2016 TITLE 24, PART 6
RESIDENTIAL

RESIDENTIAL ENVELOPE AND SOLAR READY

Energy Code Ace™
HELPING YOU PLAY YOUR CARDS RIGHT

This guide is designed to help builders and industry professionals become more familiar with the residential envelope and solar ready portions of California's 2016 Building Energy Efficiency Standards (Title 24, Part 6).

The guide provides information on technologies, design terms and principles, and best-practice approaches related to compliance with the Energy Standards.

This guide was developed and provided by Energy Code Ace, a sub-program of the California Statewide Codes & Standards Program, which offers free energy code training, tools and resources for those who need to understand and meet the requirements of Title 24, Part 6 and Title 20.

To learn more, visit EnergyCodeAce.com

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RESIDENTIAL ENVELOPE AND SOLAR READY (LOW-RISE AND SINGLE FAMILY)

CONTENTS

CHAPTER 1

INTRODUCTION

The Benefits Of Efficiency

Economic Savings

Saving energy saves money. Energy-efficient building envelopes help keep utility bills low by reducing the amount of mechanical heating and cooling needed to keep the buildings at a comfortable temperature.

Increased Comfort

Energy-efficient buildings keep occupants warm in the winter and cool in the summer. The same insulation, high-performance windows and skylights, and reduced air leakage that help save energy also contribute to the most comfortable indoor spaces all year long.

Environmental Benefits

Energy efficiency helps the planet. Designing our building envelopes for energy-efficiency means they require less gas and electricity to heat, cool, and light them. This helps us reduce our dependence on fossil fuels that contribute to climate change and air pollution, among other environmental benefits. Remember that a home built today is likely to have an impact on our environment for years to come, so it is important to design the most energy-efficient building possible.

Home Exterior

About This Guide

This is one of seven guides designed to help builders, designers, contractors, and others involved in the compliance process become more familiar with California's 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Energy Standards) as they apply to projects. It is designed to serve as a resource for industry professionals involved in the design, construction, or retrofit of California's buildings. The guides include compliance requirements and recommendations for implementing the Energy Standards in new construction, addition or renovation projects.

Introduction

This introduction gives a overview of this guide, followed by a summary of what's new in the 2016 Energy Standards, and a section on finding compliant products.

Compliance Process Overview

Chapter 2 begins with an overview of the compliance process including the responsibilities, requirements and documentation involved in each phase of a project, from design to final inspection.

Concepts & Principles

Chapter 3 is devoted to envelope concepts and principles including impact on energy use, designing for climate, building orientation, and thermal characteristics. These concepts are vital for making informed decisions regarding heat gain and loss and components such as wall assemblies, windows and doors.

Technologies, Systems and Compliance Strategies

This section includes an overview of products, common construction assemblies and strategies to improve the envelope.

Compliance Requirements

Mandatory requirements related to new homes, additions, alterations and repairs are explained in Chapter 5. This chapter also examines the prescriptive and performance compliance approaches of Title 24, Part 6, including how to decide on a compliance method for a specific project.

Requirements & Recommendations by Space Type

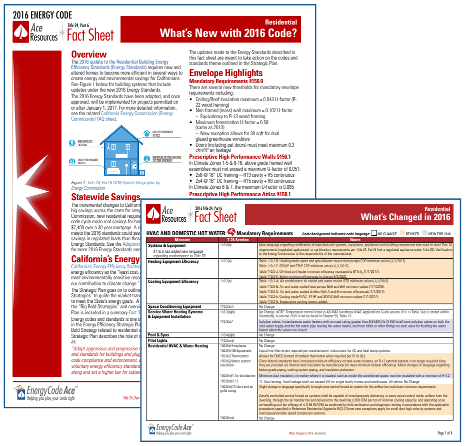
Chapter 6 presents compliance strategies for a variety of scenarios, including how to document compliance.

Designing to Code

This section of the guide includes recommendations for meeting and exceeding the low-rise residential envelope and single-family solar ready standards.

All seven guides can be found at EnergyCodeAce.com

APPLICATION GUIDE	WHAT'S COVERED
NONRESIDENTIAL ENVELOPE AND SOLAR READY	• Climate specific design • Insulation • Cool Roofs • Solar Zone • Fenestration • Compliance documentation details
NONRESIDENTIAL LIGHTING AND ELECTRICAL POWER DISTRIBUTION[1]	• Lighting design strategies • Controls • Electrical power distribution
NONRESIDENTIAL HVAC AND PLUMBING	• Mechanical Systems and Plumbing Systems • Commissioning, HERS Process & Acceptance Testing
NONRESIDENTIAL COVERED PROCESS	• Process loads • Applicable products and systems such as kitchen hoods, parking garage ventilation, laboratory fume hoods, elevators and moving walkways, escalators, and compressors
RESIDENTIAL ENVELOPE AND SOLAR READY (Low-Rise and Single Family)	• Single Family Homes, including duplexes • Low-rise residential building envelope • Climate specific design • Insulation • Cool Roofs • Single Family Solar-Ready including Solar Zones • Fenestration • Prescriptive vs. Performance compliance • Compliance documentation details
RESIDENTIAL LIGHTING[1] (Low-Rise and Single Family)	• Lighting design strategies • Compliant Products • Controls
RESIDENTIAL HVAC AND PLUMBING (Low-Rise and Single Family)	• HVAC terminology • Heating and cooling system types • Hot Water system types
1 Created by the California Lighting Technology Center (CLTC) in collaboration with Energy Code Ace.	


2016 ENERGY CODE
Fact Sheet
Residential
What's New with 2016 Code?
Fact Sheet
Residential
What's Changed in 2016

What's New and What's Changed Fact Sheets

These two documents present 2016 Title 24, Part 6 updates at a glance.

Find Fact Sheets here: energycodeace.com/content/resources-fact-sheets

New In 2016: An Overview Of Updates

For those familiar with the envelope and solar ready requirements of the 2013 Energy Standards for low-rise residential buildings, here is a list of the related changes in the 2016 code. New prescriptive measures for increased framed wall and vented attic insulation in new residences have been adopted in support of the State of California's goal of improving building energy efficiency and achieving zero net energy in newly constructed residences by 2020. The increased first cost of the measures is estimated to be less than the amount of money the building occupant is expected to save from reduced energy costs over the expected life of the building.

Prescriptive Roof/Ceiling Insulation for New Residences

The 2016 prescriptive standards for new low-rise residential buildings (see Table 150.1-A Component Package A) have restructured the insulation r equirements for roofs and ceilings, giving different options depending on the following:

- Climate zone
- Duct location
- Location of roof insulation
- Whether or not there is an air space between the roofing material and the roof decking

Vented attics with ducts in the attic require ceiling insulation in all climate zones, plus roof insulation in climate zones 4 and 8 through 16. R-38 ceiling insulation is required in climate zones 1, 2, 4, and 8 through 16, while R-30 ceiling insulation is required in climate zone 3 and 5 through 7. Roof insulation requirements vary depending on whether the insulation is installed above the roof rafters or below the roof deck between the rafters, and on whether the roofing material is or is not installed with an air space between it and the roof deck. Tile roofs are an example of roofing material typically installed with an air space, while asphalt roof shingles are typically installed without an air space. Radiant barriers are required depending on climate zone and roofing type. See Chapter 5 of this guide for more details on specific requirements.

Vented attics with ducts in conditioned space require R-38 ceiling insulation in climate zones 1 and 11 through 16, and R-30 ceiling insulation in climate zones 2 through 10. However, they do not require any additional roof insulation. Radiant barriers are required in climate zones 2 through 15.

The 2016 prescriptive standards limit prescriptive compliance for new low-rise residential buildings to either vented attics with ducts in the attic, or to vented attics with ducts in conditioned space. New low-rise residential buildings outside of these options must show compliance using the Performance Approach.

Prescriptive High Performance Walls for New Residences

The 2016 prescriptive standards for new low-rise residential buildings now require a maximum U-factor of 0.051 in framed above-grade walls for all but the mildest California climate zones, which are 6 and 7 (see Table 150.1-A Component Package A). This is equivalent to a 2x6 wood frame wall with R-19 insulation in the framing cavity plus R-5 continuous insulation added to the outside of the framing, however the same U-factor can be achieved with other combinations of cavity and continuous insulation (see Joint Appendix JA4).

Mandatory Minimum Ceiling and Rafter Roof Insulation Reduced

The mandatory minimum ceiling and rafter roof insulation requirement for new residences (§150.0(a)) has been reduced from R-30 between wood framing to R-22 between wood framing (U-factor ≤ 0.043). The mandatory minimum insulation between wood framing for ceilings and rafter roofs in an alteration is now R-19 (U-factor ≤ 0.054).

Revised Area Exception to Mandatory Fenestration U-factor

Up to 30 ft^2 of dual pane greenhouse or garden windows is now exempt from the maximum low-rise residential fenestration U-factor of 0.58 (§150.0(q)2). This is an increase in the greenhouse/garden window area exemption from the 2013 Energy Standards.

Revised Exception to Mandatory Solar Zone Area

Exception 7 to §110.10(b)1A now requires demand response signals plus a choice between specific appliances, home automation system, plumbing piping and rainwater catchment options.

Ace Training™

Title 24: Where We're Headed with the 2016 Standards

Offered in traditional classroom and virtual formats, this class presents what's new in the Title 24, Part 6 Energy Standards.

Find dates for upcoming classes: energycodeace.com/training

Decoding 2016 Title 24, Part 6: Let's Talk About What's New

A free, 2-hour interactive online event that discussed, reviewed and decoded the new 2016 code requirements for Title 24 Part 6.

Access the recorde. talk here: energycodeace.com/content/event-recordings

Finding Compliant Products

Certain building envelope products are regulated under California's Energy Standards (Title 24, Part 6), while others are regulated through the California Department of Consumer Affairs (Title 24, Part 12, Chapter 12-13, Article 3).

Products Regulated Under Title 24, Part 6

To be installed in California, manufacturers must certify to the Energy Commission that their fenestration products and exterior doors (except for field fabricated) meet the following requirements of §110.6:

- Air leakage - §110.6(a)1
- U-factor - §110.6(a)2
- Solar heat gain coefficient (SHGC) - §110.6(a)3
- Labeling - §110.6(a)5
- Fenestration acceptance requirement. - §110.6(a)6

For Title 24, Part 6 compliance, manufactured fenestration U-factor and SHGC must either be rated by the National Fenestration Rating Council (NFRC), or must be assumed to have default values from Tables 110.6-A or 110.6-B. Alternate default values may also be calculated using Nonresidential Appendix NA6 for areas of site-built fenestration up to the greater of 250 ft^2 or 5% of the conditioned floor area of a residence.

Section 110.8 of the Energy Standards, also regulates the following products:

- Insulation - §110.8(a)
- Roofing products solar reflectance and thermal emittance - §110.8(i)
- Radiant barrier -§110.8(j)

Section 110.8(a) and §110.8 (j) of the Energy Standards both require certification by the California Department of Consumer Affairs, as explained below.

For Title 24, Part 6 compliance, roofing solar reflectance and thermal emittance must either be rated by the Cool Roof Rating Council (CRRC), or must be assumed to have the default values listed in the exception to §110.8(i)1.

Products Regulated by the Department of Consumer Affairs

For the following products to be installed in California, manufacturers must certify to the California Department of Consumer Affairs, Bureau of Electronic and Appliance Repair, Home Furnishing and Thermal Insulation that the products meet the standards for Insulating Materials detailed in Title 24, Part 12, Chapter 12-13, Article 3:

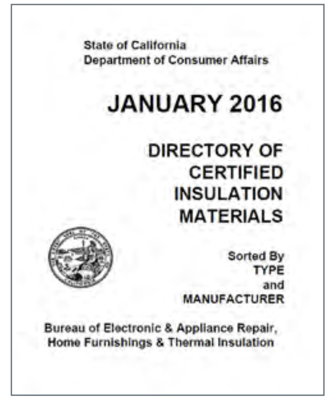
- Insulation must be certified to meet the applicable conductive thermal performance for the product type.
- Radiant barriers must be certified to have an emittance of 0.05 or less.

National Fenestration Rating Council (NFRC)

The National Fenestration Rating Council rates the performance of manufactured windows, glass doors, and skylights, and publishes the directory of NFRC-rated products on their website, shown to the right.

Cool Roof Rating Council (CRRC)

The Cool Roof Rating Council rates the solar reflectance, thermal emittance and solar reflectance index of roofing materials, and publishes the directory of CRRC-rated products on their website, shown to the right.



State of California
Department of Consumer Affairs

JANUARY 2016

DIRECTORY OF
CERTIFIED
INSULATION
MATERIALS

Sorted By
TYPE
and
MANUFACTURER

Bureau of Electronic & Appliance Repair,
Home Furnishings & Thermal Insulation

Certified insulation and radiant barriers are listed in the Consumer Guide and Directory of Certified Insulation Material, which can be downloaded from the following web site:

bearhfti.ca.gov/consumers/ti_directory

nfrc.org

coolroofs.org

CHAPTER 2

COMPLIANCE PROCESS

The following is an overview of the steps to compliance for residential envelope and solar ready systems. Additional information and resources, including the 2016 Residential Compliance Manual and forms, can be found on the California Energy Commission website: energy.ca.gov/title24/2016standards/index.html

Step 1: Discuss and Define Energy-Related Project Goals

Designers, project owners and builders have the most opportunity to identify and pursue energy savings strategies at the beginning of a project. Early coordination with as many project team members as possible is recommended to clearly define energy related project goals and understand potential opportunities and constraints.

Step 2: Determine and Design for...

Applicable Mandatory Measures

All low-rise residential buildings that are regulated occupancies must be designed and built to comply with the mandatory measures of Energy Standards. Mandatory measures are discussed in Chapter 5 of this guide.

Applicable Performance or Prescriptive Requirements

In addition to meeting the mandatory requirements, buildings also must comply with additional requirements specified within the Energy Standards. Two approaches may be taken to meet these requirements:

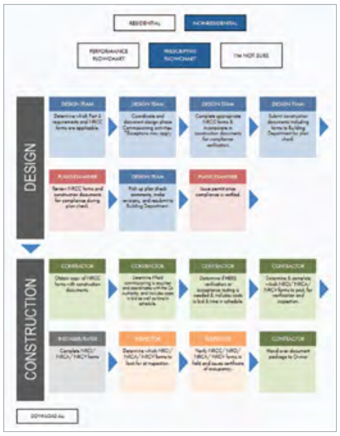
The **Performance Approach** provides one path to compliance. It requires using software approved by the California Energy Commission and is usually best suited for newly constructed buildings, for low-rise residential additions, or additions in combination with an alteration that improves existing building performance. This method allows for energy trade-offs between building systems and is thus considered more flexible.

The **Prescriptive Approach** does not require software or the same level of building science expertise as the Performance Approach. The prescriptive approach is usually best suited for simple additions and alterations.

Both the prescriptive and performance approaches are described in more detail in Chapter 5 of this guide.

Envelope Construction

Ace Navigator™



The Navigator Ace™ is your road map to energy code compliance, illustrating the compliance process step by step from the big picture down to the fine details, including links to resources and tips and tricks.

Find the tool here: energycodeace.com/content/navigator-ace/

Local Adopted Energy Standards

There may also be local standards that the local jurisdiction will enforce in addition to the Energy Standards. These local standards may affect aspects of the project such as lighting, insulation, HVAC installations, and domestic hot water. Additionally, these local standards can require third party inspections and building certifications. Being aware of these local standards in the design phase of the project will reduce cost, time and effort as well as help to avoid extensive and costly change orders.

The California Energy Commission maintains a web page that indicates local jurisdictions who have adopted local standards which exceed the Energy Standards' requirements: energy.ca.gov/title24/2016standards/ordinances/

Step 3: Prepare and Submit Permit Application

Once the design requirements in the Energy Standards have been met, the permit applicant must ensure that the plans include all the documents that building officials will require to verify compliance. Plans, specifications and certificate of compliance forms are submitted to the enforcement agency at the same time as a building permit application. There are some exceptions when plans are not required, and these can be found in Section 10-103 of the Energy Standards. If HERS verification is required for any portion of the project scope, Certificates of Compliance must be registered with a HERS Provider prior to permit application (with limited exceptions).

Step 4: Pass Plan Check and Receive Permit

Depending on the type of permit, the building department will issue a permit over the counter or require that the construction documents and plans be reviewed (aka plan check). If a plan check is required, a plans examiner must verify that the design satisfies the requirements of the Energy Standards and that the plans contain the information to be verified during field inspection. A building permit is issued by the building department after plans are approved.

Step 5: Perform Construction

The construction team must follow the approved plans, specifications, and certificates of compliance (CF1Rs) during construction. Installers must provide certificates of installation (CF2Rs) for their scope of work. Coordination will be required between installers, designers, HERS Raters, and building inspectors to properly install and verify compliant installation. During construction, certificates of installation are completed in preparation for inspection.

Step 6: Test and Verify Compliance (HERS)

When a HERS Rater is required by Title 24, Part 6, early coordination is encouraged to understand when inspections and testing are necessary during the construction process so that they can be incorporated into the schedule. Many inspections are time sensitive as the building component may be inaccessible after walls or other barriers are installed. This is especially true for residences incorporating HERS Verification of Existing Conditions or HERS-verified Quality Insulation Installation (QII) as part of their compliance strategy.

Title 24, Part 6 requires field testing and verification of certain systems, as well as registration of all certificates to a HERS Provider Registry database. Third party HERS Raters must be trained, tested and certified by a HERS Provider.

A list of providers approved by the California Energy Commission (Energy Commission) can be found on their website at energy.ca.gov/HERS/providers.html

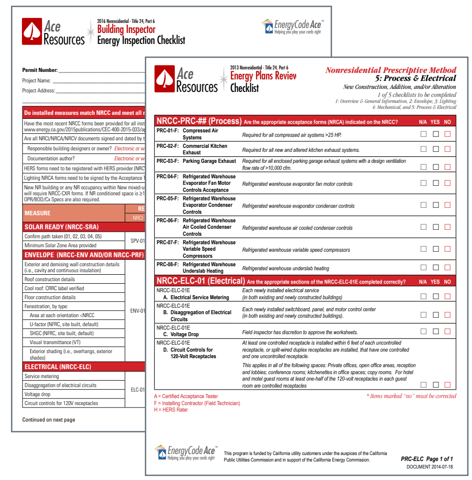
Step 7: Pass Building Inspection

The local authority having jurisdiction, often the building department, likely will require an inspection before finalizing the permit. Building inspections often are scheduled by the contractor with the building department on behalf of the building owner. Ideally, once all systems are installed and inspected and completed compliance documentation has been verified, a Certificate of Occupancy will be issued by the local jurisdiction. However, temporary, conditional, or partial Certificates of Occupancy are not uncommon for some local jurisdictions.

Step 8: Provide Documentation to Building Owners

Upon occupancy, the building owner must receive copies of the energy compliance documents along with instructions for operation and maintenance.

Ace Resources™



Plans Examiners and Building Inspector Checklists

Checklists for Plans Examiners and Building Inspectors are available for applicants to prepare for plan check and inspection as well as to guide department staff through Title 24, Part 6 compliance verification.

Find the checklists here: energycodeace.com/content/resources-checklists/

Ace Training™

Title 24, Part 6 Essentials Training

Offered in traditional classroom and virtual formats, participants learn about navigating key residential Title 24, Part 6 building standards and compliance options for new construction, alterations and additions, and compliance related documents. This course is available in several versions to fit project roles:

- Title 24 Part 6 Essentials – Residential Standards for Plans Examiners and Building Inspectors
- Title 24 Part 6 Essentials – Residential Standards for Energy Consultants
- Title 24 Part 6 Essentials – Residential Standards for AC Quality Installation Contractors

Find dates for upcoming classes: energycodeace.com/training

Building Envelope And Solar Ready Compliance Documents

The compliance process includes the completion of a set of forms to submit for review by a plans examiner within the authority having jurisdiction. Not all forms are required for all projects. Instructions are provided at the end of each form, except for the performance method forms which are filled out by the approved compliance software.

A complete list of all of the low-rise residential building envelope and solar ready compliance forms is included in the Appendix to this guide.

Form Naming Convention

Document Category

ADD = Additions (≤1000ft^2)
ALT = Alterations
ENV = Envelope
EXC = Existing Conditions
LTG = Indoor Lighting
MCH = Mechanical
NCB = New Construction & additions >1000ft^2
PLB = Plumbing (DHW)
PRF = Performance
SRA = Solar Ready
STH = Solar Thermal
SPV = Photovoltaic

Residential

CF1R - PRF - 01 - E

Document Type

Certificates of...
1R = Compliance
2R = Installation
3R = HERS Verification

Primary User

E = Enforcement agency
H = HERS Rater
F = Field Technician (Contractor)

Certificates of Compliance

The Certificate of Compliance (CF1R) documents the building features required to comply with Title 24, Part 6, for low-rise residential buildings. These features will vary depending on the particular project and the compliance approach used. CF1Rs are submitted to the building department as part of the building permit application (see Step 3 of the compliance process description).

The CF1R-PRF-01-E is required when demonstrating compliance using the Performance Approach for any low-rise residential building. There are also a variety of CF1Rs available to demonstrate prescriptive compliance, including the CF1R-NCB-01-E for newly constructed buildings or additions over 1,000 square feet. The CF1R-SRA-01-E is used to document solar ready compliance when it is required. Other CF1Rs are supporting worksheets, such as the CF1R-ENV-02-E which may be used to calculate area-weighted average U-factors or solar heat gain coefficients.

Certificates of Installation

The Certificate of Installation (CF2R) documents that the low-rise residential building products and features actually installed in the field match those required in the Certificates of Compliance. CF2Rs must be completed and signed by the installer or builder responsible for installing regulated building components (see Step 5 of the compliance process description). A full list of available CF2Rs for building envelope features is provided in the Appendix to this guide.

Certificates of Verification

The Certificate of Verification (CF3R) documents compliance with HERS measures in the CF1Rs. CF3Rs must be completed and signed by a HERS rater (see Step 6 of the compliance process description). A full list of available CF3Rs for building envelope verifications is provided in the Appendix to this guide.

Compliance Documents

Compliance Document forms can be found on the Energy Commission website.

Click here to access the forms: energy.ca.gov/2015publications/CEC-400-2015-032/appendices/forms/

Ace Forms™

The Forms Ace aids in determining which compliance forms are applicable to your specific project.

