2016 TITLE 24, PART 6
NONRESIDENTIAL

NONRESIDENTIAL 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 nonresidential envelope and solar ready portions of California's 2016 Building Energy Efficiency Standards (Title 24, Part 6).

The guide provides information on current 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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NONRESIDENTIAL
BUILDING ENVELOPE AND SOLAR READY
APPLICATION GUIDE

CONTENTS

CHAPTER 1

INTRODUCTION

The Benefits of Efficiency

Economic Savings

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

Increased Comfort

Energy-efficient buildings keep you 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.

Reduced Indoor Lighting Loads

Energy-efficient windows allow high amounts of daylight to enter the building while limiting the amount of heat energy. This allows automatic sensors to reduce lighting loads in areas where outdoor sunlight is sufficient to light the space without severely increasing cooling loads.

Environmental Benefits

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, generating many environmental benefits. Remember that the building you build 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 you can.

Rooftop Solar Installation

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) in Title 24, Part 6 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.

Compliance Process Overview

The guide 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 2 is devoted to envelope concepts and principles such as 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 code requirements related to occupancy and space type are explained in Chapter 4. This chapter also examines the mandatory measures, prescriptive and performance requirements of Title 24, Part 6, including how to determine a compliance approach.

Requirements & Recommendations by Space Type

Chapter 5 presents compliance strategies for a variety of scenarios, including how to document compliance.

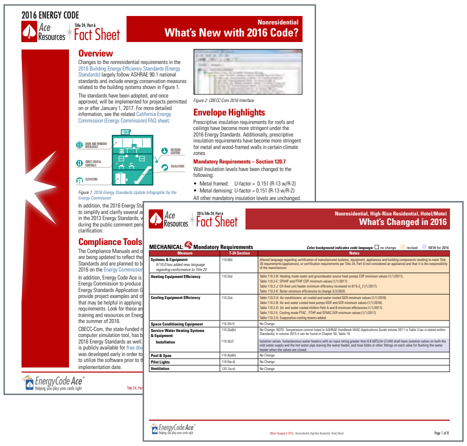
Designing to Code

This section of the guide includes recommendations for meeting and exceeding the envelope and solar ready standards in office applications.

All seven guides can be found at EnergyCodeAce.com

APPLICATION GUIDE	WHAT'S COVERED
NONRESIDENTIAL ENVELOPE AND SOLAR READY AREAS	• 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 PROCESS EQUIPMENT AND SYSTEMS	• 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 AREAS (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.	

Ace Resources™



What's New and What's Changed Fact Sheets

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

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

New in 2016: An Overview of Updates

The Energy Standards go through regular updates every three years. The 2016 updates have enhanced, corrected, and evolved the requirements closer to the State's energy policy goals.

New Mandatory Insulation Requirements

The 2016 Energy Standards changed the mandatory insulation requirements in only two areas; all other mandatory insulation requirements are unchanged. Metal framed walls now require a maximum U-factor of 0.151, which is less stringent than the maximum U-factor of 0.105 under the 2013 Energy Standards. The 2016 Energy Standards now distinguish between wood framed and metal framed demising walls. Metal framed demising walls now require a maximum U-factor of 0.151 (ex.: R-13+R-2), which is increased from a min. of R-13 cavity insulation under the 2013 Energy Standards. Wood framed demising walls still require a minimum of R-13 cavity insulation, but now have an optional maximum U-factor of 0.099.

New Prescriptive Envelope Requirements

The 2016 Energy Standards increased the stringency for many of the prescriptive envelope requirements for nonresidential buildings (Table 140.3-B) as well as hotel/motel and high-rise residential buildings (Table 140.3-C). The changes largely affect Roofs/Ceilings maximum U-factors across all climate zones and some Wall maximum U-factors in various climate zones. All other prescriptive requirements remain unchanged.

Table 140.3, Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance has been updated for the 2016 Energy Standards. The ranges of Aged Solar Reflectance, applicable climate zones and tradeoff U-factors have changed.

Clarification of Fenestration Requirements

The fenestration requirements under the 2016 Energy Standards have not changed, but the new language has clarified a few things. Altered or replaced vertical fenestration needs to meet the requirements in Table 141.0-A, except when replacing 150 ft^2 or less, under which only the U-factor requirements apply. Added vertical fenestration or skylights need to meet the requirements in Table 140.3-B, C or D, except when adding 50 ft^2 or less, under which only the U-factor requirements apply.

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 recorded talk here: energycodeace.com/content/decoding-talks/

New Envelope Commissioning Requirements

Under the 2016 Energy Standards, building envelope was added to the commissioning requirements outlined in §120.8 Nonresidential projects that trigger commissioning must comply with these mandatory requirements.

Finding Compliant Products

Certain envelope components like insulation, fenestration and roofing products must meet certification and labeling requirements when triggered by either the prescriptive or performance approach under Title 24, Part 6, while others are regulated through the California Department of Consumer Affairs (Title 24, Part 12, Chapter 12-13, Article 3).

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
- Visible transmittance (VT) - §110.6(a)4
- Labeling - §110.6(a)5
- Fenestration acceptance requirements - §110.6(a)6

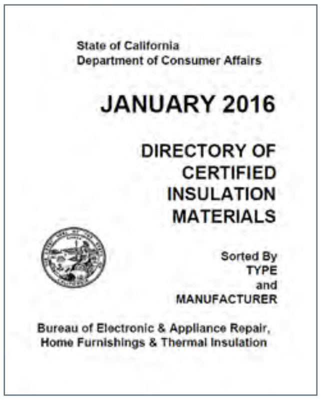
For Title 24, Part 6 compliance, manufactured fenestration U-factor and SHGC must either be rated by the National Fenestration Rating Council (NFRC), or must be assumed to have default values from Tables 110.6-A or 110.6-B. Since the default values from Tables 110.6-A or 110.6-B are so inefficient and do not meet the prescriptive fenestration requirements, the Energy Standards allow fenestration thermal performance be calculated based on center-of-glass performance values using Nonresidential Appendix, Chapter 6 (NA6). This method is only allowed for areas of site-built fenestration up to 1000 ft^2 in area, other than repair or replacement glass.

Other products regulated under Title 24, Part 6 Section §110.8(a):

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

Title 24, Part 6, §110.8(a) and §110.8 (j) both require certification by the California Department of Consumer Affairs, as explained on the following page.

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.


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/

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.

Certified insulation and radiant barriers are listed in the Consumer Guide and Directory of Certified Insulation Material, which can be downloaded from their webiste, featured to the left.

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.

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.

nfrc.org

coolroofs.org

Ace Training™

Title 24, Part 6 Essentials Training

Offered in traditional classroom and virtual formats, participants learn about navigating key nonresidential 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 – Nonresidential Standards for Plans Examiners and Building Inspectors
- Title 24 Part, 6 Essentials – Nonresidential Standards for Energy Consultants
- Title 24 Part, 6 Essentials – Nonresidential Standards for Architects

Find dates for upcoming classes: energycodeace.com/training

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 Hotline at:

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

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

CHAPTER 2

COMPLIANCE PROCESS

The following is an overview of the compliance process for nonresidential envelopes and solar ready areas. Additional information and resources, including the 2016 Nonresidential Compliance Manual and forms may be found on the California Energy Commission (Energy Commission) website: energy.ca.gov/title24/2016standards/index. html

Along with the resources provided by the Energy Commission, a wealth of information and guidance is available from Energy Code Ace. Energy Code Ace offers quick reference guides that include trigger sheets, fact sheets, forms generation, and other navigation tools for the compliance with the Energy Standards. They also provide supportive training in various forms including self study, online learning, and hands-on training.

Step 1: Discuss and Define Energy-Related Project Goals

Compliance with the Energy Standards starts at schematic design with making sure the design team and owners understand the Energy Standards requirements. The key to success is an integrated design process which requires deep coordination of the design team members working toward the energy efficiency goals. These include the mandatory elements, prescriptive differences, compliance options with the performance approach, and verification requirements in construction required to achieve a final certificate of occupancy.

Step 2: Determine and Design for:

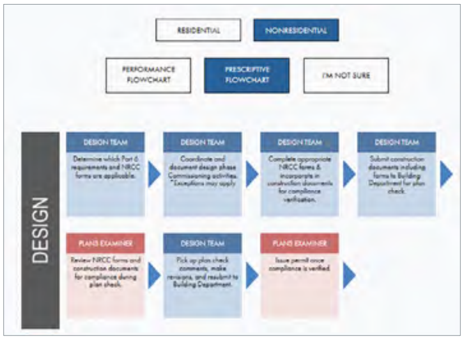
Before a construction permit is issued, starting in schematic design, a design review is required on most projects establishing:

- Clear roles for compliance
- Who needs to be involved
- When compliance documentation must be completed

At this early stage of every project, the design team players should have coordination items laid out on the table, and a path for meeting compliance agreed upon.

Daylit Office Space

Ace Navigator™



The Navigator Ace™ is your roadmap to Energy Standards compliance, illustrating the compliance process step by step from the big picture down to the fine details, including links to resources, tips, and tricks.

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

For resources on non-regulated commissioning activities and best practice applications, private non-profit groups like the California Commissioning Collaborative provide guidance through their website: cacx.org/index.html

Applicable Mandatory Measures

All nonresidential buildings that are regulated occupancies must be designed and built to comply with the mandatory measures of the 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 must also 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 Compliance Software approved by the California Energy Commission. This method allows for energy trade-offs between building systems and components, and is thus considered more flexible.

The **Prescriptive Approach** does not allow trade-offs between building components or between systems and components, but provides a simple method for meeting compliance. Building systems and components must meet or exceed each prescriptive requirement when using this approach.

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

Local Energy Standards

There may also be local energy standards that the local jurisdiction will enforce in addition to Title 24, Part 6. These local energy standards may affect aspects of the project such as lighting, insulation, HVAC installations, and domestic hot water. Additionally, these local energy standards can require third party inspections and building certifications. Being aware of these local energy 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

As the design progresses, there should be regular check in sessions, compliance checks, (or performance models created if that pathway is chosen) to help the design team stay on track to a compliant building. In the Construction Document phase of the project that are newly constructed, commissioning design review is required on all nonresidential newly constructed projects as part of documenting compliance with the Energy Standards.

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 compliance documents are submitted to the enforcement agency at the same time, as a building permit application. There are some exceptions when documentation requirements are not required, and these can be found in Section 10-103 of Title 24, Part 1.

Step 4: Pass Plan Check and Receive Permit

Depending on the type of permit, the building department may issue a permit over the counter, or require a plan check. If plan check is required, a plans examiner verfies that the design satisfies Energy Standards and other applicable requirements and that the plans contain the information to be verified during field inspection. A building permit is issued by the building department after plans and all supporting documentation are approved.

Step 5: Perform Construction

The construction team must follow the approved plans, specifications and compliance documents during construction. Coordination will be required amongst installers, designers, HERS Raters, Commissioning Agents, Acceptance Test Technicians, and building inspectors, to properly install and verify compliant installation. If changes are made to the building systems or components during construction, the compliance documents must be updated to reflect the changes, to ensure compliance with the Energy Standards. During construction, certificates of installation (NRCI) are completed in preparation for inspection.

Step 6: Document Installation and Acceptance

After construction occurs, many building energy features require an installation certificate and/or acceptance testing certificate, to document compliance with the Energy Standards. These certificates are typically completed by the installing contractor, for envelope and solar ready features. The installation certificate is used to ensure that energy features are installed to meet or exceed the energy design requirements. Acceptance testing is used to ensure that energy features are functioning or performing according to those design requirements.

Step 7: Pass Building Inspection

The local authority having jurisdiction (AHJ), often the building department, will likely require an inspection before finalizing the project. Building inspections are often scheduled by the contractor with the building department on behalf of the building owner. Once all systems are installed and inspected, and completed compliance documentation has been verified, a Certificate of Occupancy may be issued by the AHJ. 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.

