Decoding Recovery:
Let's Talk Residential Rebuilding

HELPING YOU PLAY YOUR CARDS RIGHT

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Decoding 2016 HVAC™
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This session is being recorded.

Last Decoding Talk…

Decoding 2016 Energy Standards™
Let's Talk How to Navigate

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California Statewide Codes & Standards

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This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Who Are We?

Gina Rodda
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gina@gabelenergy.com

GABEL ENERGY
BUILDING ENERGY ANALYSIS + ENERGY CODE COMPLIANCE

Host: Gina Rodda

Gina Rodda, our host for the Decoding Talk series, is a Certified Energy Analyst (CEA), and LEED Accredited Professional (AP).

She is involved in providing residential and non-residential energy calculations for a variety of building types throughout California; an instructor of full day trainings; and host of various webinars specific to Title 24 (Part 6) Building Energy Efficiency Standards.

Gina has been in the energy modeling field since 1991, starting the *ninth* California building energy code cycle of her career.

Who Are We?

Ted Tiffany
Guttmann & Blaevoet
Associate Principal/
Director of Sustainability

Ttiffany@gb-eng.com

Guest Speaker: Ted Tiffany

Ted leads Guttmann & Blaevoet's building performance modeling group and is the Director of Sustainability for the company. Ted has 17 years of experience using various energy analysis tools modeling energy, comfort, and daylighting.

He has been a part-time lecturer at Sonoma State University teaching "Computer aided applications in Energy Management & Design".

He is currently focused on Zero Net Energy buildings and their interaction with the grid systems, co-generation, and active storage systems for energy management.

Decoding Recovery

- Understand the triggers for which building features need to be rebuilt for the Energy Code requirements;
- Be aware of how the Energy Code looks at design changes associated with the rebuild;
- Know of the building features that may look very different from what was originally associated with the home;
- Be able to find help and resources to support rebuild efforts.

Agenda

Agenda for Today **Approx. Length**

- Welcome..... 5 minutes
- Why?!..... 10 minutes
- Let's Talk
  - *Challenge A:* ..... *15 minutes*
  - *Challenge B:* ..... *25 minutes*
  - *Challenge C:* ..... *30 minutes*
  - *Challenge D:* ..... *20 minutes*
- Next Steps..... 10 minutes
- Wrap Up..... 5 minutes

Why?

Handouts

2016 ENERGY CODE

Ace Resources | Title 24, Part 6 Fact Sheet

Residential
Recover & Rebuild

Decoding | Recovery™

Let's Talk Residential Rebuilding

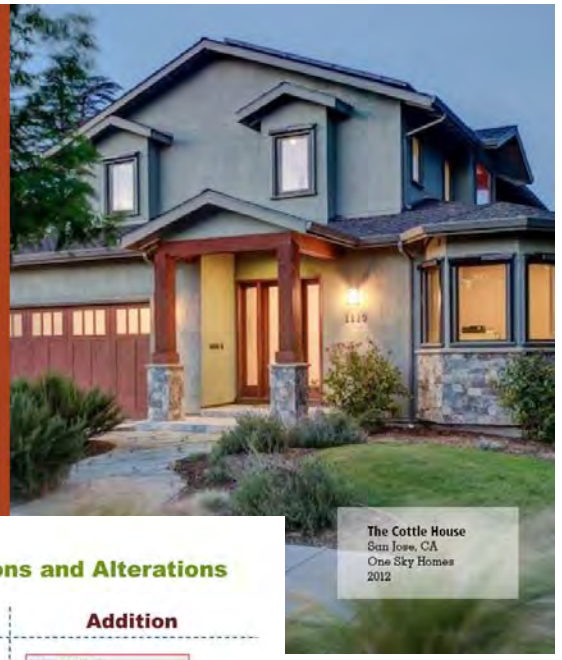
Insulation Guide

Insulation Material	R-value per inch	Appearance	Advantages	Disadvantages	Product Highlights
Batt Type					
Fiberglass	3-3.7		Readily available	Must be installed correctly to achieve full R-value	Widely available
Mineral Wool	2.8-3.7		Somewhat better fire resistance and soundproofing than fiberglass; Good for water drainage.	Same as fiberglass	ROXUL
Cotton	3-3.7		Environmentally friendly		
Loose Fill					
Fiberglass	3-3.7		Easier to install correctly		
Boxed Netting Fiberglass	3-3.7		Below roof deck insulation; Less expensive than spray insulation		
Mineral Fiber	2.8-3.7		Easier to install correctly		
Cellulose Fiber	3-3.7		Provides more resistance to air movement than other loose fill		

Energy

American Institute of Architects, California Council

ZERO NET ENERGY PRIMER



The Cottle House
San Jose, CA
One Sky Homes
2012

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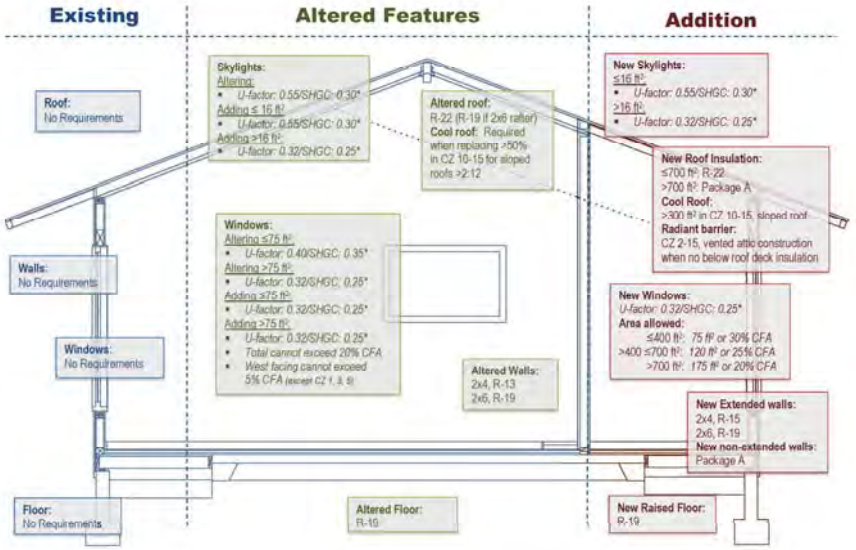
Let's Talk Residential Rebuilding

Additions and Alterations



*SHGC not required in CZ 1, 3, 5

4 | Page

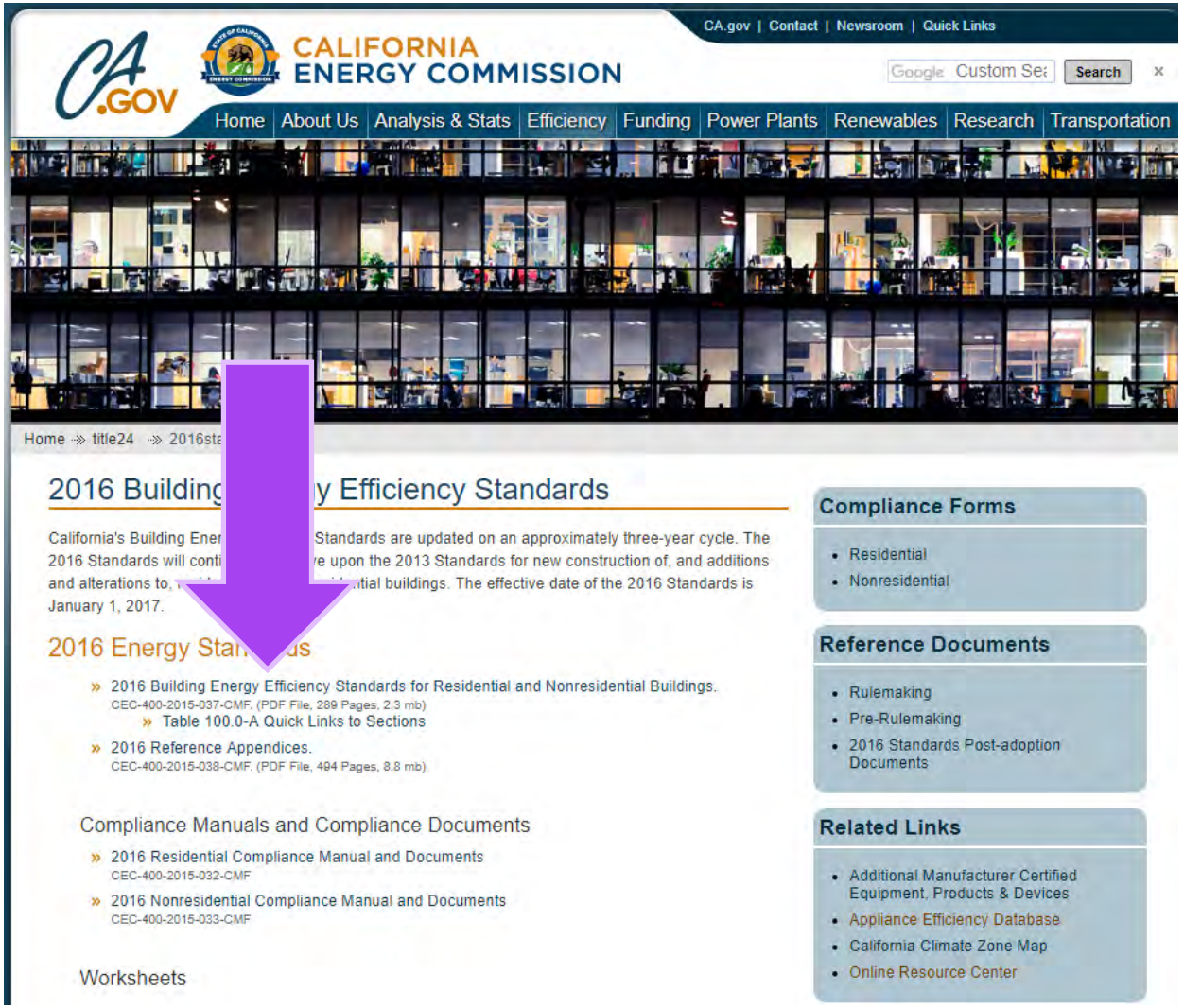
Title 24: CA Building Code

- Part 1: Administrative
- Part 2: ICC Changes
- Part 2.5: Residential Buildings
- Part 3: Electrical Code
- Part 4: Mechanical Code
- Part 5: Plumbing Code
- Part 6: ENERGY CODE
- Part 8: Historic Building
- Part 9: Fire Code
- Part 10: Existing Buildings
- Part 11: Environmental Code

Where to get the Energy Standards

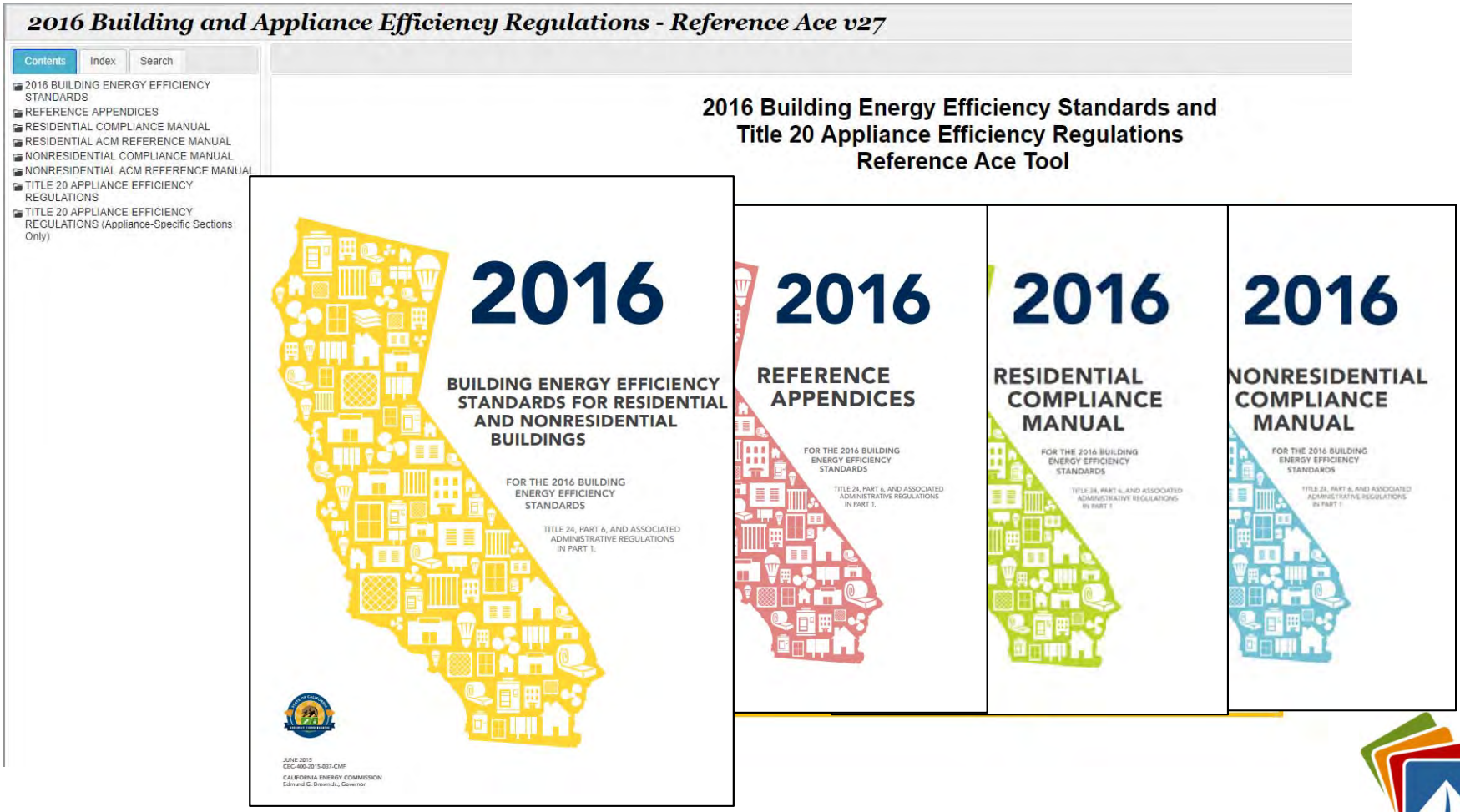
Online Resource Center

http://www.energy.ca.gov/title24/orc/



Ace Tools™

Helps you navigate the Standards using key word search capabilities, hyperlinked tables and related sections



EnergyCodeAce.com/tools

What? Title 24 Part 6: Energy Code

http://www.energy.ca.gov/title24/2016standards/index.html

Mandatory, Prescriptive, Performance

1. Mandatory Measures

- Must always be met/installed

2.

