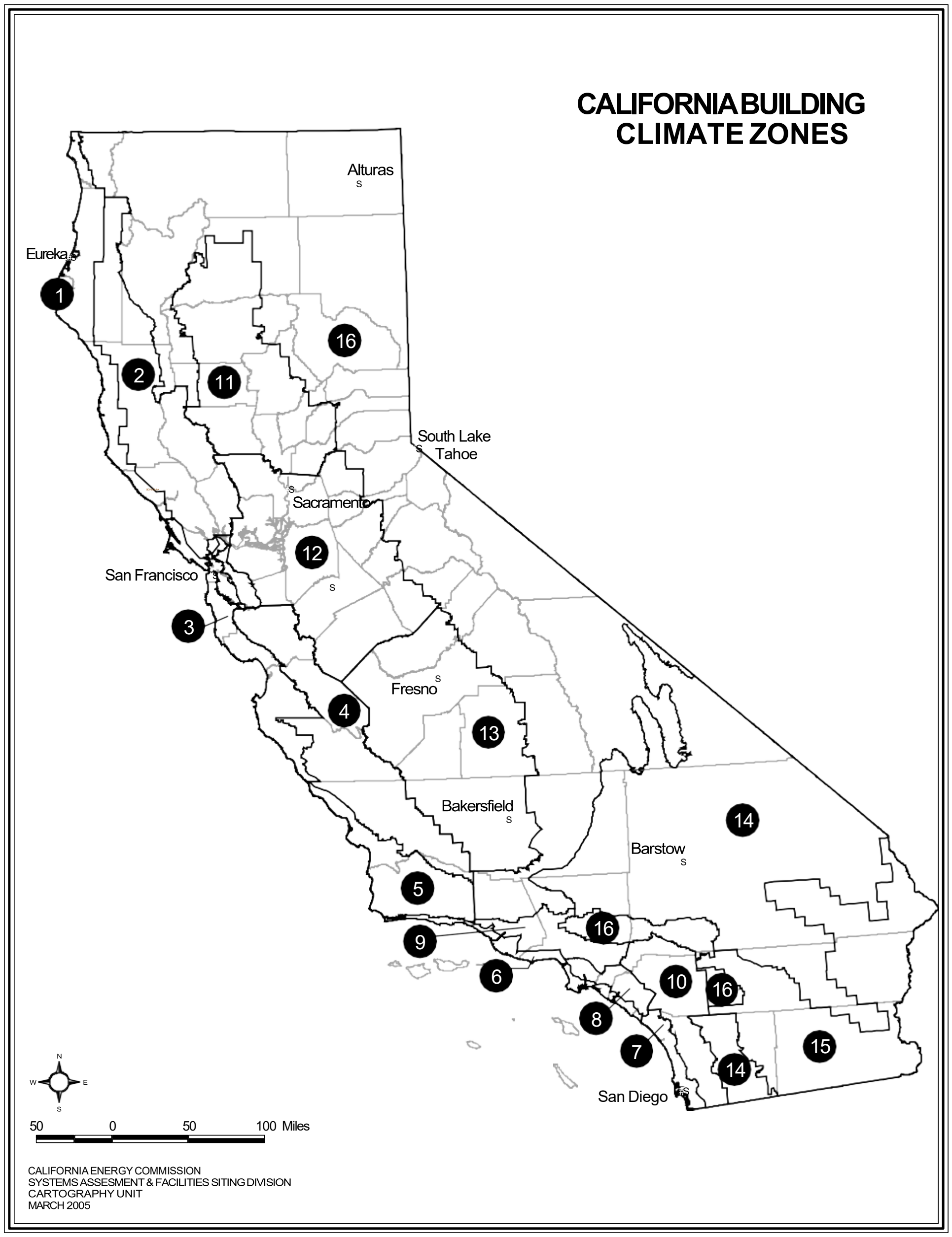
Source: California Energy Commission

APPENDIX B: California Climate Zones

All energy calculations used for compliance with the Energy Code must use the climate zone applicable to a building project is determined based on its physical location as it relates to the determinations of climate regions found in the California Energy Commission publication California Climate Zone Descriptions, which contains detailed survey definitions of the 16 climate zones.

The list of climate zone areas by ZIP code is located on the CEC website here https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/climate-zone-tool-maps-and.

Figure B- 1: California Climate Zones



Source: California Energy Commission

APPENDIX C:
Reserved

Reserved.

APPENDIX D: Eligibility Criteria for Radiant Barriers, Section RA4.2.1

Radiant barriers shall meet specific eligibility and installation criteria to be modeled by any approved compliance software and receive energy credit for compliance with the Building Energy Efficiency Standards for low-rise residential buildings.

The emittance of the radiant barrier shall be less than or equal to 0.05 as tested in accordance with ASTM C1371 or ASTM E408.

Installation shall conform to ASTM C1158 (Standard Practice for Installation and Use of Radiant Barrier Systems [RBS] in Building Construction), ASTM C727 (Standard Practice for Installation and Use of Reflective Insulation in Building Constructions), ASTM C1313 (Standard Specification for Sheet Radiant Barriers for Building Construction Applications), and ASTM C1224 (Standard Specification for Reflective Insulation for Building Applications), and the radiant barrier shall be securely installed in a permanent manner with the shiny side facing down toward the interior of the building (ceiling or attic floor). Moreover, radiant barriers shall be installed at the top chords of the roof truss/rafters in any of the following methods:

- Draped over the truss/rafter (the top chords) before the upper roof decking is installed.
- Spanning between the truss/rafters (top chords) and secured (stapled) to each side.
- Secured (stapled) to the bottom surface of the truss/rafter (top chord). A minimum air space shall be maintained between the top surface of the radiant barrier and roof decking of not less than 1.5 inches at the center of the truss/rafter span.
- Attached (laminated) directly to the underside of the roof decking. The radiant barrier shall be laminated and perforated by the manufacturer to allow moisture/vapor transfer through the roof deck.
- In addition, the radiant barrier shall be installed to cover all gable end walls and other vertical surfaces in the attic.

For Prescriptive Compliance, the attic shall be ventilated to:

- Provide a minimum free ventilation area of not less than one square foot of vent area for each 300 ft^2 of attic floor area.
- Provide no less than 30 percent upper vents.
- Ridge vents or gable end vents are recommended to achieve the best performance. The material should be cut to allow for full airflow to the venting.
- The product shall meet all requirements for California certified insulation materials (radiant barriers) of the, Bureau of Household Goods and Services (BHGS), as specified by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.

- The use of a radiant barrier shall be listed in the Special Features and Modeling Assumptions listings of the Certificate of Compliance and described in detail in the Residential ACM Manual Conform to the radiant barrier manufacturer's instructions.