Find the tool here: energycodeace.com/content/forms-ace/

CHAPTER 3

CONCEPTS & PRINCIPLES

Designing For Climate

California has a wide diversity of climate zones throughout the state, ranging from the extreme summer heat of southern California's inland deserts to the extreme cold and winter snow in the high mountains of the Sierra Nevada to the moderate year round temperatures along most of the Pacific coast. Designing building envelopes with the particular microclimate in mind is essential to building energy efficiency.

Hot Climates

When designing for hot climates, envelope designers need to find ways to reduce the impact of intense solar loads and high air temperatures in the summer and often in the spring and fall. Energy-efficient design strategies for hot climates include careful thought about orientation, size, and types of windows, glass doors and skylights, maximizing high performance fenestration (windows, glass doors and skylights) with low U-factors and SHGCs, and adding more protection from the sun through overhangs and side-fins. It also makes sense to reduce the heat gain through the roof by installing "cool roofs" with high reflectance, plus high levels of roof and attic insulation. Interior thermal mass can also help moderate indoor temperature swings.

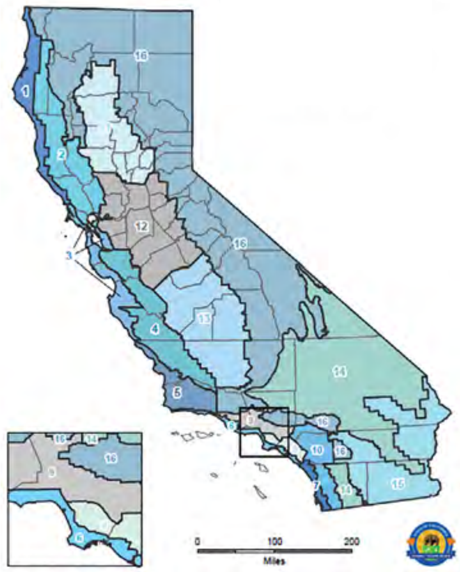
Cold Climates

When designing for cold climates, designers need to minimize heat loss through the building envelope due to cold outside air temperatures in the winter season which may extend into spring and fall. Typical design strategies for cold climates include increased wall, roof and floor insulation and high performance fenestration maximizing low U-factors, but allowing relatively high SHGCs depending on the microclimate. Areas with cold, foggy and rainy winter seasons and cool summers, like climate zone 1 along the far north coast of California, have different design needs and opportunities than climate zone 16 in the high mountains which has more extreme cold in the winter, but may be hot and sunny in the summer.

Moderate Climates

Many parts of California have moderate climates – not too cold in the winter or too hot in the summer – so buildings there need to adopt a mixed strategy. High performance fenestration and relatively high insulation levels overall are likely to perform well in moderate climates, but specific measures will need to be tailored to the particular building site and microclimate.

Loose-fill Insulation Installation



California Climate Zones

California has widely varying climate conditions across the state, resulting in a division of 16 Climate Zones. The Energy Commission has established typical weather data, prescriptive packages and energy budgets for each geogrpahic area, which are defined by zip code.

California's Building Climate Zone Areas can be found here. . energy.ca.gov/maps/renewable/building_climate_zones.html

Envelope's Impact On Energy Use

There are several energy principles to consider when designing building envelopes, all of which can have a significant impact on the amount of heating, cooling and lighting energy use in a building.

Heat Gain and Loss

Heat travels through a building's envelope (roofs, walls, windows, and other exterior and demising surfaces) and tends to travel from higher temperatures to lower temperatures by conduction, convection or radiation; the greater the temperature difference, the greater the rate of heat transfer. Therefore, heat gain in a building occurs when the outdoor temperature is greater than the indoor temperature. Heat gain in buildings can also come from people, lights, appliances and process equipment. Similarly, heat loss occurs when the indoor temperature is greater than the outdoor temperature. Heat gain and loss is measured in units called British Thermal Units (BTU). The rate in which heat travels is measured in BTUs per hour (BTU/hr). The building envelope's ability to resist unwanted heat gain and loss is directly related to its energy efficiency.

Infiltration and Air Leakage

Infiltration, also known as air leakage, is the unintentional introduction of outside air into a building. Infiltration occurs through cracks in the building envelope or through doors and windows. During summer months, infiltration can bring hot air into cooler building cavities, causing increased cooling loads. Likewise, during winter months, infiltration can increase heating loads by drawing cooler air into the building. Whenever infiltration occurs in a building, there is subsequent exfiltration elsewhere. The three primary causes of infiltration are wind, convection (the stack affect) and mechanical systems. The rate in which infiltration occurs is measured in air changes per hour (ACH). Although it is not likely for buildings to be constructed completely air tight, it is extremely important to limit the amount of infiltration through proper sealing and inspection of envelope components.

Building Orientation and Fixed Shading

Since fenestration accounts for the greatest amounts of heat entering buildings, shading provides an economical way to reduce solar heat gain during summer months. The dimensions of a building and its orientation relative to true north will influence how it interacts with the sun. North of the equator, the sun is always in the southern sky at solar noon, and this means that the south side of a building will get the most solar radiation over the year. However, the tilt of the earth's axis results in the highest sun angles at noon on the summer solstice and the lowest at noon on the winter solstice with variations throughout the year, so fixed overhangs can be designed to be most effective on the south side of a building because they will give the most shading during the summer months. Overhangs will not be as effective at shading east and west fenestration because of low sun angles in the morning and evening respectively, however there may be opportunities for fixed shading using side fins. Since skylights face up toward the sky, they are the hardest type of fenestration to shade with overhangs or side fins.

Classic passive solar design strategies recommend running the long axis of a building east-west to maximize south and north orientations and minimize east and west facing glazing and skylights.

Depending on the proposed building site, it may not be possible to change a building's orientation, but it is important design information to understand how the sun will interact with a building over the year.

Daylighting

Daylighting strategies bring natural light into a building to reduce need for electric lights, but try to minimize unwanted side effects like too much solar heat gain. For low-rise residential buildings this is usually accomplished by installing windows, glass doors and skylights that have a low solar heat gain coefficient (SHGC) while maintaining a high visible transmittance (VT). Window and/or skylight size, spacing, performance and orientation play a large role in optimizing the effectiveness of daylighting in buildings.

Fixed Overhang

Heat Transfer

Conduction

Conduction is the transfer of heat between substances which are in direct contact with each other. Conduction occurs when heat flows through a solid from hot to cold. For example, consider what happens when a cold cast iron skillet is placed onto a stovetop burner that is turned on. You decide to touch the handle of the skillet after it has been on for several minutes, and now the handle is hot. This is because heat was conducted through the portion of the skillet in contact with the stovetop all throughout the rest of the skillet.

Convection

Convection is the movement of gases and liquids caused by heat transfer. As a gas or liquid is heated, it warms, expands and rises because it is less dense resulting in natural convection. Cooler gas or liquid replaces the rising gas or liquid. Unlike conduction, convection relies on the circulating motion of the gas or liquid in order to transfer heat. For example, a hot air balloon uses a heater to heat air trapped inside the balloon, which is warmer that the ambient air outside the balloon. This effect causes the balloon to rise.

Heated air inside a hot air balloon causes the balloon to rise due to convection.

Radiation

Radiation is the transfer of heat by means of electromagnetic waves. When radiation heat transfer occurs, the electromagnetic waves move out in all directions from the energy source. All objects both emit and absorb radiant energy, although some objects are much better at this than others. For example, when you stand in front of a burning wood stove, you are warmed by the heat radiating from it.

Key Terms

Building envelope components, such as framing material, masonry or concrete, cavity insulation, continuous insulation, moisture membranes, and sheathing, make up opaque envelope assemblies for roof/ceilings, walls and floors. The Energy Standards set the minimum insulation levels and the prescriptive requirements for construction assemblies.

R-value

R-value is the measure of resistance to heat transfer through a given thickness of material. The conductive heat transfer of building materials such as insulation is measured in R-value -- the higher the R-value, the better the insulation. Although insulation is effective in resisting the movement of heat through building cavities, which is considered conductive heat transfer, it has very little resistance to other forms of heat transfer, such as convection and radiation.

U-factor

U-factor is the rate at which heat transfers through an overall construction assembly or fenestration product. U-factor is calculated as the inverse of the sum of the R-values of all the materials in an assembly, including the air films on the inside and outside, and accounting for effects of framing. NFRC-rated U-factors for fenestration products are tested values that reflect the sometimes complex thermal interactions between all different product components. The lower the U-factor, the lower the rate of heat transfer through a building component. Thermal transmittance of building components including fenestration products, and roof, wall and floor assemblies is measured in U-factors.

Thermal Mass

Thermal mass is a property of a building material, such as a concrete slab, which enables it to store heat. Thermal mass has the ability to absorb thermal energy when the surrounding temperature is higher than the mass, and then release it when the surrounding temperature is cooler than the mass. This effect can serve to flatten out the temperature fluctuations within a building envelope.

Aged Solar Reflectance

Aged solar reflectance is the solar reflectance of the surface after three years, which typically is lower than the initial reflectance value. The higher the solar reflectance, the better (the more heat is reflected from the roofing material).

Thermal Emittance

Thermal emittance provides a means of quantifying how much of the absorbed heat is rejected for a given material. The higher the thermal emittance value, the better (the more heat the roofing material emits back to the atmosphere).

Solar Reflectance Index (SRI)

Solar reflectance index (SRI) is a measure of a surface's ability to reject heat that combines both solar reflectance and thermal emittance. The higher the SRI the more heat is rejected.

Solar Heat Gain Coefficient (SHGC and RSHGC)

Solar heat gain coefficient (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space. The relative solar heat gain coefficient (RSHGC) is the effective solar heat gain coefficient that includes shading from any exterior overhang or other exterior shading. If there is no exterior shading, RSHGC equals SHGC. For hot climates, the lower the SHGC, the better the thermal comfort (less solar heat gain entering the space).

Visible Transmittance (VT)

Visible Transmittance (VT) is the ratio (expressed as a decimal value) of visible light that is transmitted through a glazing fenestration. The higher the VT rating, the better (more light is allowed through a window). Visible transmittance is important for home owners and designers to understand because it will affect the amount of daylight entering a home, but it is not part of low-rise residential energy compliance.

SRI Calculator

A worksheet to assit with SRI calculations can be found on the Energy Commission website.

Click here to access the calculator: energy.ca.gov/title24/2013standards/documents/solar_reflectance/

Resource Highlight: Building America Solution Center

Although not specific to California's Energy Standards, the US Department of Energy's Building America Solutions Center includes a library of resources for designing and building energy efficient residential structures.

Visit the website here: https//basc.pnnl.gov

CHAPTER 4

TECHNOLOGY, SYSTEMS AND COMPLIANCE STRATEGIES

Overview of Products

Insulation

Insulation is one of the most important components for reducing heat gain and loss through opaque construction assemblies. Insulation comes in many different types, forms and applications, and its effectiveness is measured in R-value, which is the measure of resistance to heat flow. The higher the R-value, the more the material insulates.

When choosing insulation, it is important to consider where the material will be installed in the building envelope assembly and how much insulation is necessary to meet or exceed code. Often, opaque construction assemblies consist of one or more types of insulation in different locations for cavity insulation and continuous insulation. In many cases, determining the best strategy for insulating depends on the building design and overall project budget.

Another consideration for selecting insulation is environmental effects from various chemical make-up components. Many of the newer insulation materials are far more "green" than previously available products, including formaldehyde-free and recycled-content insulation.

Batt or Roll Insulation

Batt or roll insulation is generally installed within framed cavities, such as between studs, rafters or floor joists. It can also be draped over framing members, such as metal building walls and roofs. The most common types of batt or roll insulation materials are:

- Fiberglass
- Mineral Wool (rock or slag)
- Plastic Fiber (e.g. recycled plastic PET)
- Natural Fiber (e.g. recycled cotton)

Batt Insulation Installation

Ace Installation™

The Installation Ace is a "field guide" to assist you in identifying proper installation techniques and which provides visual aides for some components commonly installed incorrectly.

Find the tool here. energycodeace.com/content/installation-ace

Loose-Fill Insulation

Loose-fill insulation is made up from small particles of fiber insulation material and is commonly installed by blowing them into place. These small particles form an insulation layer that easily conforms to irregular shapes and provides a consistent fill of the cavity. Loose-fill insulation is most commonly installed in attic ceilings. The most common types of loose-fill insulation materials are:

- Cellulose
- Fiberglass
- Mineral Wool

Foam Board or Rigid Insulation

Foam board and rigid insulation is manufactured into sheets and is available in various thicknesses. This product can be installed as continuous sheathing over framing members, or installed between framing members similar to batt insulation. When foam board insulation is installed as continuous sheathing over framing members, it provides a good thermal break by reducing conductive heat through framing materials. The most common types of foam board or rigid insulation materials are:

- Polystyrene
- Polyisocyanurate
- Polyurethane

Spray Foam Insulation

Spray foam insulation is a liquid foam material that can be sprayed, foamed-in-place, injected or poured. Spray foam insulation can be categorized into two different types: open cell and closed cell. Open cell foam consists of tiny cells that are not completely closed and does not provide any type of air or vapor barrier. Closed cell foam is much denser than open cell foam and consists of much smaller closed cell structures, which makes it a very good air and vapor barrier. The most common types of spray foam insulation are:

- Open- and Closed-Cell Spray Polyurethane Foam (SPF)

R-Values For Common Insulation Materials[1]

Insulation Material	R-value per inch
Fiberglass Batt	3.2-4.3
Fiberglass Loose-fill	2.2-4.3
Rock Wool Batt	3.2-4.0
Rock Wool Loose-fill	3.0-3.3
Recycled Cotton Batt	3.4
Plastic Fiber (PET) Batt	3.8-4.3
Cellulose Loose-fill	3.2-3.8
Expanded Polystyrene (EPS) Board	4.20
Extruded Polystyrene (XPS) Board	5.00
Polyisocyanurate	5.9
Medium Density Closed-Cell SPF Insulation	5.8
Low Density Open-Cell SPF Insulation	3.6

1 Source: U.S. Department of Energy

Fenestration

Fenestration is the technical term for describing a window, glazed door or skylight assembly which includes the frame and glazing components. Fenestration provides a transparent/translucent barrier between the indoor environment and the often undesirable outdoor environment. High-performance fenestration products have a substantial impact on reducing energy consumption in buildings, whether by reducing heat gain through spectrally selective glass, shading or dynamic glazing, or by reducing conductive heat loss by using wood, vinyl, fiberglass, or thermally-broken metal frame material and insulated low-e glazing. Fenestration performance is measured by overall U-factor, SHGC and VT, which are explained in Chapter 3. Typically, for U-factor and SHGC, the lower the value, the better its performance, although low SHGCs are most helpful in the hotter climate zones. For VT, the higher the value, the more daylight is transmitted.

Doors

Doors are the opaque counterpart to fenestration and provide means of entering and exiting buildings. Doors are categorized into two primary types: swinging and non-swinging doors. Exterior swinging doors include: solid wood doors, hollow metal doors and insulated metal doors. Non-swinging doors include; sectional, sliding and roll-up doors. Doors performance is measured by overall U-factor. For U-factor, the lower the value, the better its performance is.

Cool Roof

A cool roof is a roofing product with high solar reflectance and thermal emittance properties, which help reduce cooling loads by lowering roof temperatures on hot, sunny days. Solar reflectance and thermal emittance are properties of the roofing surface.

Aged solar reflectance is the solar reflectance of the surface after three years, which typically is lower than the initial reflectance value. The higher the solar reflectance, the better (the more heat is reflected from the roofing material).

Thermal emittance provides a means of quantifying how much of the absorbed heat is rejected for a given material. The higher the thermal emittance value, the better (the more heat the roofing material emits back to the atmosphere).

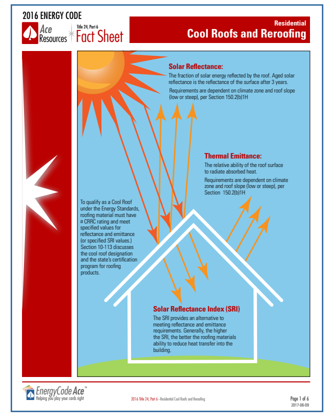
Solar reflectance index (SRI) is an alternate measure of cool roof performance which combines the aged solar reflectance and the thermal emittance.

Common Opaque Construction Assemblies

Building envelope components, such as framing material, masonry or concrete, cavity insulation, continuous insulation, moisture membranes, and sheathing make up opaque envelope assemblies for roof/ceilings, walls and floors. The Energy Standards set the minimum insulation levels and the prescriptive requirements for construction assemblies. The requirements are expressed as maximum U-factors or minimum insulation R-values to be installed between wood framing.

The assembly U-factor and descriptions of common building construction assemblies can be found in the appropriate tables listed in the Reference Joint Appendix Chapter 4 (JA4) for the prescriptive compliance approach. For the performance approach, construction assemblies are calculated based on individual assembly components representing the proposed construction assembly.

Tables and assembly details for mandatory and prescriptive requirements have been included in Chapter 5 of this guide.


2016 ENERGY CODE
Fact Sheet
Residential
Cool Roofs and Reroofing
Solar Reflectance:
Thermal Emittance:
Solar Reflectance Index (SRI)

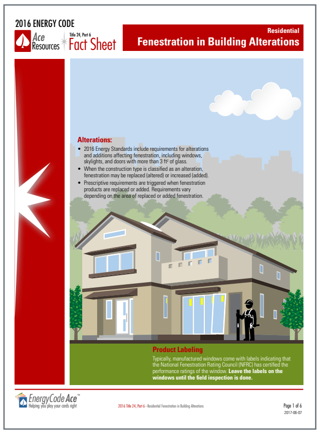

2016 ENERGY CODE
Fact Sheet
Residential
Opaque Envelopes
What is an Opaque Envelope?
Relevant Code Sections
Relevant Compliance Forms
Compliance Requirements

Cool Roof Fact Sheet & Residential Opaque Envelope Fact Sheet

These documents summarize Energy Standards requirements and offer compliance recommendations.

Find Fact Sheets here: energycodeace.com/content/resources-fact-sheets

Ace Resources™



Residential Fenestration Fact Sheet

This document summarizes Energy Standards requirements and offers compliance recommendations.

Find Fact Sheets here: energycodeace.com/content/resources-fact-sheets

Envelope Improvement Strategies

When considering recommendations for improving the envelope of a building, it's important to consider where the building is geographically located. Since energy use depends partly upon weather conditions, which differ throughout the State, the Energy Commission has established 16 climate zones representing distinct climates within California. Climate zones play a major role in choosing construction assembly features for building envelopes, which are the interface between the interior of the building and the outdoor environment. The building envelope can affect the overall heating, cooling and lighting energy use.

Magnitude of annual heating and cooling loads

Considering the magnitude of annual heating and cooling loads can play an important role in designing energy efficient building envelopes. In hotter climates, cooling loads can be reduced by minimizing the effects of solar gains. These strategies include installing low RSHGC vertical fenestration (low SHGC for skylights) while maintaining relatively high VT, increase roof/ceiling and wall insulation, and cool roofing, to name a few.

In cooler climates, heating loads can be reduced by minimizing heat loss through conduction and infiltration. These strategies include installing high R-value roof/ceiling and wall insulation, low U-factor fenestration such as products with low-e glass and nonmetal frames, and air infiltration sealing.

Fenestration

Fenestration typically accounts for one of the largest sources of heat gain in buildings located in hotter climate zones and heat losses for buildings in colder regions. Making improvements that reduce the effect of solar heat gain through windows, doors and skylights will have a significant impact on reducing cooling energy use in buildings, while improving the insulating properties of fenestration can help reduce both heating and cooling energy use. Below are several strategies to consider when considering improvements to building envelope fenestration.

Spectrally Selective Glass (low SHGC and low U-factor)

This type of glass has special properties that block or re-radiate infrared energy from the sun, reducing solar gain through the windows while maintaining higher levels of visible light transmittance. Spectrally selective glass also helps prevent conductive heat losses and gains between heated or cooled interiors and variable outdoor conditions. Low-e glass is a common type of spectrally selective glass.

Exterior Shading Devices (low RSHGC)

Shading devices control the amount of sunlight that penetrates into a building reducing the effects of solar gain through fenestration (see shading below).

Dynamic Glazing

Dynamic Glazing (DG) products are any fenestration product with the ability to change its performance properties, including U-factor, SHGC and/or VT. During hot weather, DG can allow the occupant to control their environment by tinting (or darkening) a window with the flip of a switch or by raising and lowering a shade positioned between panes of glass. Some windows and doors can change their performance automatically in response to a control or environmental signal.

Reduce The Total And West-Facing Fenestration Area

The amount of fenestration area has a large impact on heating and cooling energy consumption. This is especially true for west-facing fenestration because of the very low sun angle during summer months in the late afternoon when cooling demand is the highest.

Roofs and Walls

Because roofs and walls have a high potential for solar gains and heat losses, increasing insulation levels in these areas can provide significant reductions in heating and cooling loads in buildings. Adding continuous rigid insulation above the roof deck and over the wall sheathing can also reduce conductive heat transfer through framing members. To gain the full impact of any insulation, it is critical to install insulation properly, and there are also roof and wall framing techniques that can maximize insulation effectiveness, such as raised heel roof trusses and advanced wall framing.

Shading

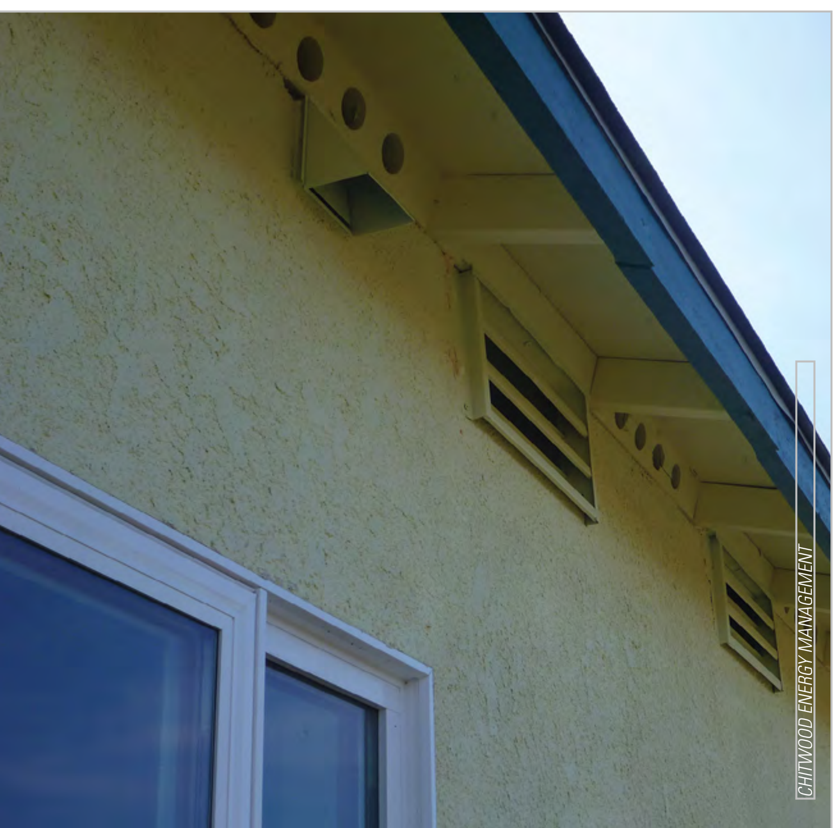
There are many different reasons for controlling the amount of sunlight that penetrates into a building. In warmer climates, reducing solar gains through fenestration results in lower cooling energy consumption; in cooler climates winter sun entering through south-facing windows can passively heat buildings, thus lowering nonrenewable heating energy consumption. Shading devices can also improve user visual comfort by controlling glare and reducing contrast ratios.