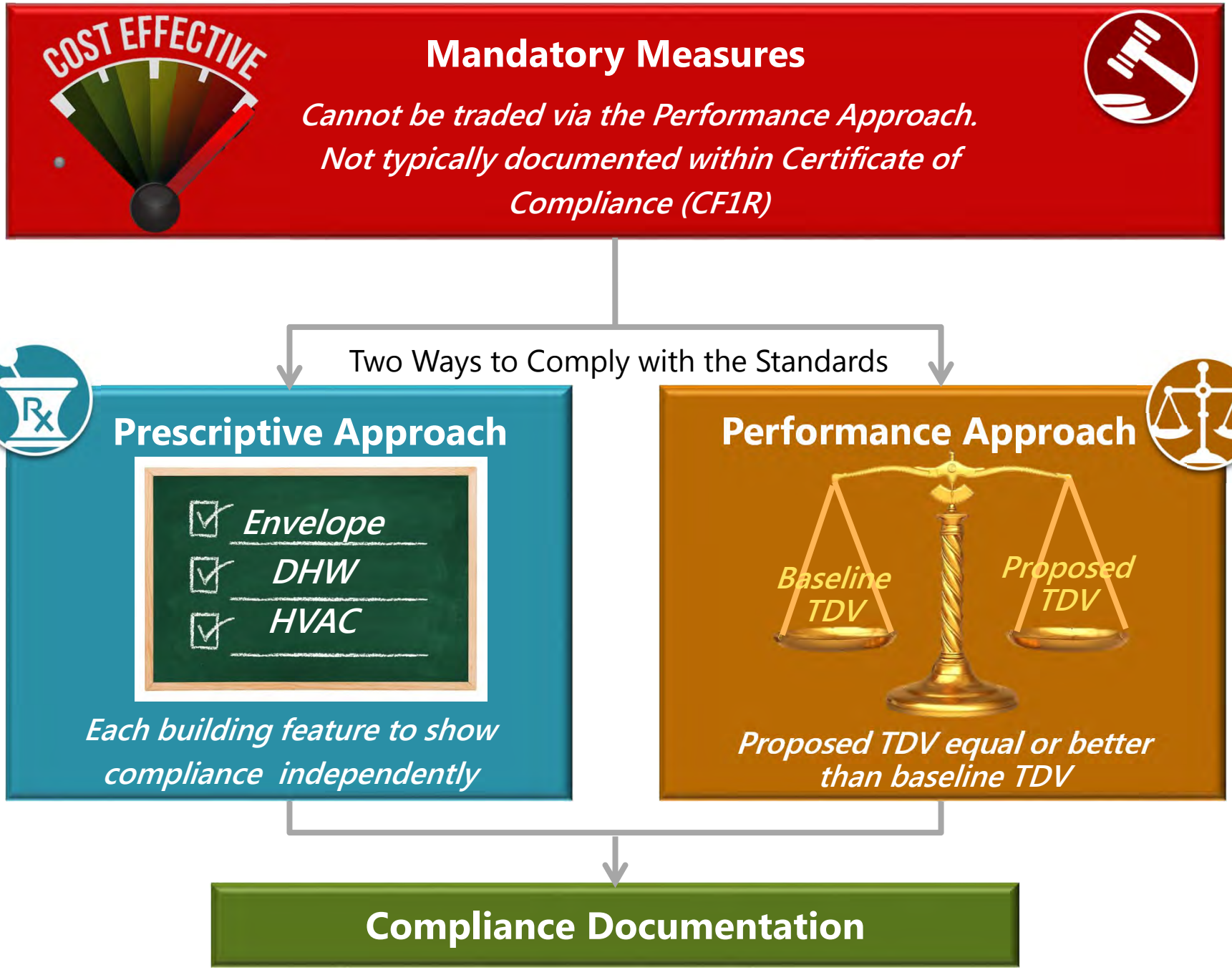
- Establish minimum level of energy efficiency and/or performance

or

3.

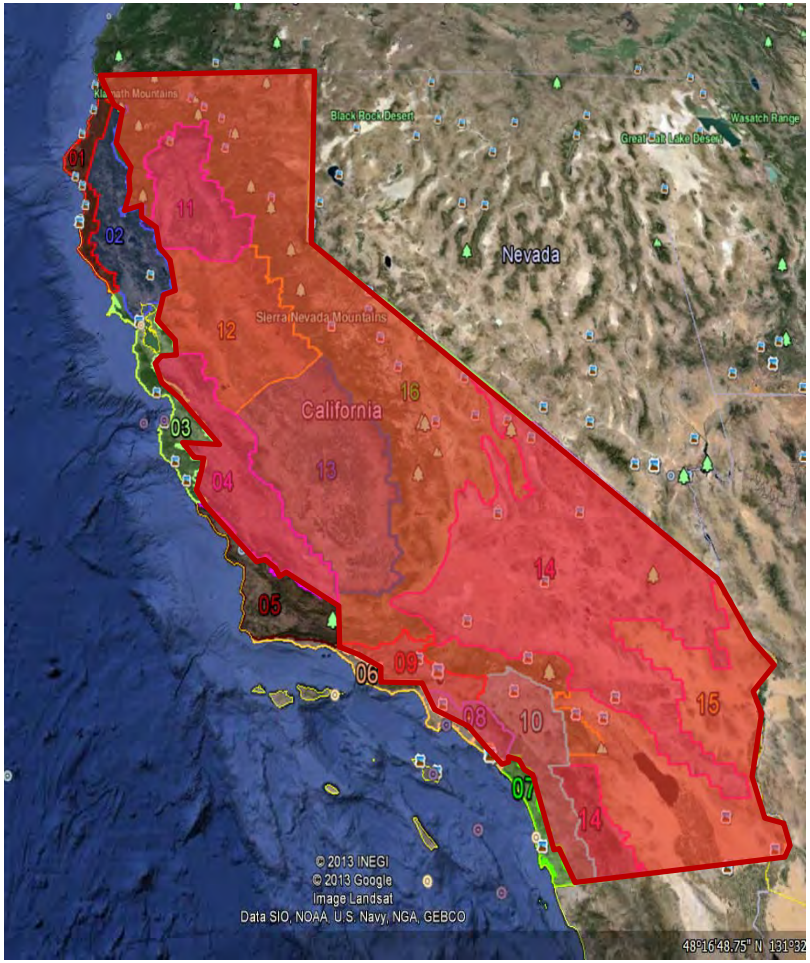
- Set of predefined efficiency requirements that must ALL be met or exceeded
- Applies to various building components

- Requires the use of Energy Commission approved software
- Most flexible approach, allows for trade-offs
- Proposed energy budget ≤ Standard energy budget

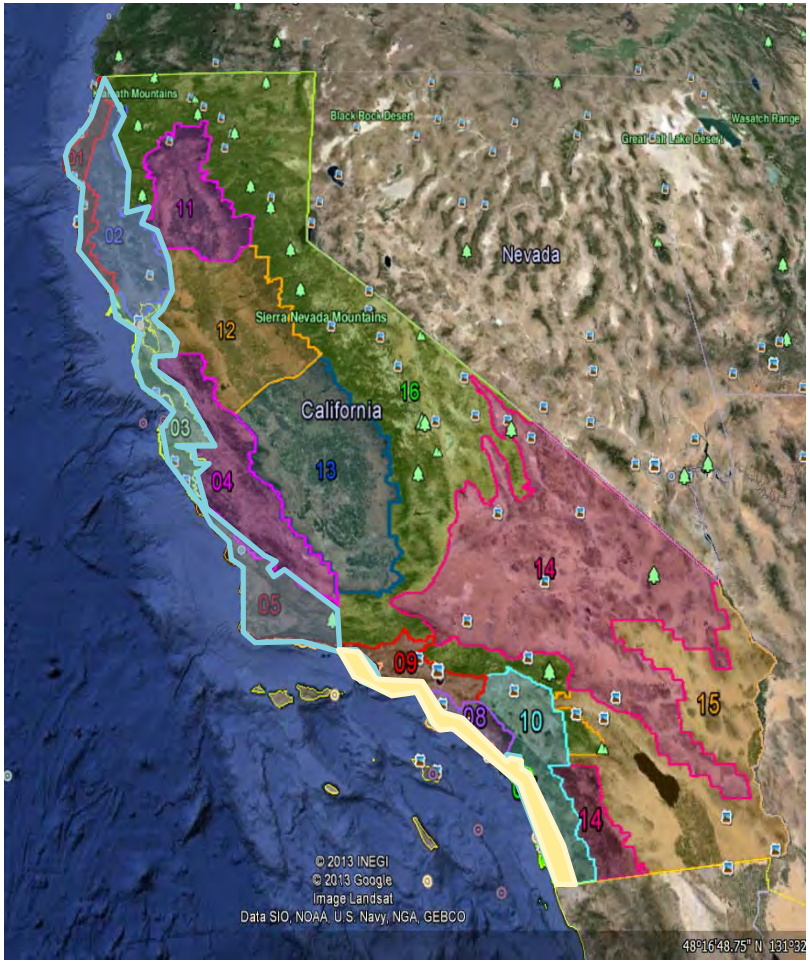

COST EFFECTIVE
Mandatory Measures
Cannot be traded via the Performance Approach.
Not typically documented within Certificate of Compliance (CF1R)
Two Ways to Comply with the Standards
Prescriptive Approach
Envelope
DHW
HVAC
Each building feature to show compliance independently
Performance Approach
Baseline TDV
Proposed TDV
Proposed TDV equal or better than baseline TDV
Compliance Documentation

Prescriptive Package A: §150.1

Hot/Cold Climate Zones



Mild Climate Zones



Our Question To You

1. *What is your understanding on how the 2016 Energy Standards are triggered when rebuilding a home?*
2. *What are your top 3 concerns regarding rebuilding under the 2016 Energy Standards?*
3. *What is your advice on how to incorporate the 2016 Energy Standards for a home that needs to be rebuilt?*
4. *If you could wave your magic wand, the 2016 Energy Standards would include _____ to further assist rebuild efforts?*

1. How can we save energy
2. How much money will it cost my Clients
3. At what point does an alteration become a new title 24 project

They are not triggered since it is not a new home. ☹

Integrated design, clear communication of the requirements throughout the plans and coordination with all team members before construction begins to ensure that all requirements are incorporated into the design and installed properly.

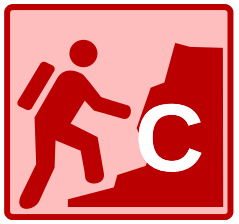
Helpful hints for specific climate zone.

Let's Talk

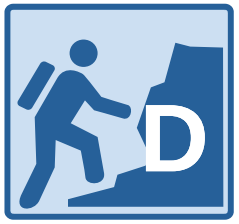
Challenges

- **Challenge A:**
  - **What's a Repair versus an Alteration?**

- **Challenge B:**
  - **Changing the Original Design**

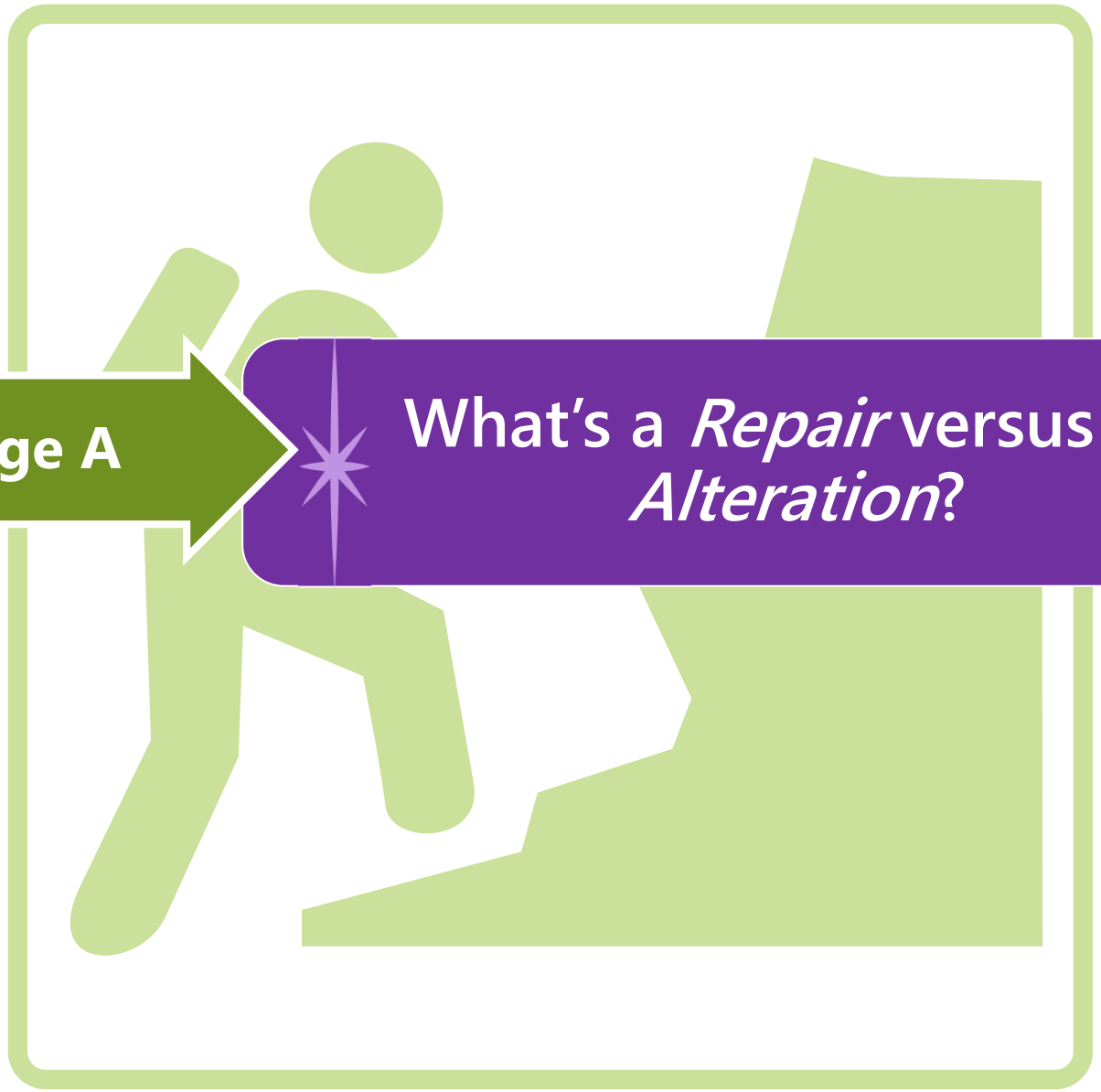


- **Challenge C:**
  - **Rebuild of Entire Home**



- **Challenge D:**
  - **Rebuilding Greener**

Challenge A



Challenge A

What's a *Repair* versus an *Alteration*?

What Doesn't Trigger the Energy Code?

- Replace a broken window pane with the sash remaining
  - Alteration: Replacing the sash AND the glazing

Does it meet the definition of repair?

- The reconstruction or renewal for the purpose of maintenance of any component, system, or equipment of an existing building.
- Repairs shall not increase the preexisting energy consumption of the repaired component, system, or equipment.
- If the item is replaced instead of repaired, the replaced item is now considered an Alteration and triggers the Energy Code.

What DOES Trigger the Energy Code?

Triggers Compliance Documentation!

- Any change to a building's:
  - water-heating system,
  - space-conditioning system,
  - lighting system, or
  - Envelope (that is not a repair)

What Doesn't Trigger the Energy Code?

Doesn't Trigger Compliance Documents

- Replacing roof tiles UNLESS
  - More than 50% replaced in CZ 10-15 only in which certified cool roof product maybe required.

- Replace the filter in the HVAC unit UNLESS
  - Replacing the ducts, furnace, and/or AC along with replacing filter

What Doesn't Trigger the Energy Code?