APPENDIX E: Natural Gas Appliance Testing (NGAT) Standards

The NGAT standards, "Natural Gas Appliance Testing (NGAT) Standards," are found in Section 24 of the "California Installation Standards" manual; edition dated July 1, 2012. A copy may be obtained from contacting:

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Internet: Richard Heath and Associates at https://www.rhainc.com/index.php/contact-us/

APPENDIX F:
Field Verification of Zonally Controlled Systems

Introduction and Scope

Zonally controlled systems are usually installed primarily for improved comfort, not improved energy consumption. Studies have shown that zonally controlled cooling systems that utilize bypass ducts or that substantially reduce the airflow across the coil when zone dampers close can actually use more energy. Because of this, ECC-Raters are required to evaluate these systems to ensure that it is consistent with what was modeled and what appears on the CF1R.

One type of zonally controlled forced air system uses motorized zone dampers in the supply ducts to send supply air from a single air handler to different zones, as needed, rather than sending air to the entire are served by that system. These require multiple thermostats or temperature sensors in each of the zones. The number of zones can be two or more. Two-zone systems are by far the most common. The most common application of this type of system is in two-story homes served by a single forced-air system. The tendency for air to stratify, along with substandard duct design, causes comfort issues that can often be overcome by zonal control.

Dampers may also be installed on the return ducts but are not required for the system to be considered a zonally controlled system.

Problems with this type of zonally controlled system arise from the excess air pressure that occurs at the air handler fan when one or more of the zone dampers close and restrict airflow to just a portion of the supply duct system. One strategy is to simply let the pressure increase, which substantially reduces airflow across the cooling coil or heat exchanger. Another is to install a bypass duct that allows the excess air to “short circuit” from the supply side back to the return side. This causes problems by sending excessively hot air (heating mode) or excessively cold air (cooling mode) back into the system.

An alternative approach is to send the “excess air” back into conditioned space rather than directly back into the return air. These are not considered bypass ducts if the air has a chance to mix with house air in a way that does not substantially change the return air temperatures. The area in the home where the excess air is sent to is referred to as a “dump zone.” These dump zones will generally be overconditioned by this excess air and are usually unoccupied portions of the home, such as hallways or vaulted ceiling areas above the occupied zones. This design may lose some of the comfort benefits of a zonally controlled system.

Zonal control can be also achieved by using two separate systems, sized appropriately for each zone. These act independently and do not need zone dampers. These also do not require bypass dampers or other strategies to handle the excess air. For example, zonal control can be achieved in a two story home by installing a single system with zone dampers that separately control air to the upstairs and downstairs; or it can be achieved by installing two small systems, one dedicated to the first floor and one to the second floor. Assuming that the house can be adequately served by a single large system, the first approach generally costs less.

If it is discovered that a zonally controlled forced air system is installed but not claimed for credit, it needs to be reported to the ECC-Provider (registry). Zonally controlled systems need to be correctly modeled in compliance software then installed. The CF1R must be revised to reflect the installed system.

Summary of Requirements

Mandatory compliance approach –

- Zonally controlled systems are not required, but if installed must meet mandatory airflow and fan efficacy requirements using slightly different test methods than for single-speed and variable-speed compressors.

Prescriptive compliance approach –

- Bypass ducts/dampers are not allowed.

Performance compliance approach –

- Zonally controlled systems must be modeled then installed.
- Bypass dampers are allowed only if modeled and indicated on the CF1R.
- Dual-speed/multispeed condensers may also qualify for a credit and, if modeled, must be installed.

When a feature is "modeled" using the performance compliance approach it will appear on the certificate of compliance.

Identifying Zonally Controlled Systems in the Field

The following are characteristics of most zonally controlled systems that use dampers. Not all of these items need to be apparent for the system to be considered zonally controlled. Final determination may require consulting with the installer, designer, and system manufacturer.

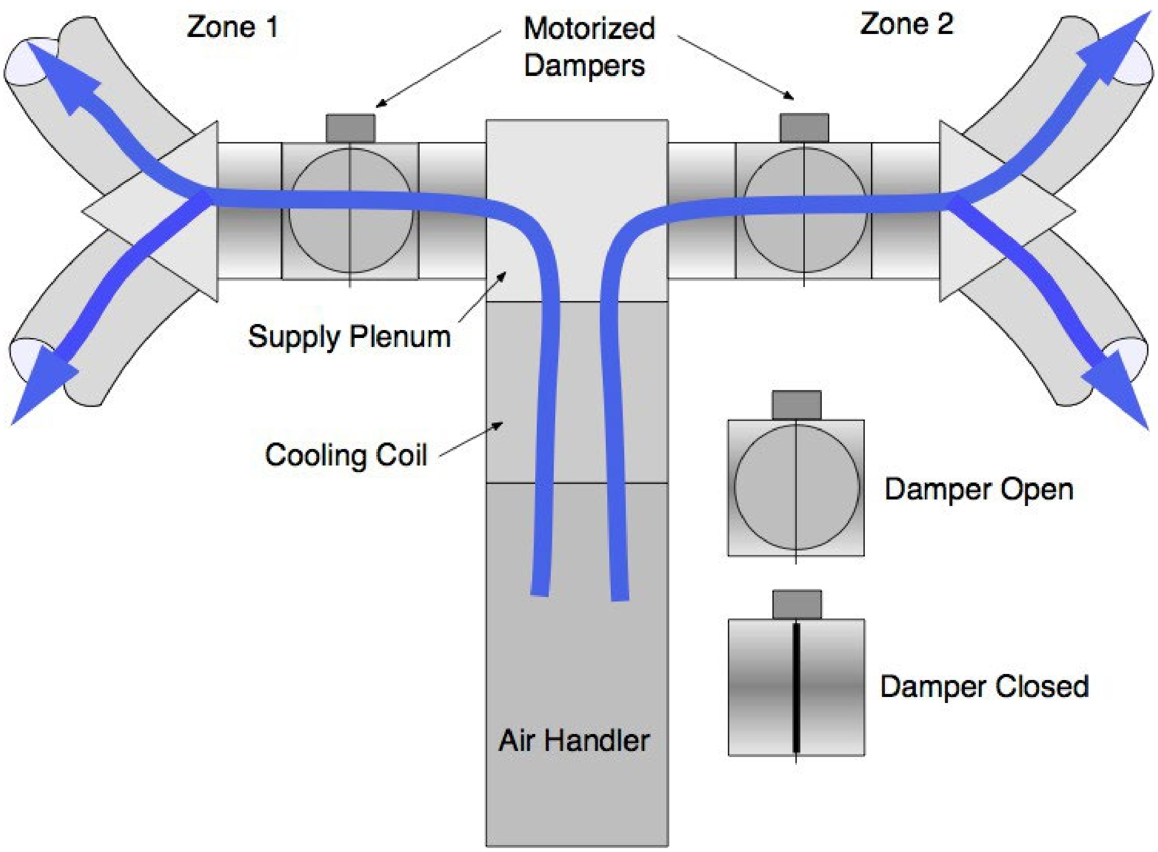
Motorized or actuated zone dampers on the supply ducts. These can be one or more large dampers in or near the supply plenum or they can be one damper for each supply outlet (register). See Figure C-1: Illustration of a Two-Zone, Two-Damper Duct System With Both Zones Open to Supply Conditioned Air through Figure C- 5: Illustration Of A System With A Bypass Duct And Barometric-Type Bypass Damper.