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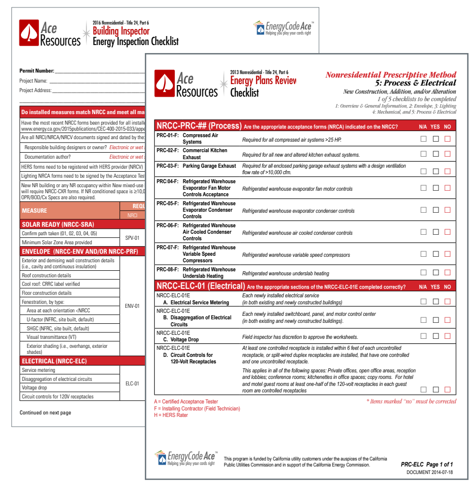


Plans Examiners and Building Inspector Checklists

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 Part 6 compliance verification.

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

Nonresidential 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.

Form Naming Convention

NRCC-ENV-02-E

Nonresidential

Document Category

- CXR = Commissioning Design Review
- ELC = Electrical
- ENV = Envelope
- LTI = Indoor Lighting
- LTO = Outdoor Lighting
- LTS = Sign Lighting
- MCH = Mechanical
- PLB = Plumbing (DHW)
- PRC = Covered Process
- PRF = Performance approach
- SRA = Solar Ready
- STH = Solar Thermal

Document Type

Certificates of...

- CC = Compliance
- CI = Installation
- CA = Acceptance
- CV = Verification

Primary User

- E = Enforcement agency
- H = HERS Rater
- F = Field Technician (Contractor)
- A = Acceptance Test Tech

Certificates of Compliance

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

Certificates of Installation

The Certificate of Installation (NRCI) documents that the building features actually installed in the field match those required in the Certificates of Compliance. NRCIs must be completed and signed by the installer or builder responsible for installing different building components (see Step 6 of the compliance process description).

Certificates of Acceptance

The Certificate of Acceptance (NRCA) summarizes the results of the acceptance tests to ensure that the building systems and equipment (as installed in the field) function and perform the way they were intended to, and certifies the information is true and correct. For envelope and solar ready requirements, NRCAs must be completed and signed by the installer or builder accepting responsibility for the different building components installed. (see Step 6 of the compliance process description). In some cases, the Certificate of Acceptance must be completed and signed by a certified Acceptance Test Technician.

Certificates of Verification

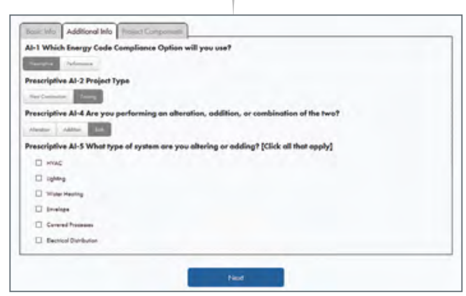
The Certificate of Verification (NRCV) is used to document nonresidential HERS Measures, and is completed by a HERS Rater. The NRCV is most commonly used for projects pursuing the performance approach. An exception to this is NRCV_MCH-04 used to document duct sealing, which is a prescriptive requirement.

Compliance Documents

Compliance Document forms can be found and downloaded on the Energy Commission's website.

Click here to access the forms: energy.ca.gov/2015publications/CEC-400-2015-033/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

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 buildings envelope (roofs, walls, windows, etc.) 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 envelopes ability to resist unwanted heat gain and loss is directly related to its energy efficiency.

Infiltration and Air Leakage

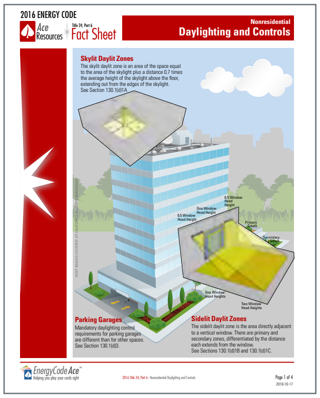
Infiltration, also known as air leakage, is the unintentional introduction of outside air into a building. Infiltration occurs through cracks in the building envelope or through doors and windows. During summer months, infiltration can bring hot air into cooler building cavities, causing increased cooling 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's not likely that buildings be constructed completely air tight, it's extremely important to limit the amount of infiltration through proper sealing and inspection of envelope components.

Shading

Since windows account for the greatest amounts of heat entering buildings[1] , shading provides an economical way to reduce solar heat gain during summer months. Shading devices outside the building envelope, such as overhangs and fins, shade the window from direct radiation which prevents a large portion of unwanted solar heat gain.

[1] Design with Climate: Bioclimatic Approach to Architectural Regionalism – Victor Olgyay, 1963

Fenestration Shading



Daylighting and Controls Fact Sheet

This Fact Sheet presents daylighting as it applies to Title 24, Part 6, at a glance.

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

The location, orientation and size of outdoor shading devices are critical in controlling the amount of solar heat gain. Because of the seasonal tilt of the Earth's axis, the high altitude of the sun during the summer months provides the ability for overhangs to block unwanted solar heat gain on windows, but still allowing sunlight to shine through windows during winter months to help warm a building.

Daylighting

Daylighting is not only enabling natural light into a building to reduce the necessity of electric light needed to light the building, but doing so without introducing some unwanted side effects like solar heat gain. For example, a proposed office building may want to take advantage of windows to reduce the lighting load without increasing the cooling load. This can be accomplished by installing windows that have a low Relative Solar Heat Gain Coefficient (RSHGC) while maintaining a high Visible Transmittance (VT), in conjunction with daylight controls that reduce the lighting output of the luminaires adjacent to the windows. Daylighting may also be accomplished through skylights. Window and/or skylight size, spacing, performance and orientation play a large role in optimizing the effectiveness of daylighting in buildings.

Design for the Climate

When considering recommendations for improving the envelope of a building, it's important to consider where the building is geographically located. 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. 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 the decision of construction assembly features for buildings, which are the interface between the interior of the building and the outdoor environment.

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.

Hotter climates in California are generally located in the central valley and southern inland regions and include climate zones (CZ) 8-15. These climate zones are typically hot and dry in the summer and mild in the winter.

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.

Cold climates in California are generally located in either the northern coastal or mountain regions and include CZs 1 and 16. These climate zones are typically cool in the summer, cold and wet in the winter with frequent fog and strong winds.

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.

Moderate climates in California are generally located in the central and southern coastal regions and include climate zones (CZ) 2-7. These climate zones are typically mild during the summer and winter months with relatively low temperature fluctuations throughout the year.

Building Orientation and Fixed Shading

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.

Heat Transfer

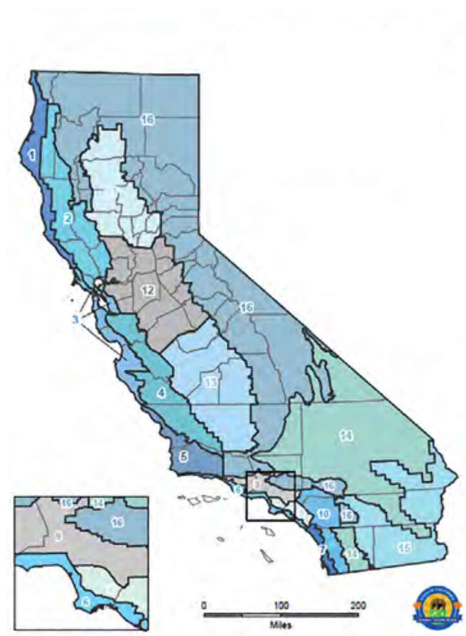
There are three ways in which heat transfers: conduction, convection and radiation.

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, a cold cast iron skillet is placed onto a stove top 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 stove top 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,



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 geographic 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

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

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.

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 producer of the energy. 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 its heat.

Key Terms

Building envelope components, such as framing material, masonry or concrete, cavity insulation, continuous insulation, moisture membranes, sheathing, etc. 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. Building materials, such as insulation are measured in R-value; the higher the R-value, the better the insulation. Although the use of 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 roofing products 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. For rated cool roof products, the higher the thermal emittance value, the better (the more heat the roofing material emits back to the atmosphere).

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 all but the mildest and coolest 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) of visible light that is transmitted through a glazing fenestration. The higher the VT rating, the better (more light is allowed through a window).

CHAPTER 4

TECHNOLOGY, SYSTEMS AND COMPLIANCE STRATEGIES

Choosing the Right Envelope Components and 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 better the insulation property is.

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 Energy Standards. 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)

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.

Fiberglass Batt Insulation

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 insulation materials are:

- Polyurethane (SPF)
- Polyisocyanurate

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 barrier between the indoor environment and the often undesirable outdoor environment. High-performance fenestration products have a substantial impact on reducing energy consumption in building, weather by reducing heat gain through spectrally selective glass, shading or dynamic glazing or reducing conductive heat loss through frame material and insulated glazing. Fenestration performance is measured by overall U-factor, SHGC and VT, which are explained in Chapter 3. For U-factor and SHGC, the lower the value, the better its performance is. For VT, the higher the value, the better in terms of energy efficiency.

Doors

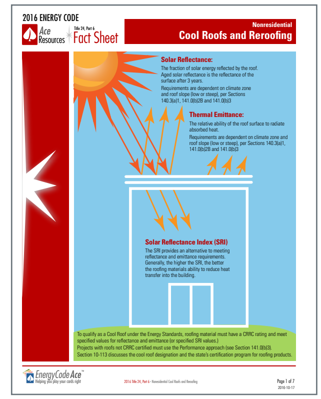
Doors are the opaque counterpart to fenestration and provide means of entering and exiting buildings. Doors are categorized into two primary types: swinging and non-swinging doors. Exterior swinging doors include; solid wood doors, hollow metal doors and insulated metal doors. Non-swinging doors include; sectional, sliding and roll-up doors. Doors performance is measured by overall U-factor, which is explained in Chapter 3. 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 interstitial space (attic) temperatures on hot, sunny days. Solar reflectance and thermal emittance are properties of the roofing material.

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).



Fact Sheet resources can help identify relevant code sections in the Energy Standards, based on the scope of the project.

Fact Sheets are available for the following HVAC related topics:

- Nonresidential Cool Roofs
- Nonresidential Fenestration
- NR Opaque Envelope

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

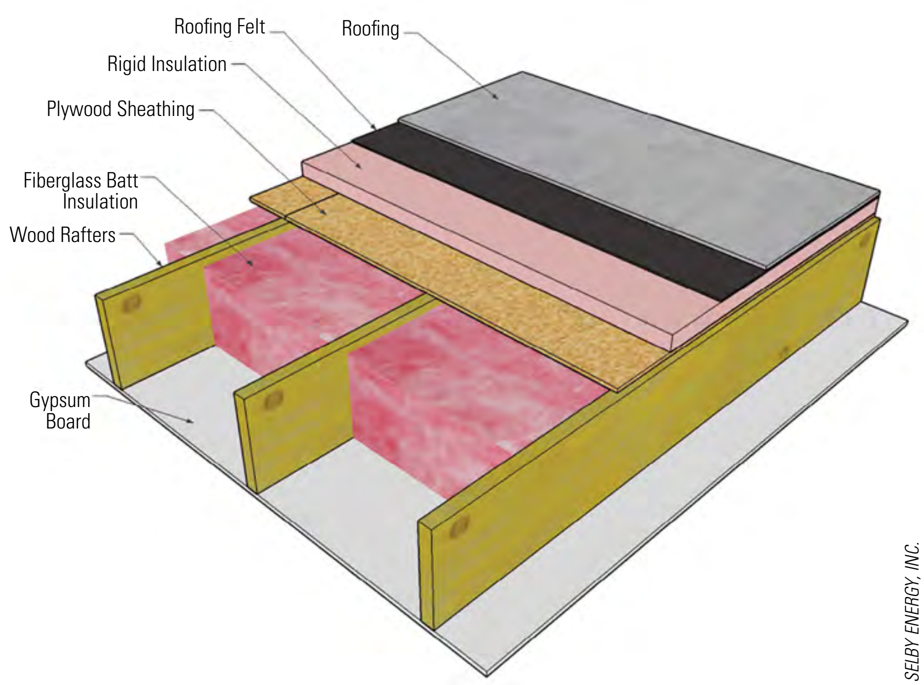
Common Opaque Construction Assemblies

Building envelope components, such as framing material, masonry or concrete, cavity insulation, continuous insulation, moisture membranes, sheathing, etc. 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.