Doesn't Trigger Compliance Documents

- Remodeling the kitchen cabinets EXCEPT
  - The new LIGHTING does have energy code requirements

- Replace the thermostat (with a setback thermostat) BUT
  - Replacing the ducts, furnace, and/or AC IS a triggering event

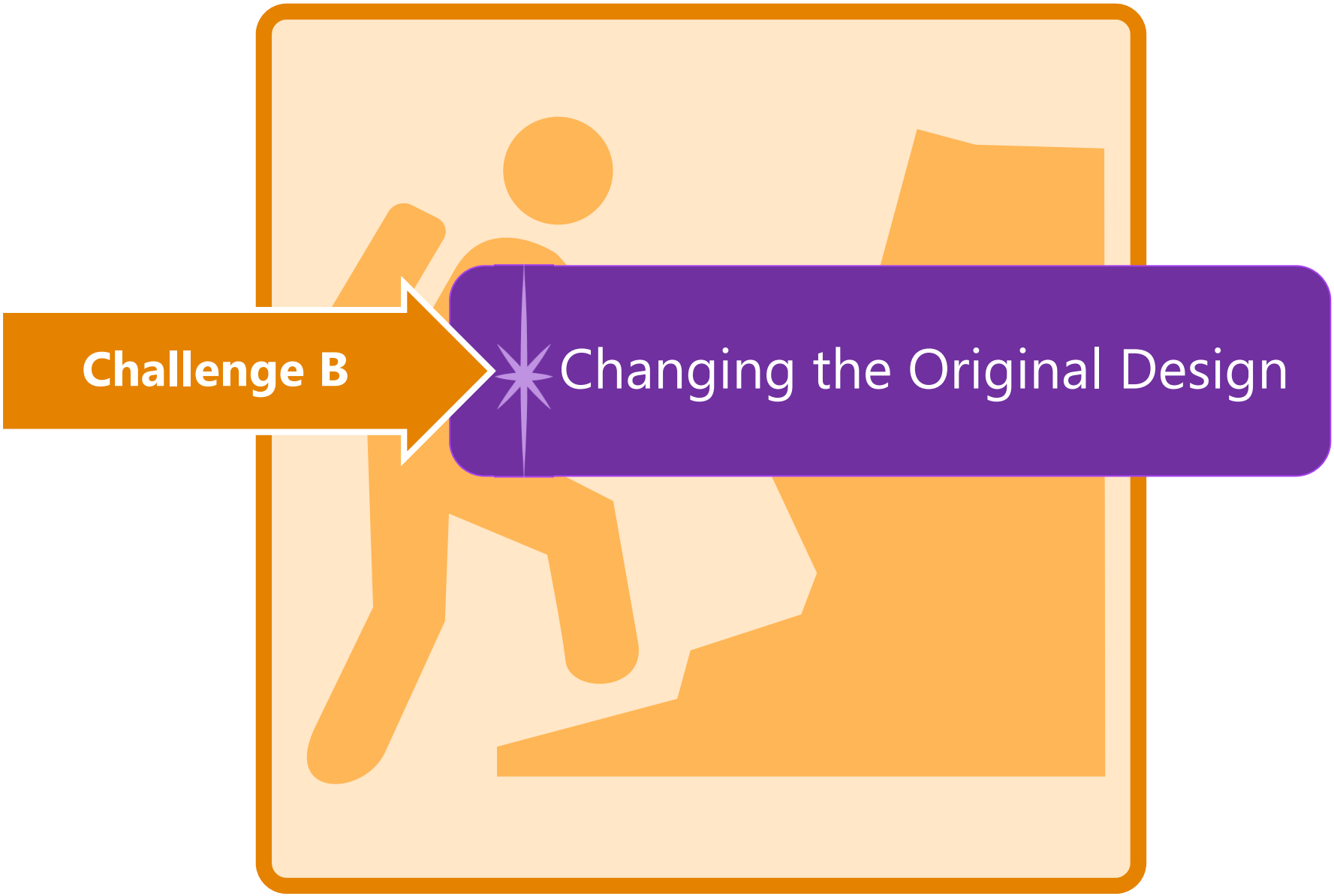
What Doesn't Trigger the Energy Code?

Doesn't Trigger Compliance Documents

- Replacing the gypboard EXCEPT
  - Those walls will now need to be insulated with mandatory minimum insulation

- Rebuilding a wall/floor/roof in same exact location (will need to be insulated)
  - Alteration: Moving any exterior wall location while repairing

Challenge B

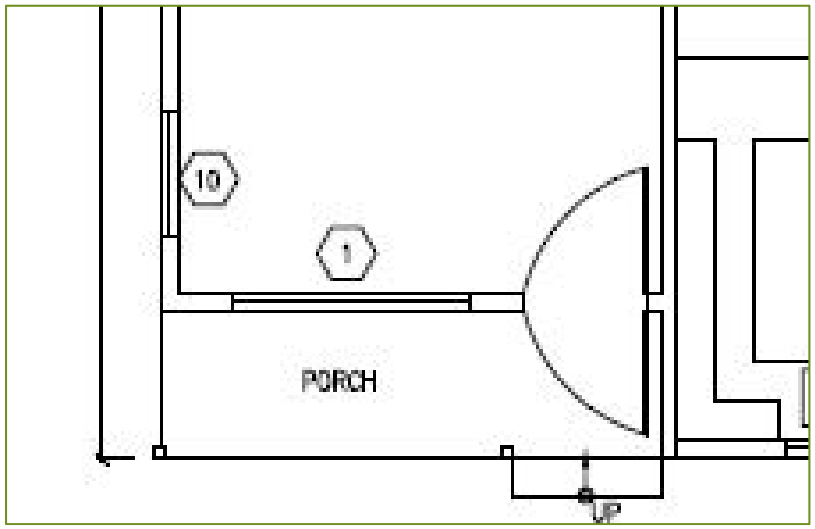


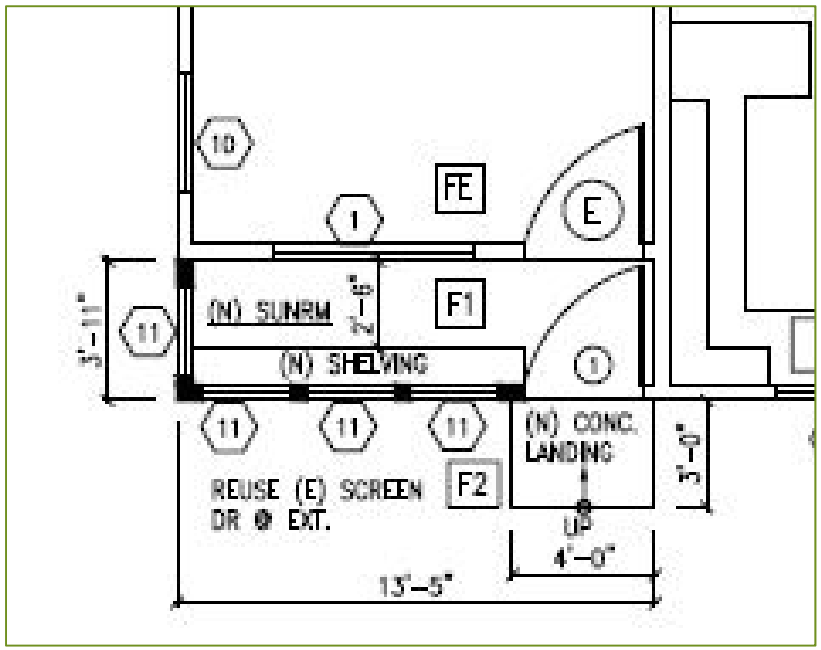
What's an Addition?

- Any change to a building that increases conditioned floor area and conditioned volume.

- Any space being converted from unconditioned to conditioned.

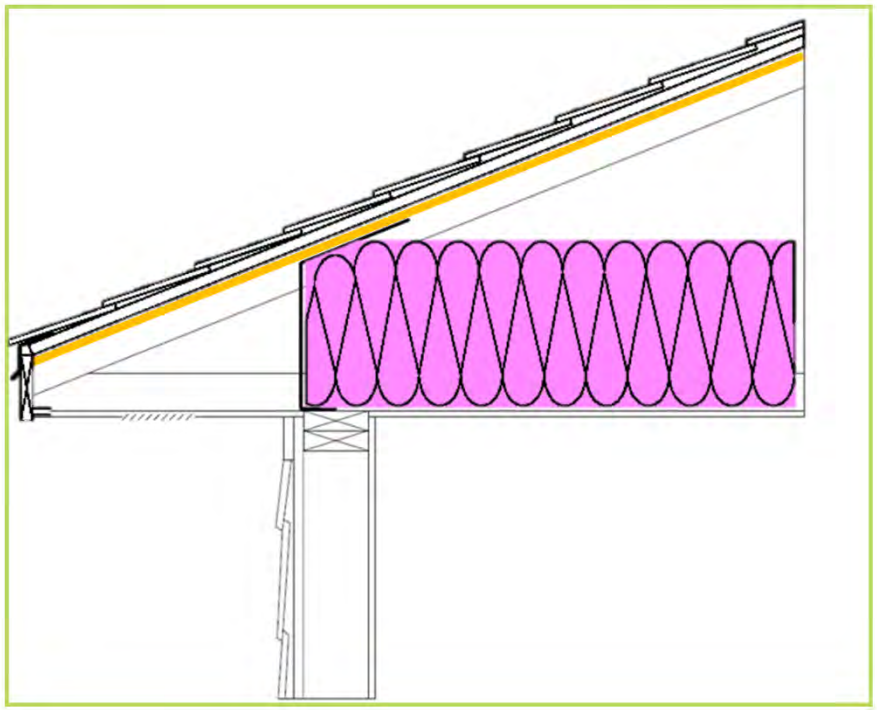
What's an Addition?





- Any change to a building that increases conditioned floor area and conditioned volume.
- Including "infill" such as enclosing a porch

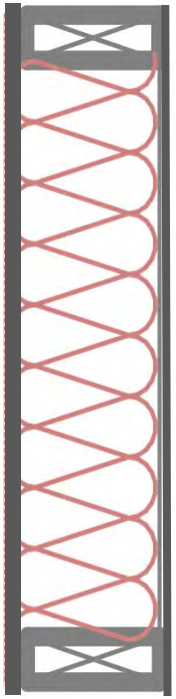
Requirements for an Addition



Roof

- Insulation:
  - ≤700 ft^2: R-22
    - >700 ft^2: Package A
- Cool Roof:
  - >300 ft^2 in CZ 10-15, sloped roof
- Radiant barrier:
  - CZ 2-15, vented attic construction when no below roof deck insulation

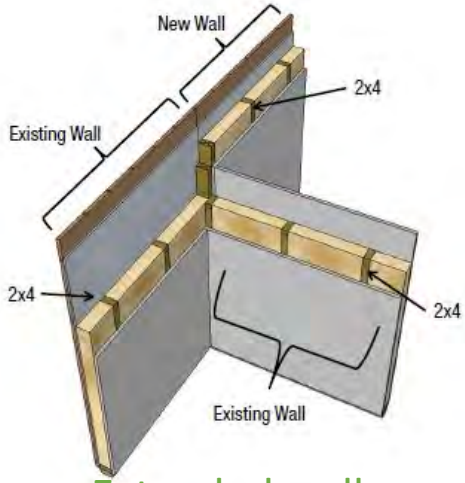
Requirements for an Addition



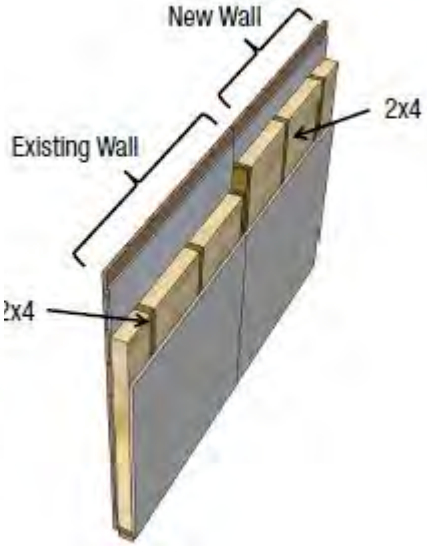
Wall

- Extended walls:
  - 2x4 = R-15
  - 2x6 = R-19
- Non-extended walls: Same as new house (Package A)
  - CZ 1-5 and 8-16
    - U-factor = 0.051
      - 2x4 = R-15 + R-8 (2”)
      - 2x6 = R-19 + R-5 (1”)

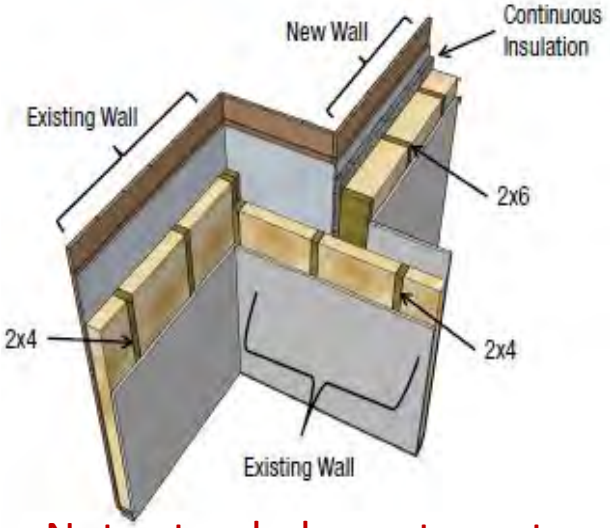
Extended Walls



Extended wall

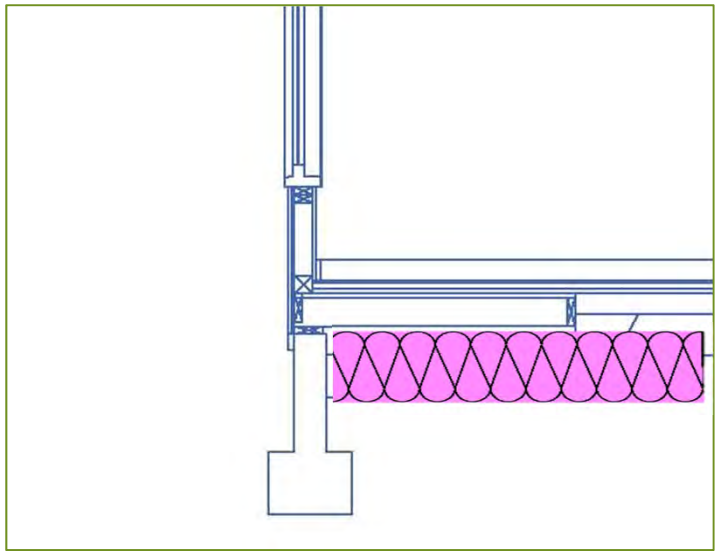


Extended wall



Not extended; must meet Package A

Requirements for an Addition



Floor

- U-factor (raised wood): 0.037
  - R-Value = R-19
- Raised concrete (multi-family)
  - CZ 1, 2, 11, 13, 14, 16 = R-8
  - CZ 12,15 = R-4
  - CZ 3-10 = none
- Slab on grade*
  - None (except for CZ 16)
- Heated Slab*
  - R-5 slab edge insulation

* Climate Zone 16 has other requirements for slabs

Requirements for an Addition

Fenestration Specifications

Area allowed: All Glazing

≤400 ft²:
- 75 ft² or 30% CFA
- West facing 60 ft²*

>400 ≤700 ft²:
- 120 ft² or 25% CFA
- West facing 60 ft²*

>700 ft²:
- 175 ft² or 20% CFA
- West facing 70 ft² or 5% CFA*

Skylights:	U-factor	SHGC*
≤16 ft²	0.55	0.30
>16 ft²	0.32	0.25

Vertical:	U-factor	SHGC*
	0.32	0.25

**CZ 2, 4, 6-16 only*

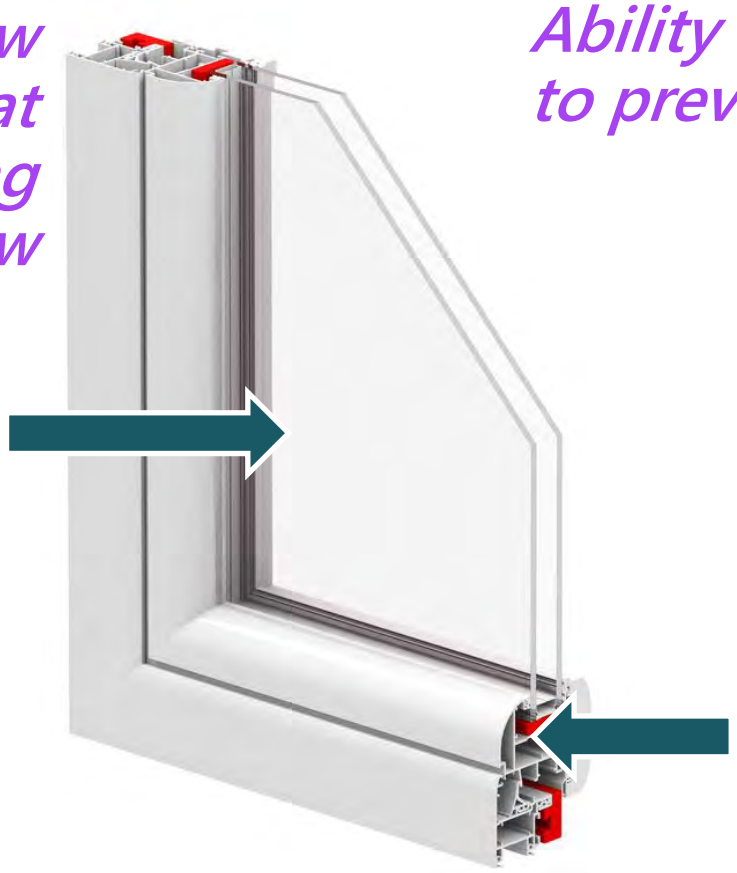
http://www.nfrc.org

Fenestration Performance

SHGC:
Ability of the window to prevent solar heat gain when sun hitting window

U-Factor:
Ability of the window to prevent heat transfer

SHGC= 0.25*
NFRC Rated Low-e[3] product



U-factor = 0.32
NFRC Rated dual paned nonmetal product

*excluding CZ 1,3,5

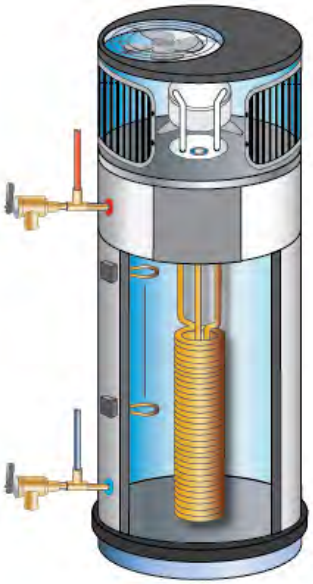
Requirements for an Addition

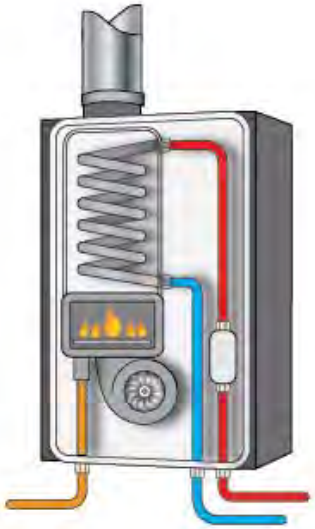
- Ducts
  - Meet insulation requirements
  - HERS duct testing if new extended duct longer than 40 ft.