Multiple thermostats or temperature sensors in area served by a single system. The most common two-zone systems use ordinary thermostats for each zone. Some systems have a single master thermostat with small temperature sensors in each zone.

A control board on or near the air handler with low-voltage wires going to the thermostats/temperature sensors and to each damper. Low-voltage wires will also connect the control board and the main air handler control board. See photos below.

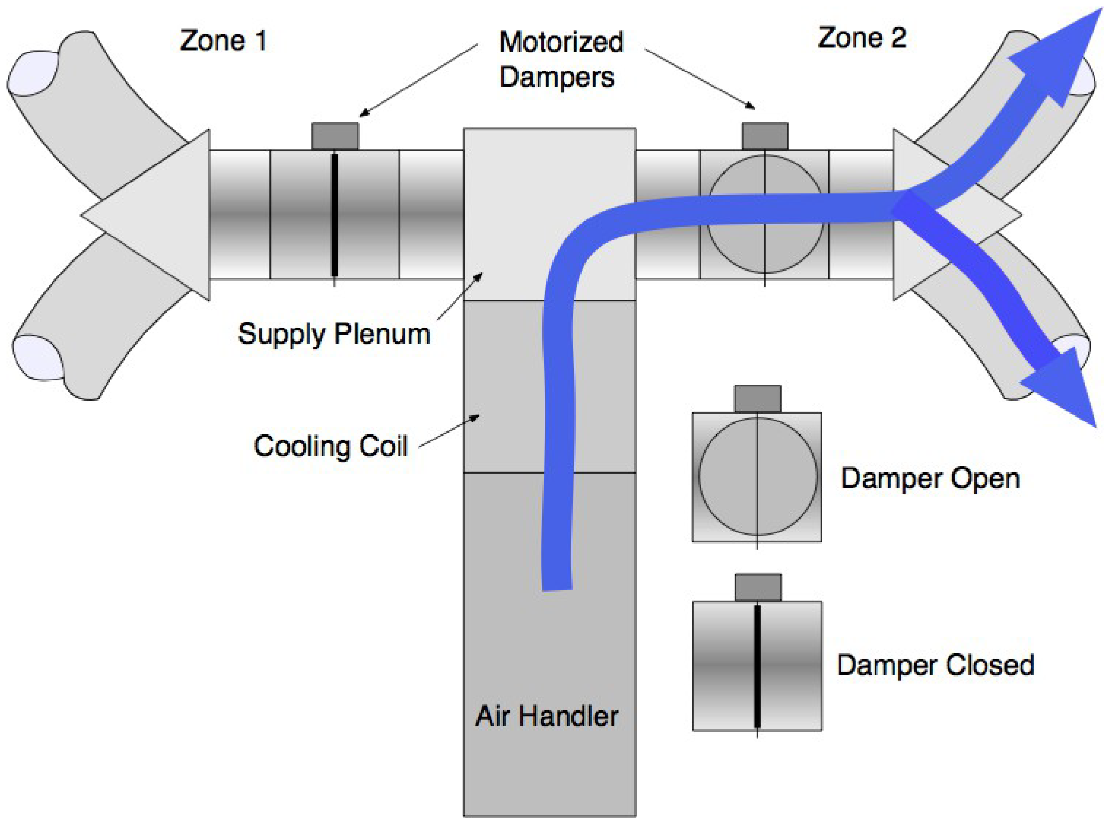
Bypass duct and damper. This will be a duct connecting the supply end directly to the return end. On the supply side it will connect after the coil and before the zone damper(s), usually off of the supply plenum. On the return side, it can either connect directly to the side of the return end of the furnace, near the return end of the furnace in a return plenum, or as far away as a return grill boot. An automatic damper will control airflow through this duct. When all zones are calling for cooling (all zone dampers open), the bypass damper should be fully closed. When one or more zone dampers close, the damper should open partially or fully as needed to reduce the supply plenum pressure. This is commonly achieved by a barometric bypass damper. Barometric dampers are held closed by an adjustable weight. When enough pressure builds up on one side of the damper, it overpowers the weight and opens the damper. See Figure C-5: Illustration of a System With a Bypass Duct and Barometric-Type Bypass Damper. Another strategy is to use a motorized damper.

Figure C-1: Illustration of a Two-Zone, Two-Damper Duct System With Both Zones Open to Supply Conditioned Air



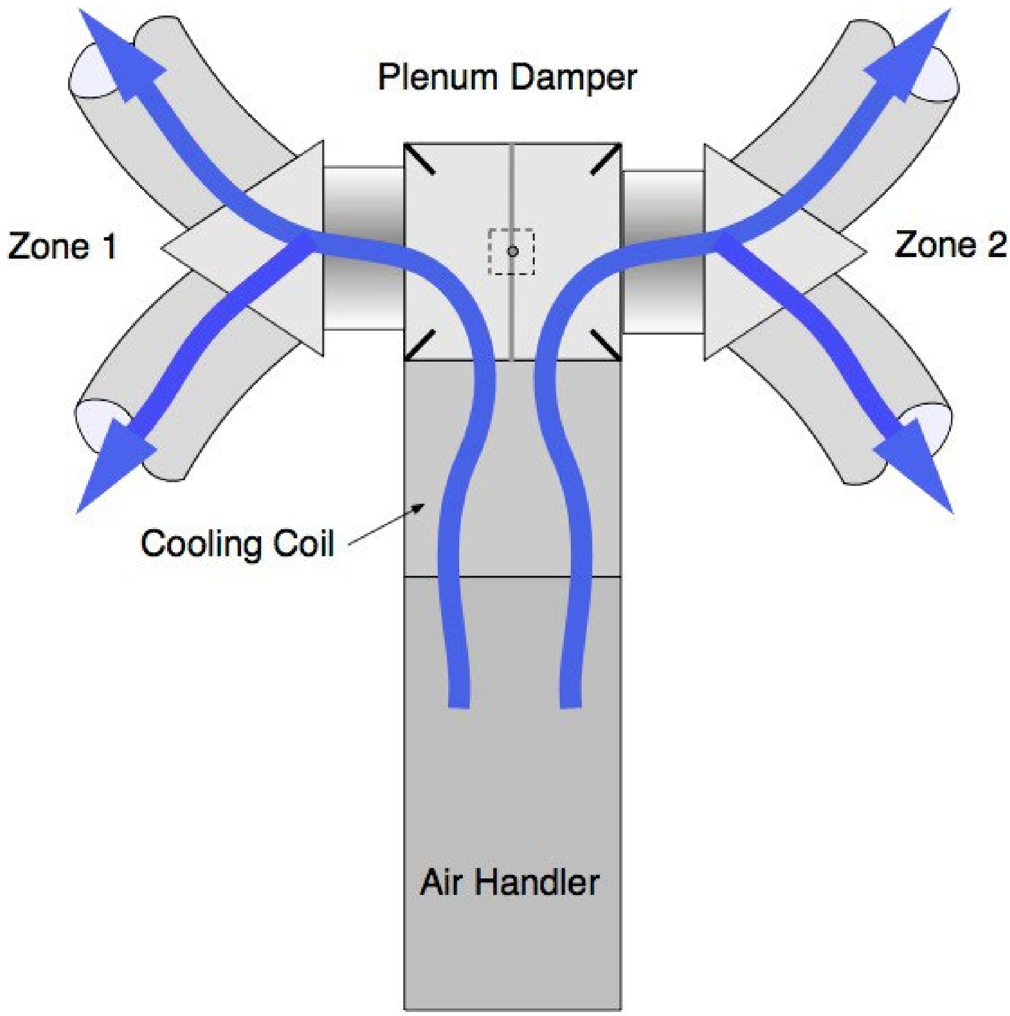
Credit: Russ King, P.E.