DOW
Styrofoam
CHITWOOD ENERGY MANAGEMENT


CHITWOOD ENERGY MANAGEMENT


Tyvek
CHITWOOD ENERGY MANAGEMENT


Area of Wall = 371 FT2
Area of Wall = 91.4 FT2
25% Wood
Area of Wall = 36.5 FT2
9.8% Wood
CHITWOOD ENERGY MANAGEMENT


CHITWOOD ENERGY MANAGEMENT

CHAPTER 5

COMPLIANCE REQUIREMENTS

Requirements Overview

There are two basic steps to comply with the Energy Standards:

1. Meet all mandatory requirements by installing required systems, equipment and devices, and ensuring that they perform all functions required by the Energy Standards.
2. Select your method of compliance by choosing either the Performance Approach or the Prescriptive Approach.

Mandatory Requirements

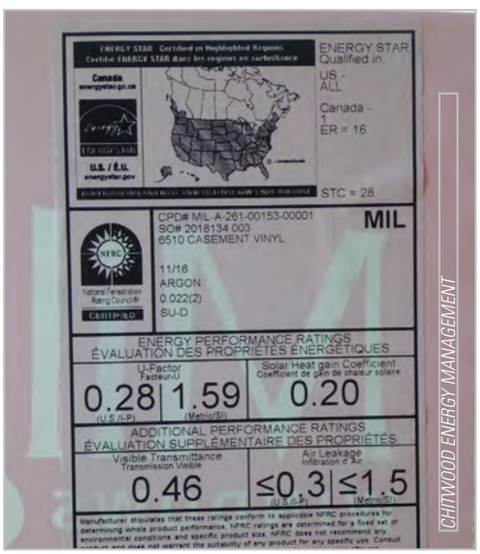
All low-rise residential buildings must meet a set of mandatory requirements for minimum envelope efficiencies and construction of assemblies. Examples of building envelope components addressed by mandatory measures include minimum insulation levels, infiltration controls, and maximum fenestration U-factor. Some new single-family residences must also meet mandatory solar ready requirements.

Prescriptive Approach

The Prescriptive Approach is considered the most direct path to compliance. It is a set of prescribed performance levels for various building components, where each component must meet the required minimum efficiency. There are different prescriptive requirements for new homes, additions, and alterations.

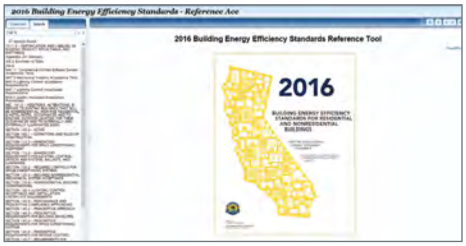
Performance Approach

The Performance Approach builds on the Prescriptive Approach by allowing energy allotments to be traded between building systems. For low-rise residential buildings, there can be proposed energy use trade-off. between features of the building envelope, space heating and cooling equipment, and domestic water heating. This compliance approach requires using energy analysis software that has been approved by the Energy Commission.



ZNE Demonstration Home, Habitat for Humanity, Dream Creek Subdivision, Stockton, CA. Designed by George H. Koertzen, Habitat for Humanity San Joaquin County, CA

Ace Reference™



The Reference Ace™ tool helps you navigate the Standards, Compliance Manual and Reference Appendices using key word search capabilities, hyperlinked tables and related sections.

Find the tool here: energycodeace.com/content/reference-ace-2016-tool

Exceptions

Only mandatory measures are required for:

1. Certain seasonally occupied agricultural housing (Exception 1 to §100.0(e)2Diib), and
2. Low-rise residences with wood space heaters or another non-mechanical space heating system and no lighting or water heating energy from depletable sources (Exception 2 to §100.0(e)2Diib).

Navigating Title 24, Part 6

The Energy Standards contain energy requirements for all newly constructed buildings, additions and alterations. The Energy Standards are divided into three general categories: mandatory requirements that apply to all buildings, nonresidential building requirements (including high-rise residential and hotel/motel buildings) and residential building requirements (including low-rise residential buildings). The 2016 Building Energy Efficiency Standards are available from the Energy Commission and may be downloaded here:

Title 24, Part 6 Building Energy Efficiency Standards

The following table provides references to sections of the Energy Standards for residential envelope and solar ready requirements, categorized by mandatory measures, prescriptive approach and performance approach. All code sections in the following table are hyperlinked to Reference Ace tool.

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	§110.6 - §110.8, §150.0(a) - §150.0(d), §150.0(f) - §150.0(g), §150.0(q)	§150.1(a), §150.1(c), Table 150.1-A	§150.1(a), §150.1(b)
Insulation	§110.8(a) - (d), §110.8(g) - (h), §150.0(a) - §150.0(d), §150.0(f)	§150.1(c)1	
Fenestration	§110.6, §150.0(q), Tables 110.6-A and 110.6-B	§150.1(c)3, §150.1(c)4	
Roofing and Radiant Barriers	§110.8(i) - §110.8(j)	§150.1(c)2, §150.1(c)11	
Limit Air Leakage	§110.7		
Vapor Retarder	§150.0(g)		
Additions, Alterations, and Repairs	§150.2(a), §150.2(b)	§150.2(a)1, §150.2(b)1	§150.2(a)2, §150.2(b)2
Additions	§150.2(a)	§150.2(a)1	§150.2(a)2
Alterations	§150.2(b)	§150.2(b)1	§150.2(b)2
Single Family Solar Ready	§110.10(a)1, §110.10(b) - §110.10(e)		
Covered Occupancies	§110.10(a)1		
Solar Zone	§110.10(b)1A, §110.10(b)2 - §110.10(b)4		
Interconnection Pathways	§110.10(c)		
Documentation	§110.10(d)		
Main Electrical Service Panel	§110.10(e)		

Note: See §100.0 Scope and Table 100.0-A Application of Standards for additional information on which sections of Title 24, Part 6 apply to any given project, in particular which code sections apply to conditioned versus unconditioned space.

New Homes, Additions, Alterations and Repairs

When starting the energy compliance process for a low-rise residential building project, the first task is to understand what sections of the Energy Standards apply. This depends in part on whether the building is brand new, or if the project is an addition, alteration or repair to an existing residence. It is also important to know if any part of the building is conditioned space, meaning that it is either directly or indirectly heated and/or cooled. Low-rise residential building envelope requirements only apply to conditioned spaces.

Newly Constructed Homes

New low-rise residential buildings need to comply with either the prescriptive requirements of §150.1(a) and (c) or the performance method requirements of §150.1(a) and (b). Overall compliance for new residences must include the building envelope, HVAC and water heating, plus all applicable mandatory measures including lighting and solar ready, not just the building envelope. New low-rise residential building envelopes need to comply with the mandatory measures applicable to all occupancies in §110.6 through §110.8, as well as the applicable low-rise residential measures in §150.0. New single-family residences in subdivisions with ten or more units are also subject to mandatory solar ready requirements in §110.10.

Additions

Additions to low-rise residential buildings need to comply with either the prescriptive requirements of §150.2(a)1 or the performance method requirements of §150.2(a)2. There are different prescriptive compliance options for residential additions which depend on their conditioned floor area. These are explained in more detail later in this chapter. Typical performance method compliance options for additions include analyzing the addition by itself, or using the existing-plus-addition-plus-alteration compliance approach. This method requires analysis of the whole existing house plus the addition, including alterations that are proposed for the existing house. Low-rise residential additions must comply with all applicable mandatory measures, similar to newly constructed buildings. Note that the mandatory solar ready requirements do not apply to low-rise residential additions.

Alterations

Alterations to low-rise residential building envelopes need to comply with either the prescriptive requirements of §150.2(b)1 or the performance method requirements of §150.2(b)2. Prescriptive compliance for residential alterations is typically limited to analysis of just the altered components, such as window replacements or an upgrade to an existing roof. As with additions, alterations can also show compliance using the existing plus alteration Performance Approach, as long as at least two altered building components from Table 150.2-C can be traded off against each other. These components can be of the same type, such as two altered windows, or of different types, such as one altered window and an altered water heater. Altered components must comply with all applicable mandatory measures.

Repairs

Title 24, Part 6 §100.1 defines repairs to an existing building as the "reconstruction or renewal for the purpose of maintenance.. Repairs do not trigger the typical Title 24, Part 6 requirements. However, repairs are not allowed to increase the preexisting energy use of the repaired component. Also, replacing any component that has requirements in the Energy Standards, such as a window or skylight, is considered an alteration, not a repair.

Exceptions

A repair as defined in §100.1 does not trigger the typical Title 24, Part 6 requirements. However, repairs are not allowed to increase the preexisting energy use of the repaired component. Also, replacing any component that has requirements in the Energy Standards, such as a window or skylight, is considered an alteration, not a repair.

Mandatory Measures: Building Envelope

Low-rise residential buildings must comply with some mandatory building envelope measures that apply to products and systems that may be found in all building occupancies (§110.6 through §110.8) and with others that are specific to only low-rise residential construction (§150.0). When applicable to their particular scope of work, low-rise residential additions and alterations must comply with most of the same envelope mandatory measures as newly constructed residences, but there are some exceptions. Mandatory measures are minimum requirements, but they may not be enough to bring a building into compliance with Title 24 using the prescriptive or performance method. Note that any particular low-rise residential project will only need to comply with the specific mandatory measures that apply to the scope of work.

Products and Systems for All Building Occupancies (§110.6-§110.8)

Energy Standards §110.0 covers mandatory requirements for products and systems that may be used in all building occupancies, including low-rise residential. These include requirements that manufacturers certify their products to meet specific performance standards for use in California as well as general product installation requirements.

Products requiring manufacturer certification include:

- Fenestration products and exterior doors, except field-fabricated (§110.6)
- Roofing products (§110.8(i))
- Radiant barriers (§110.8(j))
- Insulation (§110.8(a))

Certification helps ensure that products installed in buildings in California actually meet the energy-efficiency levels required for those buildings to comply with the prescriptive and performance standards. More details on these certification requirements are covered under "Finding Compliant Products" in Chapter 1 of this guide.

Measures dealing with product installation and construction requirements include:

- Limiting air leakage (§110.7) through all joints, penetrations and other openings in the building envelope where air leakage in or out might occur;
- Installing insulation to comply with California Building Code (CBC) flame spread rating and smoke density requirements (§110.8(c));
- Installation requirements for liquid applied roof coatings for low-sloped roofs (§110.8(i)4); and
- Insulation requirements for heated slab floors (§110.8(g)) include protecting the insulation from damage, and minimum mandatory insulation levels. Minimum mandatory heated slab insulation requirements are described in more detail below.

The National Fenestration Rating Council rates the performance of manufactured windows, glass doors, and skylights, and publishes the directory of NFRC-rated products on their website, nfrc.org

Fenestration U-factors and SHGCs for Compliance

When selecting windows, glass doors and skylights for residential buildings, it is important to understand whether the fenestration products have certified NFRC-rated U-factors and SHGCs or not.

If a product is certified as NFRC-rated, then the NFRC-rated U-factors and SHGCs may be used to demonstrate Title 24 energy compliance. However, if the product is not certified as NFRC-rated, then Energy Commission default U-factors and SHGCs must be assumed.

Table 110.6-A lists default U-factors, and Table 110.6-B lists default SHGCs. For site-built fenestration areas up to 250 ft^2 or 5% of the residence's conditioned floor area, alternate default values may also be calculated using Nonresidential Appendix NA6.

When fenestration products are installed, they are required to have temporary labels that state the certified U-factors and SHGCs. Labels for NFRC-rated products shall include the NFRC-rated values. U-factors and SHGCs for NFRC-rated products are also generally accessible on the NFRC website. Products that are not NFRC-rated shall have temporary labels that call out the "CEC Default U-factor" and "CEC Default SHGC" with the default values described above.

Roofing Aged Solar Reflectance, Thermal Emittance and SRI for Compliance

When selecting roofing materials for residential buildings, it is important to understand whether the products have certified CRRC-rated properties or not.

If the roofing product is CRRC-rated, the rated aged solar reflectance and thermal emittance values, or the rated SRI, may be used to demonstrate energy compliance with the Energy Standards. §110.8(i)2 provides an equation to calculate aged solar reflectance for products with only CRRC-rated initial solar reflectance.

If the roofing products have not been officially certified through CRRC, then the products must be assumed to have a default aged solar reflectance of 0.08 for asphalt shingles and 0.10 for all other roofing products, and a default thermal emittance of 0.75.

Ceiling/Rafter Roof, Wall, and Floor Insulation (§150.0(a, c, d))

There are mandatory insulation requirements for opaque areas of the building envelope that separate conditioned space from unconditioned space or outside air. The tables below summarize the mandatory insulation requirements for ceilings and rafter roofs, walls and raised floors (except raised concrete). The tables show the requirements for both new construction and for alterations.

There are two basic methods for meeting mandatory insulation requirements for these types of opaque construction assemblies in a residence.

- The most flexible method is to calculate the overall U-factor for each new or altered construction assembly in the proposed project, and then show that the area-weighted average U-factor for each general type of assembly (i.e. wall, roof/ceiling, or raised floor) is less that the maximum U-factor allowed in the Energy Standards. This is the only method available for metal framed assemblies, or for non-framed walls such as concrete walls or SIPS panels.
- The simplest method only applies to wood framed walls, roofs and floors, and it is just to install insulation with the minimum required R-value between the wood framing. For example, the minimum insulation level for a 2x4 wood frame wall is R-13, so any 2x4 wood frame wall with R-13 insulation or more meets the mandatory insulation level regardless of any other materials in the overall construction assembly. This method cannot be used for metal frame construction.

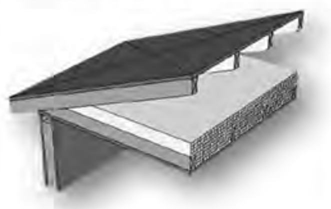
SRI Calculator

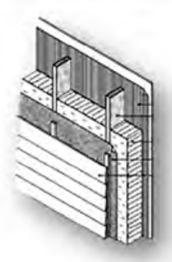
A worksheet to assit with SRI calculations can be found on the Energy Commission website.

Click here to access the calculator: energy.ca.gov/title24/2013standards/documents/solar_reflectance/

Code in Practice: Special Case for Bay/ Bow Windows

§150.0(c)4. The roofs and floors of bay or bow windows are special cases required to meet the prescriptive package A wall insulation requirements (Table 150.1-A). That would equate to having a maximum U-factor of 0.065 in climate zones 6 and 7 and a maximum U-factor of 0.051 in all other climate zones.

Mandatory Insulation: Ceiling/Rafter Roof (§150.0(a))		
Methodology: *either may be used*	New Construction	Alterations
U-Factor (area-weighted average) ***or***	≤0.043	≤0.054
Insulation R-Value (between wood framing)	≥R-22	≥R-19
Examples from Joint References Appendices	R-22 in wood framed attic: JA4.2.1-6A	R-19 in wood framed rafter roof: JA4.2.2-12A
		

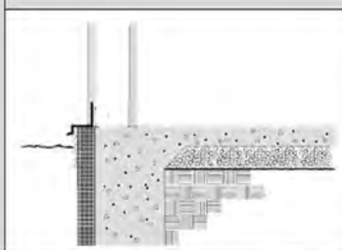
Mandatory Insulation: Walls (§150.0(c))				
Methodology: *either may be used*	New Construction and Alterations			Existing in Newly Conditioned **
	2 x 4	2 x 6	Opaque Non-framed	2 x 4
U-Factor (area-weighted average) ***or***	≤0.102	≤0.074	≤0.102	≤0.110
Insulation R-Value (between wood framing)	≥R-13	≥R-19	N/A	≥R-11
Examples from Joint Reference Appendices	R-13 wood framed wall: JA4.3.1-3A	R-19 wood framed wall: JA4.3.1-5A	R-14 SIPS panel with OSB spline: JA4.3.2-1A	R-11 in wood framed wall: JA4.3.1-2A
				

1 Must use the performance method to show compliance when using R-11 or U ≤ 0.110 in exisitng walls.

Mandatory Insulation: Raised Floor (N/A to raised concrete) (§150.0(d))	
Methodology: *either may be used*	**New Construction and Alterations**
U-Factor (area-weighted average) ***or***	**≤0.037**
Insulation R-Value (between wood framing)	**≥R-19**
Examples from Joint References Appendices	R-19 wood framed floor over crawlspace: JA4.4.1-4A R-19 wood framed floor over open: JA4.4.2-4A
	

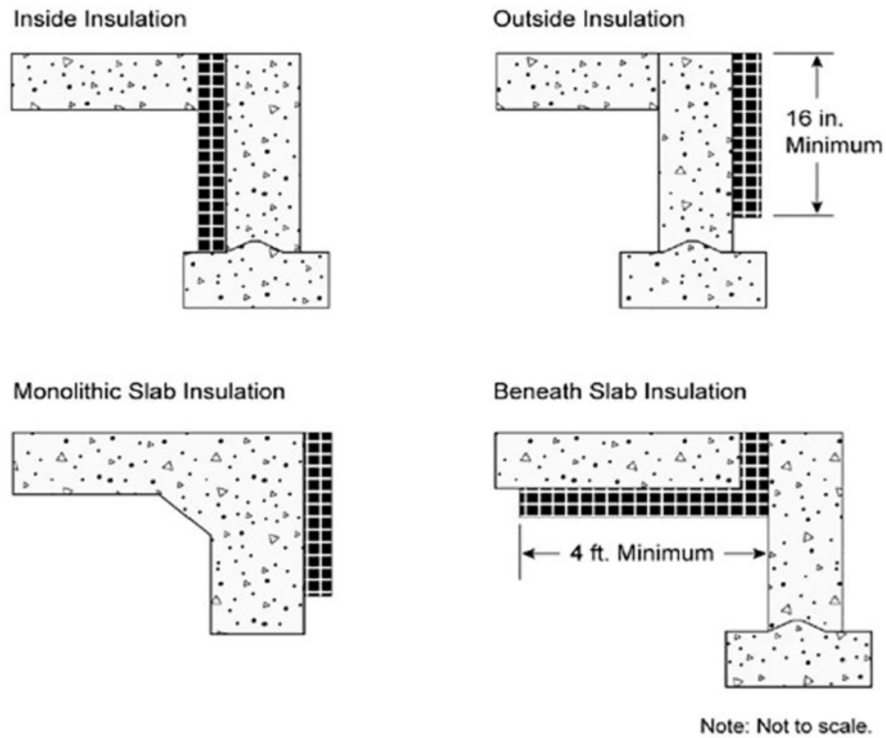
Slab-on-grade and Raised Concrete Floor Insulation (§110.8(g), §150.0(f))

There are no mandatory insulation requirements for unheated mass floors such as slab-on-grade or raised concrete floors. However, heated mass floors must be insulated to minimize heat loss to the outside of the conditioned space according to the requirements summarized below:

Mandatory Insulation: Mass Floors (§110.8(g), §150.0(f))		
Type:	**Slab on Grade**	**Raised Concrete**
Heated (including topping slabs with embedded heating elements, such as hydronic tubing) See Table 110.8-A and 2016 Residential Compliance Manual Sections 3.6.1.5 and 4.7.2 for more information.	CZ 1-15: **Slab edge insulation ≥R-5** CZ 16: **Slab edge insulation ≥R-10** *or* **Slab edge insulation ≥ R-10 +** **Under slab insulation ≥ R-7**	CZ 1-15: **Slab edge insulation ≥R-5 +** **Under slab insulation ≥ R-5** where unconditioned and/or exterior conditions below floor CZ 16: **Slab edge insulation ≥R-10 +** **Under slab insulation ≥ R-7** where unconditioned and/or exterior conditions below floor
		
Unheated	No insulation requirements	

One example of a heated mass floor would be a radiant floor hydronic heating system with space heating hot water pipes embedded in a concrete slab-on-grade.

See Energy Standards §110.8(g) and Table 110.8-A and the 2016 Residential Compliance Manual sections 3.6.1.5 and 4.7.2 for more details on the insulation installation requirements.



Heated Slab-on-Grade Floor Insulation Options (Graphic excerpted from 2016 Residential Compliance Manual, Figure 4-35, California Energy Commission)

Loose Fill Insulation (§150.0(b))

When used, loose-fill insulation must be installed to meet or exceed the manufacturer's design weight per square foot for the labeled R-value.

Vapor Retarder (§150.0(g))

Class I or II vapor retarders are required to cover the earth floor of unvented crawl spaces in all climate zones. This same requirement applies to controlled ventilation crawl spaces that take the exception to §150.0(d).

In climate zones 14 and 16, class I or II vapor retarders are also required on the conditioned space side of all insulation in all exterior walls, vented attics and unvented attics with air-permeable insulation.

Maximum Fenestration U-factor (§150.0(q))

Fenestration, including skylights, that separates conditioned space from unconditioned space or outside air must have a maximum U-factor less than or equal to 0.58. The maximum 0.58 U-factor may also be achieved by area-weighting the U-factors of all fenestration.

Exceptions to Mandatory Measures for Low-rise Residential Additions (§150.0(c)1, §150.2(a))

Low-rise residential additions must meet most of the same envelope mandatory measures as new residences (see §150.2(a)). Note that for Title 24 energy compliance, additions include converting existing unconditioned spaces, such as basements or attics, into newly conditioned space by adding new space heating and/or cooling equipment or by supplying

Mandatory Maximum Fenestration U-Factor (§150.0(q)) [1]

Methodology:	New and Altered [2]
U-Factor (area-weighted average)	**≤0.58**
Example from Table 110.6-A: Default Fenestration Product U-Factors	Dual pane nonmetal frame operable window = 0.58 U-factor 

1 This applies to all fenestration products separating conditioned from unconditioned space, including skylights.

2 Areas exempt from mandatory maximum U-factor:
(1) Up to the greater of 10 ft² or 0.5% of the conditioned floor area
(2) Up to 30 ft² of dual glazed greenhouse or garden windows

heating or cooling from an existing system. There is an exception to the mandatory wall insulation requirements (§150.0(c)1) that may apply to this particular type of addition.