The assembly U-factor and descriptions of common building construction assemblies can be found in the appropriate tables listed in the Reference Joint Appendix 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.

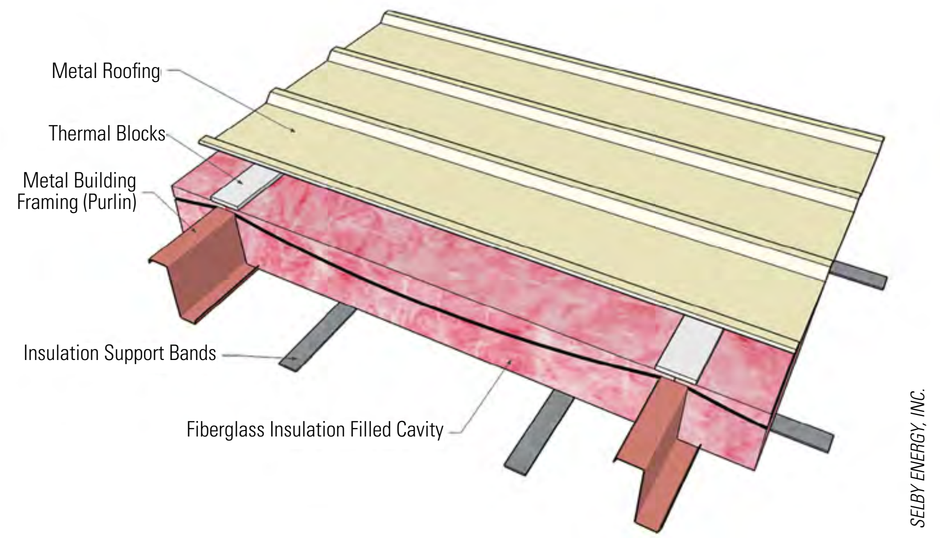
Roofs and Ceilings

Material Layers (exterior layer listed first)	JA 4.2.2-F37	Layer Manager CBECC-Com
Asphalt Roofing	U-Factor = 0.034	U-Factor = 0.034
Roofing Felt		
R-8 Rigid Insulation		
1/2" Plywood Sheathing		
2x8 Rafters w/ R-21 Cavity Insulation (with air space)		
5/8" Gypsum Board		



Example Roof Assembly: Wood rafter roof and above roof deck insulation

Material Layers (exterior layer listed first)	JA 4.2.7-23	Layer Manager CBECC-Com
Metal Roofing	U-Factor = 0.041	U-Factor = 0.041
Thermal Blocks		
R-10+R-19 Insulation (filled cavity)		

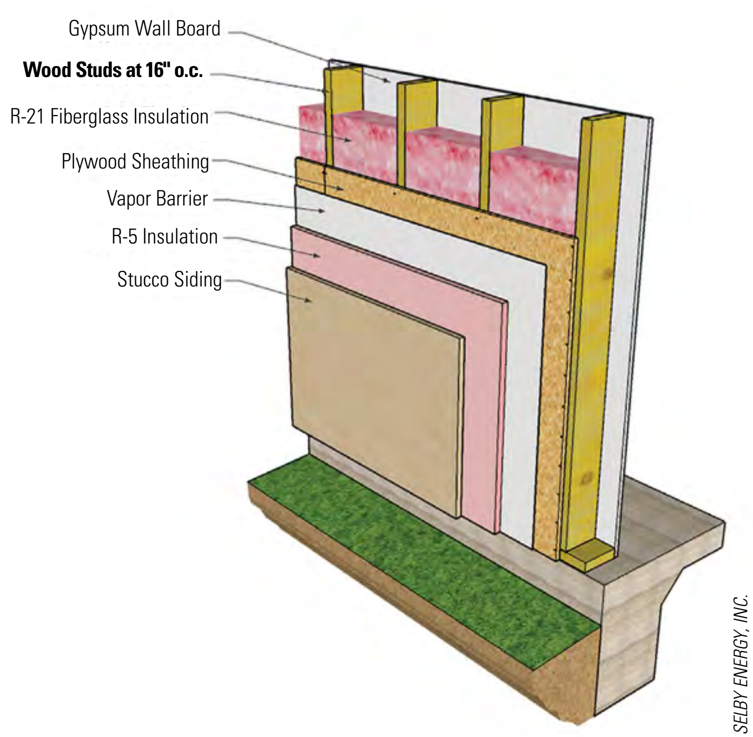


Example Roof Assembly: Metal building roof with filled cavity and thermal blocks

Wood Framed Walls

Material Layers (exterior layer listed first)	JA 4.3.1-D6	Layer Manager CBECC-Com
7/8" Stucco	U-Factor = 0.048[1]	U-Factor = 0.045
R-5 Rigid Insulation		
Vapor Barrier		
1/2" Plywood Sheathing		
2x6 Wood Stud at 16" o/c with R-21 Cavity Insulation		
5/8" Gypsum Board		

[1] JA-4 assembly assumes an exterior air film, a 7/8 inch layer of stucco, building paper, continuous insulation (as specified), the cavity insulation / framing layer, 1/2 inch gypsum board, and an interior air film. The framing factor is assumed to be 25 percent for 16 inch stud spacing.

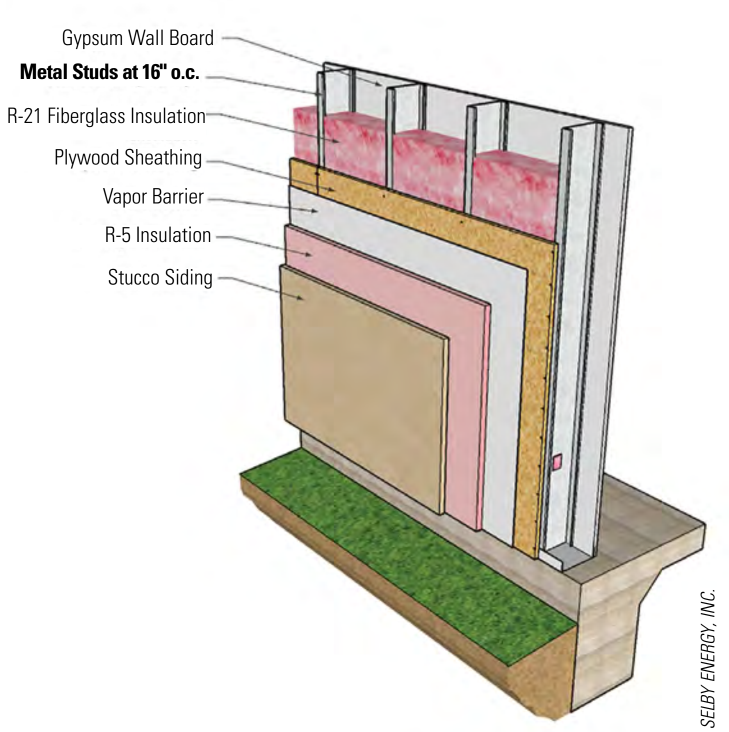


Example wood framed wall with continuous insulation.

Metal Framed Walls

Material Layers (exterior layer listed first)	JA 4.3.3-D7	Layer Manager CBECC-Com
7/8" Stucco	U-Factor = 0.094[1]	U-Factor = 0.083
R-5 Rigid Insulation		
Vapor Barrier		
1/2" Plywood Sheathing		
2x6 Metal Stud at 16" o/c with R-21 Cavity Insulation		
5/8" Gypsum Board		

[1] JA-4 assembly assumes an exterior air film, a 7/8 inch layer of stucco, building paper, continuous insulation (as specified), the cavity insulation / framing layer, 1/2 inch gypsum board, and an interior air film. The steel framing is assumed to be 0.0747 inch thick with a 15 percent knock out. The framing factor is assumed to be 25 percent for 16 inch stud spacing.



Example metal ramed wall with continuous insulation.

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 climate conditions, which differ throughout the State, the Energy Commission had established 16 climate zones representing distinct climates within California. Climate zones play a major role in the decision of construction assembly features for buildings, 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. Things to consider when making recommendation for improving the envelope include:

Magnitude of Annual Heating And Cooling Loads

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, or increase roof/ceiling and wall insulation and cool roofing.

In cooler climates, heating loads can be reduced by minimizing heat loss through conduction and infiltration. These strategies include installing increased roof/ceiling and wall insulation, low U-factor fenestration, and air infiltration sealing.

Fenestration

Fenestration typically accounts for one of the largest sources of heat gain in buildings located in hotter climate zones. 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. Here are several strategies to consider when considering improvements to building envelope fenestration:

Install Spectrally Selective Glass (low SHGC)

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 high levels of visible light transmittance.

Install 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).

Install Dynamic Glazing

Dynamic Glazing (DG) products are any fenestration product with the ability to change its performance properties, allowing 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 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. Adding cool roofing can also greatly reduce the conductive heat flow through the roof, increasing the efficiency of the roof assembly.

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 heating buildings lowering heating energy consumption; and in nearly all climates controlling and diffusing natural light will improve daylighting. Shading devices can also improve user visual comfort by controlling glare and reducing contrast ratios.

Building with Side-fin Shading

Daylighting

Daylighting is the controlled illumination of indoor space by natural light. Daylighting not only reduces the amount of electrical energy needed to light indoor spaces, it provides natural light that helps create a visually stimulating and productive indoor environment. Daylighting can be achieved through vertical fenestration (sidelit), defused skylights (skylit) and clerestory windows.


SCHOOL

CHAPTER 5

NAVIGATING YOUR COMPLIANCE STRATEGY

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 conditioned nonresidential 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.

Prescriptive Approach

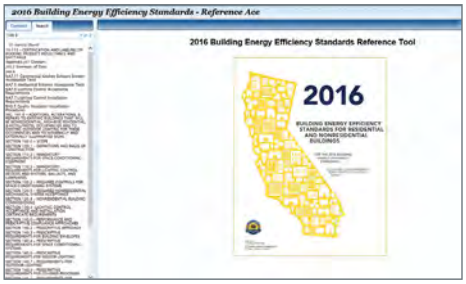
The Prescriptive Approach is considered the most direct path to compliance. It is a set of prescribed performance levels for various building components, where each component must meet the required minimum efficiency. There are different prescriptive requirements for newly constructed buildings, additions,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

Performance Approach

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

Elementary School

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

Navigating Title 24, Part 6

When starting the compliance process for a nonresidential building project, the first task is to understand what occupancies are covered under the Energy Standards as well as how to find applicable requirements. This depends in part on the building's occupancy and whether the building is newly constructed, or if the project is an addition, alteration or repair. It is also important to know if the building is conditioned, meaning that it is either directly or indirectly heated and/or cooled. Although envelope requirements generally don't apply to unconditioned spaces, some nonresidential buildings may trigger prescriptive requirements to include minimum daylighting, and are therefore important to identify.

Occupancies Covered

Nonresidential requirements cover all nonresidential occupancies, as well as high-rise residential and all hotel and motel occupancies. The Buildings Covered table to the bottom left lists which occupancies are subject to the Energy Standards and contains an example of the occupant type.

Building Energy Efficiency Standards

The Title 24, Part 6 Building Energy Efficiency 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 Energy Standards are available from the Energy Commission and may be downloaded here: Title 24, Part 6 Building Energy Efficiency Standards

Buildings Covered

OCCUPANCY GROUP		EXAMPLE
A	Assembly	Theaters, Churches
B	Businesses	Office Buildings
E	Educational Facilities	K-12 Schools
F	Factories, Low & Moderate Hazard	Industrial Manufacturing Buildings
H	High Hazard Facilities	Laboratories, Refineries
M	Mercantile	Grocery Store, Department Store
R	Residential	Apartment buildings with four or more habitable stories, hotels/motels, long-term care facilities
S	Storage, low & moderate hazard	Industrial warehouse, mini storage
U	Utility	Garages, towers

The following table provides references to sections of the Energy Standards for nonresidential building envelope and solar ready requirements and is categorized by mandatory measures, prescriptive approach and performance approach. Note that all code sections are hyperlinked in this table to ease access to code language.