Figure C-2: Illustration of a Two-Zone, Two-Damper Duct System With Zone 2 Open to Supply Conditioned Air. The Zone 1 Damper Is Closed



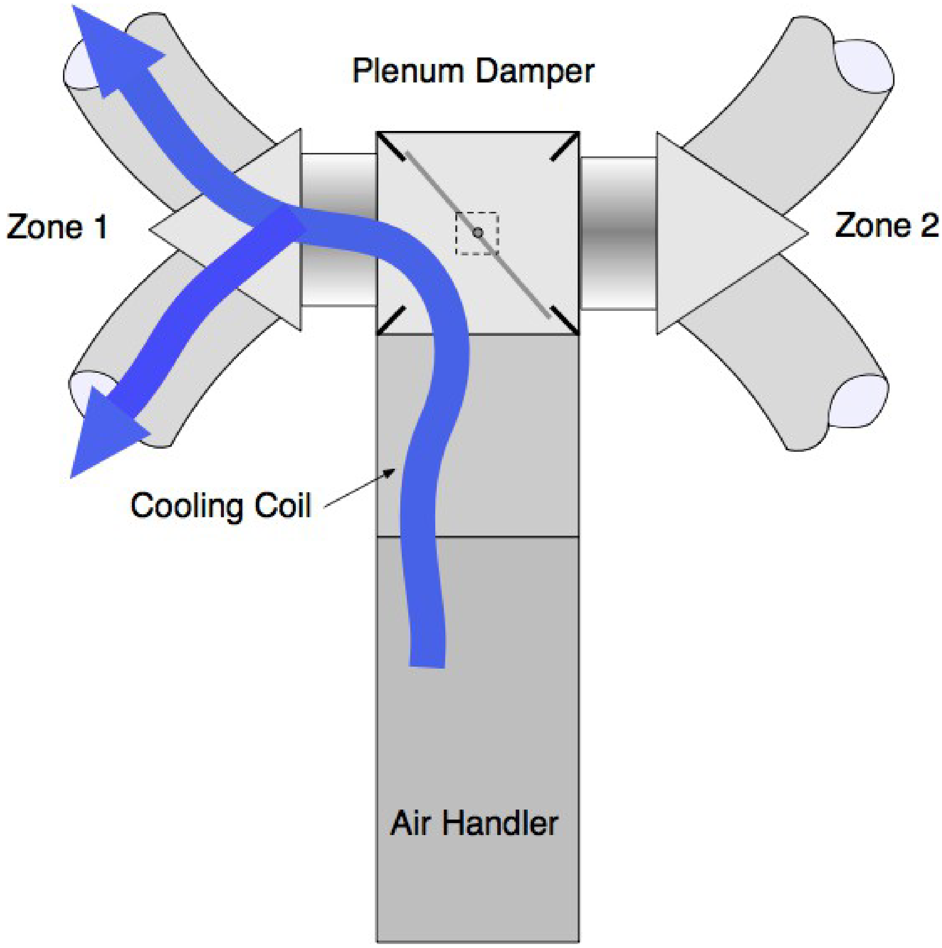
Credit: Russ King, P.E.

Figure C-3: Illustration of a Two-Zone, Single-Damper Duct System With Both Zones Open to Supply Conditioned Air



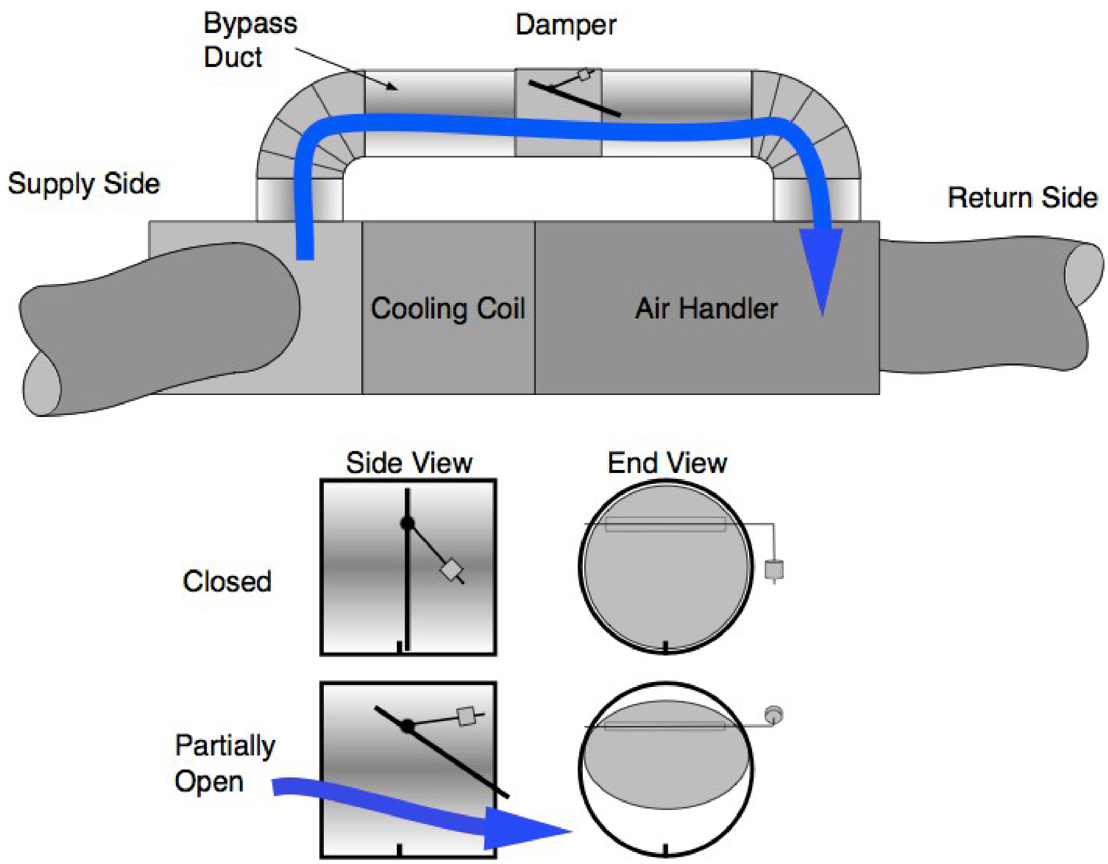
Credit: Russ King, P.E.