If a newly conditioned space has existing 2x4 wood frame walls with either R-11 insulation or a maximum assembly U-factor of 0.110, those walls are allowed to remain without being upgraded to R-13 insulation. Note, however, that those R-11 walls will not meet any prescriptive requirements, so the addition overall will need to demonstrate Title 24 energy compliance using the Performance Approach and trade-off the energy lost through the R-11 walls with some higher-efficiency measure.

Exceptions to Mandatory Measures for Low-rise Residential Alterations (§150.0(a)1, §150.2(b))

Low-rise residential envelope alterations must meet most of the same mandatory measures as new residences (see §150.2(b)1 and §150.2(b)2A), but only if they apply to the particular building feature being altered. There is an exception to the mandatory ceiling and rafter roof insulation requirement for new residences (§150.0(a)1) that allows altered ceilings and vaulted rafter roofs to have a maximum U-factor of 0.054 or a minimum of R-19 insulation installed between wood framing.

Mandatory Measures: Single-Family Solar Ready

The mandatory solar ready requirement is part of California's plan to reach zero net energy (ZNE) in residential new construction by 2020. It assures that new single family homes in residential subdivisions are designed for future solar electric or solar water heating systems.

Covered Occupancy (§110.10(a)1)

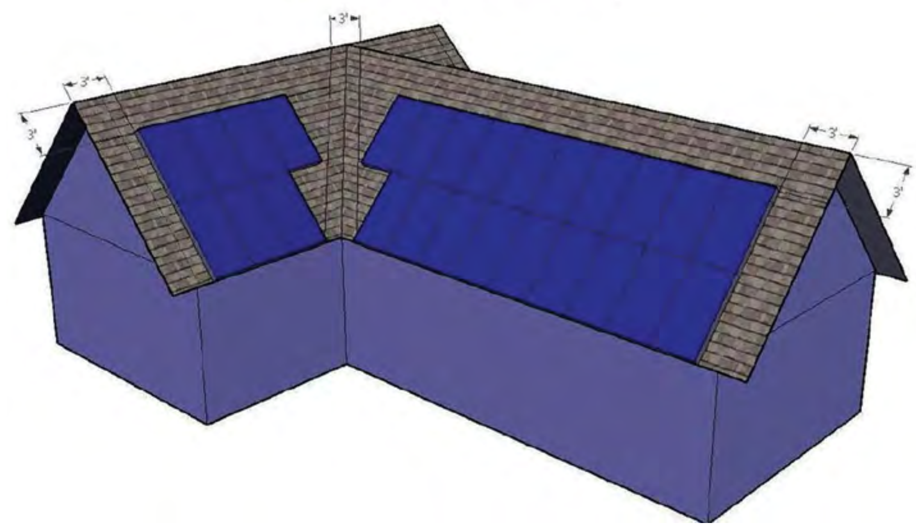
The solar ready requirements apply to new single-family residences in subdivisions with ten or more residences.

Solar Zone General Rules and Minimum Area (§110.10(b)1 and 1A)

The total solar zone for a single family residence must be at least 250 ft^2 and located on the residence roof or overhang, unless the residence meets one of the exceptions below. The solar zone may be divided into several different areas of at least 80 ft^2 each (for roofs up to 10,000 ft^2). The smallest dimension for each part of the solar zone must be at least five feet. This ensures that each zone area is large enough to accommodate actual solar PV or water heating panels.

The zone locations must comply with all state and local fire code requirements for access, pathway, smoke ventilation and spacing (see graphic for one example).

Figure 7-4 Cross Gable with Valley

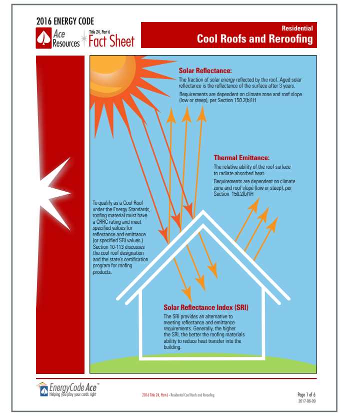


Solar PV installation that meets California Fire Code Solar Access requirements, 2016 Residential Compliance Manual Figure 7-4, complete Solar Photovoltaic Installation Guideline available at osfm.fire.ca.gov/pdf/reports/solarphotovoltaicguideline.pdf

Exceptions to Minimum Area

Here is a summary of exceptions to the minimum area requirements. For more details on calculations and installation criteria for equipment required in the exceptions, refer to the Energy Standards and 2016 Residential Compliance Manual chapter 7:

- Exception 1: 1,000 watt PV system:
  If a new residence already has a permanent 1,000 watt or higher output solar PV system, then no other solar zone area is required.
- Exception 2: Solar DHW with 0.50 solar saving fraction
  If a new residence already has a permanent solar water heating system with at least 50% solar fraction, then no other solar zone area is required.
- Exception 3: House with small footprint + 150 ft² solar zone:
  The more stories in a residence the smaller the available roof area as compared to total floor area, so single-family residences with three habitable stories or more and total floor area of 2,000 ft² or less are allowed to have a minimum solar zone area of 150 ft².
- Exception 4: Wildland-urban interface fire area, CZ 8-14:
  Minimum solar zone area can be reduced to 150 ft² for residences in these locations that also have whole-house fans. Residences in these fire areas (defined in Title 24, Part 2) require special accommodation for attic and roof venting.
- Exception 5: Half potential solar zone area:
  Some houses do not have 250 ft² of roof with at least 70% solar access, either because they have steep-sloped roofs that are not oriented between 110 and 270 degrees, or because solar access is blocked by outside obstructions adjacent to the property. This exception allows the solar zone to be reduced to half of the roof area that has adequate solar access. If none of the roof has adequate solar access, then no solar zone is required.
- Exception 6: Demand response thermostats + 150 ft² solar zone:
  The minimum solar zone may be reduced to 150 ft², if all of the thermostats in the house are occupant controlled smart thermostats per Reference Appendix JA5 that can receive and respond to demand response signals. Demand response thermostats allow utility companies or other entities providing electricity to send automatic requests to residents to reduce energy usage during high-use periods.
- Exception 7: Demand response thermostats + other options:
  No solar zone area is required if the residence has all demand response thermostats (see exception 6), plus one of the following four energy or water saving options:
  (1) An EnergyStar compliant dishwasher plus either an EnergyStar compliant refrigerator or a whole house fan; or
  (2) A home automation system that can control all home appliances and lighting as well as responding to demand response signals; or
  (3) An alternate plumbing system to allow greywater discharged from clothes washers and all showers and bathtubs to be used for irrigation; or
  (4) A rainwater catchment system that uses rainwater flowing from at least 65 percent of available roof area.
  Note that water saving options 3 and 4 must comply with the 2016 California Plumbing Code chapter 15 for grey water and chapter 16 for rainwater catchment, plus any applicable local ordinances.



Cool Roof Fact Sheet

This document summarizes Energy Standards requirements and offers compliance recommendations.

Find Fact Sheets here: energycodeace.com/content/resources-fact-sheets

California Energy Commission Online Resource Center

The Online Resource Center provides Energy Standards compliance resources including:

- Energy Commission contact information
- Trainings and Events
- Energy Standards language and documents
- Links to External Resources

Call the Energy Standards Hotline at:

- Toll-Free in California: 800-772-3300
- Outside California: 916-654-5106

Find the webpage here: http://www.energy.ca.gov/title24/orc/

Orientation (§110.10(b)2)

To maximize solar potential, all steep-sloped roof sections of the solar zone must be oriented between 110 degrees (20 degrees south of due east) and 270 degrees (due west).

Shading (§110.10(b)3)

The solar zone must be free of any obstructions that would interfere with or shade future solar systems. Prohibited obstructions might include architectural features like chimneys or rooftop HVAC equipment.

The solar zone must also be situated so that it is not substantially shaded by any other part of the residence or by anything attached to the residence that is above any part of the solar zone. To prevent blocking solar access, the horizontal distance from the edge of the solar zone to the tallest part of any obstruction must be twice the height of the obstruction according to the equation: $D \geq 2 \times H$. This does not apply to any possible obstructions that are north of the whole solar zone.

On page 71, you can find an example scenario of how to evaluate a possible solar zone obstruction.

Structural Design Loads on Construction Documents (§110.10(b)4)

Structural design loads for roof live loads and roof dead loads must be documented for the solar zone area. This does not need to include the loads from possible future solar systems.

Interconnection Pathways (§110.10(c))

Another part of being solar ready is to plan where future solar equipment would be installed. Construction documents need to show where future solar PV inverters and metering equipment would be installed, as well as showing the pathway where conduit could be installed to connect the solar zone with the main electrical service panel. Plans also need to show the pathway where piping for solar water heating could be installed to connect the solar zone to the house water heating system.

Documentation (§110.10(d))

To help make all of this planning a reality, the building occupant must be given a copy of the plans or other documents that show how the building complies with all of the solar zone and interconnection pathway requirements.

Main Electrical Service Panel (§110.10(e))

The main electrical service panel must be set up to accommodate a future solar electric system. The panel must have a minimum busbar rating of 200 amps, and reserve a space that is permanently marked “For Future Solar Electric” for a double pole circuit breaker. The reserved space must be located at the opposite end from the input feeder or main circuit location.

Prescriptive Approach: Building Envelope

The main advantage of the prescriptive compliance method is that it has straightforward and specific energy-efficiency requirements for new residences, alterations and various size additions. Building designs comply with the Energy Standards when they meet all of the prescriptive requirements that apply to their scope of work. The main disadvantage of the prescriptive method is that you cannot use it unless the proposed building design meets every one of the applicable measures.

Buildings that do not comply easily with the Prescriptive Approach can be analyzed for compliance using the more flexible Performance Approach. The prescriptive standards are used as the basis for the standard design in the performance method, so that buildings complying with either method should end up with comparable energy use per square foot. For more detailed information on this topic, see the comparison table "Prescriptive Envelope Requirements vs Performance Method Standard Design" in the Appendix.

Envelope Requirements for New Low-Rise Residences (Table 150.1-A)

To comply with the Energy Standards using the Prescriptive Approach, a new residence must meet or exceed specific requirements listed in Table 150.1-A for all parts of the building envelope that separate the indoor conditioned space from the outdoors or from any enclosed unconditioned spaces. These requirements vary by climate zone, and may include:

- Minimum insulation levels or maximum U-factors for the opaque parts of roofs and ceilings, walls, raised floors and slab-on-grade floors;
- Minimum aged solar reflectance and thermal emittance for exterior roofing; and
- Maximum U-factors and SHGCs for fenestration products.

Roof/Ceiling Insulation and Radiant Barriers (§150.1(c)1A, §150.1(c)2)

The three options to meet prescriptive roof/ceiling insulation requirements for new residences all assume vented attics with wood framing. Options A and B are the requirements if ducts are located in the attic per §150.1(c)9A. Option C is an alternative if ducts are located in conditioned space per §150.1(c)9B.

The requirements for these three options are summarized in the table on the next page.

Prescriptive roof/ceiling insulation requirements vary by climate zone and insulation location. Roof insulation requirements also vary by roofing installation. More roof insulation is required when the roofing is installed with no air space, as is typical for lightweight roofing, versus roofing installed with an air space, as is typical for concrete or tile roofing.

The 2016 Energy Standards limit prescriptive compliance for new low-rise residential buildings to either vented attics with ducts in the attic, or to vented attics with ducts in conditioned space. New low-rise residential buildings outside of this scope must show compliance with using the Performance Approach.

Code in Practice:

Prescriptive "High Performance Attics"

Remembering options is as easy as **A-B-C**.

Option A:

Above Roof Deck Insulation

Option B:

Below Roof Deck Insulation

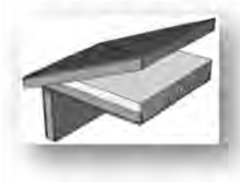
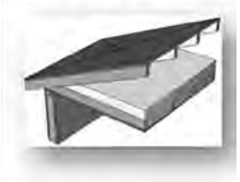
Option C:

Ducts in **C**onditioned Space

Code in Practice: Wood Framing vs. Metal Framing

Metal framing is much more conductive than wood framing, allowing more heat loss or heat gain through the building envelope. This makes it difficult to meet prescriptive or even mandatory insulation requirements with construction assemblies where insulation is penetrated by metal framing. Any time a prescriptive insulation requirement is given as an R-value, it always assumes wood framing for cavity insulation and no framing for continuous insulation.

U-factor tables for metal framed roofs, walls and floors are compiled in 2016 Reference Appendix JA4, or overall U-factors may be calculated using CBECC-Res 2016 or other Energy Commission approved software.

Prescriptive: Roof/Ceiling Insulation & Radiant Barrier			
	Option A	Option B	Option C
§150.1(c)1A §150.1(c)2	Ceiling Insulation + Continuous Roof Insulation above Framing (above or below roof deck) Ducts in Vented Attic	Ceiling Insulation + Roof Insulation Below Roof Deck between wood framing Ducts in Vented Attic	Ceiling Insulation Only Ducts in Conditioned Space
Ceiling Insulation	CZ 1, 2, 4, 8-16: R-38 CZ 3, 5-7: R-30		CZ 1, 11-16: R-38 CZ 2-10: R-30
Roof Insulation	CZ 1-3, 5-7: NR CZ 4, 8-16: R-6: Roofing w/o Air Space R-8: Roofing w/ Air Space	CZ 1-3, 5-7: NR CZ 4, 8-16: R-18: Roofing w/o Air Space R-13: Roofing w/ Air Space	NR
Radiant Barrier	CZ 1, 16: NR CZ 2-15: REQ	CZ 1, 4, 8-16: NR CZ 2, 3, 5-7: REQ	CZ 1, 16: NR CZ 2-15: REQ
Examples from Joint Reference Appendices			

Roofing Products (§150.1(c)11)

CRRC-rated cool roofs are required for prescriptive compliance in some climate zones. Minimum aged solar reflectance and thermal emittance or SRI values vary depending on roof slope.

Low-sloped Roof (≤ 2:12 pitch)

Low-sloped roofs in climate zones 13 and 15 must have minimum aged solar reflectance of 0.63 and minimum thermal emittance of 0.75, or a minimum SRI of 75.

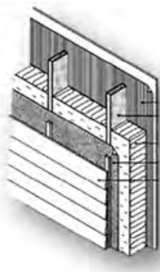
Steep-sloped Roof (> 2:12 pitch)

Steep-sloped roofs in climate zones 10 through 15 must have minimum aged solar reflectance of 0.20 and minimum thermal emittance of 0.75, or a minimum SRI of 16.

Note that all roofs covered by solar collectors or with thermal mass that weighs at least 25 lb/ft^2 above the roof membrane are exempt from the prescriptive cool roof requirements.

Wall Insulation (§150.1(c)1B)

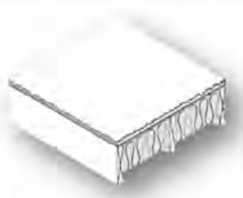
The energy standards require different prescriptive wall insulation levels for above grade framed and mass walls and for below grade walls, which are also typically mass walls.

Prescriptive Insulation: Walls (§150.1(c)1B)									
	Mass Walls							Framed Walls [1]	
Insulation Location	Interior		Exterior						
Above or Below Grade	Either Above or Below		Above		Below			Above	
Climate Zones	1-15	16	1-15	16	1-13	14,15	16	1-5, 8-16	6, 7
U-Factor (area-weighted average) *or*	≤0.070	≤0.066	≤0.125	≤0.070	≤0.200	≤0.100	≤0.053	≤0.051	≤0.065
Insulation R-Value (cavity for interior, continuous for exterior)	≥R-13	≥R-15	≥R-8	≥R-13	≥R-5	≥R-10	≥R-19	N/A	
	 								

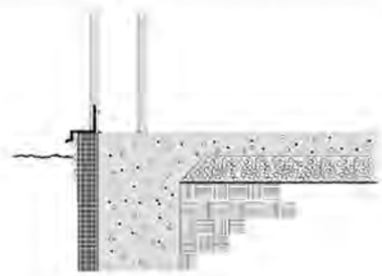
1 Only mandatory minimum insulation is required for demising partitions and knee walls next to unconditioned spaces (such as a garage or attic).

Floor Insulation (§150.1(c)1C, §150.1(c)1D)

The prescriptive standards have different insulation requirements for concrete raised floors, for wood frame and other non-concrete raised floors, and for slab-on-grade floors. Any floors with radiant heating installed must also meet the mandatory measures for heated floors, and these sometimes exceed the prescriptive requirements.

Prescriptive Insulation: Raised Floors (§150.1(c)1C, §150.1(c)1D)				
Methodology: *either may be used*	Raised Floors	Concrete (Note: If heated, mandatory insulation may exceed prescriptive.)		
Climate Zones	1-16	1,2,11, 13,14,16	12, 15	3-10
U-Factor (area-weighted average) *or*	≤0.037	≤0.092	≤0.138	≤0.269
Insulation R-Value (cavity for wood framed, continuous for concrete)	≥R-19	≥R-8	≥R-4	NR
Examples from Joint Reference Appendices				

NFRC label

Prescriptive Insulation: Slab on Grade (§110.8(g),	
Unheated (§150.0(f))	CZ 1-15: NR CZ 16: U-factor ≤ 0.58 *or* Slab edge insulation ≥ R-7
Heated (§110.8(g))	Same as mandatory measures
	

Fenestration (§150.1(c)3, §150.1(c)4)

The area and thermal performance of the windows, glass doors and skylights in a residence are critical factors for a building's energy efficiency and Title 24 compliance.

Maximum Total and West-facing Areas

The prescriptive limit for total fenestration area in all climate zones is 20% or less of the total conditioned floor area (CFA). In climate zones 2, 4 and 6 through 16, there is also a prescriptive limit of 5% or less of the CFA for west-facing fenestration. Total west-facing fenestration includes skylights tilted in any direction when the skylight pitch is less than 1:12.

Maximum U-factor and SHGC

This table covers prescriptive U-factor and SHGC requirements for both new residences and alterations. See later in this chapter for more discussion of prescriptive envelope requirements for additions and alterations.

Prescriptive: Fenestration Maximum U-Factor and SHGC [1]						
	New [2] (§150.1(c) 3-4)	Alterations (§150.1(b)1)				
		Replacement			Added [3]	
		Vertical		Skylight	Vertical	Skylight
Area-weighted average:		≤ 75 ft²	> 75 ft²	Any ft²	≤ 75 ft²	≤ 16 ft²
U-Factor	≤0.32	≤0.40	≤0.32	≤0.55	≤0.32	≤0.55
SHGC (only in CZ 2, 4, 6-16)	≤0.25	≤0.35	≤0.25	≤0.30	≤0.25	≤0.30
Example of an NFRC-rated window that would meet a prescriptive U-factor ≤ 0.32 and prescriptive SHGC ≤ 0.25 when required.						

. This applies to all fenestration products separating conditioned from unconditioned space,
. . including skylights.
. For each dwelling unit, areas exempt from prescriptive maximum U-factor and SHGC:
(1) Up to 3 ft² of new glazing in doors and up to 3 ft² of new tubular skylights
(2) Up to 16 ft² of new skylight with U-factor ≤ 0.55 and SHGC ≤ 0.30
. Added fenestration in alterations meeting these requirements complies prescriptively without
. meeting the total and west-facing area limits.

Note that maximum SHGCs are only required prescriptively in climate zones 2, 4 and 6 through 16, but not in climate zones 1, 3 and 5. Prescriptive SHGCs can be achieved with fenestration SHGC alone, or through a combination of fenestration SHGC plus permanent exterior shading devices such as exterior louvers. 2016 Residential Compliance Manual Table 3-3 lists SHGCs for some exterior shades.

South-facing glazing with optimally designed overhangs per §150.1(c)4D is also allowed to comply with the prescriptive SHGC requirement. The optimal overhang is defined as providing full shading at solar noon on August 21st, but allowing a substantial amount of direct sun penetration at solar noon on December 21st. This is a classic passive solar design strategy that allows solar space heating in the winter but protects the building from excess solar gain in the summer.

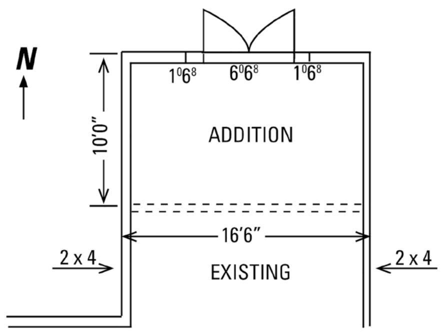
Form CF1R-ENV-03 is used to calculate SHGCs based on a combination of devices.

Prescriptive Additions (§150.2(a)1)

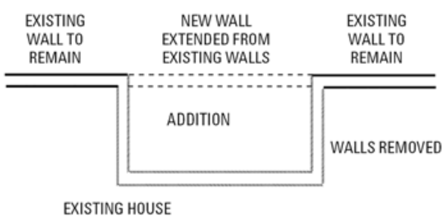
The prescriptive path for additions can be a useful compliance alternative to a performance method analysis. Most of the prescriptive envelope requirements for low-rise residential additions are the same as those for newly constructed residences, but there are some important exceptions for fenestration area, extensions to existing walls, roof/ceiling insulation for additions less than or equal to 700 ft², and cool roof for additions less than 300 ft².

Code in Practice: NFRC-Rated vs Default Values

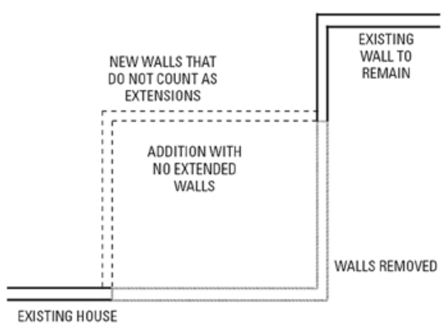
NFRC-rated windows, glass doors and skylights are usually required to comply with Title 24 prescriptively. In practice, none of the default U-factors or SHGCs for different fenestration types meet the prescriptive requirements on their own, and only a few even meet the mandatory maximum U-factor of 0.58. A residence might comply prescriptively by area-weighting a few products with default values with a majority of high-performing NFRC-rated fenestration.