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
Nonresidential Buildings	**§110.6 - §110.8, §120.7**	**§140.3, Table 140.3-B[1]**	**§140.0-§140.1**
Insulation	§110.6 - §110.8, §120.7	§140.3(a)B - §140.3(a)4	
Fenestration	§110.6, Tables 110.6-A and 110.6-B	§140.3(a)5 - §140.3(a)6	
Roofing and Radiant Barriers	§110.8(i) - §110.8(j)	§140.3(a)1	
Daylighting		§140.3(c)	
Air Barrier	§110.7	§140.3(a)9	§141.0
Additions, Alterations, and Repairs	**§110.6 - §110.8, §120.7, §141.0**	**§141.0**	**§141.0(a)2**
Additions	§110.6 - §110.8, §120.7	§141.0(a)1	§141.0(a)2

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
Alterations	§141.0(b)1	§141.0(b)2, Table 141.0-A – Table 141.0-C	
Repairs	See exception note	See exception note	See exception note
Solar Ready Nonresidential Buildings	§110.10(a)4, §110.10(b) - §110.10(e)		
Covered Occupancies	§110.10(a)4		
Solar Zone	§110.10(b)1B, §110.10(b)2 - §110.10(b)4		
Interconnection Pathways	§110.10(c)		
Documentation	§110.10(d)		
Main Electrical Service Panel	§110.10(e)		

[1] For High-rise Residential buildings and Guest Rooms in Hotel/Motel Buildings, use Table 140.3-C. For Relocatable Public School Buildings, use Table 140.3-D

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.

Nonresidential Compliance Manual

The Nonresidential Compliance Manual is designed as a supplement to the Energy Standards and provides additional guidance and instruction to help better understand the Energy Standards. The Nonresidential Compliance Manual and supporting documents are available from the Energy Commission and may be downloaded here:

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

Reference Appendices

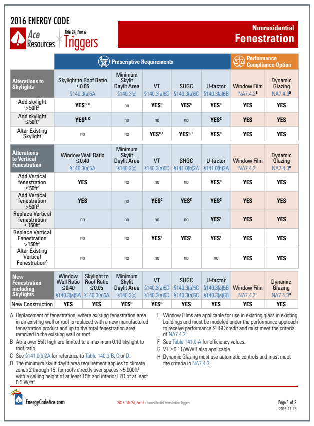
The Reference Appendices contains two documents pertinent to nonresidential buildings; the Joint Appendices and the Nonresidential Appendices. The Joint Appendices contains a glossary, reference weather and climate data, time dependent valuation data, opaque assembly U-factors and other essential reference information. The Nonresidential Appendices contains field verification and testing procedures, fan motor efficiencies, alternate default fenestration procedures, installation and acceptance requirements and default luminaire power. The Reference Appendices are available from the Energy Commission and may be downloaded here:

energy.ca.gov/2015publications/CEC-400-2015-038/CEC-400-2015-038-CMF.pdf

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.

Ace Resources™


2016 ENERGY CODE
Nonresidential Fenestration
Triggers

Nonresidential Fenestration Trigger Sheet

This resource presents which sections of the Energy Standards are triggered by different project types and scopes of work.

Find the resource here: energycodeace.com/content/resources-trigger-sheets/

Nonresidential Alternative Calculation Method (ACM)

The Nonresidential Alternative Calculation Method Reference Manual (ACM) contains rules for compliance software used for analyzing nonresidential buildings. These rules establish: the process for creating a building model, proposed energy use, standard design (energy budget) and how the information is reported on the NRCC-PRF-01-E. All energy compliance software must be certified by the Energy Commission following the rules established by the ACM. The Nonresidential ACM is available from the Energy Commission and may be downloaded here:

energy.ca.gov/2015publications/CEC-400-2015-025/CEC-400-2015-025-CMF.pdf

Define the Project Type

Newly Constructed

All new nonresidential buildings, including high-rise residential buildings and Hotel or Motel buildings, must first meet the applicable envelope mandatory measures, and then comply with either the prescriptive envelope requirements, or by using the performance method.

Additions

Additions to nonresidential buildings including high-rise residential buildings and guest rooms in Hotel or Motel buildings must first meet the applicable envelope mandatory measures, and then comply with either the prescriptive requirements, or by use of the performance method to comply. 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 building plus the addition, including any other alterations that may be proposed for the existing building. Another method is using the "entire building" option, as both added and existing are considered as a new building per §141.0(d).

Alterations

Alterations to nonresidential buildings including high-rise residential buildings and Hotel or Motel buildings must first meet the applicable envelope mandatory measures in §110.6 through §110.8, as well as §120.7 and §141.0(b)1, then comply with either the prescriptive requirements of §141.0(b)2 or use the performance method of §141.0(b)3. Nonresidential alterations, such as window replacements or roof replacements, typically use the prescriptive approach for compliance. As with additions, alterations can also show compliance using the existing plus alteration performance approach, as long as there is two or more altered building components. 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 HVAC system.

Repairs

Section §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. For example, replacing 200 square feet of storefront window would trigger compliance with the Energy Standards, but replacing a broken pane of glass within the storefront would not trigger compliance.

Conditioned vs. Unconditioned Space

It is very important to understand what space type your project is to know how to apply the Energy Standards. Conditioned space is defined as a space in a building that is either directly conditioned or indirectly conditioned, meaning that the space is mechanically heated and/or cooled. Unconditioned space is just the opposite of conditioned space; it is neither mechanically heated nor cooled. Another space type that is important to understand is process space.

Conditioned Space

There are two types of conditioned space, directly conditioned and indirectly conditioned (see definitions in sidebar). When it comes to applicable envelope requirements, both space types are treated the same. All newly constructed buildings, added and altered conditioned spaces must meet applicable mandatory envelope measures, then comply with either the prescriptive or performance approach, which is covered later in this chapter.

Unconditioned Space

Unconditioned spaces do not trigger mandatory envelope measures. Depending on certain features, unconditioned spaces may need to meet prescriptive lighting and daylighting requirements, which may also require the installation of skylights.

Process Space

Process Space is a space that is 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. A space with a conditioning system designed and controlled to be incapable of operating at temperatures above 55°F or incapable of operating at temperature below 90°F is also considered precess space. Mandatory requirements for process spaces are covered in the 2016 Nonresidential Covered Process Application Guide.

Mandatory Requirements

Conditioned nonresidential buildings must first meet all applicable mandatory measures for minimum envelope requirements and solar ready requirements. Mandatory measures ensure that minimum requirements are met regardless of the compliance approach.

Mandatory Requirements for Fenestration Products and Exterior Doors §110.6

This section describes product requirements including tested air-leakage rates, standards used to rate SHGC, U-factors, VT and product labeling. It also describes fenestration acceptance testing requirements for site-built fenestration. Tables 110.6-A and B include default U-factors and SHGC's respectively.

Mandatory Requirements to Limit Air Leakage §110.7

This must be the shortest section in the Energy Standards! It requires that joints, penetrations and other openings be sealed to limit infiltration and exfiltration.

Code in Practice: Directly Conditioned Space

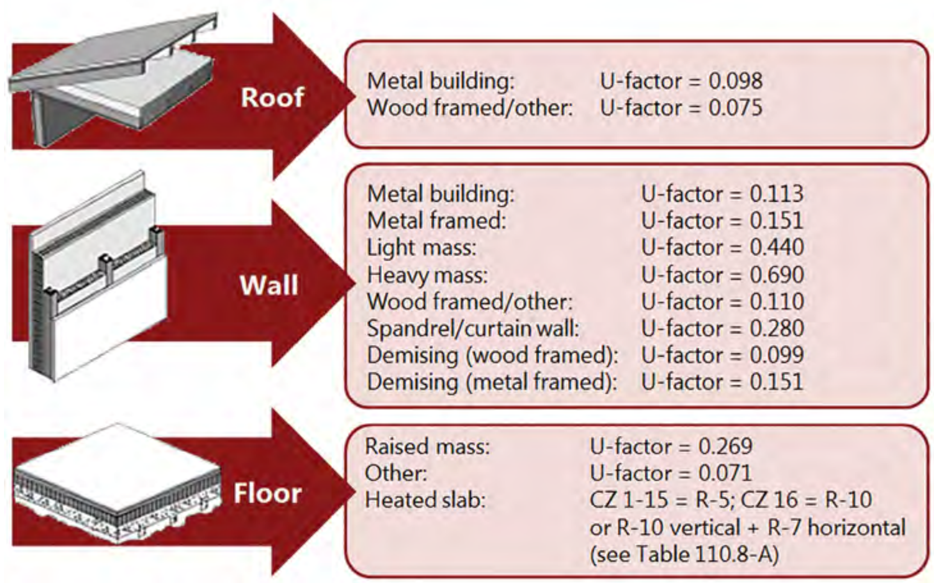
Directly conditioned space is an enclosed space that is provided with wood heating, is provided with mechanical heating that has a capacity exceeding 10 Btu/hr-ft^2, or is provided with mechanical cooling that has a capacity exceeding 5 Btu/hr-ft^2, unless the space-conditioning system is designed for process space or process load.

Code in Practice: Indirectly Conditioned Space

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 load.

Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers §110.8

Section 110.8 includes product requirements for insulation and radiant barriers, such as flame spread rating and certification with the Department of Consumer Affairs as described in Chapter 1 of this Application Guide. This section also includes insulation requirements for heated slabs, and requirements for the rating, certification and labeling of roofing products (solar reflectance, thermal emittance, solar reflectance index).



Mandatory Insulation Requirements §120.7

Roof/Ceiling insulation, wall insulation and floor and soffit insulation requirements can be found in this Section. Note that these are required minimums, often exceeded using either the prescriptive or performance compliance paths.

The graphic below summarizes mandatory asembly U-factors per §120.7. Energy Code Ace has estimated insulation R-values to give you an idea of insulation levels that may achieve requirements.

Mandatory Commissioning Requirements §120.8

New in the 2016 Energy Standards is the addition of envelope components to the commissioning scope in Section 120.8. In particular, projects that trigger the development of the Owner's Project Requirements (OPR) per 120.8(b) will need to include "building envelope performance requirements" in the OPR. The OPR sets the scope of building components to be commissioned, so whatever is included in the OPR will need to follow through the rest of the commissioning process.

Mandatory Solar Ready Requirements §110.10

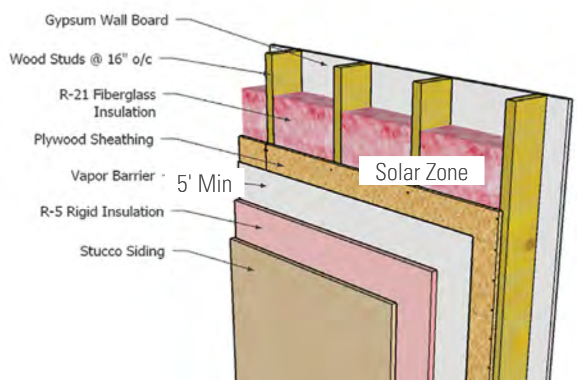
Most new construction is required to be "solar ready." This includes designating roof space for solar panels, identifying wiring pathways and structural design loads on the plans, and other details. The solar ready requirements apply to newly constructed buildings and to additions ≥2,000 ft^2 for the following occupancies:

- Nonresidential buildings with three habitable stories or fewer.

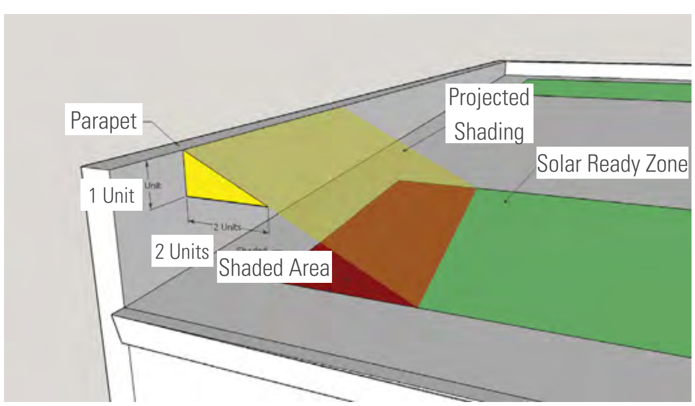
- High-rise multi-family buildings with ten habitable stories or fewer.
- Hotel and Motel occupancies with ten habitable stories or fewer.