HVAC

- Air Handler Unit (Furnace or Heat Pump) AND/OR AC Unit
  - Meet minimum efficiency
  - HERS duct testing even if not replacing ducts
  - HERS fan watt draw/airflow if new AC, air handler unit AND ducts
  - HERS refrigerant charge if AC involved in CZ 2, 8-15

Requirements for an Addition





- Replace/Upgrade existing water heater with electric
  - Tank electric resistance can be replaced if not more than 60 gallons
  - Use tank heat pump meeting min. efficiency allowed per CZ

DHW

- Can add (1) gas tankless system (<199,000 BTUH) with addition
  - Meet minimum efficiency
  - If only (1) water heater there already
- Replace/Upgrade existing water heater
  - Gas tank water heater to meet minimum efficiency
  - Gas tank water heater to tankless (meet min. efficiency)

Requirements for an Addition

Appendix JA8: Qualification Requirements for High Efficacy Light Sources — Partial List

Specification	Requirement
Initial Efficacy	≥ 45 lumens/Watt
Power Factor at Full Rated Power	≥ 0.90
Correlated Color Temperapture (CCT)	For inseparable SSL luminaires, LED light engines and GU24 LED lamps, ≤4000 Kelvin. For all other sources, ≤3000 Kelvin.
Color Rendering Index (CRI)	≥90
R9	≥50
Rated Life	≥15,000 hours
Minimum Dimming Level	≤10%
Flicker	<30% for frequencies of 200 Hz or below, at 100% and 20% light output.

This table contains a partial list of requirements. Additional qulification requirements may be found in JA8.

Lighting

- Bathrooms, Utility/Laundry Rooms, Garage
  - One fixture must be on vacancy sensor
- Everywhere
  - Under cabinet lighting switched separately*
  - High efficacy: On/Off switch is allowed
  - JA8-2016/JA-2016-E: Dimmer or vacancy sensor

What's High Efficacy?

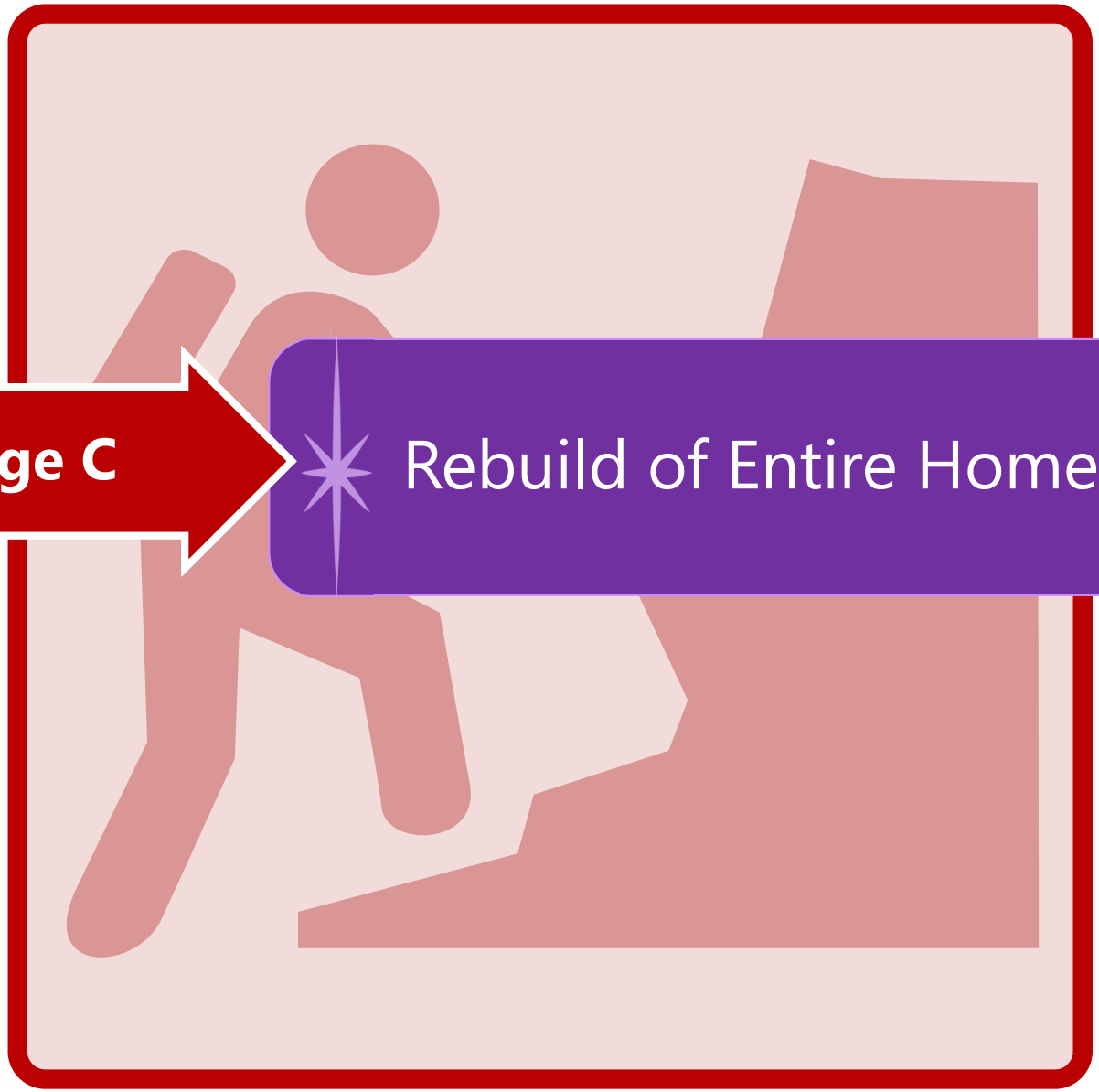
Indoor High Efficacy Luminaires	JA8 High Efficacy Lighting	Recessed Downlights in Ceilings
❑ Pin-based linear fluorescent ❑ Pin-based compact fluorescent ❑ GU-24 other than LEDs ❑ Inseparable SSL luminaires with colored light sources for decorative lighting purpose 	❑ LED luminaires with integral sources ❑ Screw-based LED lamps ❑ Pin-based LED lamps ❑ GU-24 based LED light source  	❑ **Shall not have screw based sockets** ❑ Shall contain JA8-certified light sources 

Outdoor Lighting

- High Efficacy Fixture

- Controls:
  - On/Off switch AND
  - Photocell AND motion sensor OR
  - Photocontrol AND automatic time switch OR
  - Astronomical time clock OR
  - EMCS that provides the functionality of a astronomical time clock AND meets installation criteria of §130.4 AND does not allow the luminaire to always be on, AND is programmed to turn the outdoor lights off during the day.

Challenge C



Challenge C

Rebuild of Entire Home

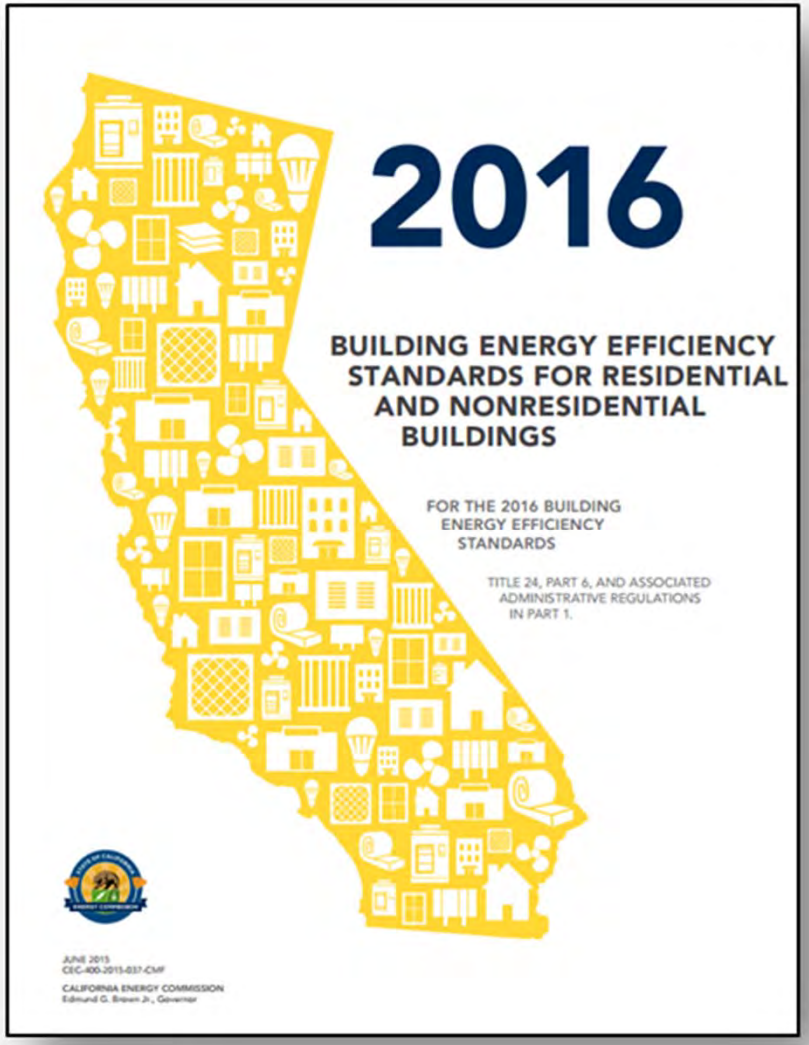
Why?

Energy Code Evolution

- Warren Alquist Act: Energy Code to become more energy stringent every 3 years
- AB 32 "Global Warming Solutions Act" moved us in the direction to use building efficiency to reduce energy use
- SB 350 "Clean Energy and Pollution Reduction Act" sets the goal to double energy efficiency savings by 2030

Which Code Year Applies? Permit pulled….

Jan. 2017- Dec. 2019



Jan. 2020- Dec. 2023

SUBCHAPTER 1
ALL OCCUPANCIES—GENERAL PROVISIONS

SECTION 100.0 – SCOPE

(a) **Buildings Covered.** The provisions of Part 6 apply to all buildings:

1. That are of Occupancy Group A, B, E, F, H, I, M, R, S, or U; and
2. For which an application for a building permit or renewal of an existing permit is filed (or is required by law to be filed) on or after the effective date of the provisions, or which are constructed by a governmental agency; and
3. That are:
   A. Unconditioned; or
   B. Indirectly or directly conditioned ~~by mechanical heating or mechanical cooling~~, or process spaces; ~~or~~
   ~~C. Low-rise residential buildings that are heated with a non-mechanical heating system.~~

EXCEPTION 1 to Section 100.0(a): Qualified historic buildings, as regulated by the California Historic Building Code (Title 24, Part 8). Lighting in qualified historic buildings shall comply with the applicable requirements in Section 140.6(a)3Q.

EXCEPTION 2 to Section 100.0(a): Building departments, at their discretion, may exempt temporary buildings, temporary outdoor lighting or temporary lighting in an unconditioned building, or structures erected in response to a natural disaster. Temporary buildings or structures shall be completely removed upon the expiration of the time limit stated in the permit.

EXCEPTION 3 to Section 100.0(a): Buildings in Occupancy Group I-3 and I-4.

(b) **Parts of Buildings Regulated.** The provisions of Part 6 apply to the building envelope, space-conditioning systems, water-heating systems, pool and spas, solar ready buildings, indoor lighting systems of buildings, outdoor lighting systems, electrical power distribution systems, and signs located either indoors or outdoors, in buildings that are:

1. Covered by Section 100.0(a); and
2. Set forth in TABLE 100.0-A.

(c) **Habitable Stories.**

1. All conditioned space in a story shall comply with Part 6 whether or not the story is a habitable space.
2. All unconditioned space in a story shall comply with the lighting requirements of Part 6 whether or not the story is a habitable space.

(d) **Outdoor Lighting and Indoor and Outdoor Signs.** The provisions of Part 6 apply to outdoor lighting systems and to signs located either indoors or outdoors as set forth in TABLE 100.0-A.

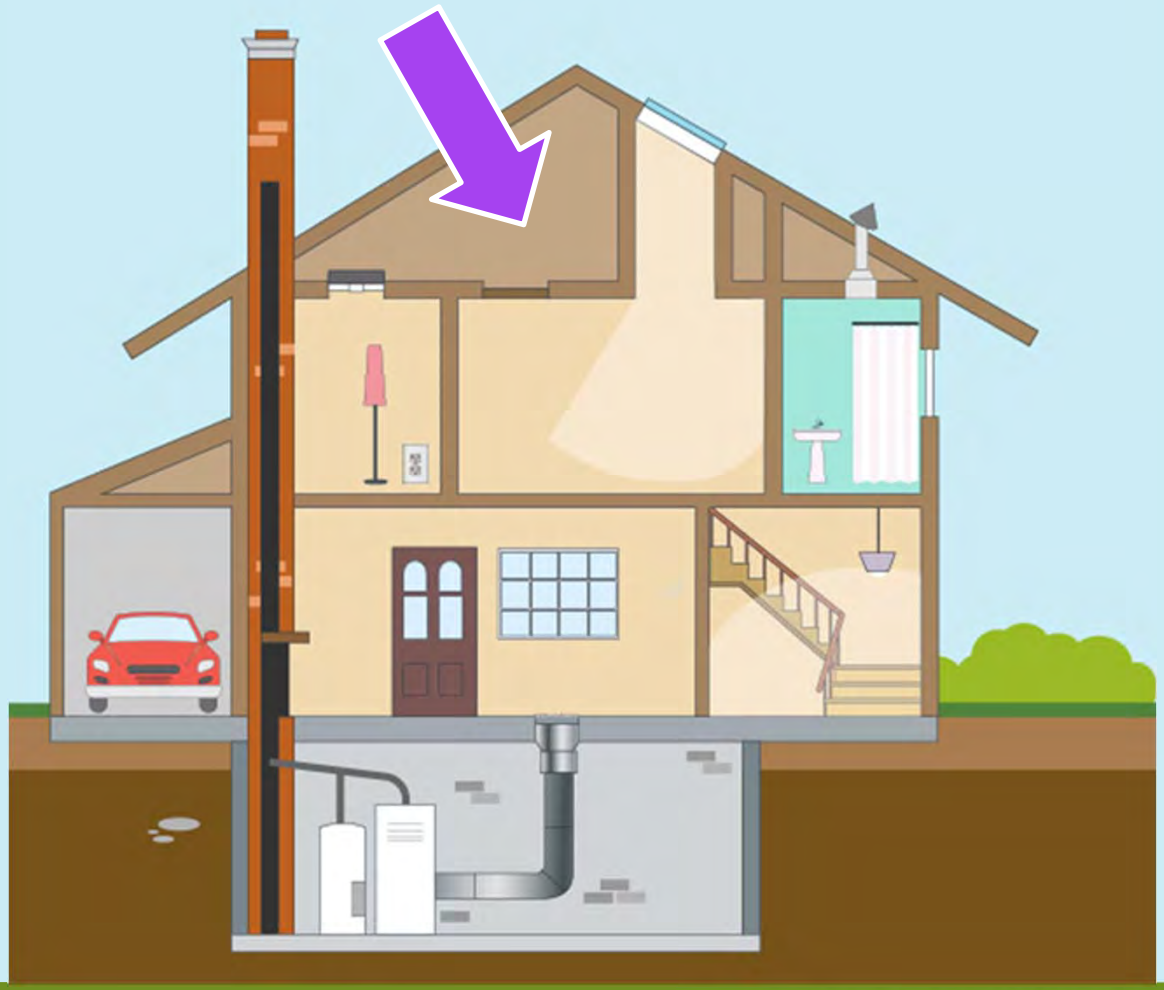
(e) **Sections Applicable to Particular Buildings.** TABLE 100.0-A and this subsection list the provisions of Part 6 that are applicable to different types of buildings covered by Section 100.0(a).