Prescriptive Addition Example with Wall Extensions



Wall Extension Example



Another Wall Extension Example

Fenestration Area

Small residential additions often have more than 20% total fenestration area or more than 5% west-facing fenestration area compared to conditioned floor area, so the Energy Standards allow somewhat higher prescriptive maximum areas or percentages for additions, depending on their conditioned floor area. Table 9-3C from the Residential Compliance Manual copied below shows the total and west-facing area allowances, as well as confirming that the required U-factors and SHGCs are the Package A values.

Table 9-3C: Envelope Glazing Requirements for Prescriptive Additions

Component	Requirements of Additions ≤ 400 ft^2	Requirements of Additions > 400 ft^2 and ≤ 700 ft^2	Requirements of Additions > 700 ft^2
Total Glazing Area:	Up to 75 ft^2 or 30% of Conditioned Floor Area, whichever is greater	Up to 120 ft^2 or 25% of Conditioned Floor Area, whichever is greater	Up to 175 ft^2 or 20% of Conditioned Floor Area, whichever is greater
West-Facing Glazing Area: In Climate Zone 2, 4, 6-16	Up to 60 ft^2	Up to 60 ft^2	The greater of 70 ft^2 or 5% of Conditioned Floor Area in Climate Zones 2, 4, 6-16
Glazing U-Factor & SHGC[1]:	Package A: All CZs: U = 0.32 CZ 2, 4 & 6-16: SHGC = 0.25	Package A: All CZs: U = 0.32 CZ 2, 4 & 6-16: SHGC = 0.25	Package A: All CZs: U = 0.32 CZ 2, 4 & 6-16: SHGC = 0.25

1. See §150.0(q) and §150.1(c)3 for new and replaced window and skylight exceptions .

Extensions to Existing Walls

In any size addition, new walls that are extensions of existing wood frame walls are allowed to maintain the same framing dimensions as the existing walls. Extended 2x4 wood frame walls must have R-15 cavity insulation, and extended 2x6 wood frame walls must have R-19 cavity insulation.

Roof/Ceiling Insulation for Additions ≤ 700 ft^2

Additions less than or equal to 700 ft^2 only need to have the mandatory roof/ceiling insulation levels installed per §150.0(a) to comply prescriptively. These correspond to at least R-22 cavity insulation in wood framing or an assembly U-factor of 0.043 or less.

Cool Roof Exception for Additions < 300 ft^2

Additions smaller than 300 ft^2 do not have to have cool roofs to comply prescriptively.

Prescriptive Alterations (§150.2(b)1)

Prescriptive compliance for low-rise residential envelope alterations is generally quite straightforward. Altered or new components within the existing building envelope typically comply prescriptively by just meeting the applicable mandatory measures described above. However, there are additional requirements for new and replacement fenestration in alterations and for roof replacements.

Replacement and Added Fenestration

Windows, glass doors and skylights that replace fenestration in an existing wall or roof have varied U-factor and SHGC requirements depending on the amount replaced. Fenestration replacements alone do not trigger the total and west-facing area limits that apply to new residences.

When fenestration area is increased as part of an alteration, it triggers all of the prescriptive fenestration requirements for new residences, including the total and west-facing area limits, with two exceptions.

See the prescriptive fenestration U-factor and SHGC table above for a summary of the alteration replacement requirements and the exceptions for added fenestration in an alteration.

Roof Replacement

When more than half of an existing roof surface is being replaced, steep-sloped roofs in climate zones 10 through 15 and low-sloped roofs in climate zones 13 and 15 must comply with the prescriptive cool roof requirements for new residences in §150.1(c)11. However, the exception to §150.2(b)1Hi gives numerous alternative options to that requirement for steep-sloped roofs, including, but not limited to, having R-38 ceiling insulation, a radiant barrier, or no ducts in the attic. Low-sloped roofs are exempt from the cool roof requirements if there are no ducts in the attic, or they have the option of meeting the cool roof aged solar reflectance requirement by insulating the roof deck per Table 150.2-B.

Refer to the Energy Standards and chapter 9 of the 2016 Residential Compliance Manual for more details.

Code in Practice

Performance method compliance software calculates estimated energy use for Title 24 energy code compliance purposes.

It is important to understand that the proposed design TDV energy use calculated from Energy Commission approved compliance software is an estimated value that is unlikely to exactly correspond to the actual TDV energy use for the building over the course of any particular year. Variations in weather and how people actually use their homes from day to day are just a couple of the factors that cannot and need not be perfectly defined for code-compliance software. The purpose of compliance software is to fairly and consistently evaluate whether or not a proposed building project meets California's energy efficiency standards, when compared to similar buildings across the state.

Performance Approach: Building Envelope

The Performance Approach is the most flexible compliance method, and it can be used to analyze and demonstrate compliance for buildings that do not comply easily with the prescriptive method. In the Performance Approach, proposed buildings are analyzed using Energy Commission approved compliance software, and their estimated annual energy use is compared to a "standard design" baseline energy use. Energy used for space heating, space cooling, IAQ ventilation, and water heating, and energy offset (saved) by installation of solar photovoltaic (PV) systems, are added together and become the "Compliance Energy Total" documented on the CF1R-PRF-01 form (see sample below):

A building complies with the Energy Standards using the Performance Approach when the calculated compliance energy total for the proposed design is less than or equal to that for the standard design.

Performance method energy use is measured in kTDV/ft^2-yr. Per §100.2, TDV (time dependent valuation) energy is calculated by multiplying the site energy use (electricity KWh, natural gas therms, or fuel oil or LPG gallons) for each energy type by the applicable TDV multiplier summarized in Reference Joint Appendix JA3.

Standard Design

The "standard design" is a baseline building model, used to set the energy budget in the performance method. The standard design starts with basic features of the proposed building, such as the conditioned floor area and the gross areas of exterior surfaces and demising partitions, but then applies prescriptive and mandatory requirements related to the scope of work, and as defined in the 2016 Residential ACM Reference Manual. Knowing the characteristics of the standard design for a particular building will help explain the results of a performance method analysis and can give insight into which energy efficiency measures are likely to improve performance method compliance.

The standard design for new low-rise residential buildings is based on Table 150.1-A Component Package A – Standard Design, but there are several variations worth knowing that depend on the particular construction in the proposed design. This guide compares the envelope requirements of Package A and the standard design for new residences in the appendix table "Prescriptive Envelope Requirements vs Performance Method Standard Design."

Energy Standards Table 150.2-C details the code requirements for the standard design for altered components. 2016 Residential ACM Reference Manual Tables 22 through 26 define the envelope components of the standard design for different size additions and for alterations with or without verified existing conditions (see Appendix).

ENERGY USE SUMMARY				
04	05	06	07	08
Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	21.37	22.74	-1.37	-6.4%
Space Cooling	10.20	3.90	6.30	61.8%
IAQ Ventilation	1.17	1.17	0.00	0.0%
Water Heating	9.82	9.82	0.00	0.0%
Photovoltaic Offset	----	0.00	0.00	----
Compliance Energy Total	42.56	37.63	4.93	11.6%

Note that while the standard design used in the Performance Approach sets the baseline TDV energy budget for the building, the features of the actual proposed building may be better or worse than the standard design assumptions.

Proposed Design

The "proposed design" is the building being analyzed for Title 24 energy compliance. To comply with Title 24, Part 6, using the Performance Approach, the total compliance energy use of the proposed design must be less than that for the standard design. The performance method analysis of a low-rise residential building includes the proposed space conditioning system (heating, cooling and ventilation) and domestic water heating, as well as the building envelope. Building features have to be defined in the energy compliance software as new, existing or altered (with or without HERS verification of existing) depending on the scope of work.

Trade-offs

The Performance Approach allows trade-offs between different components of the proposed energy use, as well as allowing compliance credit for some HERS-verified energy-efficiency measures.

Trade-offs between more or less energy-efficient characteristics of the building envelope, the HVAC system and the domestic water heating system are at the heart of Title 24 energy compliance using the Performance Approach. Energy savings due to special envelope features, such as raised heel trusses that maximize attic insulation, can help offset lower than prescriptive insulation levels elsewhere in the building.

Space heating and space cooling energy use both depend on the features of the building envelope in combination with the type and efficiency of the HVAC system. Therefore, upgrading HVAC features such as furnace or air conditioner efficiency can provide energy savings that may offset energy losses due to envelope design choices such as high glazing percentages. Water heating energy use is influenced by the conditioned floor area of the residence and the type and efficiency of the water heating equipment, including the fuel type and distribution system. Water heating energy use tends to be a large component of overall energy use in small houses, so energy-efficient systems can be especially helpful for compliance there.

HERS Compliance Credits

One advantage of demonstrating energy compliance using the Performance Approach is that it offers compliance credits not available in the Prescriptive Approach for several HERS-verified energy-efficiency measures.

- Quality Insulation Installation (QII): This measure requires field verification of high quality insulation installation over the course of the construction process, as defined in the 2016 Reference Appendices RA3.5. This credit applies to the entire building envelope and will generally only be possible for new buildings or major envelope alterations. To take this compliance credit, all proposed building envelope insulation must meet the QII requirements.
- Building Envelope Air Leakage: This measure gives compliance credit for reduced envelope air leakage, but requires field verification and diagnostic testing, as defined in the 2016 Reference Appendices RA3.8.

Raised Heel Truss detail, Habitat for Humanity, Dream Creek Subdivision, Stockton, CA. Designed by George H. Koertzen, Habitat for Humanity San Joaquin County, CA

Ace Resources™

2016 ENERGY CODE

Ace Resources Title 24, Part 6 Quick Reference

Residential & Nonresidential HERS Measures

Residential HERS Measures

HERS Measure	Mandatory	Prescriptive	Performance[A]	Reference Appendices
MECHANICAL				
Duct sealing (maximum leakage)	§150.0(m)11			RA 3.1
Indoor air quality ventilation (consistent with ASHRAE Standard 62.2)	§150.0(o)			RA 3.7
Refrigerant charge or Installation of a fault indicator display (FID)		Climate Zones 2, 8-15 §150.1(c)7A	X	RA 1.2, RA 3.2, RA 3.4
Duct design (surface area, insulation, and location)	150.0(m)		X	RA 3.1
Ducts entirely in conditioned space	§150.0(m)1	§150.1(c)9	X	RA 3.1
Ducts <12 feet outside conditioned space			X	RA3.1.4.1.2
Low leakage ducts (if a low leakage air handler is installed)			X	RA 3.1
Low leakage air handlers			§150.1(b)4B	RA 3.1.4.3
Cooling coil air flow and air handler fan watt draw **OR** Verified return duct design and air filter device	§150.0(m)13			RA3.1, RA3.3
High SEER and/or High EER			§150.1(b)4B	RA 3.4
Central fan integrated (CFI) ventilation cooling systems		§150.1(c)10		RA 3.3, RA 3.7
Zonally controlled systems - Bypass ducts not used		§150.1(c)13	X	RA3.1.4.6
Evaporatively cooled condensers (verify duct sealing, EER and refrigerant charge)			X	RA 3.1, RA3.2, RA 3.4, RA 4.3
ENVELOPE				
Quality insulation installation (QII)			X	RA 3.5
Building envelope sealing			X	RA 3.8
PLUMBING				
Pipe insulation			X	RA 3.6
Verified design (parallel piping, compact design, recirc control)			X	RA 3.6
Multifamily recirculation loops			X	RA 3.6
SOLAR PV				
Photovoltaic (PV) system capacity to qualify for PV rebate via New Solar Home Partnership			X	RA 4.6

[A] An "X" indicates "may be taken as a performance measure and must be field-verified if taken."

EnergyCodeAce™ Helping you play your cards right

2016 Title 24, Part 6 - Residential & Nonresidential HERS Measures

Page 1 of 2
2016-10-28

HERS Quick Reference Guide

This quick reference sheet presents Title 24, Part 6 HERS measures triggers at a glance.

Find it here: energycodeace.com/content/resources-fact-sheets

- Verified Existing Conditions: This measure can be used in the existing-plus-addition-plus-alteration compliance approach to document actual existing conditions being altered, rather than having the standard design assume current mandatory measures or prescriptive values. This allows a more realistic assessment of energy savings as a result of an upgrade to an inefficient existing component, and the increased energy savings may be used to trade-off against other less energy-efficient proposed features.

Using this approach can make a big difference in the energy compliance of an alteration. For example, suppose an existing residence has uninsulated 2x4 wood framed walls, and the homeowner plans to upgrade the walls to have R-13 insulation as part of a larger alteration. The following excerpt from the 2016 Residential ACM Reference Manual, Table 23: Addition (and Alteration) Standard Design for Exterior Walls, shows that without HERS verification of the existing conditions, the standard design assumes that the existing walls prior to the remodel are already insulated with R-13, but with the verification, the standard design uses the actual existing conditions, in this case R-0:

Table 23: Addition Standard Design for Exterior Walls

Proposed Design Exterior Wall Assembly Type	Standard Design Values Based on Proposed Wall Status		
	Addition	Altered	Verified Altered
Framed Walls	CZ 1-5, 8-16 = R19+R5 in 2x6 (U0.051) CZ 6-7 = R15+R4 in 2x4 (U-0.065)	R-13 in 2x4 R-19 in 2x6	Existing

This example is quite dramatic. With HERS verification, the existing-plus-addition-plus-alteration method would give significant compliance credit for the energy savings of going from uninsulated to R-13 insulated walls. Without HERS verification of existing conditions, there would be no compliance credit for upgrading the existing walls to R-13, because the existing walls would be assumed to have R-13 insulation already.

Photovoltaic Offset

Electricity generated by eligible solar photovoltaic (PV) systems installed in climate zones 1 through 5 and 8 through 16 can be modeled for compliance credit in the Performance Approach. The credit is only available for new buildings with PV systems generating at least 2 kW of electricity for single family residences (or 1 kW for multifamily residential units), and installed according to 2016 Reference Residential Appendix RA4.6.1. The amount of PV offset credit varies by the size of the system and climate zone, as defined in the 2016 Residential ACM Reference Manual Section 2.2.3.

Energy Commission Approved Software Required

To show Title 24 energy compliance using the Performance Approach requires use of energy compliance software that has been tested and approved by the California Energy Commission. The software must be approved for the Energy Standards in effect at the time a project is submitted to the local building department for permit.

The Energy Commission maintains a list of 2016 Standards "Approved Compliance Modeling Software" that can be accessed from the 2016 Building Energy Efficiency Standards page of their website.

energy.ca.gov/title24/2016standards/2016_computer_prog_list.html

This list typically includes software developed by the Energy Commission and also that from private software vendors. All approved low-rise residential compliance software for the 2016 Energy Standards uses the Energy Commission CBECC-Res 2016 Compliance Manager.

California Building Energy Code Compliance for Residential (CBECC-Res) software is an open-source software program developed by the California Energy Commission for use in demonstrating compliance with the Residential Energy Standards.

Visit the CBECC-Res webpage to download the software or find more information: bwilcox.com/BEES/cbecc2016.html

CHITWOOD ENERGY MANAGEMENT

Case Study: Habitat for Humanity San Joaquin, Dream Creek Subdivision

Prescriptive Versus Performance in Practice

Both the prescriptive and performance methods have advantages, depending on the particular building being analyzed. This section of the guide evaluates the features of one particular residence to assess the pros and cons of the different compliance approaches when applied in the real world.

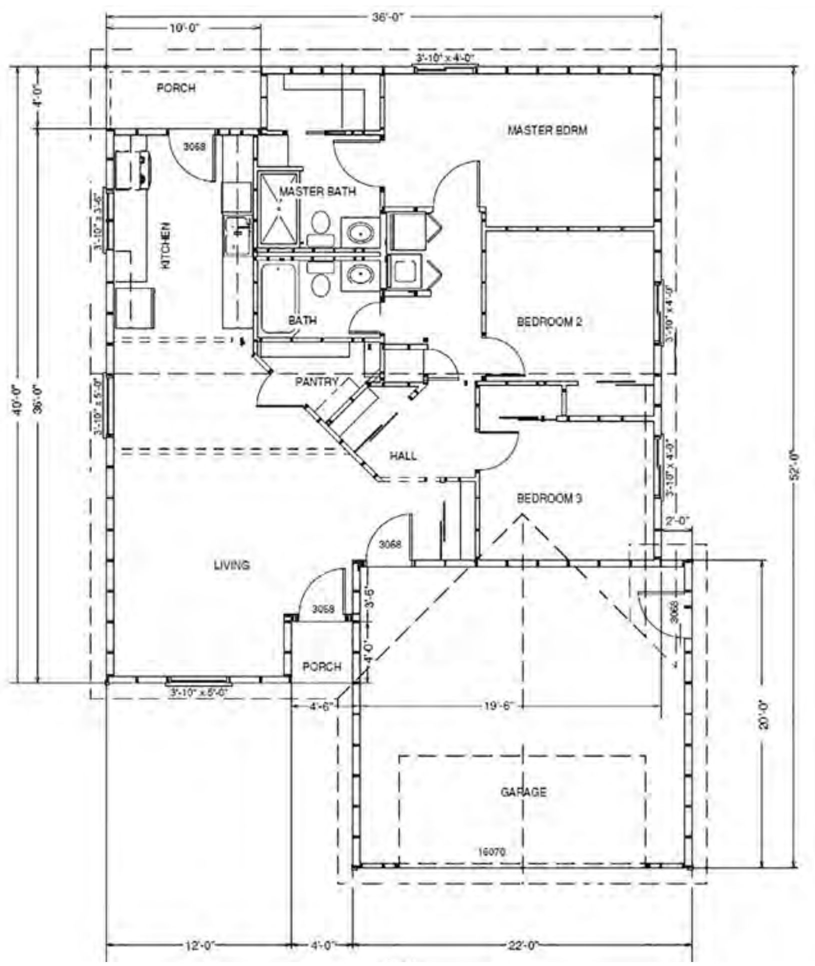
The case study residence for this section is a remarkable building designed to far exceed the 2008 Title 24 Energy Standards in effect when it originally went for permit – so much so, that it still complies with the much tougher 2016 Title 24 Energy Standards! The home is in the Habitat for Humanity San Joaquin, Dream Creek subdivision in Stockton, California, and it is a PG&E ZNE (zero net energy) production builder demonstration project.

An important goal of the project was to show that it is possible to achieve ZNE goals cost-effectively as a result of paying careful attention to construction details and how all building systems work together. The project team concentrated on all of the following areas:

- Adaptive and efficient architectural design
- Advanced framing and high performance enclosure
- High performance heating, ventilation, and air conditioning (HVAC)
- Water heating
- Water conservation
- Lighting
- Solar electricity

This guide concentrates primarily on energy-efficient building envelopes, but all these features work together to make the home as sustainable and energy efficient as possible.

NOTE: All architectural details on the following page depict th. ZNE Demonstration Home, Habitat for Humanity, Dream Creek Subdivision, Stockton, CA. Designed by George H. Koertzen, Habitat for Humanity San Joaquin County, CA



Floor Plan

Project Team

Project Manager:

George Koertzen, Habitat for Humanity

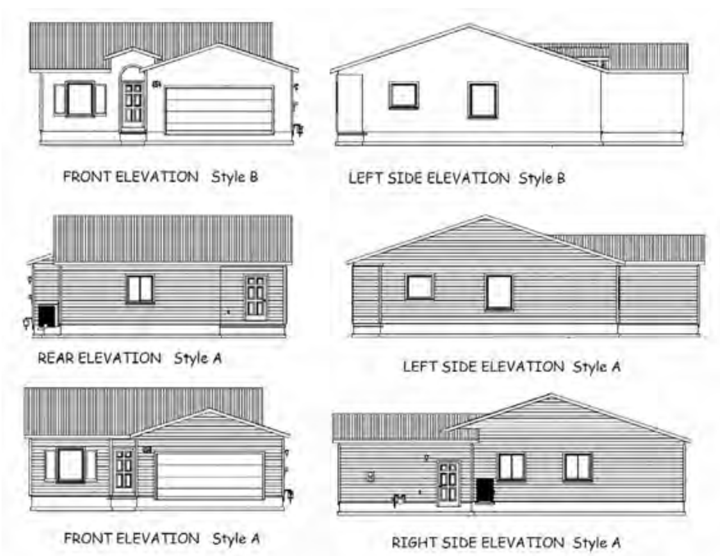
Consultants:

Ann Edminster, Design AVEnues LLC

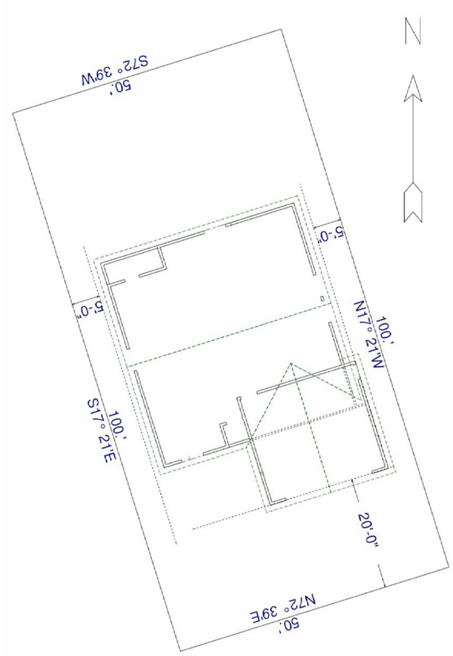
Rick Chitwood, Chitwood Energy Management

Steve Easley, Steve Easley & Associates

Special thanks go to George Koertzen and Habitat for Humanity San Joaquin for allowing access to the project drawings and technical information, and to Rick Chitwood of Chitwood Energy Management, for bringing Dream Creek to our attention and sharing his photos of advanced construction details.



Elevations



Plot Plan

Code in Practice: Conditioned Floor Area

For a more complete explanation of how to calculate total conditioned floor area, see Section 1.8 of the 2016 Residential Compliance Manual. Note that other government or business entities may have different rules than the Energy Commission for calculating the floor area of a residence. Make sure to use Energy Commission rules for Title 24 energy compliance calculations.

Prescriptive vs Performance Method Compliance Analysis

The following tables and discussion compare the envelope features of the case study residence with the applicable prescriptive requirements and the performance method standard design assumptions for climate zone 12 to assess compliance options in practice.