Figure C-4: Illustration of a Two-Zone, Single-Damper Duct System With the Damper Positioned to Supply Conditioned Air to Zone 1



Credit: Russ King, P.E.

Figure C-5: Illustration of a System With a Bypass Duct and Barometric-Type Bypass Damper



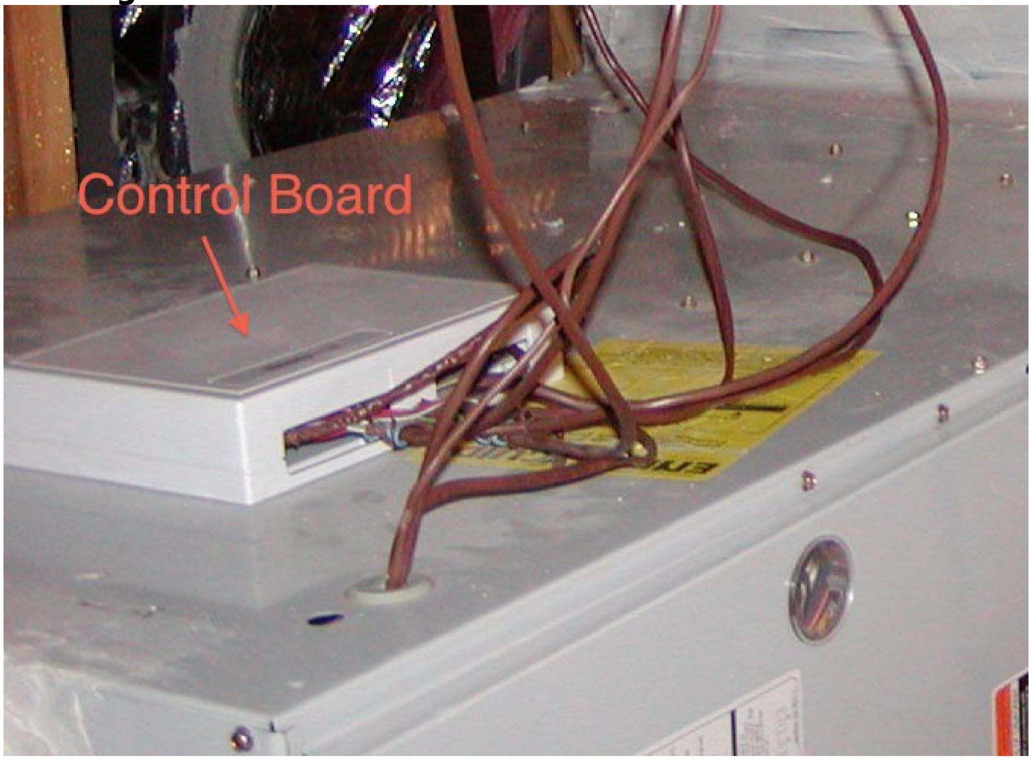
Credit: Russ King, P.E.

These photos show two examples of zonal control control-boards:

Figure C-6: Photo of a Duct-Mounted Control Board

Credit: Russ King, P.E.

Figure C-7: Photo of a Cabinet-Mounted Control Board



Credit: Russ King, P.E.

Identifying Multispeed/Variable-Speed Condensers

Most condensers operate at a single speed and capacity and either run for longer or shorter periods during hotter or cooler weather, respectively. Short run times (aka, short cycling) reduce efficiency. Multispeed condensers typically have a high and low speed. This can be accomplished by two separate compressors inside a single condenser, or by a single dual-stage compressor. During cooler weather (aka, part load times) the condenser will run in low speed for longer run periods. When needed, the condenser can run in high speed.

Variable-speed condensers are not limited to just high and low speeds. They can gradually ramp from lowest to highest speeds as needed.

There are several features that can indicate that a condenser is multispeed. These include:

- Product tags, labels and marketing names that indicate two-stage, dual-stage, multistage, etc.
- Two compressors observed by looking down through the condenser fan.
- High and low capacities or nominal tonnages indicated on nameplate.

The definitive way to determine if the condenser is multispeed or variable-speed is to record the make and model number and find the manufacturer's specifications.

REFERENCES

JA1: Glossary

ZONAL CONTROL is the practice of dividing a residence into separately controlled HVAC zones. This may be done by installing multiple HVAC systems that condition a specific part of the building, or by installing one HVAC system with a specially designed distribution system that permits zonal control. The Energy Commission has approved an alternative calculation method for analyzing the energy impact of zonally controlled space-heating and -cooling systems. To qualify for compliance credit for zonal control, specific eligibility criteria specified in the Residential ACM Manual must be met.

§150.0(m)13C. **Zonally Controlled Central Forced Air Systems.** Zonally controlled central forced air cooling systems shall be capable of simultaneously delivering, in every zonal control mode, an airflow from the dwelling, through the air handler fan and delivered to the dwelling, of greater than 350 CFM per ton of nominal cooling capacity, and operating a gas furnace air-handling unit fan efficacy of less than or equal to 0.45 W/cfm or an air-handling unit that is not a gas furnace fan efficacy of less than or equal to 0.58 W/CFM as confirmed by field verification and diagnostic testing in accordance with the procedures specified in Reference Residential Appendix RA3.3.

EXCEPTION 1 to 150.0(m)13C: Multispeed compressor systems or variable speed compressor systems shall demonstrate compliance for airflow (cfm/ton) and fan efficacy (watt/cfm) by operating the system at maximum compressor capacity and maximum system fan speed and with all zones calling for conditioning.

EXCEPTION 2 TO 150.0(M)13C: Gas furnace air-handling units manufactured before July 3, 2019, shall with a fan efficacy value less than or equal to 0.58 W/cfm.