The solar zone is a dedicated space on a building's roof, overhang, another building's roof or overhang within 250' of the primary building or on the roof of an associated parking structure reserved for future solar electric or solar thermal system. This space must be clear of any obstruction, such as vents, chimneys, or architectural features of roof mounted equipment that may shade the designated area.

The solar zone must be at least 15% of the building's total roof area (minus any skylights). It can be broken up into several different sub-areas as long as a sub-area is not smaller than 5' in width or depth. For buildings where the total roof area is 10,000 ft^2 or less, each sub-area must be at least 80 ft^2. Likewise, for buildings where the total roof area is greater than 10,000 ft^2, then each sub-area must be at least 160 ft^2. See example below.



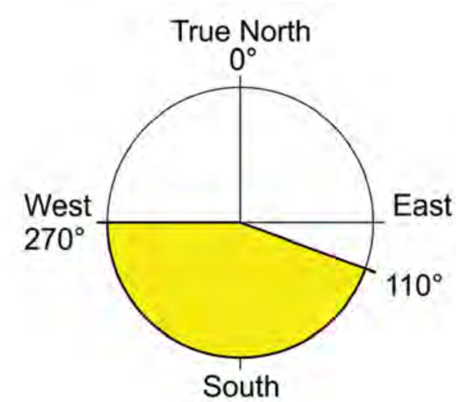
In the event the solar zone is shaded by an obstruction that is not associated with the proposed project and there is not enough unshaded area to meet the minimum area requirement, then the solar zone may be reduced. For example, a new building may be shaded by an existing building that is located to the South. In this case, the amount of unshaded area has 70% or greater unshaded area (solar access). Therefore, if the unshaded area is less than the required 15%, then the solar zone can be reduced to half the area of the unshaded area (potential solar zone). If there is no area that is unshaded, then the solar ready requirements do not apply. See an example of solar area obstruction below.



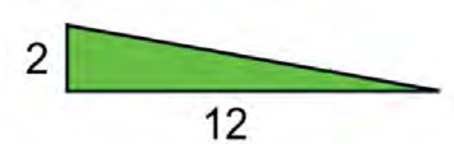
For buildings with steep-sloped roofs (2:12 or more), the solar zone must be oriented in a direction that allows adequate solar exposure (between 110° and 270°).

Exceptions

Buildings that have a permanently installed solar PV (≥1Watt/ft^2 DC), domestic solar water heating system (min 0.20 solar fraction in CZ1-9 and 0.35 solar fraction in CZ10-16), or have roofs designed for vehicular travel, or heliport are exempt from the minimum solar ready requirements. Low-rise and high-rise residential buildings may also be exempt from the minimum solar ready requirement by meeting conditions listed in §110.10(b)1B.



Required orientation for solar zone per §110.10



Minimum slope that is considered "steep sloped" per the Energy Standards

Determine Compliance Approach

Determining an appropriate compliance approach depends on several factors including: the design of the building, project specifications, type of project and overall budget to name a few. Generally speaking, the prescriptive approach is considered the least complicated, but doesn't offer flexibility. The performance approach is more complicated than the prescriptive approach, but offers added flexibility by allowing trade-offs with other envelope features as well as other system components if under the same permit.

Prescriptive Approach

The Prescriptive Approach is a set of prescribed minimum performance levels for various building envelope components, where each component of the proposed building must meet all the prescribed requirements. With the prescriptive approach, envelope components are treated separately and cannot be traded-off with other envelope components or other building systems, such as lighting and mechanical features.

Newly Constructed

The prescriptive approach can be used to demonstrate compliance for newly constructed projects. This is often done with certain occupancies when a new shell only building is proposed and the mechanical and lighting will be installed at a later time.

U-factors for common construction assemblies can be determined based on framing type, spacing, cavity insulation and various thicknesses of continuous insulation (see example table from JA4 below, and enlarged detail to the left).

When exact construction assemblies cannot be found in JA4, then the most thermally similar JA4 assembly can be used. In most cases, when unusual construction assemblies occur, the U-factor can be calculated by using the equations provided in JA4.1.2.2 and JA4.1.2.3.

Truss Spacing	R-value of Attic Insulation		None	R-2
			A	B
16 in. OC	None	1	0.300	0.187
	R-11	2	0.079	0.068
	R-13	3	0.071	0.062
	R-19	4	0.049	0.045
	R-21	5	0.042	0.039
	R-22	6	0.043	0.039
	R-25	7	0.038	0.035
	R-30	8	0.032	0.030
	R-38	9	0.026	0.024
	R-44	10	0.021	0.020
	R-49	11	0.020	0.019
	R-60	12	0.017	0.016

Enlarged detail of JA4 Table 4.2.1

Table 4.2.1 – U-factors of Wood Framed Attic Roofs

Truss Spacing	R-value of Attic Insulation		Rated R-value of Continuous Insulation[1] None	R-2	R-4	R-6	R-7	R-8	R-10	R-14
			A	B	C	D	E	F	G	H
16 in. OC	None	1	0.300	0.187	0.136	0.107	0.097	0.088	0.075	0.058
	R-11	2	0.079	0.068	0.060	0.053	0.051	0.048	0.044	0.037
	R-13	3	0.071	0.062	0.055	0.050	0.047	0.045	0.041	0.036
	R-19	4	0.049	0.045	0.041	0.038	0.037	0.035	0.033	0.029
	R-21	5	0.042	0.039	0.036	0.034	0.032	0.031	0.030	0.026
	R-22	6	0.043	0.039	0.037	0.034	0.033	0.032	0.030	0.027
	R-25	7	0.038	0.035	0.033	0.031	0.030	0.029	0.028	0.025
	R-30	8	0.032	0.030	0.028	0.027	0.026	0.025	0.024	0.022
	R-38	9	0.026	0.024	0.023	0.022	0.022	0.021	0.020	0.019
	R-44	10	0.021	0.020	0.019	0.019	0.018	0.018	0.017	0.016
	R-49	11	0.020	0.019	0.019	0.018	0.018	0.017	0.017	0.016
	R-60	12	0.017	0.016	0.016	0.015	0.015	0.015	0.014	0.013
24 in. OC	None	13	0.305	0.189	0.137	0.108	0.097	0.089	0.075	0.058
	R-11	14	0.076	0.066	0.058	0.052	0.050	0.047	0.043	0.037
	R-13	15	0.068	0.060	0.054	0.048	0.046	0.044	0.041	0.035
	R-19	16	0.048	0.043	0.040	0.037	0.036	0.034	0.032	0.029
	R-21	17	0.043	0.040	0.037	0.034	0.033	0.032	0.030	0.027
	R-22	18	0.041	0.038	0.036	0.033	0.032	0.031	0.029	0.026
	R-25	19	0.037	0.034	0.032	0.030	0.029	0.028	0.027	0.024
	R-30	20	0.031	0.029	0.028	0.026	0.025	0.025	0.024	0.022
	R-38	21	0.025	0.024	0.023	0.022	0.021	0.021	0.020	0.018
	R-44	22	0.021	0.020	0.019	0.019	0.018	0.018	0.017	0.016
	R-49	23	0.019	0.019	0.018	0.017	0.017	0.017	0.016	0.015
	R-60	24	0.016	0.016	0.015	0.015	0.014	0.014	0.014	0.013

Notes:
1. Continuous insulation shall be located at the ceiling, below the bottom chord of the truss and be uninterrupted by framing.
2. In climate zones 1 and 16 the insulating R-value of continuous insulation materials installed above the roofs waterproof membrane shall be multiplied by 0.8 before choosing the table column for determining assembly U-factor.

Code in Practice

A single-story, multi-tenant retail building is proposed to be built in Berkeley (climate zone 3). The owner would like to get a permit to build out the shell, but will not be installing lighting or mechanical systems until a tenant leases the space. Since the individual tenant space will be conditioned at some point in time, the envelope will need to comply with the Energy Standards. In this case, the envelope of the proposed building may comply with the prescriptive requirements in §140.3 and TABLE 140.3-B (see table below).

Envelope				Climate Zone															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Envelope	Maximum U-factor	Roofs/ Ceilings	Metal Building	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
			Wood Framed and Other	0.034	0.034	0.034	0.034	0.034	0.049	0.049	0.049	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
		Walls	Metal Building	0.113	0.061	0.113	0.061	0.061	0.113	0.113	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.061
			Metal-framed	0.069	0.062	0.082	0.062	0.062	0.069	0.069	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
			Mass Light[1]	0.196	0.170	0.278	0.227	0.440	0.440	0.440	0.440	0.440	0.170	0.170	0.170	0.170	0.170	0.170	0.170
			Mass Heavy[1]	0.253	0.650	0.650	0.650	0.650	0.690	0.690	0.690	0.690	0.650	0.184	0.253	0.211	0.184	0.184	0.160
			Wood-framed and Other	0.095	0.059	0.110	0.059	0.102	0.110	0.110	0.102	0.059	0.059	0.045	0.059	0.059	0.059	0.042	0.059
		Floors/ Soffits	Raised Mass	0.092	0.092	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.092	0.092	0.092	0.092	0.092	0.058
			Other	0.048	0.039	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.039	0.071	0.071	0.039	0.039	0.039
	Roofing Products	Low-sloped	Aged Solar Reflectance	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
			Thermal Emittance	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
		Steep-Sloped	Aged Solar Reflectance	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
			Thermal Emittance	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0. 75	0.75	0.75	0.75	0.75	0.75	0.75
	Air Barrier			NR	NR	NR	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ
	Exterior Doors, Maximum U-factor		Non-Swinging	0.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.50
			Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

					All Climate Zones			
					Fixed Window	Operable Window	Curtainwall or Storefront	Glazed Doors[2]
Envelope	Fenestration	Vertical	Area-Weighted Performance Rating	Max U-factor	0.36	0.46	0.41	0.45
				Max RSHGC	0.25	0.22	0.26	0.23
			Area-Weighted Performance Rating	Min VT	0.42	0.32	0.46	0.17
			Maximum WWR%		40%			
		Skylights			Glass, Curb Mounted	Glass, Deck Mounted	Plastic, Curb Mounted	
			Area-Weighted Performance Rating	Max U-factor	0.58	0.46	0.88	
				Max SHGC	0.25	0.25	NR	
			Area-Weighted Performance Rating	Min VT	0.49	0.49	0.64	
			Maximum SRR%		5%			

1 Light mass walls are walls with a heat capacity of at least 7.0 Btu/ft²-oF and less than 15.0 Btu/ft²-oF. Heavy mass walls are walls with a heat capacity of at least 15.0 Btu/ft²-oF.


Nonresidential Appendix NA6

Appendix NA6 – Alternate Default Fenestration Procedure to Calculate Thermal Performance

Nonresidential Appendix 6 NA 6

Default values for U-factor, SHGC, and VT in NA6 can be used in some cases.

Find the resource here: energy.ca.gov/2015publications/CEC-400-2015-038/CEC-400-2015-038-CMF.pdf

Additions

The prescriptive approach can also be used to demonstrate compliance for an addition alone. The process is very similar to newly constructed buildings when complying prescriptively. All envelope features must meet all the prescriptive requirements from §140.3 and TABLE 140.3-B, C, or D, depending on the project's primary occupancy. This approach has a distinct advantage for documenting compliance because the existing building does not require documentation, which saves time and greatly simplifies the process.

Alterations

Often the prescriptive approach is used to demonstrate compliance for envelope alterations. Prescriptive compliance for nonresidential alterations are typically limited to analysis of just the altered components, such as fenestration alterations, roof alterations and roof/ceiling, wall, floor and door alterations.