1. **All buildings.** Sections 100.0 through 110.12~~110.10~~ apply to all buildings.

   EXCEPTION to Section 100.0(e)1: Spaces or requirements not listed in TABLE 100.0-A.

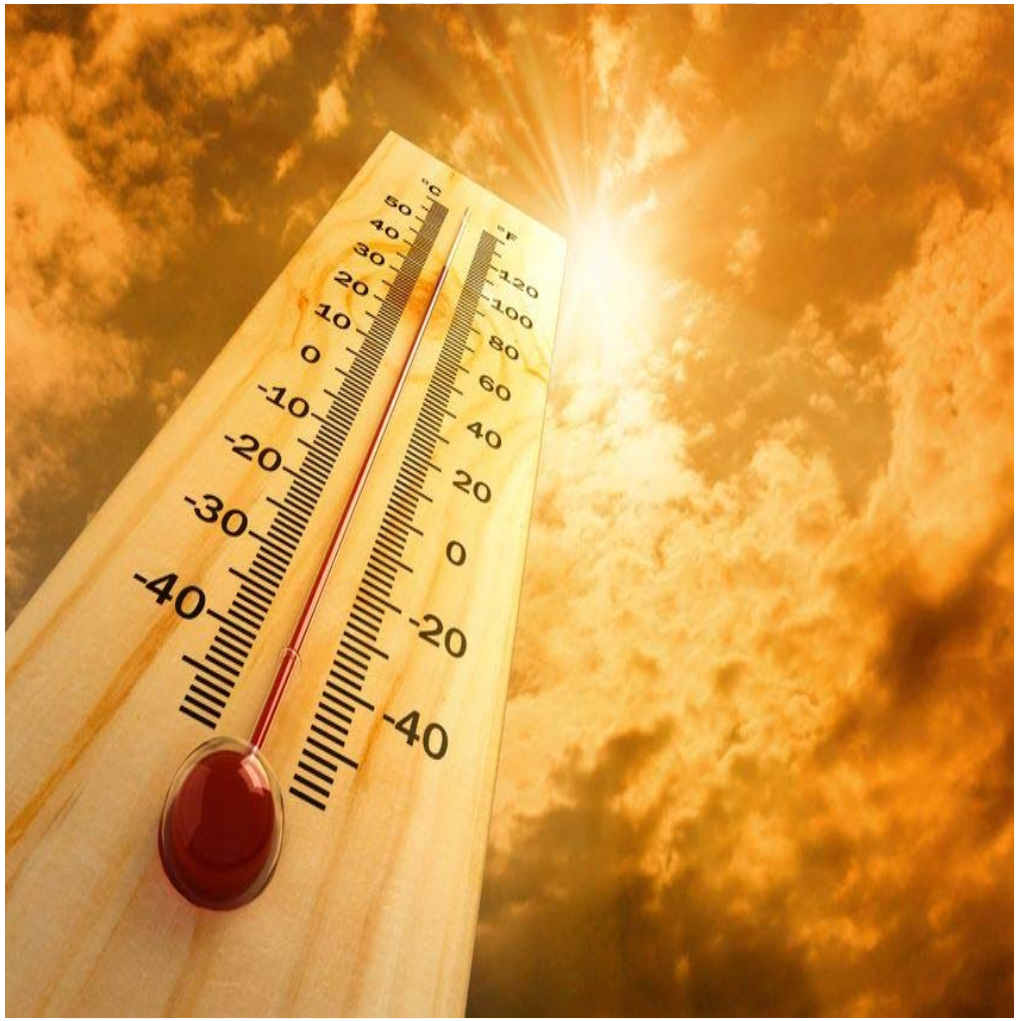
2. **Newly constructed buildings.**
   A. **All newly constructed buildings.** Sections 110.0 through 110.12~~110.10~~ apply to all newly constructed buildings within the scope of Section 100.0(a). In addition, newly constructed buildings shall meet the requirements of Subsections B, C, D or E, as applicable.

Attics



HELPING YOU PLAY YOUR CARDS RIGHT

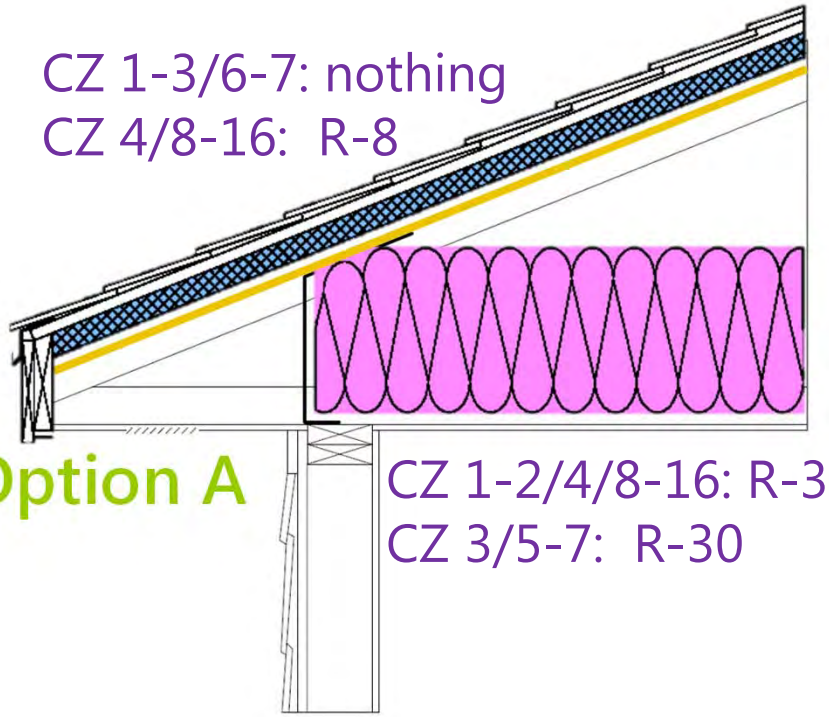
High Performance Attic: Intent



- High Performance Attics (HPA) is a package of measures that minimizes the temperature difference between the attic and the conditioned air in ducts.

High Performance Attic: Evolution

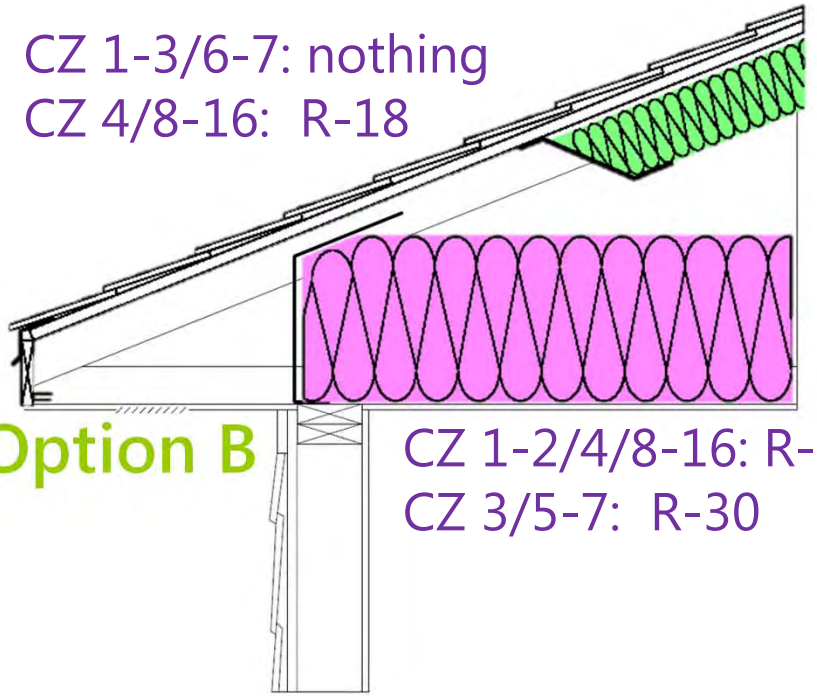
CZ 1-3/6-7: nothing
CZ 4/8-16: R-8



Option A

CZ 1-2/4/8-16: R-38
CZ 3/5-7: R-30

CZ 1-3/6-7: nothing
CZ 4/8-16: R-18



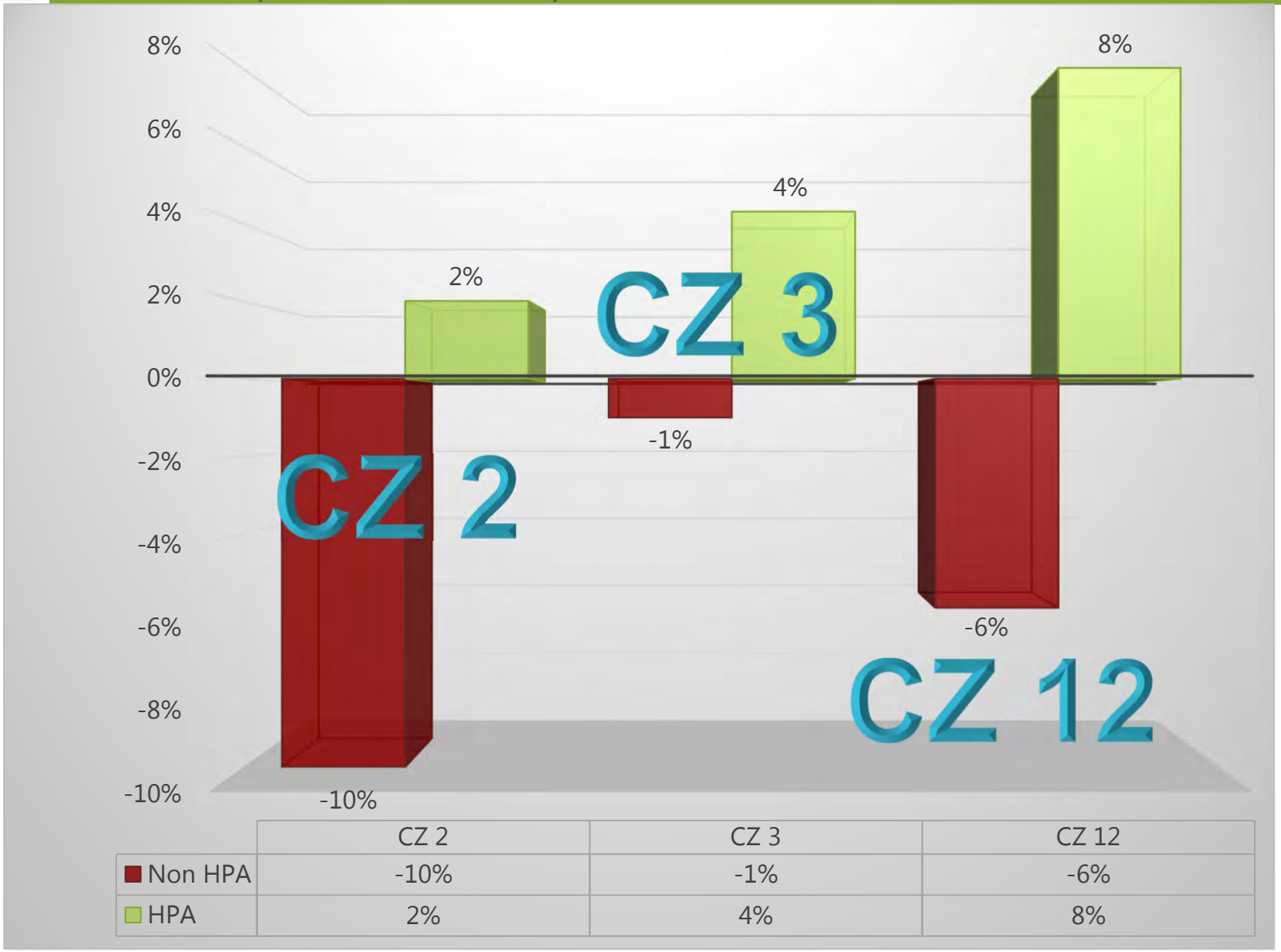
Option B

CZ 1-2/4/8-16: R-38
CZ 3/5-7: R-30

*No air space

Below Roof Deck Insulation Options

Compliance Impact

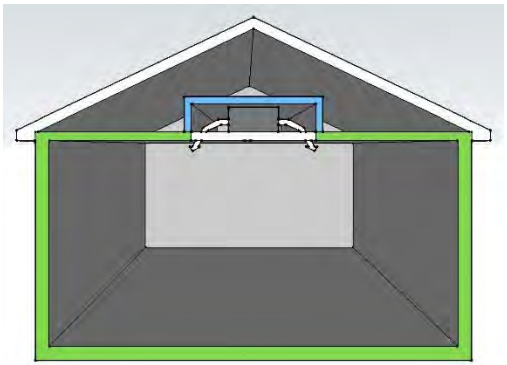


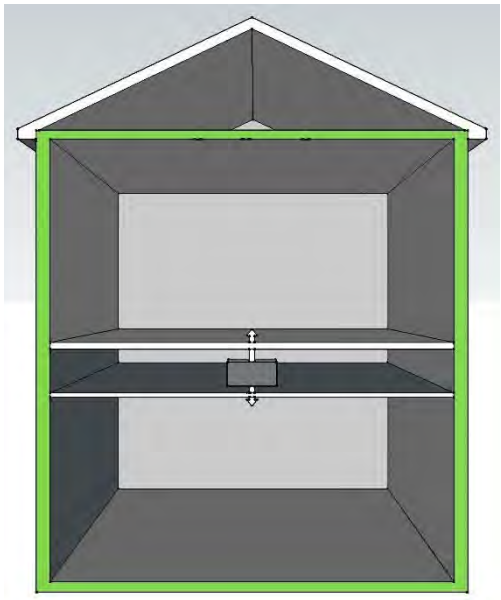
	CZ 2	CZ 3	CZ 12
Non HPA	-10%	-1%	-6%
HPA	2%	4%	8%