§150.1(c)13. **HVAC System Bypass Ducts.** Unless otherwise specified on the Certificate of Compliance, bypass ducts that deliver conditioned supply air directly to the space conditioning system return duct airflow shall not be used. All zonally controlled forced air systems shall be verified by a ECC-Rater utilizing the procedure in Reference Residential Appendix Section RA3.1.4.6 to confirm compliance with 150.1(c)13.

RA 3.1.4.6 Verification of Prescriptive Bypass Duct Requirements for Zonally Controlled Forced Air Systems

When a zonally controlled forced air system is installed, one the following shall be verified to determine compliance as required by Energy Standards §150.1(c)13:

- A visual inspection shall confirm that bypass ducts that deliver conditioned supply air directly to the space conditioning system return duct airflow are not used.
- If the certificate of compliance indicates an allowance for use of a bypass duct, the bypass duct shall conform to the specifications given on the certificate of compliance.

If the zonally controlled system meets one of these criteria, the system complies. Otherwise, the system does not comply.

APPENDIX G:
Verification of the Existing Features of a Home for Existing + Addition + Alteration Performance Approach

When adding to or altering an existing home, compliance credit can be taken for upgrading existing features by using the performance approach when the existing features are verified by a qualified Energy Code Compliance (ECC)-Rater before registration of the certificate of compliance (CF1R).

The performance approach provides a means to trade off against features that may not meet the prescriptive requirements, such as exceeding the allowed maximum glass area, by demonstrating that the project (proposed design) achieves the same level of efficiency as it would if it were built to the prescriptive requirements (standard design). The standard design is a hypothetical building with prescriptive requirements from Table 150.1-A that sets the target energy budget for the proposed project.

The Existing + Addition + Alteration approach gives further credit for upgrading existing features. It does this by modifying the standard design for an altered building feature to match the requirements specified in Section 150.2, particularly Table 150.2-G. The greater the efficiency of the altered building feature is relative to the existing energy efficiency, the greater the compliance credit will be. Third-party verification of the features before construction is required to achieve the maximum compliance credit.

The proposed design is calculated using the actual energy efficiency values of the existing unaltered components of the existing building, and the proposed values of the altered components, plus the proposed addition’s features. Each building component must be modeled with one of the following classifications to determine the standard design:

“Existing” — building components that remain unchanged (e.g., exterior walls in the existing portion of the building that will not be altered) but must be verified.

“Altered” existing building components proposed to be changed (e.g., added roof insulation, or a furnace that is being replaced).

“New” — building components that do not exist prior to the construction work (e.g., new walls added to create the addition). This includes building components in a previously unconditioned space being converted to conditioned space.

All these building components determine how the standard design is calculated. Existing features are modeled the same in the proposed and standard designs. New features are modeled in the standard design according to prescriptive requirements in Table 150.1-A. Altered features are modeled in the standard design according to Table 150.2-D.

There are two columns in Table 150.2-D. One column defines how the standard design is calculated for altered components when the existing features are not verified by an ECC-Rater. The other column indicates how the standard design is calculated when the existing features are verified by an ECC-Rater before construction.

For the building to comply, the proposed design (proposed project details as modeled) must be equal to or less than the standard design. When a feature in the proposed design is better than the standard design, it receives a compliance credit that can be used to trade against less efficient features. For example, without third-party verification, windows to be altered are assumed to have 0.40 U-factor and 0.35 solar heat gain coefficient (SHGC). With ECC-Verification, if the existing windows are single-pane metal-framed, they are assumed to have 1.28 U-factor and 0.80 SHGC, resulting in substantial potential compliance credit if the new windows meet current prescriptive requirements of 0.30 U-factor and 0.23 SHGC.

Example:

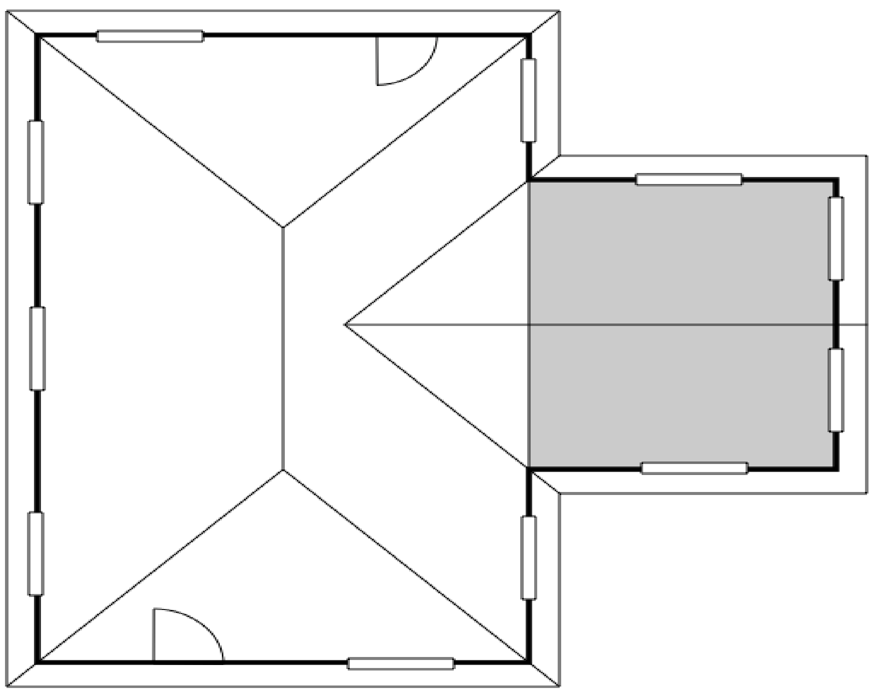
Consider the house in Figure G-1: The Proposed Addition and Alterations in Climate Zone 12. The shaded area is the addition. Some windows and walls are removed to build the addition. These are ignored. The existing home has the following features:

Single-pane metal-framed windows

2x4 R-0 walls, and R-19 attic insulation

AFUE 75 furnace

Figure G- 1: The Proposed Addition and Alterations



Source: California Energy Commission

Table G- 1: Standard Design for Component

Component	Status	Proposed	Standard Design w/o verification	Standard Design w/ verification
Attic	Existing/Altered	NA	R-22	R-19
Attic[i]	New	R-38	n/a	n/a

Component	Status	Proposed	Standard Design w/o verification	Standard Design w/ verification
Wall	Existing/Altered	n/a	R-13	R-0
Walls[ii]	New	R-15	n/a	n/a
Window	Existing/Altered U-factor; SHGC	n/a	0.40; 0.35	1.28; 0.80
Window	New	0.30; 0.23	n/a	n/a
Furnace	Existing/Altered/New	0.92 AFUE	0.80 (Federal Minimum)	0.75

Source: California Energy Commission

Part of the construction work includes replacing all of the windows with low-emissivity (low-E) vinyl windows to match the new windows in the addition, adding insulation to the existing attic, and replacing the existing furnace.