Window Replacement

When replacing more than 150 ft^2 of existing vertical fenestration, all altered fenestration must meet the vertical fenestration area-weighted performance rating listed in Table 141.0-A (condensed version below). Additionally, altered site-built replacement fenestration may use the Alternate Default Fenestration Procedure to Calculate Thermal Performance (NA6 calculation) to determine the maximum U-factor, RSHGC and VT for up to 1000 ft^2 of glazing area. For replacement glass in existing site-built fenestration, the NA6 calculation may be used to determine maximum U-factor, RSHGC and VT regardless of the total glazing area.

Climate Zone	1 and 16	3 and 5	2, 4, and 6-15
U-factor	0.47	0.58	0.47
RSHGC	0.41	0.41	0.31
Min. VT	See TABLE 140.3-B, C and D for all Climate Zones		

TABLE 141.0-A Altered Window Maximum U-factor and RSHGC (condensed)

When replacing 150ft^2 or less of the entire buildings vertical fenestration, only the U-factor in TABLE 141.0-A applies. All skylight alterations must meet the requirements of TABLE 140.3-B, C, or D

Adding Windows or Skylights

Window alterations can also include added fenestration. The Energy Standards have included exceptions for added vertical fenestration and skylights up to 50 ft^2, in this case, only the U-factor requirements in TABLE 141.0-A apply. When more than 50 ft^2 of vertical fenestration, or when any amount of skylights are added, it must meet the requirements of TABLE 140.3-B, C, or D.

Example Window Installation

				All Climate Zones			
				Fixed Window	Operable Window	Curtainwall or Storefront	Glazed Doors
Fenestration	Vertical	Area-Weighted Performance Rating	Max U-factor	0.36	0.46	0.41	0.45
			Max RSHGC	0.25	0.22	0.26	0.23
		Area-Weighted Performance Rating	Min VT	0.42	0.32	0.46	0.17
		Maximum WWR%	40%				

			Glass, Curb Mounted	Glass, Deck Mounted	Plastic, Curb Mounted
Skylights	Area-Weighted Performance Rating	Max U-factor	0.58	0.46	0.88
		Max SHGC	0.25	0.25	NR
	Area-Weighted Performance Rating	Min VT	0.49	0.49	0.64
	Maximum SRR%	5%			

Top and bottom table details show fenestration and skylight requirements per Table 140.3-B. (TABLE 140.3-C and D have the same fenestration requirements as Table 140.3-B)

Roofing Alterations

Another common type of envelope alteration that occurs in nonresidential buildings is roofing alterations. Roofing material can either be covered over with new roofing, recoated with liquid applied roofing or completely replaced by removing the old roofing and installing new roofing. When more than 50% of the roof area, or more than 2,000 ft^2 of roof (whichever is less) is altered, it triggers the prescriptive roofing product requirements for minimum aged solar reflectance and thermal emittance. These requirements vary based on the slope of the roof and the primary occupancy of the building (see table below).

Occupancy	All Climate Zones			
	Roof Slope	Min. Solar Reflectance	Min. Thermal Emittance	SRI
Nonresidential Buildings	Low-sloped	0.63	0.75	75
	Steep-sloped	0.20	0.75	16
	Climate Zones 10, 11, 13, 14 and 15 only			
High-rise residential and Hotel/Motel	Low-sloped	0.55	0.75	64
	Steep-sloped	0.20	0.75	16
Note: see exceptions to §141.0(b)2Bi and ii				

Cool Roof Requirements for Nonresidential, High-rise residential and Hotel/Motel Buildings.

The aged solar reflectance requirements may be reduced if roof/ceiling insulation is increased based on TABLE 141.0-B (see table below).

Aged Solar Reflectance	Climate Zone 1, 3-9 U-factor	Climate Zone 2, 10-16 U-factor
0.62-0.60	0.075	0.052
0.59-0.55	0.066	0.048
0.54-0.50	0.060	0.044
0.49-0.45	0.055	0.041
0.44-0.40	0.051	0.039
0.39-0.35	0.047	0.037
0.34-0.30	0.044	0.035
0.29-0.25	0.042	0.034
Note: see exceptions to §141.0(b)2Biii		

TABLE 141.0-B Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance

When roofing is completely replaced and low-sloped roofs are exposed to the roof deck or roof recover boards, the exposed area must be insulated according to TABLE 141.0-C (see table below).

	Nonresidential		High-rise residential and Guest Rooms of Hotel/Motel Buildings	
Climate Zone	Continuous Insulation	U-factor	Continuous Insulation	U-factor
1	R-8	0.082	R-14	0.055
2	R-14	0.055	R-14	0.055
3-9	R-8	0.082	R-14	0.055
10-16	R-14	0.055	R-14	0.055
Note: see exceptions to §141.0(b)2C				

TABLE 141.0-C Insulation Requirements for Roof Alterations

All other nonresidential building envelope alterations must meet the requirements in §140.3 and TABLE 140.3-B, C or D.

Daylighting

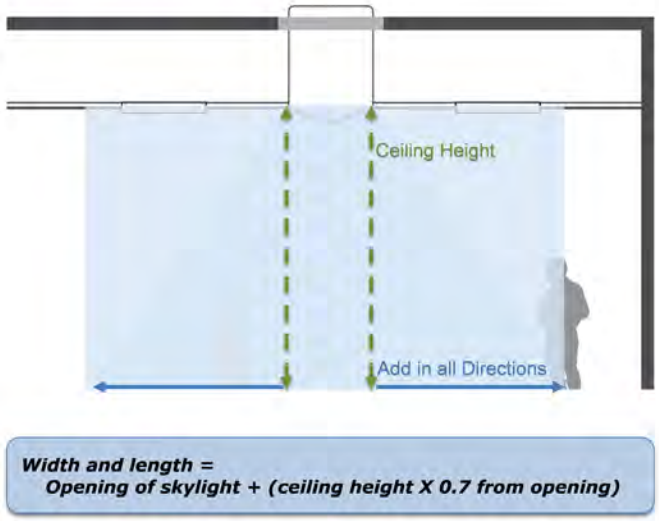
Minimum daylighting for large enclosed spaces is prescriptively required for certain nonresidential buildings when built in climate zones 2-15 regardless of whether or not the enclosed space is conditioned or unconditioned. Daylighting can reduce the amount of electrical energy required to light the space when adequate natural light is available, therefore saving energy. Daylighting requires that luminaires in the daylit area must be controlled, which is covered in the 2016 Nonresidential Lighting and Electrical Power Distribution Guide. The minimum daylighting requirements are triggered when:

The enclosed space is:

- Greater than 5,000 ft^2, and;
- Is directly under a roof with a ceiling height greater than 15', and;
- Has an installed lighting power greater than 0.50 Watts per ft^2.

When these conditions occur, the enclosed space is prescriptively required to install skylights. Skylights must be defusing with a measured haze rating of 90% or greater and meet the performance rating for U-factor, SHGC and VT per TABLE 140.3-B. Skylights must also have an effective area (daylit and primary sidelit zone) of at least 75% of the floor area. The daylit and primary sidelit zone is calculated according to §130.1(d)1A and B.

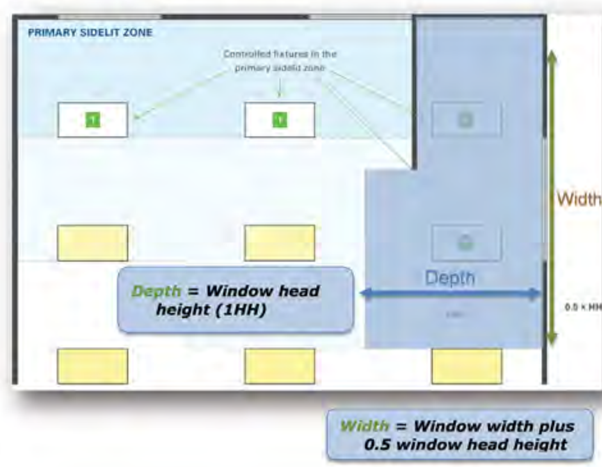
Skylit Daylit Zone



Calculation Steps:

1. Define the approximate shape of the opening of the skylight
2. Determine the ceiling height (CH)
3. Multiply the CH by 0.7
4. Add this value in all directions around the skylight (starting at the edge of the rough opening)
5. Subtract any area in which a permanent obstruction would block daylight (taller than half the distance from the floor to the bottom of the skylight)

Primary Sidelit Zone



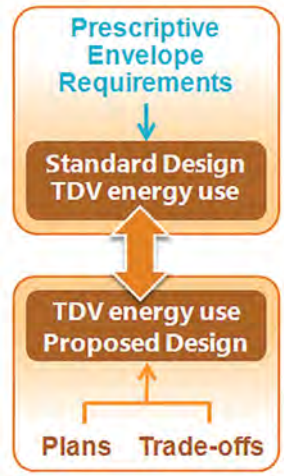
Calculation Steps

1. Determine the window head height for each window
2. The **depth** of the zone is one window head height (HH) into the area adjacent to the window
3. The **width** of the zone is the width of the window plus half the window head height on each side of the window
4. Subtract any area on a plan that is blocked by a permanent obstruction that is six feet or taller.

The Energy Standards have made exceptions for large enclosed spaces that typically do not have skylights or would not want them installed. These include: auditoriums, churches, movie theaters, museums, and refrigerated warehouses. Additionally, if a proposed shell only building is complying prescriptively and can demonstrate that future improved space will either have a floor area 5,000 ft^2 or less, or have a ceiling height 15′ or less, then skylights are not required. Additional exceptions are found in §140.3(c).

What Happens When the Prescriptive Requirements Can't be Met?

There are many reasons for not meeting the prescriptive envelope requirements, including design, budget and preference constraints. When this occurs and proposed envelope features do not meet one or all of the prescriptive requirements, the performance approach must be used. For example: a new multi-story office building is proposed with a lot of windows (e.g. 46% WWR). In this case, the ratio of vertical fenestration to wall area exceeds the prescriptive maximum requirement of 40% and the building will have to comply using the performance approach.



This graphic illustrates TDV Energy Use application.

Performance Approach

The performance approach is considered 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, the proposed building is analyzed using Energy Commission approved compliance software, and its estimated annual energy use is compared to a "standard design" baseline energy use. Energy used for space heating, space cooling, indoor fans, pumps, water heating and indoor lighting are added together and become the "Compliance Energy Total" documented on the NRCC-PRF-01-E (see sample below):

B. COMPLIANCE RESULTS FOR PERFORMANCE COMPONENTS				§ 140.1
BUILDING COMPLIES				
1. Energy Component	2. Standard Design (TDV)	3. Proposed Design (TDV)	4. Compliance Margin (TDV)	5. Percent Better than Standard
Space Heating	9.0	14.2	-5.2	-57.8%
Space Cooling	142.1	134.0	8.1	5.7%
Indoor Fans	321.9	326.7	-4.8	-1.5%
Heat Rejection	--	--	--	--
Pumps & Misc.	--	--	--	--
Domestic Hot Water	7.2	--	7.2	--
Indoor Lighting	86.4	43.4	43.0	49.8%
COMPLIANCE TOTAL	**566.6**	**518.3**	**48.3**	**8.5%**
Receptacle	63.7	63.7	0.0	0.0%
Process	4.6	4.6	0.0	0.0%
Process Ltg	--	--	--	--
TOTAL	**634.9**	**586.6**	**48.3**	**7.6%**

The "standard design" is a baseline analysis of the proposed building, used to set the energy budget in the performance method. For envelope measures the "standard design" assumes all envelope components meet the prescriptive requirements in §140.3 and TABLE 140.3-B, C or D. The "proposed design" is the building being analyzed for compliance with proposed building energy features. A building complies with when the calculated compliance energy total for the proposed design is less than 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.

The Performance Approach allows trade-offs between different envelope components. If envelope is combined with other parts of the building for energy compliance, then more trade-offs can be made. For example: increasing indoor lighting and/or mechanical equipment efficiency in order to allow lower envelope efficiency.

Often the performance approach is used for new construction projects, analyzing the building as a whole (envelope, mechanical and indoor lighting). The performance approach may also be used to analyze and document compliance for additions and alterations. The performance approach may be used to perform compliance analysis for the following scenarios:

- Whole building (envelope, mechanical and indoor lighting)
- Envelope only, or mechanical only
- Envelope + lighting, envelope + mechanical, or mechanical + lighting

Note: The performance approach is not allowed for lighting only analysis; this must be done using the prescriptive approach.