HPA: Option C

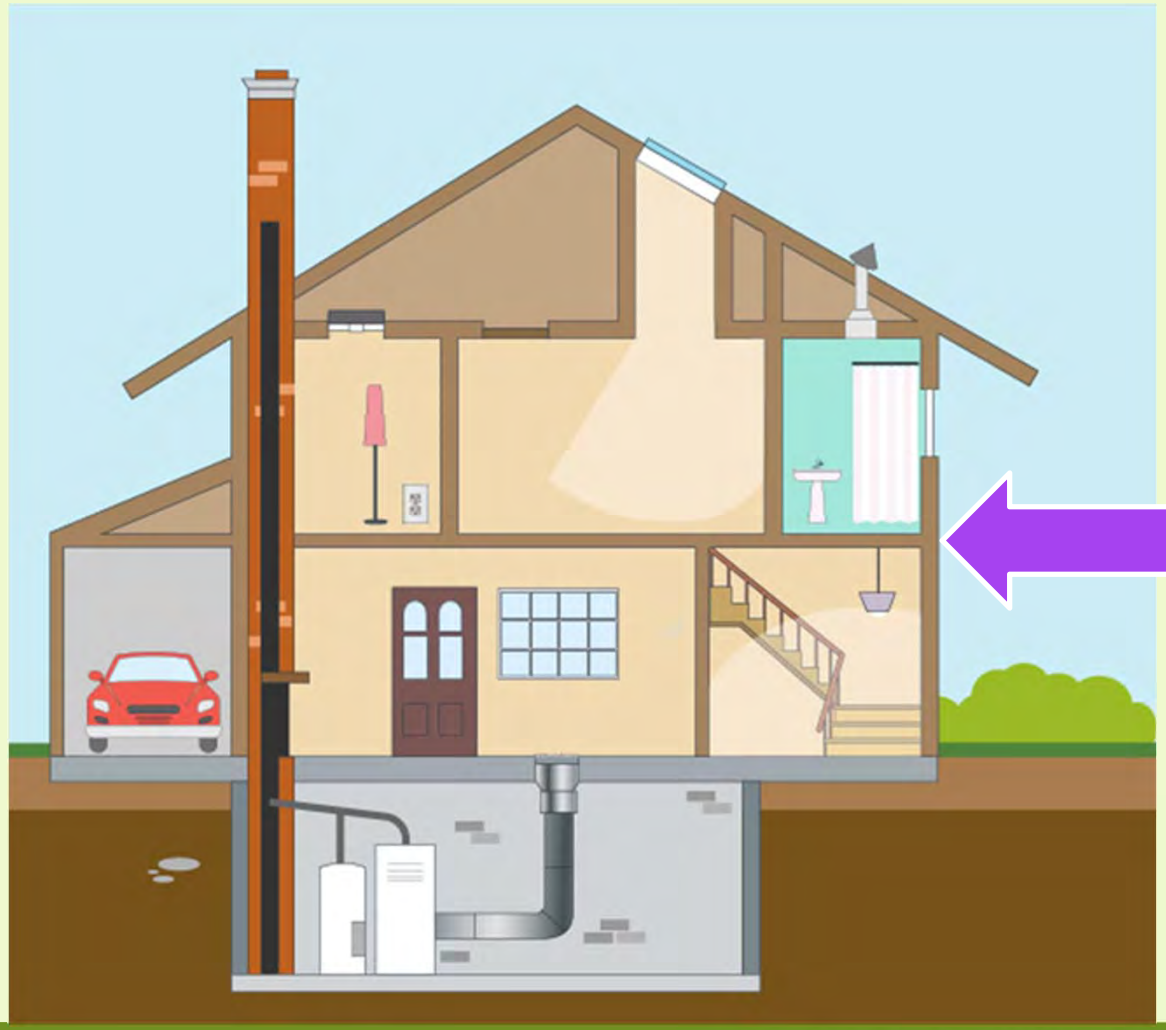
Basic Design: 3 Options

In a plenum (box or scissor truss)	Dropped ceiling soffit	Open-Web floor truss in two story homes





Walls and Windows



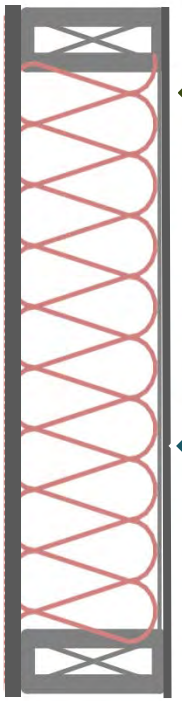
High Performance Wall: Intent

- The Residential High Performance Walls measure is intended to increase the performance of the residential envelope, reducing the amount of heat transfer through walls and thus reduce HVAC loads.

The most common thermal bridges in residential buildings are from the framing members. In wood framed construction, the framing, while not highly conductive, still provide less thermal resistance than common cavity insulation materials and therefore reduces the effective thermal resistance of the wall assembly.

Buyers Guide to Continuous Insulation; Written by Building Science Corporation for Dow

High Performance Wall: Evolution

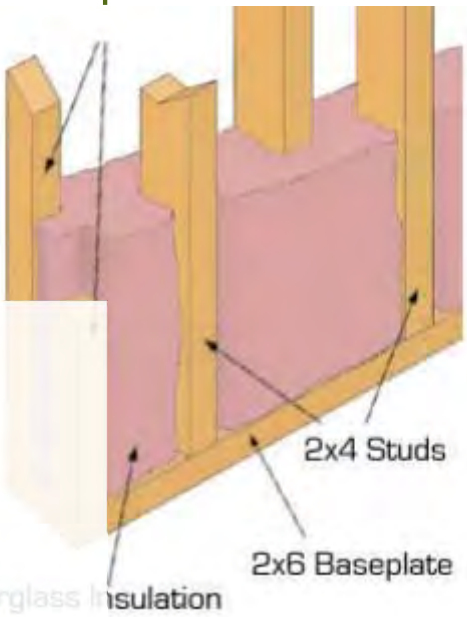


Old Way
Cavity insulation

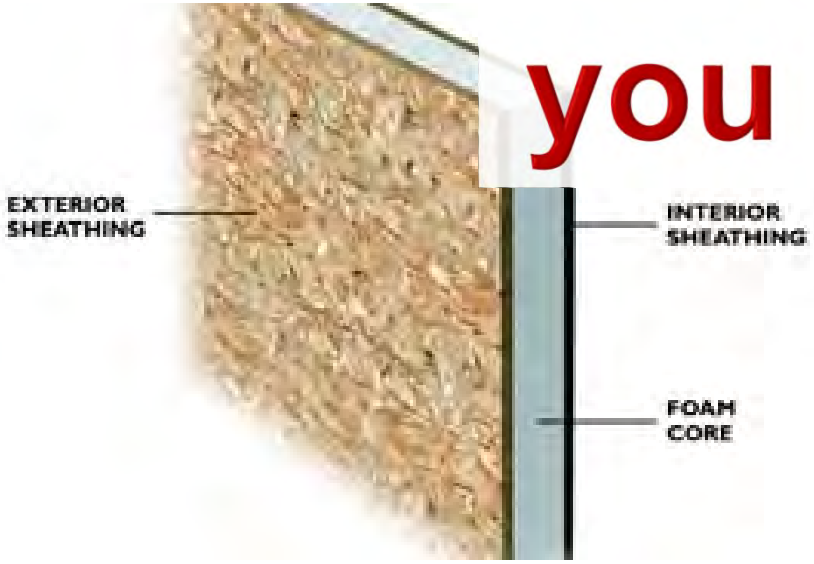
New Way
U-factor: 0.051 (2 x 6 with R-19 + R-5)

High Performance Wall Options

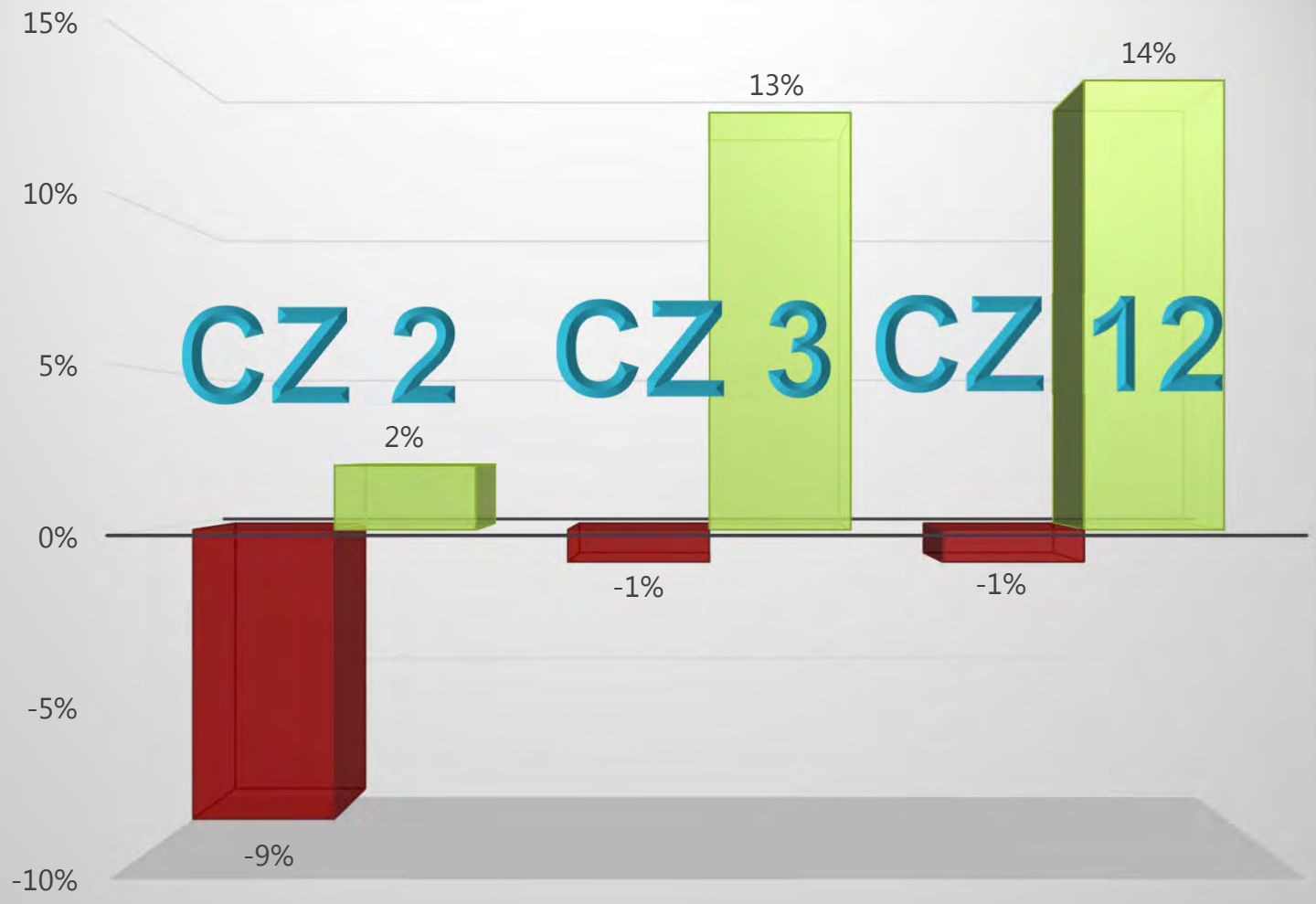
Source: SPFA



Which one do you like?

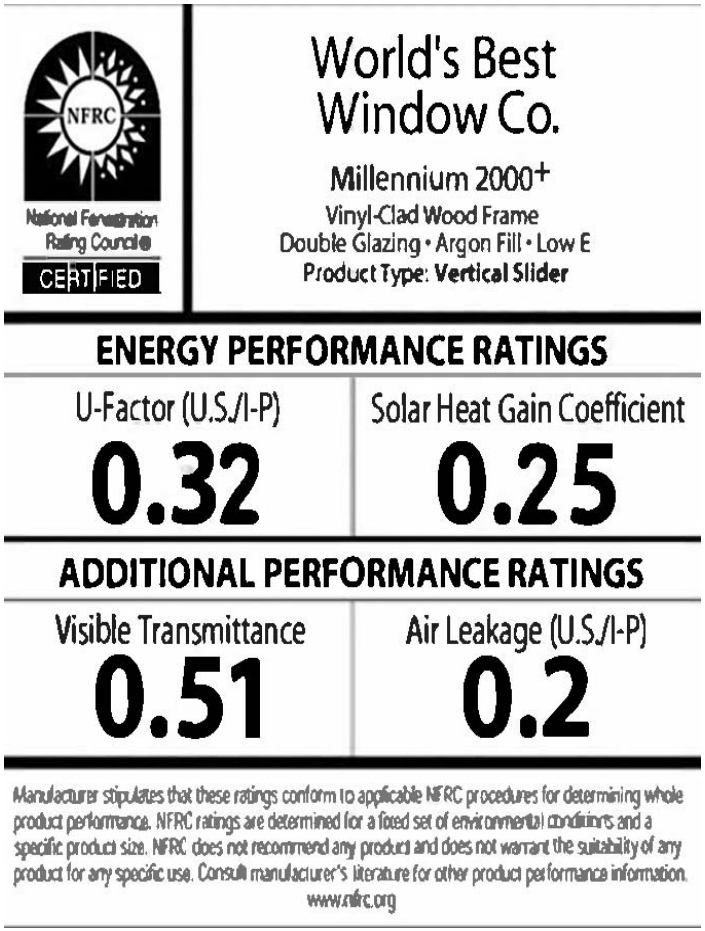


Compliance Impact



	CZ 2	CZ 3	CZ 12
2x4 R-15	-9%	-1%	-1%
2x6 R-21 and R-4	2%	13%	14%

High Performance Window: Intent



- Fenestration has a significant impact on heating and cooling loads in a home.
- The size, orientation, and types of fenestration products can dramatically affect the overall energy performance of a house.
  - Fenestration area limitations, some of which is dependent upon orientation.
  - Products expected to be NFRC rated verifying performance of product.

Fenestration Area

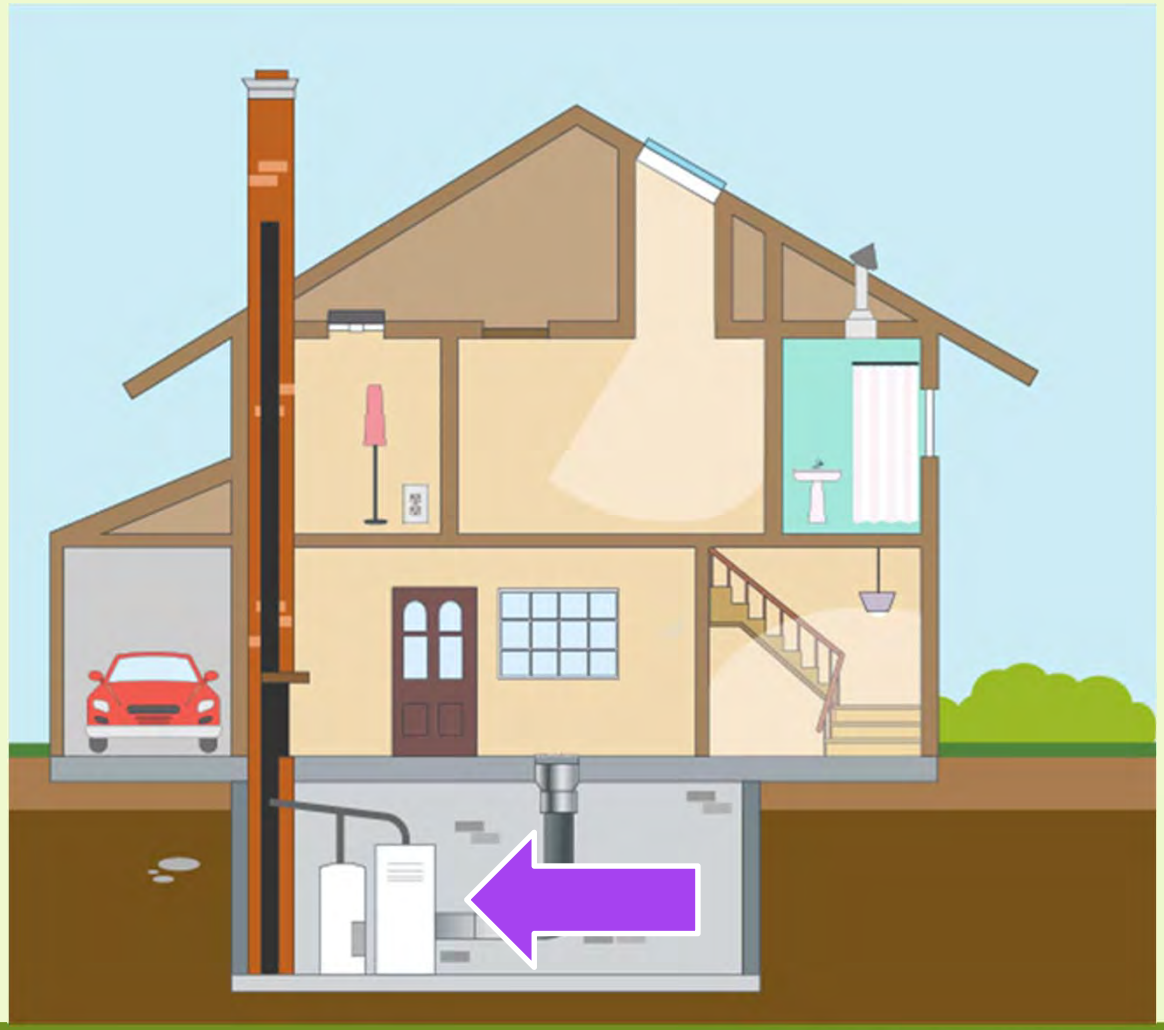
How Much?