For the proposed design, none of the attic is modeled as existing because insulation is being added to the existing building ("altered"), and the attic in the addition is "new." None of the windows are modeled as existing (unless any are not replaced). Replaced windows in the existing building are "altered" and the windows in the addition are "new." The furnace, even though it is new, is modeled as "altered" because it is replacing an existing heating system. The walls, windows, and other components that are removed as part of the addition and alterations are ignored.

Table G-1: Standard Design for Component illustrates how the proposed features and the standard design features are calculated, depending on whether there is ECC-Verification of the existing conditions.

The ECC-Rater must complete the verification of the existing conditions to register the certificate of compliance (CF1R).

ECC-Raters follow the protocols for a Whole-House Home Energy Rating (WHHER) when verifying existing conditions. The WHHER protocols are established by the HERS Technical Manual (CEC-400-2008012). Appendix A of that document details the protocols for verification of each component. ECC-Raters must follow all Energy Commission approved procedures established by the ECC-Provider. The HERS Technical Manual can be downloaded from: https://www.energy.ca.gov/publications/2019/hers-home-energy-rating-system-technicalmanual. The ECC-Rater is trained by an ECC-Provider to verify the existing conditions of the home consistent with Energy Commission-approved ECC-Provider training for the verification requirements specified in Table 150.2-D. The data registry will generate a CF3R-EXC-20-H compliance document based on the output from the performance compliance software. The CF3R-EXC-20-H will list the features of the existing conditions that must be field-verified by the ECC-Rater. A registered CF3R-EXC-20-H that agrees with the existing conditions input for the proposed building is required by the ECC-Registry as a prerequisite the registration of the CF1R for the project.

ECC-Raters must follow all CEC-approved procedures established by the ECC-Provider.

For comparisons with approaches used during the 2016 Energy Code cycle and before, Table G- 2: Standard Design for an Altered Component (2016 Code Cycle and Before) below was used to model existing conditions based on the year that a building was constructed. This table was superseded during the 2019 code cycle, and in the 2022 Energy Code, the table that supersedes Table G-2: Standard Design for an Altered Component (2016 Code Cycle and Before) is Table 150.2-G.

Table G-2: Standard Design for an Altered Component (2016 Code Cycle and Before)

Conservation Measure	Before 1978	1978 to 1983	1984 to 1991	1992 to 1998	1999 to 2000	2001 to 2003	2004 to 2005	2006 to 2013	2014 to Present
Cool Roof Solar Reflectance	0.10	0.10	0.10	0.10	0.10	0.10	0.10	Table 150.1-A	Table 150.1-A
Radiant Barrier	None	None	None	None	None	None	Table 150.1-A	Table 150.1-A	Table 150.1-A
Roof/Ceiling U-factor	0.079	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.031
Wall U-factor	0.356	0.110	0.110	0.102	0.102	0.102	0.102	0.102	0.102
Raised Floor – Crawl Space U-factor	0.099	0.099	0.099	0.049	0.049	0.049	0.049	0.049	0.037
Raised Floor- No Crawl Space U-factor	0.238	0.238	0.238	0.064	0.064	0.064	0.064	0.064	0.049
Slab Edge F-factor	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Duct R-value	R-2.1	R-2.1	R-2.1	R-4.2	R-4.2	R-4.2	R-4.2	Table 150.1-A	Table 150.1-A
Building Leakage (ACH50)	7.7	7.7	7.7	7.7	7.7	7.7	7.7	6.8	5.0
Duct Leakage (%)	15%	15%	15%	15%	15%	15%	15%	15%	6%

Conservation Measure	Before 1978	1978 to 1983	1984 to 1991	1992 to 1998	1999 to 2000	2001 to 2003	2004 to 2005	2006 to 2013	2014 to Present
Fenestration U-factor	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages	Use Energy Standards Table 110.6-A, §110.6 for all vintages
Fenestration SHGC	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.	Use Energy Standards Table 110.6-B, §110.6 for all vintages.
Fenestration Shading Devices	Exterior: Assumed to have 50% bug screens, model actual overhangs	Exterior: Assumed to have 50% bug screens, model actual overhangs	Exterior: Assumed to have 50% bug screens, model actual overhangs	Exterior: Assumed to have 50% bug screens, model actual overhangs	Exterior: Assumed to have 50% bug screens, model actual overhangs	Exterior: Assumed to have 50% bug screens, model actual overhangs	Exterior: Assumed to have 50% bug screens, model actual overhangs	Exterior: Assumed to have 50% bug screens, model actual overhangs.	Exterior: Assumed to have 50% bug screens, model actual overhangs
Space Heating Central Gas Furnace (AFUE)	0.75	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78

Conservation Measure	Before 1978	1978 to 1983	1984 to 1991	1992 to 1998	1999 to 2000	2001 to 2003	2004 to 2005	2006 to 2013	2014 to Present
Space Heating Gas Room Heater (AFUE)	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Space Heating Hydronic/Comb Hydronic (TE)	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Space Heating Heat Pump (HSPF)	5.6	5.6	6.6	6.6	6.8	6.8	6.8	7.4	7.7
Space Heating Electric Resistance (HSPF)	3.413	3.413	3.413	3.413	3.413	3.413	3.413	3.413	3.413
Electric Resistance Radiant (HSPF)	3.55	3.55	3.55	3.55	3.55	3.55	3.55	3.55	3.413
Space Cooling All Types (SEER)	8.0	8.0	8.9	9.7	9.7	9.7	9.7	13.0	13.0
Water Heating Energy Factor	0.525	0.525	0.525	0.525	0.575	0.575	0.575	0.575	0.575

Source: California Energy Commission

APPENDIX H: Demand-Responsive Controls

This appendix to the residential compliance manual addresses the demand-responsive (DR) control requirements in the *2022 Building Energy Efficiency Standards* (Energy Standards).

Demand response is an increasingly important function of buildings as distributed energy resources become more common and customers have access to time-of-use electricity rates and incentive programs designed to encourage demand side optimization. Demand response occurs on a range of timescales, from seconds to seasons, and represents any demand change in response to grid or economic needs. In addition to current time-of-use electricity rates, utilities in the future will likely connect electricity costs to high-frequency fluctuations in the supply and demand for electricity. Appropriate demand-responsive controls allow building operators to maintain the quality of services a building provides and reduce the total cost of energy by automating a building's response to changes in electricity rates.

The following definitions from §100.1 are relevant to the DR control requirements:

- **Demand response** is short-term changes in electricity usage by end-use customers, from their normal consumption patterns. Demand response may be in response to:
    - Changes in the price of electricity; or
    - Participation in programs or services designed to modify electricity use.
        - In response to wholesale market prices.
        - When system reliability is jeopardized.
- **Demand-response period** is a period during which electricity loads are modified in response to a demand-response signal.
- **Demand-response signal** is a signal that indicates a price or a request to modify electricity consumption for a limited period.
- **Demand responsive control** is an automatic control that is capable of receiving and automatically responding to a demand response signal.