Habitat For Humanity Case Study Residence Compared To Prescriptive Envelope Requirements And Performance Method Standard Design (Climate Zone 12)

Total Conditioned Floor Area and Fenestration

	CASE STUDY	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	ZNE Demonstration Home Dream Creek Subdivision Stockton, CA	Package A Climate Zone (CZ) 12 (§150.1 Table 150.1-A)	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
Total Conditioned Floor Area (CFA)	1,236 ft²	1,236 ft²	1,236 ft²
Fenestration:	NFRC-rated dual pane argon-fill low-e glass + vinyl frame		
Area	Total fenestration area = 97.8 ft² (97.8/1,236) x 100 = 7.9% CFA Total west-facing area = 32.6 ft² (32.6/1,236) x 100 = 2.6% CFA	Total Area: All CZ: ≤ 20% CFA West-facing Area: CZ 12: ≤ 5% CFA	Proposed design fenestration area is < 20% CFA, so the standard total area = the proposed total area.
U-factor	NFRC-rated U-factor=0.28	All CZ: ≤ 0.32	All CZ: 0.32
SHGC	NFRC-rated SHGC=0.20	CZ 12: ≤0.25	CZ 12: 0.25

The proposed conditioned floor area is a basic characteristic of the residence that stays constant across all compliance paths. For low-rise residential Title 24 energy compliance, the total conditioned floor area is measured from the building floor plan, and it includes the area of the exterior walls and any demising walls that separate conditioned from enclosed unconditioned space. In this case, there are demising walls between the main house and the unconditioned garage that need to be included.

Using the dimension lines shown on the floor plan, the total conditioned floor area is:

$$(36' \times 40') - (4' \times 10') - (4' \times 4.5') - (19.5' \times 7.5') = 1{,}236 \text{ ft}^2$$

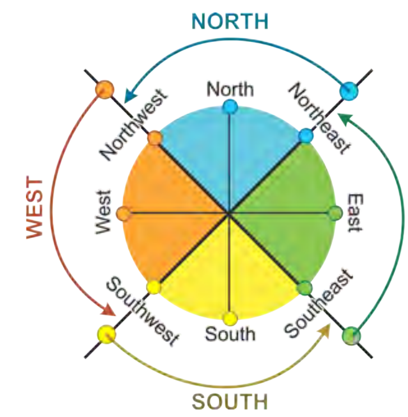
The next items to check for prescriptive compliance are the total and west-facing fenestration areas. Fenestration area includes both the glazing and frame for all windows, glass doors and skylights, and can be calculated using the nominal or rough opening dimensions for each fenestration product. As shown on the building floor plan and elevations, the case study house has a total of six windows, but no glass doors or skylights, although there are some solid wood doors. The attached floor plan gives the nominal window opening sizes, showing all the windows at 3'10" width with 3'6", 4'0", or 5'0" heights. The calculated window areas by orientation are:

Front (South):	(3.83' x 5') =	19.2 ft²
Left (West):	(3.83' x 5') + (3.83' x 3.5') =	32.6 ft²
Rear (North)	(3.83' x 4') =	15.3 ft²
Right (East)	2 x (3.83'x 4') =	30.7 ft²
Total Fenestration Area:		**97.8 ft²**

In this case, the house has 97.8 ft² total fenestration and a total conditioned floor area of 1,236 ft², so the fenestration area is 7.9% of the conditioned floor area. This is less than the maximum 20% allowed prescriptively, so the total fenestration area complies. For climate zone 12, Package A also limits west-facing fenestration to no more than 5% of the conditioned floor area. The house has 32.6 ft² of west-facing fenestration, or 2.6% of the conditioned floor area, so the west-facing area also complies prescriptively.

The performance method standard design matches the actual total fenestration area when it is less than 20%, so a 7.9% total area would be neither a credit nor a penalty for the Performance Approach. If the proposed building had over 20% total fenestration, then it would not comply prescriptively and would have to be analyzed using the performance method. The total fenestration area in the standard design in that case would be 20%, and the amount of proposed glazing over 20% would be a compliance penalty.

After considering the total and west-facing areas, it is important to look at the types of windows, glass doors and other fenestration to be installed. In this case, all of the proposed windows have high performance dual pane argon-filled low e glass with vinyl frames, resulting in an NFRC-rated U-factor of 0.28 and SHGC of 0.20. These values are better than the prescriptive and standard design U-factor of 0.32 and SHGC of 0.25, so they would work well for either compliance approach.



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"Orientation" refers to the direction that a building surface faces. For prescriptive compliance, "west-facing" includes all fenestration facing (or tilted to) within 45 degrees of true west (compass orientation from 236 to 315 degrees), plus any skylights with pitch less than 1:12.

The case study plot plan on page 55 shows that the whole building is rotated 17 degrees counterclockwise from true north, so the west elevation compass orientation is 253 degrees. The actual building orientation is modeled in the performance method.

Roof and Ceiling Insulation, Radiant Barriers and Roof Surface

	CASE STUDY	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	ZNE Demonstration Home Dream Creek Subdivision Stockton, CA	Package A Climate Zone (CZ) 12 (§150.1 Table 150.1-A)	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
Roof/Ceiling Insulation and Radiant Barrier:			
Vented attic with ducts in conditioned space	Ceiling Insulation: R-42 installed with wood framed raised heel truss Roof Insulation: No Radiant Barrier: Yes	Option C: Requires wood framing, ceiling insulation and radiant barrier for CZ 12: Ceiling Insulation: R-38 Roof Insulation: NR Radiant Barrier: REQ	Standard design assumes wood framing, prescriptive Package A ceiling insulation and Option B roof insulation, and radiant barrier requirements for a vented attic with ducts in the attic. Steep-sloped roof, so assumes air space. Ceiling Insulation: R-38 Roof Insulation: R-13 Radiant Barrier: NR
Roofing:			
Aged Solar Reflectance	Steep-sloped (4:12), No Cool Roof	Steep-sloped (> 2:12): CZ 12: > 0.20	Steep-sloped (> 2:12): CZ 12: 0.20
Thermal Emittance	Steep-sloped (4:12). No Cool Roof	Steep-sloped (> 2:12): CZ 12: > 0.75	Steep-sloped (> 2:12): CZ 12: 0.85

The proposed house has a vented attic, and the ductwork for the heating and cooling system will be located in the conditioned space of the house, not in the attic or any other unconditioned space. This is important to know because there are different prescriptive requirements for insulation and radiant barriers depending on the duct location. Option C is the prescriptive path for vented attics with ducts in conditioned space, and for climate zone 12 it requires R-38 ceiling insulation with wood framing, no roof insulation, and a radiant barrier. The case study house has R-42 ceiling insulation, a wood framed raised heel truss, and a radiant barrier, so it meets the prescriptive insulation and radiant barrier requirements.

The next thing to consider is the roofing material. The exterior roof pitch for the proposed house is 4:12, so it is considered a steep-sloped roof. To comply prescriptively, steep-sloped roofs in climate zone 12 must have CRRC-rated cool roofs with aged solar reflectance of 0.20 or greater and thermal emittance of 0.75 or greater. However, the case study house does not have a cool roof, so it does not meet that prescriptive requirement. As mentioned earlier, a downside of the Prescriptive Approach is that it is only available as a compliance path if the proposed building meets all applicable prescriptive requirements, so in a case like this, with no cool roof, the prescriptive path is out!

The performance method standard design for the case study assumes both ceiling and roof insulation, as if there were ducts in the attic, as well as the prescriptive cool roof, so the proposed design will lose some compliance credit as a result. On the other hand, the standard design for this particular situation does not include a radiant barrier, so that will gain some compliance credit. The performance method analysis will consider the building overall, and look into energy trade-offs available for compliance.

Wall and Floor Insulation

	CASE STUDY	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	ZNE Demonstration Home Dream Creek Subdivision Stockton, CA	Package A Climate Zone (CZ) 12 (§150.1 Table 150.1-A)	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
Wall Insulation:			
Framed walls: Above grade	2x6 wood frame with advanced wall framing (AWF) R-21 cavity insulation + R-5 continuous, U-factor =0.044	CZ 12: U-factor ≤ 0.051	CZ 12: U-factor = 0.051 (2x6 wood frame with R-19 cavity insulation + R-5 continuous)
Demising partitions next to unconditioned garage	2x6 wood frame with AWF, R-21 cavity insulation, U-factor =0.057	Mandatory insulation: 2x6 wood frame: U-factor ≤ 0.074 or ≥ R-19 cavity insulation	2x4 wood frame, 16" o.c. with R-15 cavity insulation
Opaque portions of exterior doors with less than 50% glass	Wood doors with U-factor = 0.50	No prescriptive insulation requirements	All CZ: U-factor = 0.50
Raised Floor Insulation:			
Framed raised floor	Raised floor over crawl space: 4x6 wood frame, 32" o.c. with R-21 cavity insulation, U-factor = 0.035	All CZ: U-factor ≤ 0.037 or ≥ R-19 cavity insulation in wood frame	2x6 wood frame, 16" o.c. with R-19 cavity insulation

The exterior and demising walls and the raised floor over a crawl space are other important components of the proposed building envelope.

The exterior walls of the case study house have 2x6 wood framing with R-21 cavity insulation and R-5 continuous insulation, while the demising walls between the conditioned space and the garage have 2x6 wood framing with R-21 cavity insulation, but no continuous insulation. All of the walls are built using advanced wall framing techniques that substantially reduce the amount of wood framing in the walls compared to typical construction, allowing for a higher percentage of insulation to wood frame and corresponding improvements in thermal performance. 2016 Reference Appendix JA4 Table 4.1.6 shows walls with typical 24" o.c. stud spacing at 22% framing, while 24" o.c. advanced wall systems only have 17% framing.

For the case study house, the combination of high insulation and reduced framing results in an exterior wall U-factor of 0.044, as compared to a prescriptive maximum or performance method standard U-factor of 0.051. Similarly, the case study demising wall U-factor is 0.057, compared to the prescriptive maximum U-factor of 0.074. The performance standard design for demising walls assumes 2x4 wood framing 16" o.c. with R-15 insulation. Thus, the exterior and demising walls all comply prescriptively and would result in compliance credits in the performance method.

The case study house has a raised floor over crawl space with 4x6 wood framing 32" o.c. and R-21 cavity insulation. The thermally closest floor assemblies from the 2016 Reference Appendix JA4 Table 4.4.1 "Standard U-factors for Wood-Framed Floors with a Crawl Space" have R-19 and R-22 insulation in 2x6 or 2x8 wood framing 16" o.c. Using Energy-Commission-approved software to interpolate between the U-factors for those assemblies results in a U-factor of 0.035. The proposed R-21 floor insulation level exceeds both the prescriptive requirement and the performance method standard design assumption, so it is an advantage for both compliance paths.

HERS Measures and Special Features

	CASE STUDY	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	ZNE Demonstration Home Dream Creek Subdivision Stockton, CA	Package A Climate Zone (CZ) 12 (§150.1 Table 150.1-A)	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
HERS Measures			
High Quality Insulation Installation	Yes	No compliance credit	Not modeled in standard design, but provides compliance credit
Special Features			
Raised Heel Truss	Yes	No compliance credit	Not modeled in standard design, but provides compliance credit
Advanced Wall Framing	Yes	Can be used to improve proposed wall U-factor for compliance	Not modeled in standard design, but provides compliance credit

Finally, the proposed building envelope has been designed and constructed with additional energy efficiency measures beyond standard industry practice.

One of these is the HERS-verified high quality insulation installation (QII), or simply correct insulation installation, as the case study design team would say. QII strategies substantially improve the thermal performance of the building envelope, and HERS-verified QII can be modeled in the compliance software for performance method compliance credit.

The case study building also includes raised heel attic trusses that leave room for the full thickness of ceiling insulation for more of the attic, as well as the advanced wall framing discussed earlier. Both of these features can be modeled for performance method compliance credit.

There is no prescriptive compliance credit for QII or raised heel trusses, but the improved wall U-factors from advanced wall framing could help achieve prescriptive wall insulation requirements.

Envelope Compliance Analysis Summary

Checking the case study residence against the prescriptive requirements and performance method standard design shows that the building envelope complies with every prescriptive requirement except for the cool roof, and exceeds most of the performance method standard design assumptions. The design team for this project determined that a cool roof would not be cost-effective considering all other measures already implemented, so that leads to completing a full performance method compliance analysis.

HVAC, Water Heating and Solar PV Summary for Performance

As discussed earlier, a performance method compliance analysis for a low-rise residential building needs to include the proposed HVAC and water heating systems, and it can also include compliance credit for solar PV. Here's a summary of those features being modeled for the case study residence:

Space heating, cooling and ventilation system:

- Ducted mini split heat pump with 10.3 HSPF, 15.1 SEER and 11.2 EER, HERS-verified minimum airflow, SEER and fan efficacy watts/cfm[1]
- R-8 ducts entirely located in conditioned space and sealed and tested for leakage, HERS-verified reduced duct leakage and duct location
- HERS-verified indoor air quality (IAQ) mechanical ventilation[1]

Water heating system:

- Tankless gas water heater with 150,000 Btuh input and 0.82 energy factor (or equivalent uniform energy factor), located near the center of the house so that the longest hot water pipe run is 12', HERS-verified compact distribution system

Solar photovoltaic (PV) system:

- 2.8 kW PV system installed

Case Study Performance Method Results

1 Note that some of these HERS verifications are new requirements in the 2016 Energy Standards which were not needed for performance method compliance at the time this building actually went for permit under the 2008 Energy Standards. They are included in this case study performance method analysis to be consistent with the 2016 code.

Using the CBECC-Res 2016.2.0 Energy-Commission-approved energy compliance software to analyze the proposed building envelope, HVAC and water heating systems, and solar PV contribution, the case study building complies with Title 24 using the Performance Approach. Similar results could be achieved using other Energy-Commission-approved compliance software.

The first page of the performance method CF1R-PRF-01 form lists general project information and the compliance results, including the important statement that the "Building Complies with Computer Performance", plus notes that the building includes HERS measures and other special features, followed by the energy use summary.

The energy use summary shows that the proposed design saves energy compared to the standard design for space heating and water heating, but loses energy on space cooling. The solar PV system provides a large photovoltaic offset compliance credit. Cooling energy use is a dominant feature of climate zone 12, where the building is located, and it is the largest single component of energy use for both the standard and proposed designs. The losses on space cooling are mostly because the building does not have a CRRC-rated cool roof and because the standard design assumes both roof and ceiling insulation even for buildings with ducts in conditioned space.

The compliance energy total of all the different components shows that the proposed building saves energy as compared to the standard design energy budget, and exceeds requirements by 24.6%.

Designing To Code

CERTIFICATE OF COMPLIANCE - RESIDENTIAL PERFORMANCE COMPLIANCE METHOD **CF1R-PRF-01**

Project Name: Habitat for Humanity, ZNE Demonstration **Calculation Date/Time:** 22:43, Mon, Jul 18, 2016 **Page 1 of 8**

Calculation Description: Title 24 Analysis **Input File Name:** H4H Residence_CBECC-Res 2016.2.0-857.ribd16

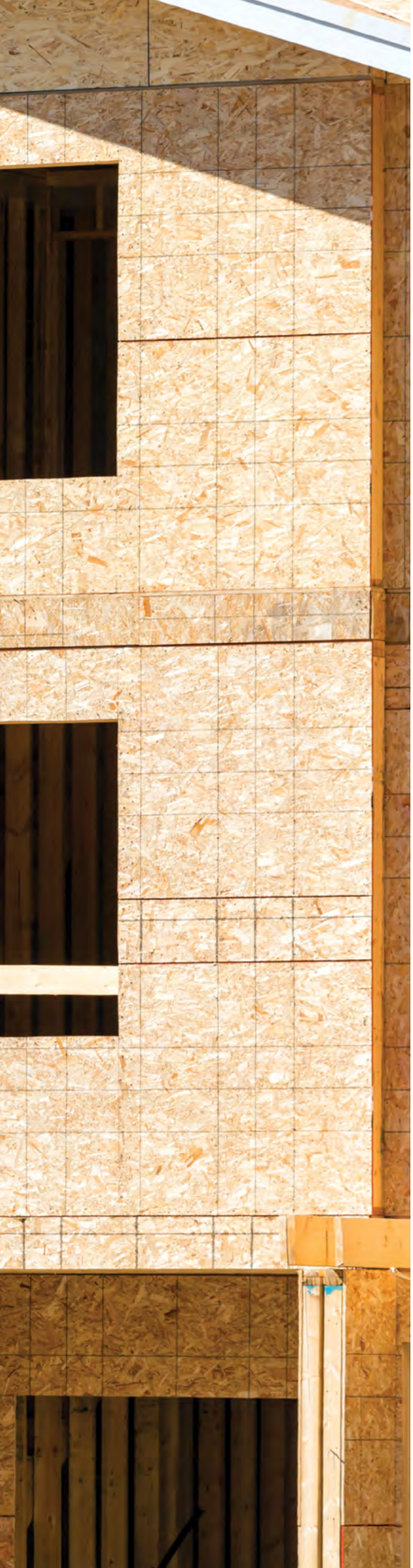
GENERAL INFORMATION					
01	Project Name	Habitat for Humanity, ZNE Demonstration			
02	Calculation Description	Title 24 Analysis			
03	Project Location	Dream Creek Subdivision			
04	City	Stockton	05	Standards Version	Compliance 2017
06	Zip Code		07	Compliance Manager Version	BEMCmpMgr 2016.2.0 (592)
08	Climate Zone	CZ12	09	Software Version	CBECC-Res 2016.2.0 (857)
10	Building Type	Single Family	11	Front Orientation (deg/Cardinal)	163
12	Project Scope	Newly Constructed	13	Number of Dwelling Units	1
14	Total Cond. Floor Area (ft^2)	1236	15	Number of Zones	1
16	Slab Area (ft^2)	0	17	Number of Stories	1
18	Addition Cond. Floor Area	N/A	19	Natural Gas Available	Yes
20	Addition Slab Area (ft^2)	N/A	21	Glazing Percentage (%)	7.9%

COMPLIANCE RESULTS	
01	Building Complies with Computer Performance
02	This building incorporates features that require field testing and/or verification by a certified HERS rater under the supervision of a CEC-approved HERS provider.
03	This building incorporates one or more Special Features shown below

ENERGY USE SUMMARY

04	05	06	07	08
Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	14.37	6.89	7.48	52.1%
Space Cooling	22.11	29.34	-7.23	-32.7%
IAQ Ventilation	1.64	1.64	0.00	0.0%
Water Heating	15.32	14.50	0.82	5.4%
Photovoltaic Offset	----	-12.08	12.08	----
Compliance Energy Total	53.44	40.29	13.15	24.6%

Performance Method Compliance Results for Habitat for Humanity Case Study Residence, Form CF1R-PRF-01, Page 1 of 8, Energy Commission approved software version CBECC-Res 2016.2.0 (857)



CHAPTER 6

RECOMMENDATIONS AND EXAMPLE APPLICATONS

A well-designed, energy-efficient building envelope that complies with California's Energy Standards has many advantages for the individual residents and for the larger community. And this holds true for residential subdivisions that are designed for the future by meeting the solar ready requirements.

Design Flexibility

The combination of prescriptive and performance method energy standards gives designers and builders choices in the goal of meeting code and saving energy. Designers juggle many, sometimes conflicting, desires and requirements, from the client who cares about energy-efficiency, but wants to have large west-facing windows to take advantage of a wonderful view, to structural and site issues, to specific local building codes, and, of course, to budget limitations. Sometimes the best way to balance all these goals and also comply with Title 24 may be sticking with a simple prescriptive package, but often the more flexible performance method may be the only way to resolve conflicting needs.

Immediate Advantages

Homes built to code do a better job of keeping their occupants comfortable and safe than those that are not, and they also cost less to heat and cool. Houses designed for climate to be warm in the winter and cool in the summer can help give occupants a solid, comfortable home base from which to enjoy life.

Future Benefits

When we build homes now, we are building for the future. Much of the energy we use today goes to heat and cool residences, so when we install high performing windows and good insulation now, we are also reducing energy demand for years to come. And as we move toward a future where it is more and more important to reduce greenhouse gases and other pollution due to burning fossil fuels, solar ready strategies will ease our transition into more solar electricity and solar water heating.

Topic Specific Scenarios

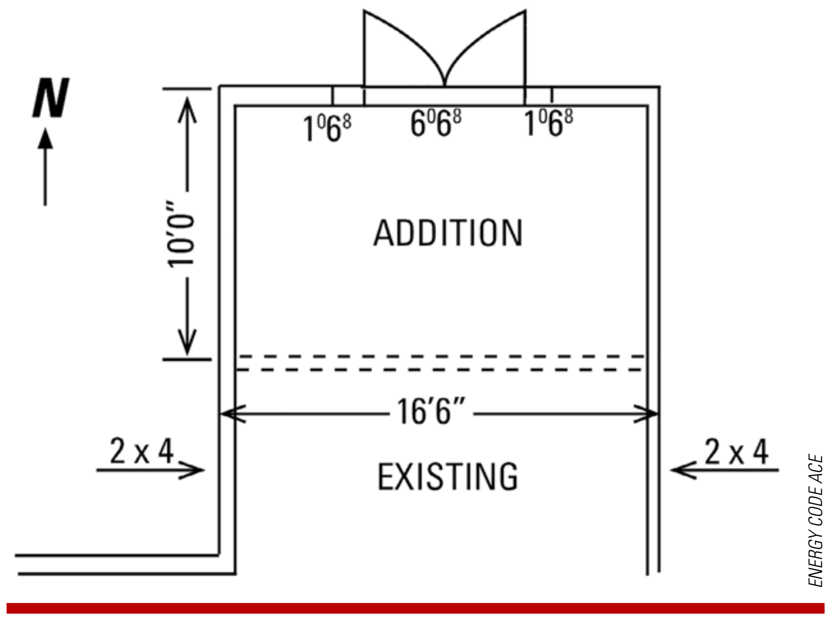
Prescriptive Addition

A builder is planning a 165 ft² addition (10'0" x 16'6") to an existing family room in Pasadena (climate zone 9).

As shown in the plan, the new east and west walls of the addition will extend from existing 2x4 wood frame walls, and the owner would prefer that all walls in the addition remain 2x4 wood frame, if possible. The addition has a 2x10 wood frame vaulted rafter roof with R-30 cavity insulation and roofing material that has not been CRRC-rated. There is an R-19 wood framed raised floor over a crawlspace.

The addition has a pair of 6'0" x 6'8" French doors with two 1'0" x 6'8" fixed side lights facing north, but no other glazing. The doors and windows will be dual pane with clad wood frames.

To comply prescriptively, this addition would need to meet the requirements for additions



Addition where new east and west-facing walls are extensions of existing 2x4 walls.

less than 300 ft².

The roof and floor insulation meet or exceed prescriptive R-value requirements, and there is no cool roof required for additions this size, so those features comply prescriptively.