- We look at energy use as a "TDV" evaluation:
  - What **T**ime is the energy being used,
  - **D**ependent on where the building is located,
  - And looking at the **V**alue of the energy source required.

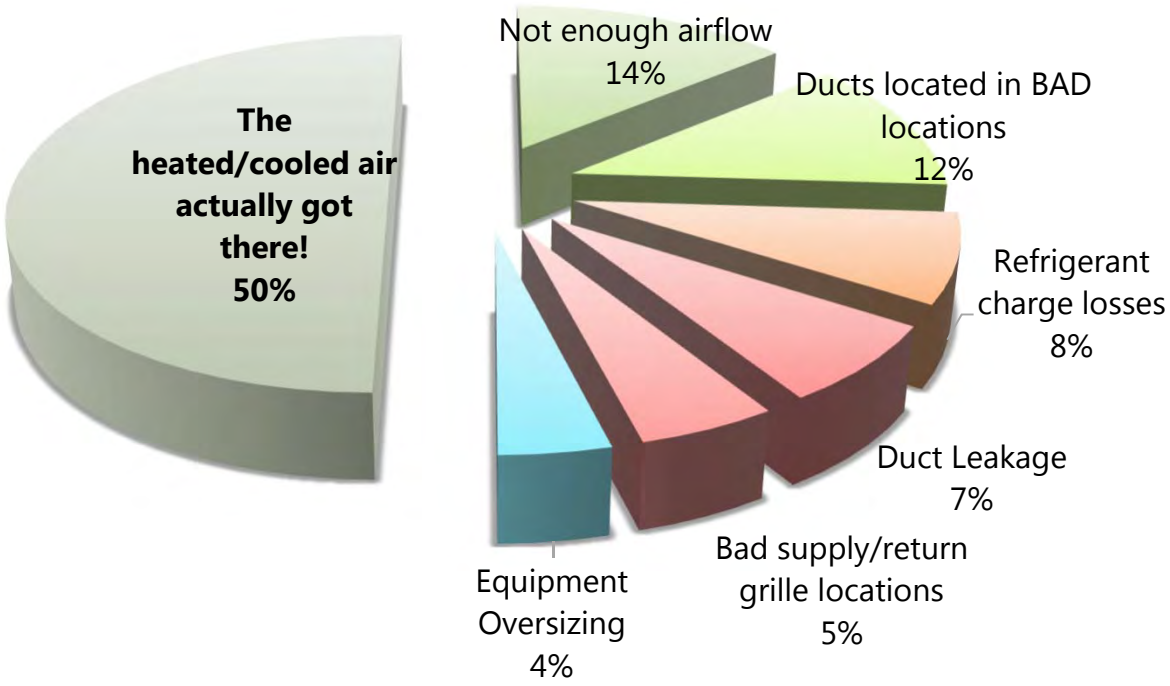
- **20% vertical fenestration** area to conditioned floor area
  - 2,000 sq. ft. home = 400 sq. ft. of glass window and/or glass doors
- **5% West* facing** fenestration area to conditioned floor area
  - 2,000 sq. ft. home = 100 sq. ft. of facing west

*excluding CZ 1,3,5

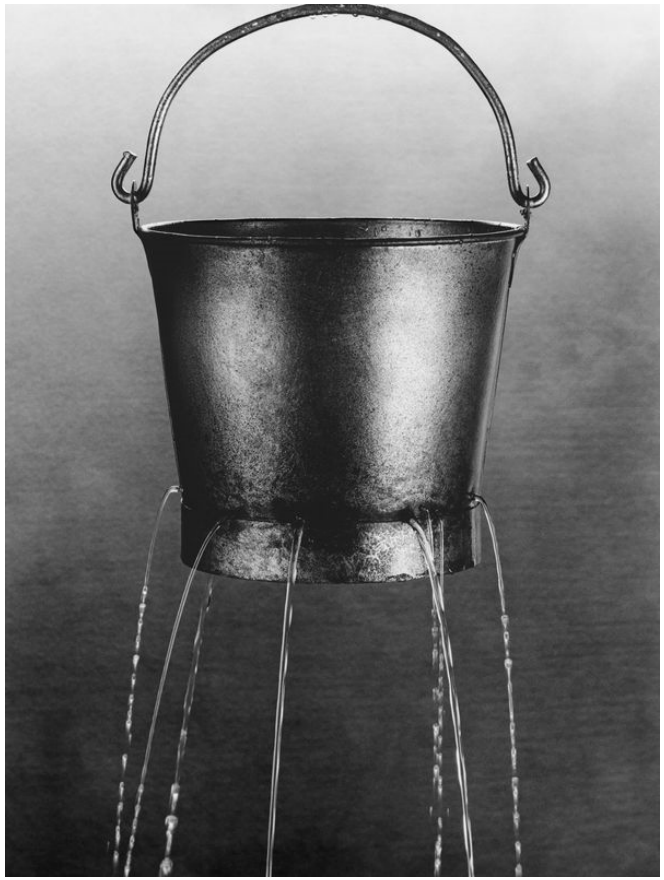
Mechanical Systems



What Can Go Wrong?



Duct leakage

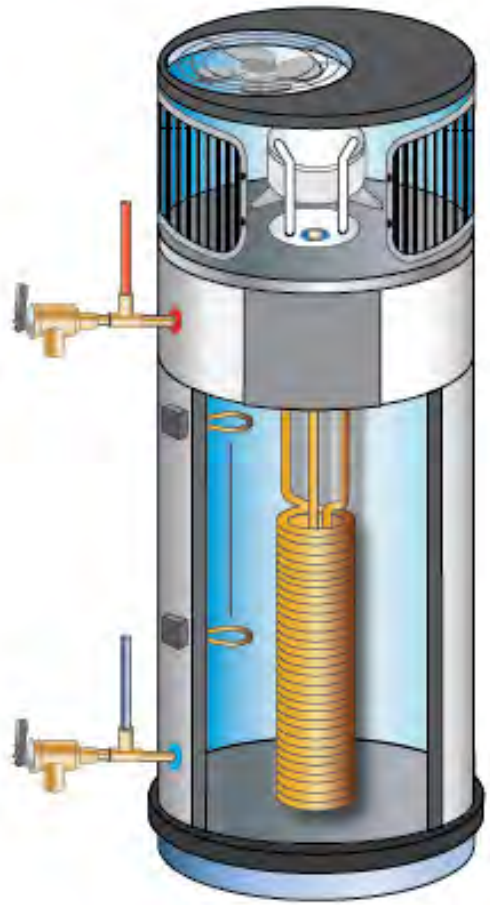


HERS (Home Energy Rating System)

- Required verification of:
  - Duct Leakage
  - AC equipment:
    - Cooling Airflow
    - Fan watt draw
    - Refrigerant charge
  - Ventilation

- Extra Credit
  - Ducts in conditioned space
  - Verification of high efficiency HVAC equipment
  - Quality Insulation Installation (QII)

Domestic Hot Water



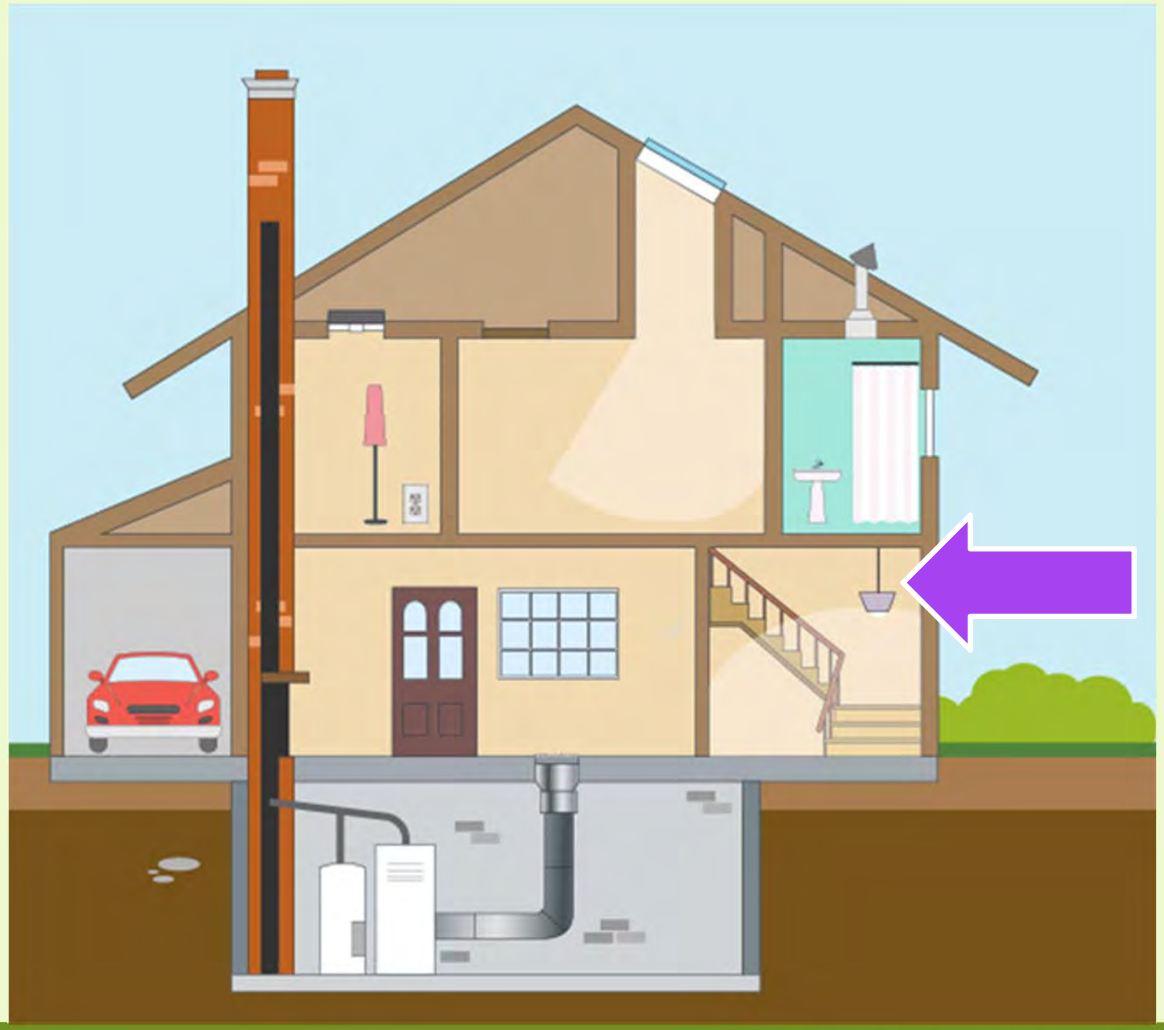
Minimize the Wait

- On-demand tankless gas unit
  - If natural gas available in neighborhood

But..I don't want gas

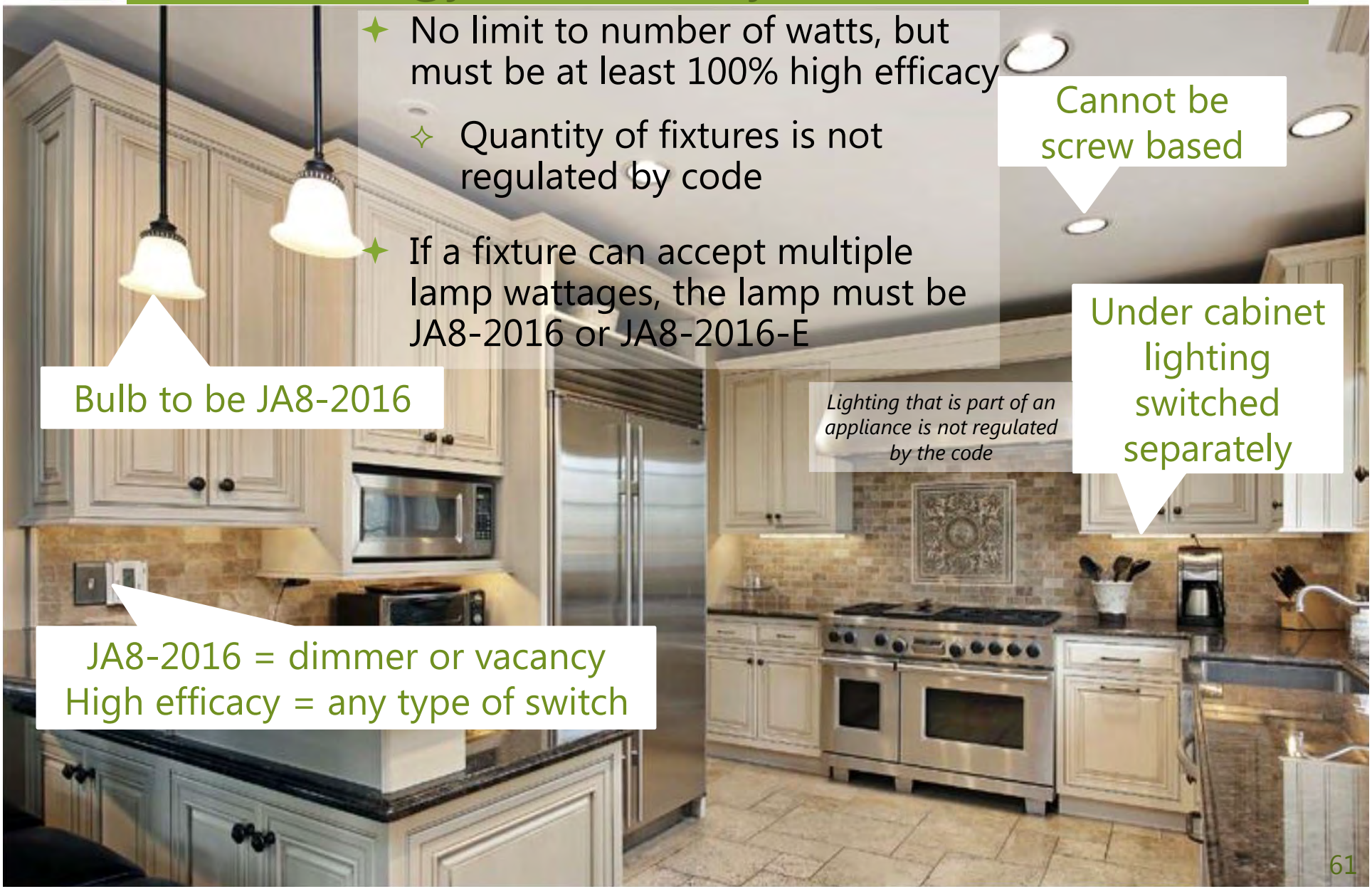
- High Efficiency heat pump water heater
  - Will need to make improvements to design to allow for this type of water heater such as (but not limited to):
    - PV system
    - Solar hot water system

Lighting and PV



Technology – Room by Room

Kitchen



- No limit to number of watts, but must be at least 100% high efficacy
  - Quantity of fixtures is not regulated by code
- If a fixture can accept multiple lamp wattages, the lamp must be JA8-2016 or JA8-2016-E