Case Study: Phocus Office and Warehouse

The case study project, Phocus Office and Warehouse is a sample project created for training purposes and was used to provide a basis for comparison of the prescriptive and performance approaches. The building consists of a 2,070 ft^2 conditioned offices, conference rooms, employee lounge, support spaces and a 1,630 ft^2 unconditioned warehouse. The project envelope features include a slab-on-grade foundation, with metal framed walls and a mix of storefront and manufactured windows.

Below is the floor plan, and on the following pages is a comparison of Prescriptive versus Performance approaches to achieve compliance with the Energy Standards.

Prescriptive vs Performance

The following tables compare the envelope features of the case study building with the applicable prescriptive requirements and the performance method standard design assumptions for climate zone 9 (Valencia) to assess compliance options in practice.

	CASE STUDY	PRESCRIPTIVE	PERFORMANCE
Nonresidential Buildings	Nonresidential office and warehouse building	Climate Zone (CZ) 9	2016 Residential ACM Reference Manual (Sections 2.5 to 2.7)
Total Conditioned Floor Area (CFA)	2,370 ft^2	2,370 ft^2	2,370 ft^2
Unconditioned area	1,630 ft^2	1,630 ft^2	1,630 ft^2
Fenestration:	Dual pane site-built storefront and glass door fenestration with thermally broken metal frame and manufactured windows, NFRC rated, dual pane with thermally broken metal frame		
Area	Total west-facing area = 0 ft^2 West facing WWR = 0% Total fenestration area = 511 ft^2	Total West-facing WWR = 40%	The Standard Design is identical to the Proposed Design with exception when the WWR (west-facing or total) exceeds 40%, then: Total West-facing WWR = 40%
	WWR = 20.5%	Total WWR = 40%	Total WWR = 40%
U-factor	Storefront U-factor = 0.28 (COG), (0.46 calc)	All CZ: ≤ 0.41	All CZ: ≤ 0.41
	Glass door U-factor = 0.28 (COG), (0.46 calc)	All CZ: ≤ 0.45	All CZ: ≤ 0.45
	Manufactured Operable Window = 0.34 (NFRC)	All CZ: ≤ 0.46	All CZ: ≤ 0.46
SHGC	Storefront RSHGC= 0.27, (0.31 calc), (0.18 w/overhang)	All CZ: ≤ 0.26	Same as Prescriptive
	Glass door RSHGC = 0.27, (0.31 calc), (0.18 w/overhang)	All CZ: ≤ 0.23	Same as Prescriptive
	Manufactured Operable Window = 0.27 (NFRC)	All CZ: ≤0.22	Same as Prescriptive

	CASE STUDY	PRESCRIPTIVE	PERFORMANCE
VT	Storefront VT = 0.64	All CZ: ≥ 0.46	All CZ: ≥ 0.46
	Glass door VT = 0.64	All CZ: ≥ 0.17	All CZ: ≥ 0.17
	Manufactured Operable Window = 0.50 (NFRC)	All CZ: ≥ 0.32	All CZ: ≥ 0.32
Roof/Ceiling:			
Metal building with standing seam roofing	Metal building standing seam roofing and R-10 over purlins and R-19 cavity insulation (filled) U-factor = 0.041	CZ 9: ≤ 0.041	CZ 9: ≤ 0.041
Roofing:			
Aged Solar Reflectance	Low-sloped (0.5:12), 0.69	Low-sloped (0.5:12): CZ 9: ≥ 0.63	Low-sloped (0.5:12): CZ 9: ≥ 0.63
Thermal Emittance	Low-sloped (0.5:12), 0.83	Low-sloped (0.5:12): CZ 9: ≥ 0.75	Low-sloped (0.25:12): CZ 9: ≥ 0.75
Walls:			
Metal stud framed exterior walls	2x6 metal frame @ 16" o.c. with R-21 cavity insulation + R-5 continuous, U-factor = 0.083	CZ 9: U-factor ≤ 0.059	CZ 9: U-factor ≤ 0.059
Demising partitions next to unconditioned space	2x4 metal frame @ 16" o.c. with R-13 cavity insulation + R-2 continuous U-factor = 0.134	CZ 9: U-factor ≤ 0.151	CZ 9: U-factor ≤ 0.151
Opaque swinging doors	Metal insulated doors U-factor = 0.50	CZ 9: U-factor ≤ 0.70	CZ 9: U-factor ≤ 0.70
Floors:			
Unheated slab-on-grade floor	5" Slab-on-grade with no perimeter insulation U-factor = 0.730	CZ 9: U-factor ≤ 0.092	CZ 9: U-factor ≤ 0.092
Daylighting: Conditioned Unconditioned	No skylights installed Four – 2'x2' skylights installed	Skylights not required for conditioned space and unconditioned workshop area	Skylights not required for conditioned space

Envelope Compliance Analysis Summary

Checking the proposed case study building against the prescriptive requirements and performance method for the envelope only, the standard design shows that the building envelope.

Since it doesn't meet all the prescriptive requirements, the project must use the performance method for the envelope to comply.

Case Study Performance Method Results

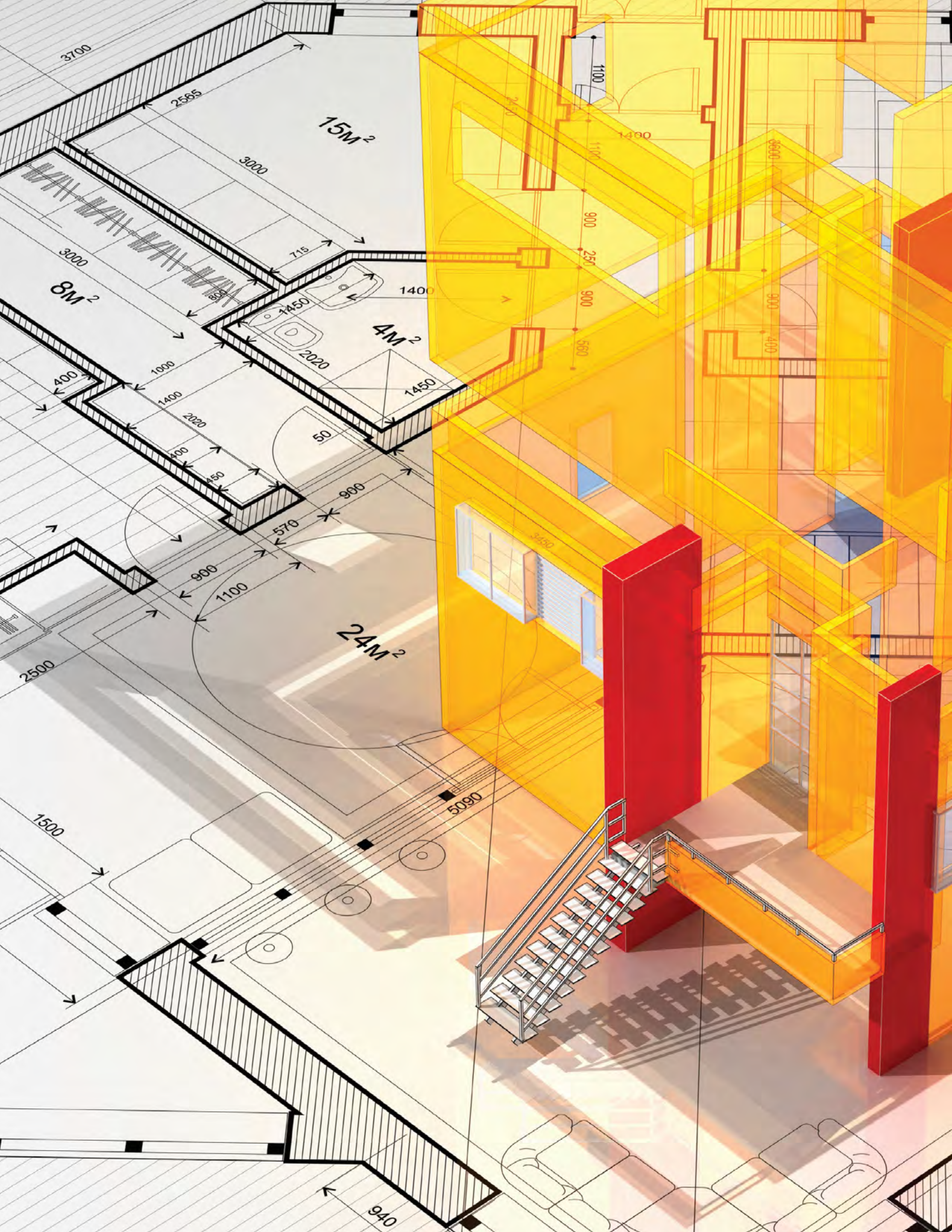
Using Energy Commission approved energy compliance software to analyze the proposed building envelope, the case study building complies with the Energy Standards using the Performance Approach. Similar results could be achieved using other Energy-Commission-approved compliance software.

Project Name:	Phocus Office	NRCC-PRF-01-E	Page 1 of 15
Project Address:	2020 Vision Court Valencia 91354	Calculation Date/Time:	10:06, Wed, Aug 31, 2016
Compliance Scope:	NewEnvelope	Input File Name:	Phocus Office-Warehouse T24.cibd16x

A. PROJECT GENERAL INFORMATION					
1.	Project Location (city)	Valencia	**8.**	Standards Version	Compliance2016
2.	CA Zip Code	91354	**9.**	Compliance Software (version)	EnergyPro 7.0
3.	Climate Zone	9	**10.**	Building Orientation (deg)	(S) 180 deg
4.	Total Conditioned Floor Area in Scope	2,370 ft^2	**11.**	Permitted Scope of Work	NewEnvelope
5.	Total Unconditioned Floor Area	1,630 ft^2	**12.**	Building Type(s)	Nonresidential
6.	Total # of Stories (Habitable Above Grade)	1	13	Gas Type	NaturalGas
7.	Total # of dwelling units	0			

B. COMPLIANCE RESULTS FOR PERFORMANCE COMPONENTS (Annual TDV Energy Use, kBtu/ft ^{2}-yr)				**§ 140.1**
BUILDING COMPLIES				
1. Energy Component	**2. Standard Design (TDV)**	**3. Proposed Design (TDV)**	**4. Compliance Margin (TDV)**	**5. Percent Better than Standard**
Space Heating	9.0	10.6	-1.6	-17.8%
Space Cooling	85.2	83.3	1.9	2.2%
Indoor Fans	99.4	94.4	5.0	5.0%
Heat Rejection	--	--	--	--
Pumps & Misc.	--	--	--	--
Domestic Hot Water	--	--	--	--
Indoor Lighting	47.3	47.3	--	0.0%
COMPLIANCE TOTAL	**240.9**	**235.6**	**5.3**	**2.2%**
Receptacle	79.1	79.1	0.0	0.0%
Process	--	--	--	--
Other Ltg	--	--	--	--
TOTAL	**320.0**	**314.7**	**5.3**	**1.7%**

The first page of the performance method NRCC-PRF-01-E form lists general project information and the compliance results, including the important statement that the "Building Complies"