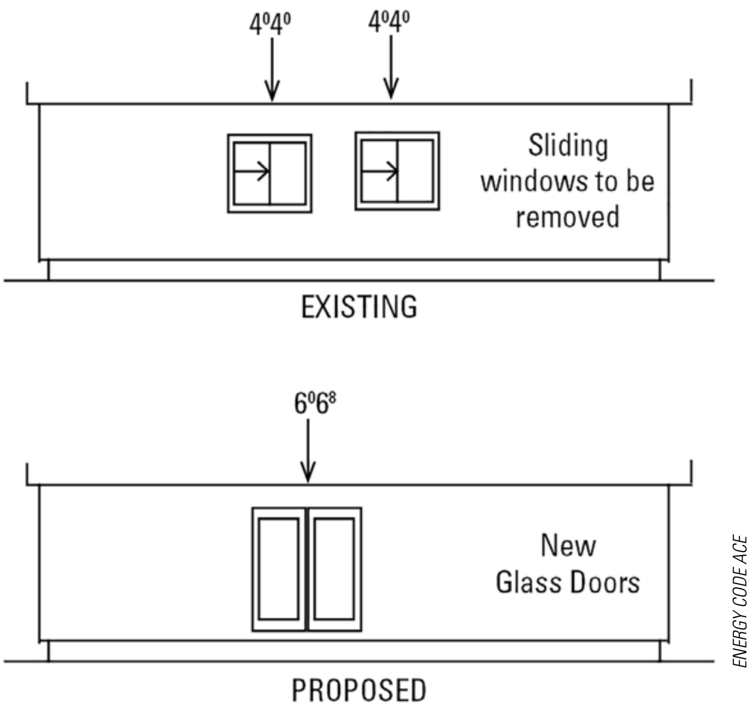
The total fenestration area is 53.3 ft², which is more than 20% of the addition conditioned floor area. However, additions smaller than 400 ft² are allowed at least 75 ft² prescriptively, so the total area complies. There are no west-facing windows or skylights, so the west-facing area limits do not apply. For climate zone 9, the fenestration would need NFRC-rated U-factors of 0.32 or less and SHGCs of 0.25 or less. If the dual glazing has a low e coating, then there are numerous manufactured glass doors and fixed side lights with low e glass and clad wood frames that would meet the prescriptive values.

For prescriptive compliance, new wood frame walls that are extensions of existing can maintain the existing framing size, so the east and west-facing walls can remain as 2x4 as long as they have R-15 insulation. However, the new north-facing wall is not an extension of an existing wall, so it would have to meet the Package A wall U-factor of 0.051 for climate zone 9, which typically corresponds to a 2x6 wood frame wall with R-19 cavity insulation plus R-5 continuous insulation.

If the owner is willing to make these changes, then the addition will comply prescriptively. If not, then the addition will need to be analyzed for compliance using the Performance Approach.

Fenestration Alteration

A homeowner in Oakland (climate zone 3) wants to replace two existing single pane metal frame sliding windows with a new pair of dual pane low-e wood frame swinging glass doors on the west side of the house. The windows to be removed are 4'0" x 4'0" each, and the pair of glass doors measures 6'0" x 6'8".



Fenestration Alteration Example

To comply as a prescriptive fenestration alteration requires calculating the total window area replaced plus the area of any new fenestration. In this case, the windows being replaced are 16 ft^2 each for a total of 32 ft^2, and the new glass doors are 40 ft^2. Since the glass door area is 8 ft^2 larger than the existing windows removed, this alteration has 32 ft^2 of fenestration replaced and 8 ft^2 of new fenestration. Theoretically, those two areas could be shown to comply prescriptively by meeting the different requirements for replacement and new fenestration, but practically speaking, the new doors will just have to meet the performance requirements for a new fenestration alteration.

There is less than 75 ft² of new fenestration, so it has to meet the Package A U-factor and SHGC requirements, but not the total or west-facing area limits. For climate zone 3, there are no SHGC or west-facing area requirements, so the new glass doors just need to meet the prescriptive U-factor of 0.32 or less. This is easily achieved with many NFRC-rated dual pane low-e wood frame glass doors.

Note that since the windows being removed are in somewhat different parts of the wall than the new door, part of this alteration will be to fill some openings with new wall. Assuming that the existing and new walls are 2x4 wood framing, the new walls will just need to meet the mandatory minimum R-13 cavity insulation to comply. This requirement will also apply to any existing walls that are opened up as part of the alteration.

Duplexes

Question: How are duplexes -- buildings with two dwelling units – treated in the Energy Standards?

Answer: Duplexes are in the same R-3 occupancy category as single family residences, so they need to meet all of the same Energy Standards requirements.

4-story Single Family vs Multifamily

Question: A single family residence is to be built with four habitable stories. Will this building be covered by the low-rise residential Energy Standards? How about a four-story building with three dwelling units?

Answer: Single family residences, including duplexes, are always covered by the low-rise residential Energy Standards, no matter how many habitable stories they have. This is not true for multifamily residences which are residential buildings with three or more dwelling units. Multifamily buildings with up to three habitable stories fall under the low-rise residential Energy Standards, but those with four stories or more are covered by the high-rise residential standards and have substantially different requirements.

Evaluating Possible Energy Compliance Options Based on the Performance Approach CF1R-PRF-01 Energy Use Summary

Energy analysts and designers can use performance method compliance software to help understand the energy performance of proposed buildings and to evaluate what measures are likely to be most effective at saving energy and bringing a residence into compliance with the Energy Standards.

Consider a possible new home in Palm Springs, out in the hot desert region of inland southern California. Here is a summary of the features of the proposed design as it might arrive at an energy consultant's office for Title 24 energy analysis.

General information:

- New single family residence in Palm Springs, CA, climate zone 15
- 3,400 ft² conditioned floor area, 2 stories, 4 bedrooms, 440 ft² unconditioned garage

Building envelope at conditioned space:

- 20.8% total fenestration area, dual pane low-e fiberglass frame windows and glass doors with NFRC-rated U-factor = 0.32, SHGC = 0.28, 2' overhangs shading all south-facing windows and glass doors
- Vented attic with R-38 ceiling insulation and wood framing
- Steep-sloped roof (4:12 pitch), asphalt shingles with CRRC-rated aged solar reflectance = 0.20, thermal emittance = 0.85
- Exterior walls: R-21 cavity insulation in 2x6 wood frame 16" o.c. plus R-5 continuous insulation

- Demising and knee walls between conditioned space and garage or garage attic: R-21 cavity insulation in 2x6 wood frame 16" o.c.
- Uninsulated slab-on-grade floor
- Raised floor over garage: R-19 cavity insulation in 2x6 wood frame 16" o.c.

Space heating, cooling and ventilation system:

- Split system gas furnace with 80% AFUE plus air conditioner with 14 SEER and 11 EER, HERS-verified minimum airflow, EER, refrigerant charge and fan efficacy watts/cfm
- R-8 ducts located in the vented attic and sealed and tested for leakage, HERS-verified reduced duct leakage
- Cooling ventilation whole house fan
- HERS-verified indoor air quality (IAQ) mechanical ventilation

Water heating system:

- Tankless gas water heater with 120,000 Btuh input and 0.82 energy factor (or equivalent uniform energy factor), standard distribution system

Here are the results of an initial compliance analysis showing that house is out of compliance as designed. Look carefully at the information in the Energy Use Summary, and you will see that the estimated energy use for space cooling far outweighs every other component of the compliance total:

CERTIFICATE OF COMPLIANCE - RESIDENTIAL PERFORMANCE COMPLIANCE METHOD — **CF1R-PRF-01**

Project Name: Palm Springs Residence — **Calculation Date/Time:** 15:08, Fri, Jul 22, 2016 — **Page 1 of 8**

Calculation Description: Palm Springs Residence: Base Design — **Input File Name:** Palm Springs Residence_CBECC-Res 2016.2.0-857.ribd16

GENERAL INFORMATION					
01	Project Name	Palm Springs Residence			
02	Calculation Description	Base Case Design			
03	Project Location	Climate Zone 15			
04	City	Palm Springs, CA	05	Standards Version	Compliance 2017
06	Zip Code		07	Compliance Manager Version	BEMCmpMgr 2016.2.0 (592)
08	Climate Zone	CZ15	09	Software Version	CBECC-Res 2016.2.0 (857)
10	Building Type	Single Family	11	Front Orientation (deg/Cardinal)	0
12	Project Scope	Newly Constructed	13	Number of Dwelling Units	1
14	Total Cond. Floor Area (ft^2)	3400	15	Number of Zones	1
16	Slab Area (ft^2)	1560	17	Number of Stories	2
18	Addition Cond. Floor Area	N/A	19	Natural Gas Available	Yes
20	Addition Slab Area (ft^2)	N/A	21	Glazing Percentage (%)	20.8%

COMPLIANCE RESULTS	
01	Building Does Not Comply
02	This building incorporates features that require field testing and/or verification by a certified HERS rater under the supervision of a CEC-approved HERS provider.
03	This building incorporates one or more Special Features shown below

ENERGY USE SUMMARY

04	05	06	07	08
Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	1.37	1.25	0.12	8.8%
Space Cooling	74.13	87.02	-12.89	-17.4%
IAQ Ventilation	0.97	0.97	0.00	0.0%
Water Heating	4.84	4.84	0.00	0.0%
Photovoltaic Offset	----	0.00	0.00	----
Compliance Energy Total	81.31	94.08	-12.77	-15.7%

The design team will need to find ways to reduce the proposed cooling energy use. The fenestration and roof/ceiling conditions are the most likely features of the building envelope to either increase or reduce cooling energy use. The proposed windows and glass doors are already reasonably high-performing NFRC-rated products with U-factor of 0.32 and SHGC of 0.28, but the NFRC.org website lists many products that could bring the U-factor down to 0.30 or less and SHGC down to 0.20 or less, and a lower SHGC, in particular, will help reduce the cooling load.

There is no radiant barrier in the attic, so that's a relatively easy improvement. The building has a CRRC-rated cool roof, but the aged solar reflectance is only 0.20 with thermal emittance of 0.85, and there are asphalt shingle roofs with reflectance values up to 0.37 and thermal emittance up to 0.92 on the Cool Roof Rating Council's website.

Trying a combination of fenestration U-factor = 0.30 and SHGC = 0.20, plus a roof aged solar reflectance of 0.29 and thermal emittance of 0.89, and an attic radiant barrier, the building just makes it into compliance:

COMPLIANCE RESULTS	
01	Building Complies with Computer Performance
02	This building incorporates features that require field testing and/or verification by a certified HERS rater under the supervision of a CEC-approved HERS provider.
03	This building incorporates one or more Special Features shown below

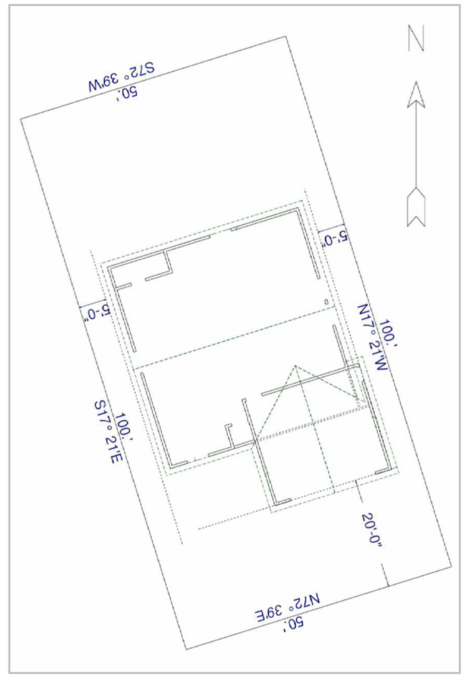
ENERGY USE SUMMARY				
04	05	06	07	08
Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	1.37	1.85	-0.48	-35.0%
Space Cooling	74.13	73.53	0.60	0.8%
IAQ Ventilation	0.97	0.97	0.00	0.0%
Water Heating	4.84	4.84	0.00	0.0%
Photovoltaic Offset	----	0.00	0.00	----
Compliance Energy Total	81.31	81.19	0.12	0.1%

It is always good to have options, so another way to improve the roof/ceiling conditions would be to install R-13 insulation between the roof framing, in addition to the R-38 ceiling insulation already planned. This is a new prescriptive requirement for vented attics with ducts in the attic, so the standard design energy budget assumes that feature. Here are the results of the analysis that adds the roof insulation and turns the attic into a high performance attic, without any of the other measures from Option 1 above:

COMPLIANCE RESULTS	
01	Building Complies with Computer Performance
02	This building incorporates features that require field testing and/or verification by a certified HERS rater under the supervision of a CEC-approved HERS provider.
03	This building incorporates one or more Special Features shown below

ENERGY USE SUMMARY				
04	05	06	07	08
Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	1.39	1.02	0.37	26.6%
Space Cooling	74.45	70.48	3.97	5.3%
IAQ Ventilation	0.97	0.97	0.00	0.0%
Water Heating	4.84	4.84	0.00	0.0%
Photovoltaic Offset	----	0.00	0.00	----
Compliance Energy Total	81.65	77.31	4.34	5.3%

So, just adding the roof insulation brings the residence into compliance by a wider margin than the combination of other measures above, and might end up being less expensive. It does reinforce the understanding that it is usually easier to comply with Title 24 if you meet or exceed as many of the prescriptive values as possible. In this second option, performance method trade-offs allow the residence to have more glass than the prescriptive 20%, as well as an SHGC of 0.28 which is worse than the 0.25 prescriptive requirement, while still meeting California's energy-efficiency requirements.



Plot Plan, ZNE Demonstration Home, Habitat for Humanity, Dream Creek Subdivision, Stockton, CA. Designed by George H. Koertzen, Habitat for Humanity San Joaquin County, CA

Solar Zone Orientation Example

Question: Considering the plot plan for the Habitat for Humanity case study house in chapter 4, which parts of the roof meet the orientation requirements for a solar zone? The roof has a 4:12 pitch.

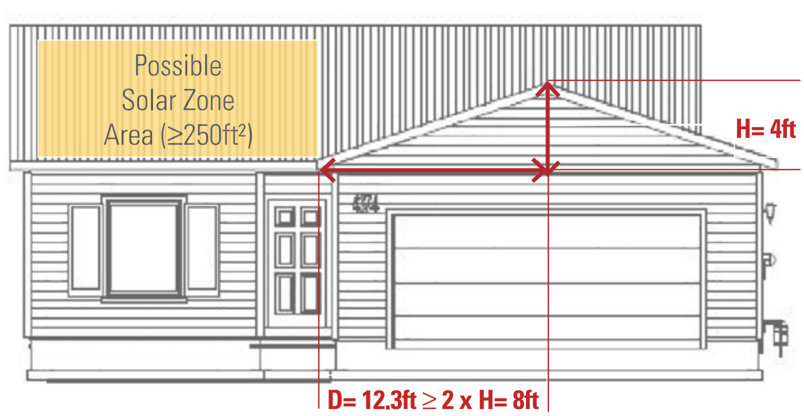
Answer: Any roof pitch over 2:12 is considered steep-sloped, and to be part of the solar zone a steep-sloped roof must be oriented between 110 and 270 degrees. The building is rotated 17 degrees counterclockwise from true north, so the front-facing part of the roof over the main house has an orientation of 163 degrees and the left-facing part of the roof over the garage has an orientation of 253 degrees, so both of those roof sections meet the orientation requirements. The rear-facing roof (353 degrees) and the right-facing roof (73 degrees) do not meet solar zone orientation requirements.

Note that if the house had a low-sloped roof, the orientation would not matter and the whole roof could be part of the solar zone.

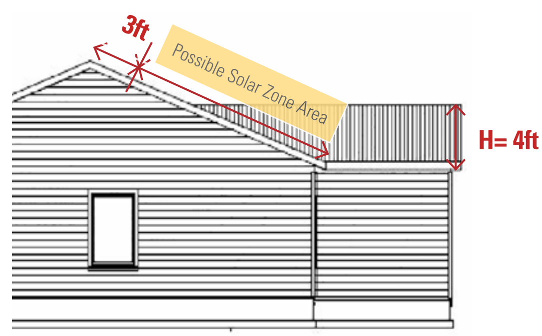
Evaluating a Possible Solar Zone Obstruction

To meet the solar ready requirement for a single family residence in a subdivision with at least ten single family residences requires evaluating which parts of the roof have good solar access without obstructions. Any building feature that projects above any part of the designated solar zone area needs to be far enough away from the zone that it will not cause any significant shading.

The attached front and partial left elevations from the Habitat for Humanity case study residence show a possible area of solar zone on the front roof (orientation 163 degrees) and a potential obstruction caused by the peak of the garage roof to the east of the



Front Elevation Style A



Left Elevation Style A

Evaluating possible obstruction to solar zone using simplified front and partial left elevations from ZNE Demonstration Home, Habitat for Humanity, Dream Creek Subdivision, Stockton, CA. Designed by George H. Koertzen, Habitat for Humanity San Joaquin County, CA solar zone. The height (H) of the obstruction is shown in the front elevation as a vertical distance of 4 feet measured from the bottom edge of the solar zone to the peak of the garage roof. The horizontal distance (D) from the tallest part of the garage roof to the nearest edge of the solar zone is 12.3 feet. The minimum required distance between any obstruction and the solar zone is calculated in the equation: $D > 2 \times H$, or, in this case, $D > 2 \times 4' = 8'$. The measured distance of 12.3 feet is more than the minimum required 8 feet, so the peak of the garage roof does not obstruct the solar zone area as shown.

APPENDIX

Glossary

BUILDING ENVELOPE is the ensemble of exterior and demising partitions of a building that enclose conditioned space.

FIELD-FABRICATED FENESTRATION is a fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product. It does not include site-built products made from prefabricated components.

HIGH-RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel, of Occupancy Group R, Group R-2 or R-4 with four or more stories.

LOW-RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel that is Occupancy Group:

- R-2, multifamily (three or more dwelling units); or
- R-3, single family or duplex; or
- U-building, located on a residential site.

MASS WALL has a thermal heat capacity greater than or equal to 7.0 Btu/hrft^2.

MECHANICAL HEATING is raising the temperature within a space using electric resistance heaters, fossil fuel burners, heat pumps, or other systems that require energy from depletable sources to directly condition the space.

SPACE CONDITIONING definitions:

- **DIRECTLY CONDITIONED SPACE** is an enclosed space that is provided with wood heating, is provided with mechanical heating that has a capacity exceeding 10 Btu/hrft^2, or is provided with mechanical cooling that has a capacity exceeding 5 Btu/hrft^2, unless the space-conditioning system is designed and thermostatically controlled to maintain a process environment temperature less than 55°F or to maintain a process environment temperature greater than 90°F for the whole space that the system serves, or unless the space-conditioning system is designed and controlled to be incapable of operating at temperatures above 55°F or incapable of operating at temperatures below 90°F at design conditions.
- **INDIRECTLY CONDITIONED SPACE** is enclosed space, including, but not limited to, unconditioned volume in atria, that (1) is not directly conditioned space; and (2) either (a) has a thermal transmittance area product (UA) to directly conditioned space exceeding that to the outdoors or to unconditioned space and does not have fixed vents or openings to the outdoors or to unconditioned space, or (b) is a space through which air from directly conditioned spaces is transferred at a rate exceeding three air changes per hour.
- **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.
- **UNCONDITIONED SPACE** is enclosed space within a building that is not directly conditioned, or indirectly conditioned.

ROOF, LOW-SLOPED is a roof that has a ratio of rise to run of 2:12 or less (9.5 degrees from the horizontal).

ROOF, STEEP-SLOPED is a roof that has a ratio of rise to run of greater than 2:12 (9.5 degrees from the horizontal).

SINGLE FAMILY RESIDENCE is a building that is of occupancy group R-3. Occupancy group R-3 includes buildings with one or two dwelling units.

TIME DEPENDENT VALUATION (TDV) ENERGY is the time varying energy caused to be used by the building to provide space conditioning and water heating and for specified buildings lighting. TDV energy accounts for the energy used at the building site and consumed in producing and in delivering energy to a site, including, but not limited to, power generation, transmission and distribution losses. Per §100.2, TDV energy is calculated by multiplying the site energy use (electricity KWh, natural gas therms, or fuel oil or LPG gallons) for each energy type by the applicable TDV multiplier summarized in Reference Joint Appendix JA3.

Low-Rise Residential Building Envelope and Single-Family Solar Ready Compliance Documents

Here is a list of all Certificates of Compliance, Installation and Verification that are available to document Title 24, Part 6 low-rise residential building envelope and single-family solar ready compliance. The particular forms required for any given project depends on the specific scope of work.

Compliance forms and instructions for completing them can be accessed on the Energy Commission website:

energy.ca.gov/title24/2016standards

Certificates of Compliance

CF1R-PRF-01-E Performance Low-rise Residential Buildings (all types)

CF1R-NCB-01-E Prescriptive Newly Constructed Buildings (any size) and Additions greater than or equal to 1,000 ft^2

CF1R-ADD-01-E Prescriptive Additions less than 1,000 ft^2

CF1R-ADD-02-E Prescriptive Additions – Simple NonHERS (paper version)

CF1R-ALT-01-E Prescriptive Alterations

CF1R-ALT-05-E Prescriptive Alterations – Simple NonHERS (paper version)

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) Calculation Worksheet

CF1R-SRA-01-E Solar Ready Area – New Construction

CF1R-SRA-02-E Minimum Solar Zone Area Worksheet – New Construction

CF1R-PRF-01-E is required for all low-rise residential buildings demonstrating compliance using the Performance Approach.

CF1R-NCB-01-E is required for all newly constructed low-rise residential buildings demonstrating compliance using the Prescriptive Approach. It is also required for prescriptive additions greater than or equal to 1,000 ft^2 that include any HERS measures.

CF1R-ADD-01-E is required for prescriptive additions less than 1,000 ft^2 that include HERS measures, and CF1R-ADD-02-E is for any size prescriptive additions that do not include HERS measures.

CF1R-ALT-01-E is required for prescriptive alterations that include HERS measures, and CF1R-ALT-05-E is for prescriptive alterations that do not include HERS measures.

CF1R-ENV-02-E, CF1R-ENV-03-E, and CF1R-ENV-04-E are calculation worksheets submitted as necessary with the primary Certificates of Compliance described above.

CF1R-SRA-01-E and CF1R-SRA-02-E document compliance with the mandatory solar ready area requirements, when applicable.

Certificates of Installation

CF2R-ADD-02-E Prescriptive Additions – Simple NonHERS (paper version)

CF2R-ALT-05-E Prescriptive Alterations – Simple NonHERS (paper version)

CF2R-ENV-01-E Fenestration Installation

CF2R-ENV-03-E Insulation Installation

CF2R-ENV-04-E Roofing – Radiant Barrier

CF2R-ENV-20-H Building Leakage Diagnostic Test – HERS

CF2R-ADD-02-E and CF2R-ALT-05-E may be used to document features installed in prescriptive additions and alterations that do not include HERS measures.