The DR control requirements ensure that the building is DR capable (i.e., capable of responding to a DR signal). The decision to employ demand response is up to the building owner or manager, in coordination with their utility company or a governing authority or both. A building capable of receiving and responding to a demand response signal is sufficient to meet the requirements of the Energy Standards. DR-capable is described as follows:

- **DR-capable:** A building is capable of DR when the building has loads that can be curtailed, DR controls are installed, and the controls have been programed/configured so the test control strategy that is defined in the building code can be deployed. (The DR controls can be programmed with additional control strategies.)
- **DR-enabled:** The DR of a building is enabled when the connection between the entity that sends the DR signal and the DR control in the building has been tested and communications have been allowed or "enabled."

- **DR-enrolled:** A building is enrolled when the building owner/occupant has enrolled in a DR program. (This may include updating the settings or programming of the DR controls to better match the terms of the program.)

The requirements for DR controls only apply if the controls are used to comply with the building standards (i.e., DR thermostats or a heat pump water heater). If DR control are installed voluntarily and do not contribute to compliance with minimum code requirements, they do not need to adhere to requirements in Title 24, Part 6.

For residential dwellings, DR controls are only required as a part of specific Exceptions to HVAC and Solar Ready requirements.

Communications Requirements for DR Controls

§110.12(a)1-5

There are two main communication requirements that apply to all DR controls:

- The control must, at minimum, be able to understand a signal sent using OpenADR.
- The control must, at a minimum, be able to communicate with the virtual end node using a wired or wireless bidirectional communication pathway.

These are minimum requirements, meaning that the control can have (and use) additional communication features provided that the required features are included.

Communication With Entity That Initiates DR Signal

§110.12(a)1

DR controls must have the capability of communicating with the entity that initiates a DR signal by way of an OpenADR-certified virtual end node (VEN).

The OpenADR is the primary open-standard protocol used in the California market. It implements a profile within the Organization of Structured Information Standards (OASIS) Energy Interoperation information and communication model that defines two types of communications entities — virtual top nodes (VTNs) and virtual end nodes (VENs). VTNs are information exchange servers typically operated by utilities or third-party providers and can dispatch events. VENs are the recipients of DR payloads and are typically the gateway or end-use devices installed at customer facilities throughout a dispatcher's territory. See OpenADR Alliance's website (http://www.openadr.org/) for more information about OpenADR certified VENs.

There are two ways to comply with the OpenADR certified VEN requirement:

Option A: Install an OpenADR 2.0a, 2.0b certified VEN, or a certified Baseline Profile OpenADR 3.0 VEN within the building as part of the DR control system (§110.12(a)1A)

If complying using Option A (§110.12[a]1A), the designer of the DR control system(s) must select a VEN that the OpenADR Alliance has certified as being compliant with the OpenADR 2.0a, 2.0b specification or Baseline Profile OpenADR 3.0. The OpenADR Alliance maintains a list of certified VENs (https://products.openadr.org/). If using Option A, the certified VEN must be installed inside the building at the time of inspection. The building can comply if the DR control system has a certified VEN that is incorporated into a networked system of devices such that the single VEN communicates control strategy information to multiple devices in the network (e.g., a gateway system), or if each device (e.g., thermostat) in the building is itself a certified VEN.

Option B: Install a DR control system that has been certified to the Energy Commission as being capable of communicating with an OpenADR 2.0b certified VEN or a Baseline Profile OpenADR 3.0 certified VEN (§110.12[a]1B)

If complying using Option B (§110.12[a]1B), the designer of the DR control system(s) must select a DR control system that the Energy Commission has approved for the certified list of DR control systems. The Energy Commission maintains a list of certified products and instructions on how manufacturers can certify products on their website at http://www.energy.ca.gov/title24/equipment_cert/. If using Option B, the manufacturer of a DR control system must submit documentation to the Energy Commission confirming that the DR control system is capable of communicating with an OpenADR 2.0b-certified VEN or a Baseline Profile OpenADR3.0-certified VEN. Demand-responsive controls must be programmed or configured so any test control strategy defined in building code can be deployed at the time of permitting.

Option B requires that the manufacturer of the DR control system certify to the Energy Commission that the control system is capable of communicating with an OpenADR 2.0b-certified VEN or a Baseline Profile OpenADR3.0-certified VEN. This requirement does not mean that the DR control system must be connected to a 2.0b-certified VEN or a Baseline Profile OpenADR3.0-certified VEN. When the DR control system is connected to a VEN, it can be connected to either a 2.0a- or 2.0b-certified VEN or a Baseline Profile OpenADR3.0-certified VEN.

The DR control system must comply with Option A or Option B, but the control system can also include features that allow the control system to use other communications protocols.

When specifying DR control systems, it is recommended that the controls designer check to see which DR programs are available in the area and specify controls that are compliant with Title 24, Part 6, and eligible for the area's DR programs.

Other Requirements for DR Controls

Perform Regular Functions When Not Responding to DR Events

§110.12(a)4

Controls that include demand response with other control functions must perform the regular control functions, as required by other parts of the building code, when the control is not performing DR-related functions. This includes when the controls are not responding to a DR event, when the DR functions are not enabled (see description of DR-enabled in the introduction to this chapter of the compliance manual) or when the DR controls are temporarily disabled or disconnected (e.g., due to a network outage).

For example, if the building owner/operator never enables the DR controls or enrolls in a DR program, the building control system(s) must comply with all other applicable controls requirements and continue to provide those control functions. Similarly, if the building owner/operator does enable the DR controls and is enrolled in a DR program, the building control system(s) must perform as required by the applicable building code requirements whenever the building is not participating in a DR event. The DR control functionality is an additional control feature on top of all the other required building controls.

Certification Requirements for DR Thermostats

§110.12(a)5

Residential DR thermostats, also called occupant-controlled smart thermostats (OCSTs), must comply with the technical specifications described in Joint Appendix 5 (JA5). According the requirement in JA5, manufacturers of DR thermostats must submit documentation to the Energy Commission to certify that the thermostat meets the code requirements. See the Energy Commission's website for a list of certified products and instructions on how manufacturers can certify products on their website at http://www.energy.ca.gov/title24/equipment_cert/.

Energy Management Control Systems and Home Automation Systems

Required thermostatic and lighting control functions (including DR control functions) can be incorporated into and performed by an energy management control system (EMCS). Using an EMCS to perform these control functions complies with Title 24 provided that all the criteria that would apply to the control are met by the EMCS.

A home automation system that manages energy loads (such as HVAC and lighting systems) is considered a type of energy management control system and, as such, can similarly incorporate the ability to provide required control functions.