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3000
8м2
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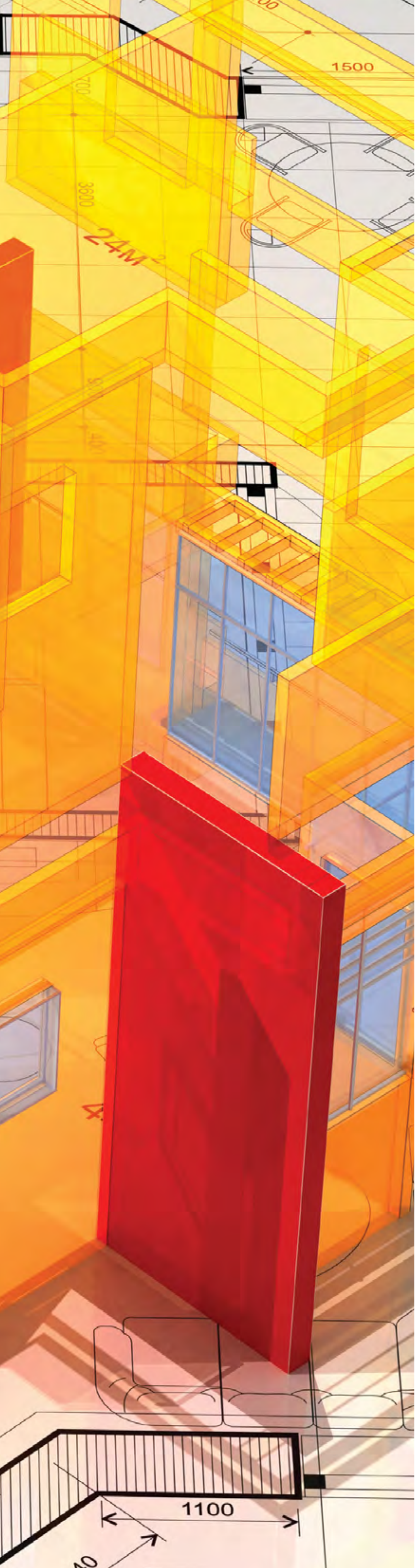


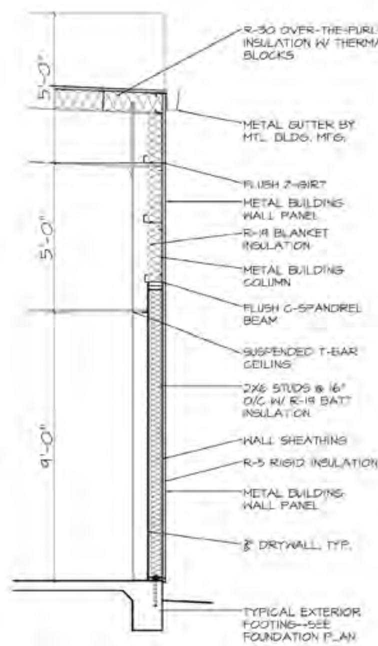
CHAPTER 6

RECOMMENDATIONS AND EXAMPLE APPLICATIONS

Documenting Energy Features on the Plans

Assembly Details

It is important that assembly details in the plans match those used in the compliance documentation to demonstrate compliance with the Energy Standards.



Example Assembly Detail

Schedules and Notes

It is also important that schedules and notes be consistent with the features used in the compliance documentation to demonstrate compliance with the Energy Standards.

WINDOW SCHEDULE

MARK	QTY.	SIZE		FRAME TYPE	GLAZING	PERFORMANCE			
		WIDTH	HEIGHT			RATING	U-FTR	SHGC	VT
1	4	15'-0"	7'-0"	THERMALLY BROKEN ALUM	DBL PANE	CO6	0.28	0.27	0.64
2	6	4'-0"	3'-6"	THERMALLY BROKEN ALUM	DBL PANE	NFRC	0.64	0.59	0.50
3	6	6'-0"	4'-0"	THERMALLY BROKEN ALUM	DBL PANE	NFRC	0.64	0.59	0.50
4	6	4'-0"	4'-0"	THERMALLY BROKEN ALUM	DBL PANE	NFRC	0.64	0.59	0.50

Example Window Schedule

WALL LEGEND

8" PRE-ENGINEERED STEEL GIRT WALL SYSTEM W/ PREFORMED EXTERIOR METAL SIDING & INTERIOR PLYWOOD SHEATHING FROM FINISH FLOOR TO GIRT @ 8'-0" HT.

6" OCCUPANCY SEPARATION WALL (1 HR) - 2X6 METAL STUDS @ 16" O/C W/ 5/8" TYPE "X" G.W.B. BOTH SIDES & R-19 CAVITY INSULATION.

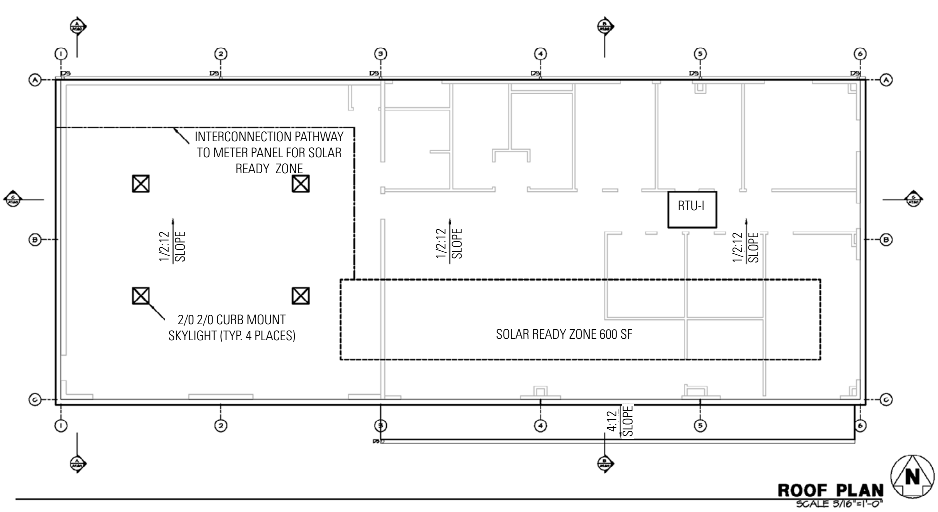
6" EXTERIOR WALL - 2X6 METAL STUDS @ 16" O/C W/ R-19 CAVITY INSULATION. EXTERIOR STUCCO SIDING OVER R-5 RIGID INSULATION, V.B. & ½" OSB SHEATHING. INTERIOR 5/8" G.W.B.

4" INTERIOR WALL - 2X4 METAL STUDS @ 16" O/C W/ 1/2" G.W.B. BOTH SIDES.

Example Wall Legend

Solar Ready and Daylit Zones

The Energy Standards require that solar ready zones, interconnection pathways and equipment locations be documented on the plans. Daylit and primary sidelit zones must also be on the plans.



Example Solar Ready Zone Detail

Topic Specific Scenarios

Prescriptive Nonresidential Roof Alteration

A K-8 school building located in climate zone 7 is replacing 2,500 ft^2 of roofing on a 5,000 ft^2 classroom building with a low-sloped roof. The existing roofing will be removed to the roof deck and replaced with a new TPO membrane roofing material. In this case, since none of the exceptions in §141.0(b)2Bi and ii apply, the portion of roof that is being replaced will need to meet the prescriptive roofing product requirements of 0.63 or greater Solar Reflectance and 0.75 or greater Thermal Emittance (or SRI of 75 or greater).

Occupancy	All Climate Zones			
	Roof Slope	Min. Solar Reflectance	Min. Thermal Emittance	SRI
Nonresidential Buildings	Low-sloped	0.63	0.75	75
	Steep-sloped	0.20	0.75	16
	Climate Zones 10, 11, 13, 14 and 15 only			
High-rise residential and Hotel/Motel	Low-sloped	0.55	0.75	64
	Steep-sloped	0.20	0.75	16

Cool Roof Requirements for Nonresidential, High-rise residential and Hotel/Motel Buildings.

In this case, since the roofing is completely replaced and the low-sloped roof is exposed to the roof deck and none on the exceptions to §141.0(b)2C apply, the exposed area must also be insulated with R-8 continuous insulation according to TABLE 141.0-C (see below).

	Nonresidential		High-rise residential and Guest Rooms of Hotel/Motel Buildings	
Climate Zone	Continuous Insulation	U-factor	Continuous Insulation	U-factor
1	R-8	0.082	R-14	0.055
2	R-14	0.055	R-14	0.055
3-9	R-8	0.082	R-14	0.055
10-16	R-14	0.055	R-14	0.055
Note: see exceptions to §141.0(b)2C				

TABLE 141.0-C Insulation Requirements for Roof Alterations

Required Compliance Documentation

Phase 1: Permit Application

NRCC-ENV-01-E Envelope Component Approach Certificate of Compliance

NRCC-ENV-03-E Cool Roof and SRI Worksheet

Phase 2: Inspection

NRCI-ENV-01-E Envelope Certificate of Installation

Prescriptive Nonresidential Window Alteration

A building owner is replacing 900 ft^2 of existing single pane storefront glazing with new double pane glazing in their retail building in climate zone 10. The new glazing has a manufacturer's center-of-glass U-factor rating of 0.29, SHGC rating of 0.27 and a VT rating of 0.64 and will be installed with a new thermally-broken aluminum frame. In this case the prescriptive approach would require that all altered fenestration meet the vertical fenestration area-weighted performance rating for climate zone 10 listed in Table 141.0-A (condensed version below).

Climate Zone	1 and 16	3 and 5	2, 4, and 6-15
U-factor	0.47	0.58	0.47
RSHGC	0.41	0.41	0.31
Min. VT	See TABLE 140.3-B		

TABLE 141.0-A (condensed)

Additionally, since the replacement fenestration is less than 1000ft^2, the Alternate Default Fenestration Procedure to Calculate Thermal Performance (NA6 calculation) can be used to determine the maximum U-factor, RSHGC and VT. Calculating the alternate default fenestration thermal performance is as follows:

Alternate Default U-factor Equation NA6-1

$$UT = C1 + (C2 \times Uc)$$

$$UT = 0.202 + (0.867 \times 0.29)$$

$$\mathbf{UT = 0.453}$$

Proposed U-factor of 0.45 ≤ the prescriptive requirement of 0.47 = Complies

Where:

- UT = U-factor Is the Total Performance of the fenestration including glass and frame
- C1 = Coefficient selected from TABLE NA6-5
- C2 = Coefficient selected from TABLE NA6-5
- UC = Center of glass U-factor calculated in accordance with NFRC 100 Section 4.5.3.1 nfrc.org/software.aspx

Product Type	Frame Type	C1	C2
Site-built Vertical Fenestration	Metal	0.311	0.872
	Metal Thermal Break	0.202	0.867
	Non-metal	0.202	0.867
Skylights with a Curb	Metal	0.711	1.065
	Metal Thermal Break	0.437	1.229
	Non-metal	0.437	1.229
Skylights with no Curb	Metal	0.195	0.882
	Metal Thermal Break	0.310	0.878
	Non-metal	0.310	0.878

TABLE NA6-5

Alternate Default SHGC Equation NA6-2

SHGCT = 0.08 + (0.86 x SHGCc)

SHGCT = 0.08 + (0.86 x 0.27)

SHGCT = 0.31

Proposed SHGC of 0.31 ≤ the prescriptive requirement of 0.31 = Complies

Where:

- SHGCT = SHGC Is the Total Performance of the fenestration including glass and frame
- SHGCC = Center of glass SHGC calculated in accordance with NFRC 200 Section 4.5.1.1 nfrc.org/software.aspx

Alternate Default VT Equation NA6-3

VTT = VTF x VTC

VTT = 0.88 x 0.64

VTT = 0.56

Proposed VT of 0.56 ≥ the prescriptive requirement of 0.46 = Complies

Where:

- VTT = Is the Total Performance of the fenestration including glass and frame
- VTF = 0.53 for projecting windows, such as casement and awning windows
- VTF = 0.67 for operable or sliding windows
- **VTF = 0.77 for fixed or non operable windows**
- VTF= 0.88 for curtain wall/storefront, Site-built and manufactured non-curb mounted skylights
- VTF = 1.0 for Curb Mounted manufactured Skylights
- VTC = Center of glass VT is calculated in accordance with NFRC 200 Section 4.5.1.1 or NFRC 202 for Translucent Products or NFRC 203 for Tubular Daylighting Devices and Hybrid Tubular Daylighting Devices or ASTM E972 nfrc.org/software.aspx

Required Compliance Documentation

Phase 1: Permit Application

NRCC-ENV-01-E Envelope Component Approach Certificate of Compliance

NRCC-ENV-02-E Fenestration Worksheet

NRCC-ENV-05-E Fenestration Certificate Label

Phase 2: Inspection

NRCI-ENV-01-E Envelope Certificate of Installation

Phase 3: Final Inspection

NRCA-ENV-02-F Fenestration Certificate of Acceptance