CF2R-ENV-01-E, CF2R-ENV-03-E, and CF2R-ENV-04-E document installation of fenestration, insulation, roofing and radiant barriers, as applicable.

CF2R-ENV-20-H is required for buildings that show compliance using HERS-verified reduced building envelope air leakage.

CF2R-SPV-01-E PV Systems

CF2R-SPV-01-E is required when a project is installing a solar PV system in order to comply with an exception to solar ready requirements from Section 110.10.

Certificates of Verification

CF3R-ENV-20-H Building Leakage Diagnostic Test

CF3R-ENV-21-H Quality Insulation Installation (QII) – Air Infiltration Sealing – Framing Stage for Batt, Loose Fill and SPF

CF3R-ENV-22-H Quality Insulation Installation (QII) – Air Infiltration Sealing – Ceiling/ Roof Deck

CF3R-ENV-23-H Quality Insulation Installation (QII) – Insulation Installation

CF3R-ENV-24-H Quality Insulation Installation (QII) – Air Infiltration Sealing – Framing Stage for SIP and ICF

CF3R-EXC-20-H Existing Conditions for Residential Alterations

CF3R-ENV-20-H is required for buildings that show compliance using HERS-verified reduced building envelope air leakage.

CF3R-ENV-21-H through CF3R-ENV-24-H verify compliance with QII requirements through different stages of construction.

CF3R-EXC-20-H documents HERS-verified existing conditions if they are used as a compliance credit in the existing-plus-addition-plus-alteration performance method.

Tables

Table 100.0-A Application of Standards

TABLE 100.0-A APPLICATION OF STANDARDS

Occupancies	Application	Mandatory	Prescriptive	Performance	Additions/Alterations
General Provisions for All Buildings		100.0, 100.1, 100.2, 110.0			
Nonresidential, High-Rise Residential, And Hotels/Motels	General	120.0	140.0, 140.2	140.0, 140.1	141.0
	Envelope (conditioned)	110.6, 110.7, 110.8,120.7	140.3		
	Envelope (unconditioned process spaces)	N.A.	140.3(c)		
	HVAC (conditioned)	110.2, 110.5, 120.1, 120.2, 120.3, 120.4, 120.5, 120.8	140.4		
	Water Heating	110.3, 120.3, 120.8, 120.9	140.5		
	Indoor Lighting (conditioned, process spaces)	110.9, 120.8, 130.0, 130.1, 130.4	140.3(c), 140.6		
	Indoor Lighting (unconditioned and parking garages)	110.9, 120.8, 130.0, 130.1, 130.4	140.3(c), 140.6	N.A.	
	Outdoor Lighting	110.9, 130.0, 130.2, 130.4	140.7		
	Electrical Power Distribution	110.11, 130.5	N.A.		
	Pool and Spa Systems	110.4, 110.5, 150.0(p)	N. A.		141.0
	Solar Ready Buildings	110.10	N.A.		141.0(a)
Covered Processes[1]	Envelope, Ventilation, Process Loads	110.2, 120.6	140.9	140.1	120.6, 140.9
Signs	Indoor and Outdoor	130.0, 130.3	140.8	N.A.	141.0, 141.0(b)2H
Low-Rise Residential	General	150.0	150.1(a, c)	150.1(a), 150.1(b)	150.2(a), 150.2(b)
	Envelope (conditioned)	110.6, 110.7, 110.8, 150(a), 150.0(b), 150.0(c), 150.0(d), 150.0(e), 150.0(g)			
	HVAC (conditioned)	110.2, 110.5, 150.0(h), 150.0(i), 150.0(j), 150.0(m), 150.0(o)			
	Water Heating	110.3, 150.0(j, n)			
	Indoor Lighting (conditioned, unconditioned and parking garages)	110.9, 130.0, 150.0(k)			
	Outdoor Lighting	110.9, 130.0,150.0(k)			
	Pool and Spa Systems	110.4, 150.0(p)	N. A.	N.A.	150.2(a), 150.2(b)
	Solar Ready Buildings	110.10	N. A.	N.A.	N.A.

[1] Nonresidential, high-rise and hotel/motel buildings that contain covered processes may conform to the applicable requirements of both occupancy types listed in this table.

Table 110.6-A Default Fenestration Product U-factors

TABLE 110.6-A DEFAULT FENESTRATION PRODUCT U-FACTORS

FRAME	PRODUCT TYPE	SINGLE PANE [3,4] U-FACTOR	DOUBLE PANE [1,3,4] U-FACTOR	GLASS BLOCK [2,3] U-FACTOR
Metal	Operable	1.28	0.79	0.87
	Fixed	1.19	0.71	0.72
	Greenhouse/garden window	2.26	1.40	N.A.
	Doors	1.25	0.77	N.A.
	Skylight	1.98	1.30	N.A.
Metal, Thermal Break	Operable	N.A.	0.66	N.A.
	Fixed	N.A.	0.55	N.A.
	Greenhouse/garden window	N.A.	1.12	N.A.
	Doors	N.A.	0.59	N.A.
	Skylight	N.A.	1.11	N.A.
Nonmetal	Operable	0.99	0.58	0.60
	Fixed	1.04	0.55	0.57
	Doors	0.99	0.53	N.A.
	Greenhouse/garden windows	1.94	1.06	N.A.
	Skylight	1.47	0.84	N.A.

[1] For all dual-glazed fenestration products, adjust the listed U-factors as follows:

a. Add 0.05 for products with dividers between panes if spacer is less than 7/16 inch wide.

b. Add 0.05 to any product with true divided lite (dividers through the panes).

[2] Translucent or transparent panels shall use glass block values when not rated by NFRC 100.

[3] Visible Transmittance (VT) shall be calculated by using Reference Nonresidential Appendix NA6.

[4] Windows with window film applied that is not rated by NFRC 100 shall use the default values from this table.

Table 110.6-B Default Solar Heat Gain Coefficient (SHGC)

TABLE 110.6-B DEFAULT SOLAR HEAT GAIN COEFFICIENT (SHGC)

FRAME TYPE	PRODUCT	GLAZING	FENESTRATION PRODUCT SHGC		
			Single Pane[2,3] SHGC	Double Pane[2,3] SHGC	Glass Block[1,2] SHGC
Metal	Operable	Clear	0.80	0.70	0.70
	Fixed	Clear	0.83	0.73	0.73
	Operable	Tinted	0.67	0.59	N.A.
	Fixed	Tinted	0.68	0.60	N.A.
Metal, Thermal Break	Operable	Clear	N.A.	0.63	N.A.
	Fixed	Clear	N.A.	0.69	N.A.
	Operable	Tinted	N.A.	0.53	N.A.
	Fixed	Tinted	N.A.	0.57	N.A.
Nonmetal	Operable	Clear	0.74	0.65	0.70
	Fixed	Clear	0.76	0.67	0.67
	Operable	Tinted	0.60	0.53	N.A.
	Fixed	Tinted	0.63	0.55	N.A.

[1] Translucent or transparent panels shall use glass block values when not rated by NFRC 200.

[2] Visible Transmittance (VT) shall be calculated by using Reference Nonresidential Appendix NA6.

[3] Windows with window film applied that is not rated by NFRC 200 shall use the default values from this table

Prescriptive Envelope Requirements vs Performance Method Standard Design

	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	Package A (§150.1 Table 150.1-A)	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
Total Conditioned Floor Area (CFA)	Same as proposed design	Same as proposed design
Fenestration:		
Area	Total Area: All CZ: ≤ 20% CFA West-facing Area: CZ 1, 3, 5. No area limits CZ 2,4, 6-16: ≤ 5% CFA	If the proposed design fenestration area is < 20% CFA, the standard total area = the proposed total area. If the proposed design fenestration area is ≥ 20% CFA, the standard total area = 20% CFA. In both cases, the standard design fenestration area is distributed equally between north, east, south and west.
U-factor	All CZ: ≤ 0.32	All CZ: 0.32
SHGC	CZ 1, 3, 5: NR CZ 2, 4, 6-16: ≤ 0.25	CZ 1, 3, 5: 0.50 CZ 2,4, 6-16: 0.25

Important Note on Performance Method Standard Design

The standard design used in the Performance Approach sets the baseline TDV energy budget for the building. However, the features of the actual proposed building may be better or worse than the standard design assumptions and still comply with the Energy Standards, as long as the compliance energy total for the proposed design is less than or equal to the standard design and the proposed building meets all applicable mandatory measures.

Exception:

Roofs covered by solar collectors or with thermal mass above the roof membrane that weighs at least 25 lb/ft^2 are exempt from the prescriptive aged solar reflectance and thermal emittance requirements. They are also assumed to meet the standard design requirements in the Performance Approach.

	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	Package A (§150.1 Table 150.1-A)	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
Roof/Ceiling Insulation and Radiant Barrier:		
Vented attic with ducts in the attic	Requires ceiling insulation, roof insulation and radiant barrier which vary by climate zone: Ceiling Insulation: CZ 1, 2, 4, 8-16. R-38 CZ 3, 5-7: R-30 Roof Insulation and Radiant Barrier: Option A: Continuous insulation installed above roof rafters: Roofing w/o air space: CZ 1-3, 5-7. NR CZ 4, 8-16: R-8 Roofing with air space: CZ 1-3, 5-7. NR CZ 4, 8-16: R-6 Radiant Barrier: CZ 1, 16: NR CZ 2-15: REQ Option B: Insulation below the roof deck between rafters: Roofing w/o air space: CZ 1-3, 5-7. NR CZ 4, 8-16: R-18 Roofing with air space: CZ 1-3, 5-7. NR CZ 4, 8-16: R-13 Radiant Barrier: CZ 1, 4, 8-16: NR CZ 2, 3, 5-7: REQ	Standard design assumes prescriptive Package A ceiling insulation and Option B roof insulation with roofing type, as follows: Low slope roofs (≤ 2:12) are assumed to have lightweight roofs w/o an air space. Steep slope roofs (> 2:12) are assumed to have tile roofs with an air space. Standard design also assumes Option B radiant barrier requirements.
Vented attic with ducts in conditioned space	Option C: Requires ceiling insulation and radiant barrier which vary by climate zone: Ceiling Insulation: CZ 1, 11-16. R-38 CZ 2-10: R-30 Radiant Barrier: CZ 1, 16: NR CZ 2-15: REQ	Standard design assumes the same ceiling insulation, roof insulation, and radiant barrier requirements shown above for a vented attic with ducts in the attic.
Any ceiling and roof configuration not meeting options A, B or C, including: - Vented attic with ducts in non-attic unconditioned space such as crawl space or outdoor. - Any non-attic (cathedral) ceiling and roof with ducts in any location	Cannot comply with Title 24 prescriptively. (See 2016 Residential Compliance Manual Section 3.6.2.1 for more details.)	Title 24 compliance may be demonstrated using the performance method. Standard design assumes a vented attic with ducts in the attic and the same ceiling and Option B roof insulation and radiant barrier requirements as shown above.

	PRESCRIPTIVE	PERFORMANCE
Roofing:		
Aged Solar Reflectance	Low-sloped (≤ 2:12): CZ 1-12, 14, 16: NR CZ 13, 15: ≥ 0.63 Steep-sloped (> 2:12): CZ 1-9, 16: NR CZ 10-15: ≥ 0.20	Low-sloped (≤ 2:12): CZ 1-12, 14, 16: 0.10 CZ 13, 15: 0.63 Steep-sloped (> 2:12): CZ 1-9, 16: 0.10 CZ 10-15: 0.20
Thermal Emittance	Low-sloped (≤ 2:12): CZ 1-12, 14, 16: NR CZ 13, 15: ≥ 0.75 Steep-sloped (> 2:12): CZ 1-9, 16: NR CZ 10-15: ≥ 0.75	Low-sloped (≤ 2:12): CZ 1-12, 14, 16: 0.85 CZ 13, 15: 0.85 Steep-sloped (> 2:12): CZ 1-9, 16: 0.85 CZ 10-15: 0.85

Prescriptive Maximum U-factors and Framing for Walls and Floors:

When prescriptive insulation requirements are stated as maximum U-factors, the U-factors can be met with any combination of materials and framing that meets the requirement for the overall construction assembly, and U-factors for different assemblies may be area-weighted.

U-factors for metal-framed or non-framed assemblies may be found in Reference Appendix JA4 or calculated using CBECC-Res 2016 or other Energy Commission approved software.

	PRESCRIPTIVE	PERFORMANCE
New Low-Rise Residential Buildings	Package A (§150.1 Table 150.1-A)	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
Wall Insulation:		
Framed walls: Above grade	CZ 1-5, 8-16: U-factor ≤ 0.051 CZ 6-7: U-factor ≤ 0.065	CZ 1-5, 8-16: U-factor = 0.051 (R-19 cavity insulation in 2x6 wood frame + R-5 continuous) CZ 6-7: U-factor = 0.065 (R-15 cavity insulation in 2x4 wood frame + R-4 continuous)
Mass walls with interior insulation: Above or below grade	CZ 1-15: Overall wall U-factor ≤ 0.07. or ≥ R-13 cavity insulation; CZ 16: Overall wall U-factor ≤ 0.05. or ≥ R-17 cavity insulation	Same as prescriptive Package A

	PRESCRIPTIVE	PERFORMANCE
Mass walls with exterior insulation: Above grade	CZ 1-15: Overall wall U-factor ≤ 0.12. or ≥ R-8 continuous insulation; CZ 16: Overall wall U-factor ≤ 0.07. or ≥ R-13 continuous insulation	Same as prescriptive Package A
Mass walls with exterior insulation: Below grade	CZ 1-13: Overall wall U-factor ≤ 0.20. or ≥ R-5 continuous insulation; CZ 14-15: Overall wall U-factor ≤ 0.10. or ≥ R-10 continuous insulation; CZ 16: Overall wall U-factor ≤ 0.05. or ≥ R-19 continuous insulation	Same as prescriptive Package A
Demising partitions and knee walls next to unconditioned space (i.e., garage or attic)	Mandatory insulation only: 2x4 wood frame: U-factor ≤ 0.102 or ≥ R-13 cavity insulation; 2x6 wood frame: U-factor ≤ 0.074 or ≥ R-19 cavity insulation	R-15 cavity insulation in 2x4 wood frame, 16" o.c.
Opaque portions of exterior doors with less than 50% glass	No prescriptive insulation requirements	All CZ. U-factor = 0.50
Raised Floor Insulation:		
Framed raised floor	All CZ: U-factor ≤ 0.037 or ≥ R-19 cavity insulation	R-19 cavity insulation in 2x6 wood frame, 16" o.c.
Concrete raised floor	CZ 1,2,11,13,14,16: Overall floor U-factor ≤ 0.09. or ≥ R-8 continuous insulation; CZ 12, 15: Overall floor U-factor ≤ 0.13. or ≥ R-4 continuous insulation; CZ 3-10: NR	6" normal weight concrete + continuous insulation as follows: CZ 1,2,11,13,14,16: R-8 CZ 12, 15: R-4 CZ 3-10: R-0
Slab on Grade Insulation:		
Unheated slab on grade	CZ 1-15: NR CZ 16: U-factor ≤ 0.58 or ≥ R-7 perimeter insulation	Perimeter insulation to 16" depth: CZ 1-15: R-0 CZ 16: R-7
Heated slab on grade (see Table 110.8-A)	Mandatory insulation levels: Vertical: CZ 1-15: ≥ R-5 CZ 16: ≥ R-10 Vertical + Horizontal: CZ 1-15: ≥ R-5 CZ 16: ≥ R-10 vert + R-7 horiz	Perimeter insulation to 16" depth: CZ 1-15: R-5 CZ 16: R-10

Table 150.2-C Standard Design for an Altered Component

TABLE 150.2-C 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.
Space-Heating and Space-Cooling Equipment	The requirements of TABLE 150.1-A.	The existing efficiency levels.
Air Distribution System – Duct Sealing	The requirements of Section 150.2(b)1D.	
Air Distribution System – Duct Insulation	The proposed efficiency levels.	The existing efficiency levels.
Water Heating Systems	The requirements of Section 150.1(b)1 without the solar water heating requirements.	The existing efficiency energy factor.[A]
Roofing Products	The requirements of Section 150.2(b)1H.	
All Other Measures	The proposed efficiency levels.	The existing efficiency levels.

A Or equivalent uniform energy factor

2016 Residential ACM Reference Manual, Table 22: Addition (and Alteration) Standard Design for Roofs/Ceilings

Table 22: Addition Standard Design for Exterior Walls

Proposed Design Exterior Wall Assembly Type	Standard Design Values Based on Proposed Wall Status		
	Addition	Altered	Verified Altered
Framed Walls	CZ 1-5, 8-16 = R19+R5 in 2x6 (U0.051) CZ 6-7 = R15+R4 in 2x4 (U-0.065)	R-13 in 2x4 R-19 in 2x6	Existing
Framed Wall Adjacent to Unconditioned (Garage Wall)	R-15 in 2x4 R-19 in 2x6	R-13 in 2x4 R-19 in 2x6	Existing
Mass Interior Insulation	CZ 1-15 = R-13 CZ 16 = R-17	Mandatory requirements have no insulation for mass walls	Existing
Mass Exterior Insulation	CZ 1-15 = R-8 CZ 16 = R-13		Existing
Below Grade Mass Interior Insulation	CZ 1-15 = R-13 CZ 16 = R-15		Existing

2016 Residential ACM Reference Manual, Table 23: Addition (and Alteration) Standard Design for Exterior Walls

Table 23: Addition Standard Design for Fenestration (in Walls and Roofs)

Proposed Design Fenestration Type	Standard Design Based on Proposed Fenestration Status				
	Add ≤ 400 ft^2	Add > 400 and ≤ 700 ft^2	Add > 700 ft^2	Altered	Verified Altered
Vertical Glazing: Area and Orientation	75 ft^2 or 30%	120 ft^2 or 25%	175 ft^2 or 20%	See full description below.	Existing
West Facing Maximum Allowed	CZ2, 4, 6 -16=60 ft^2	CZ2, 4, 6 -16=60 ft^2	CZ2, 4, 6 -16=70 ft^2 or 5%	NR	NR
Vertical Glazing: U-Factor	0.32	0.32	0.32	0.40	See below
Vertical Glazing: SHGC	CZ2, 4, 6 -16=0.25 CZ1,3 & 5=0.50	CZ2, 4, 6 -16=0.25 CZ1,3 & 5=0.50	CZ2, 4, 6 -16=0.25 CZ1,3 & 5=0.50	CZ2, 4 & 6-16=0.35 CZ1,3 & 5=0.50	Existing
Skylight: Area and Orientation	No skylight area in the standard design	No skylight area in the standard design	No skylight area in the standard design	NR	Existing
Skylight: U-Factor	0.32	0.32	0.32	0.55	Existing
Skylight: SHGC	CZ2, 4, 6 -16=0.25 CZ1,3 & 5=0.50	CZ2, 4, 6 -16=0.30 CZ1,3 & 5=0.50	CZ2, 4, 6 -16=0.30 CZ1,3 & 5=0.50	CZ2, 4, 6 -16=0.30 CZ1,3 & 5=0.50	Existing

2016 Residential ACM Reference Manual, Table 24: Addition (and Alteration) Standard Design for Fenestration (in Walls and Roofs)

Table 24: Addition Standard Design for Overhangs, Sidefins and Other Exterior Shading

Proposed Design Shading Type	Standard Design Based on Proposed Shading Status		
	Addition	Altered	Verified Altered
Overhangs and Sidefins	No overhangs or sidefins	Proposed altered condition	Same as Altered
Exterior Shading	Standard (bug screens on fenestration, none on skylights)	Proposed altered condition	Existing exterior shading
Window Film	No window film	Proposed altered condition	Existing exterior shading

2016 Residential ACM Reference Manual, Table 25: Addition (and Alteration) Standard Design for Overhangs, Sidefins and Other Exterior Shading

Table 25: Addition Standard Design for Raised Floor, Slab-on-Grade and Raised Slab			
Proposed Design Floor Type	Standard Design Based on Proposed Floor Status (Tag)		
	Addition	Altered (mandatory)	Verified Altered
Raised Floor Over Crawl Space or Over Exterior	R-19 in 2x6 16" o.c. wood framing	R-19 in 2x6 16" o.c. wood framing	If proposed U ≤ 0.037, standard design = existing raised; if proposed U > 0.037, standard design = Altered
Slab-on-Grade: Unheated	CZ1-15: R-0 CZ16: R-7 16" vertical	Proposed design	Existing unheated slab-on-grade
Slab-on-Grade: Heated	CZ1-15: R-5 16" vertical CZ 16: R-10 16" vertical	Proposed design	Existing heated slab-on-grade
Raised Concrete Slab	CZ1,2,11,13,14,16: R-8 CZ3-10: R-0 CZ12,15: R-4	Proposed design	Existing raised concrete slab

2016 Residential ACM Reference Manual, Table 26: Addition (and Alteration) Standard Design for Raised Floor, Slab-on-Grade and Raised Slab

Table 26: Addition Standard Design for Raised Floor, Slab-on-Grade and Raised Slab			
Proposed Design Floor Type	Standard Design Based on Proposed Floor Status (Tag)		
	Addition	Altered (mandatory)	Verified Altered
Raised Floor Over Crawl Space or Over Exterior	R-19 in 2x6 16" o.c. wood framing	R-19 in 2x6 16" o.c. wood framing	If proposed U ≤ 0.037, standard design = existing raised; if proposed U > 0.037, standard design = Altered
Slab-on-Grade: Unheated	CZ1-15: R-0 CZ16: R-7 16" vertical	Proposed design	Existing unheated slab-on-grade
Slab-on-Grade: Heated	CZ1-15: R-5 16" vertical CZ 16: R-10 16" vertical	Proposed design	Existing heated slab-on-grade
Raised Concrete Slab	CZ1,2,11,13,14,16: R-8 CZ3-10: R-0 CZ12,15: R-4	Proposed design	Existing raised concrete slab

Resources

2016 Building Energy Efficiency Standards

2016 Reference Appendices

2016 Residential Alternative Calculation Method (ACM) Reference Manual

2016 Residential Compliance Manual

CASE Studies on HPA and HPW

Energy Code Ace website (energycodeace.com)

Solar Photovoltaic Installation Guideline (osfm.fire.ca.gov/pdf/reports/solarphotovoltaicguideline.pdf)

U.S. Department of Energy website (energy.gov)