Cannot be screw based

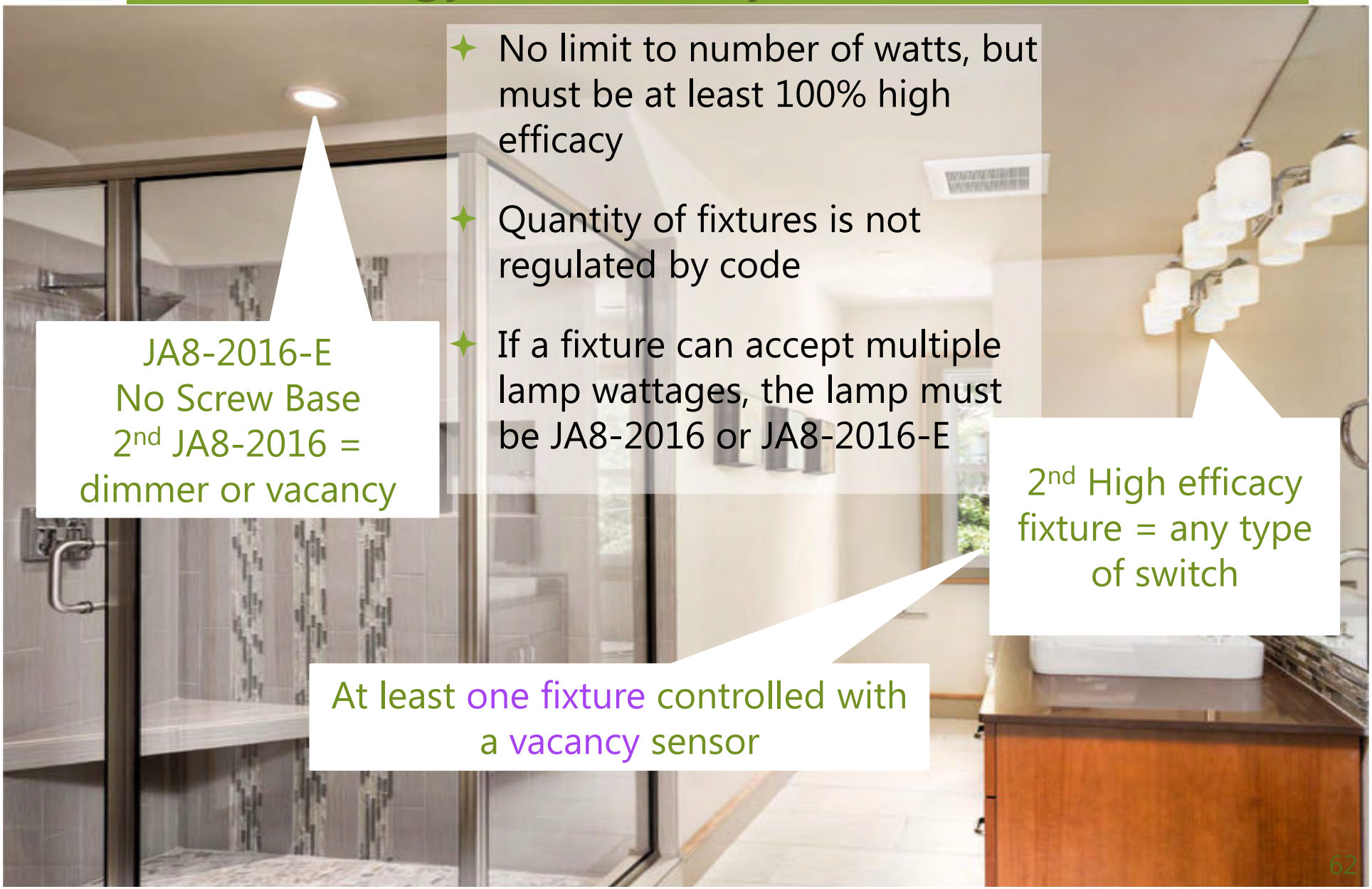
Bulb to be JA8-2016

Lighting that is part of an appliance is not regulated by the code

Under cabinet lighting switched separately

JA8-2016 = dimmer or vacancy
High efficacy = any type of switch

Technology – Room by Room Bathroom



- No limit to number of watts, but must be at least 100% high efficacy
- Quantity of fixtures is not regulated by code
- If a fixture can accept multiple lamp wattages, the lamp must be JA8-2016 or JA8-2016-E

JA8-2016-E
No Screw Base
2nd JA8-2016 = dimmer or vacancy

2nd High efficacy fixture = any type of switch

At least one fixture controlled with a vacancy sensor

Residential PV Systems

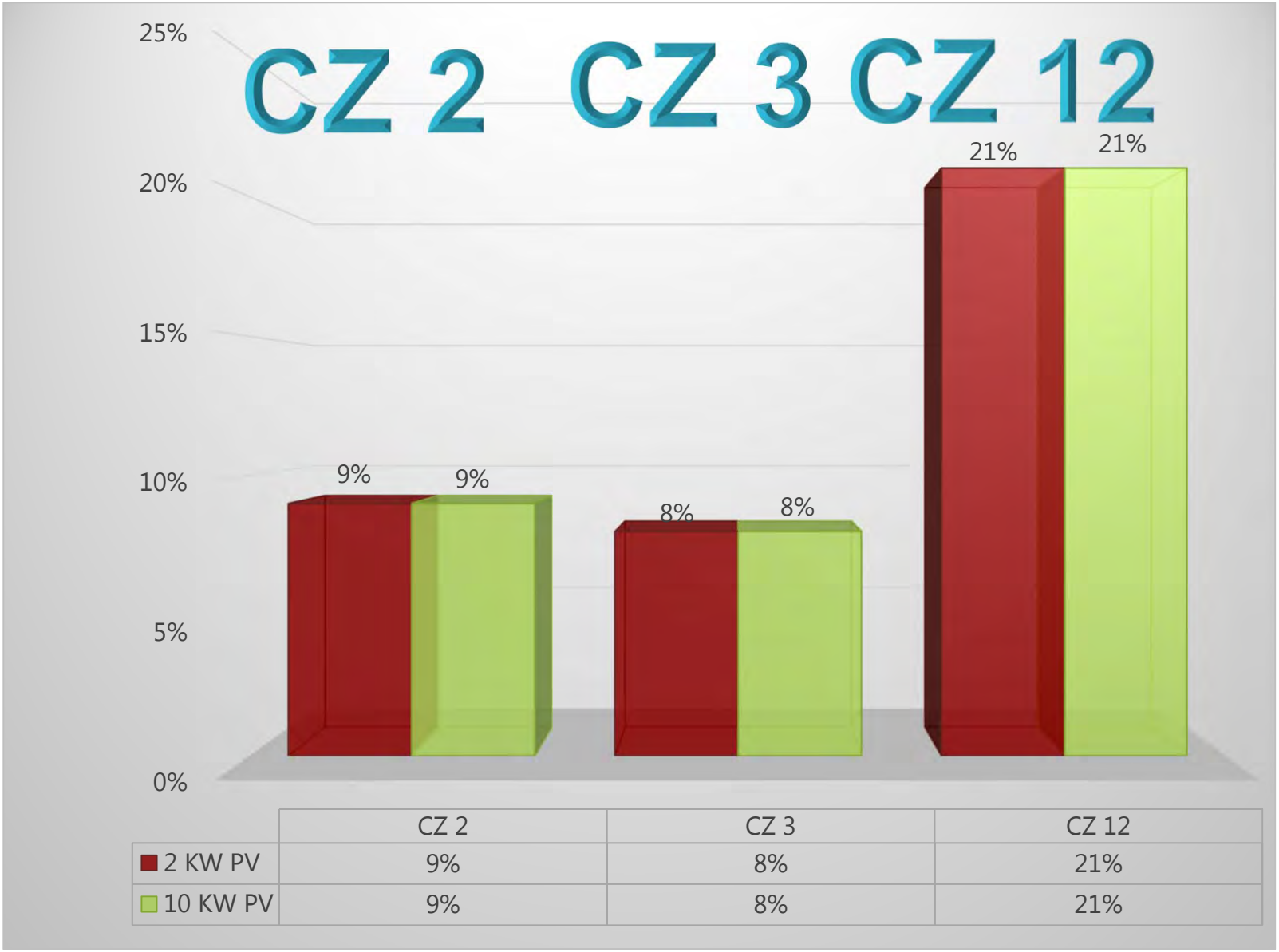
* kilowatts direct current

A typical 1kWdc system often has approximately four PV panels

PV Credit

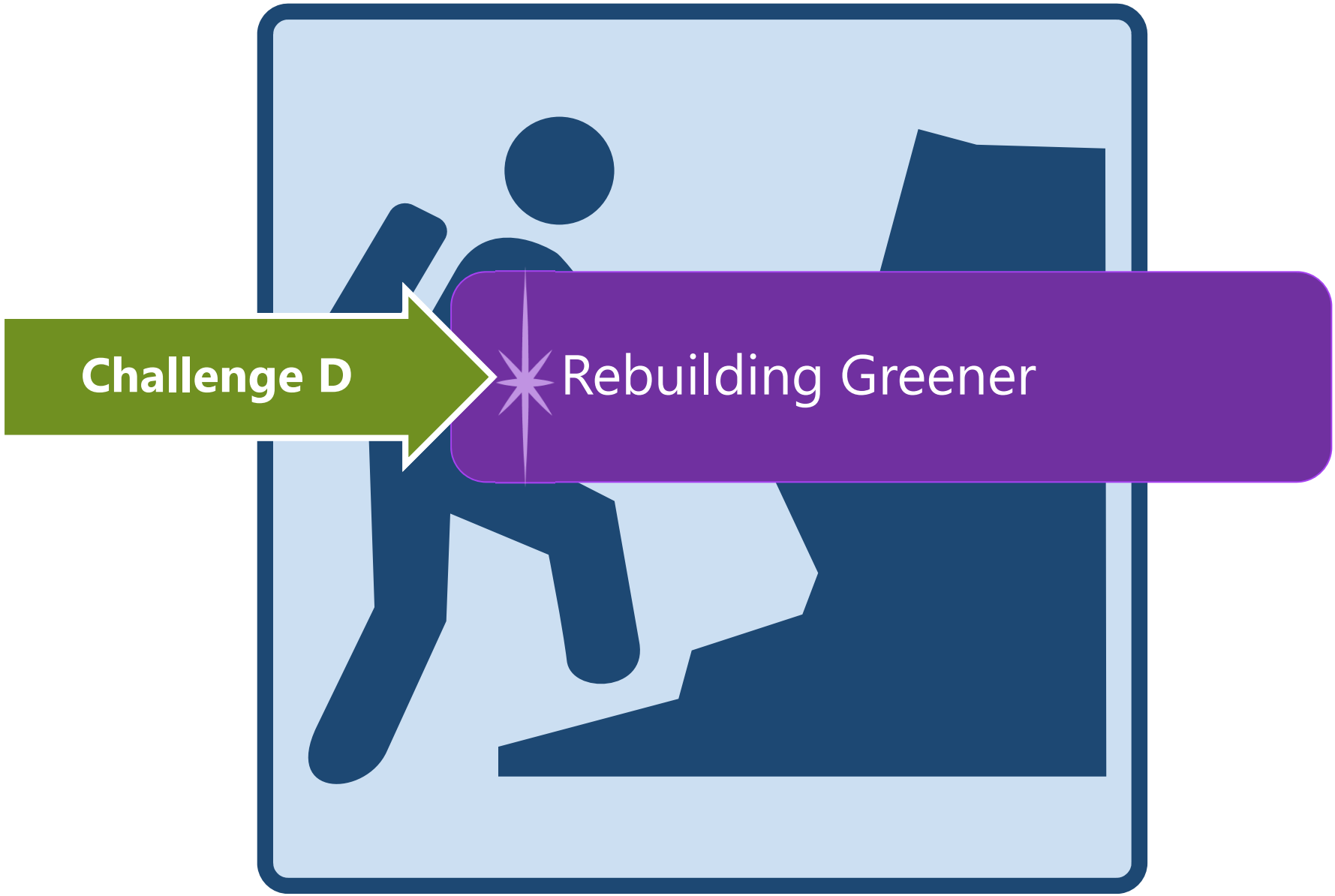
- The PV System Credit is available only if:
  - The Performance Approach is used
  - The project is in:
    - Climate Zones 1-5, 8-16
  - The system is:
    - ≥ 2 kWdc* for Single Family
    - ≥ 1 kWdc* for Multi Family
    - The amount of credit will depend upon the Climate Zone and the Conditioned Floor Area of the dwelling.

Compliance Impact



	CZ 2	CZ 3	CZ 12
2 KW PV	9%	8%	21%
10 KW PV	9%	8%	21%

Challenge D



Look How Far We Have Come

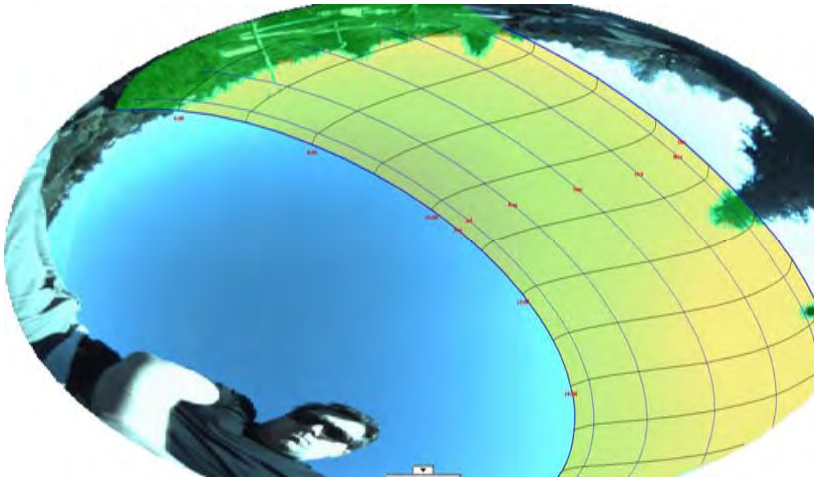
Cottle Net Zero Energy Home

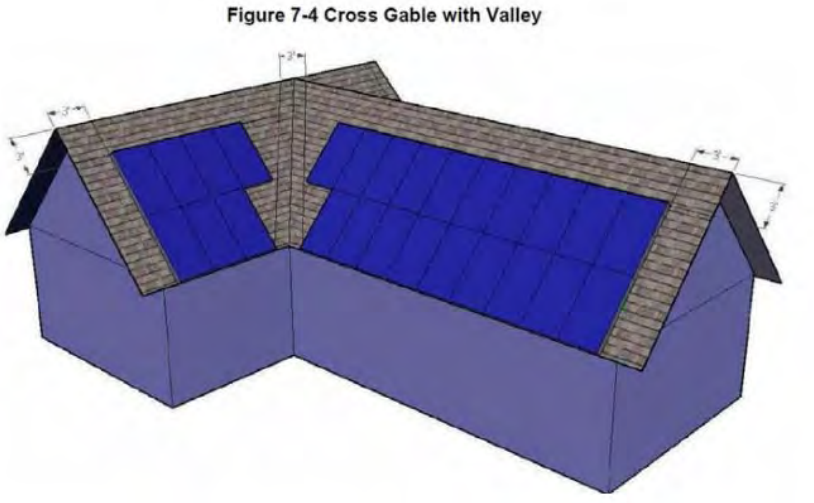
Design | Build: The Cottle Zero Energy Home was the **1st Net Zero Energy new home in California** and is recognized as one of the highest-performance, greenest and most energy efficient homes in the State. It was awarded a special commendation by the California Energy Commission. It boasts all the features you would expect in a custom luxury home in Silicon Valley, and much more. Explore the information, document links and videos below to learn about this ground-breaking contemporary home redefining performance standards for indoor air quality, comfort, energy and water efficiency, and of course, modern style and luxury.

Beyond Code Thinking

Solar Ready for Single Family Residences

- NOT Required by 2016 Code -> Only for developments >10 Units
  - -GOOD IDEA? YES!
    - **Conduits for future installation**
    - **Electrical Infrastructure Ready**
    - **Roof Designed for Solar with Orientation and Structure**
    - **Battery Ready**
    - **Electrical Vehicle Ready (Part – 11 CALGreen)**





Beyond Code Thinking

Advanced Home Controls

- NOT Required by 2016 Code ->
  - -GOOD IDEA? YES!
    - **Learning Thermostats**
    - **IoT Connected Appliances**
    - **EnergyStar Appliances**
    - **HVAC Systems Dual Speed, Variable Speed,**
    - **Advanced Zoning Control for Sleeping & Living Areas**

ENERGY STAR

Engaging Customers in the Supply Chain

By 2020, in SCE's service area there may be as many as 10 million intelligent devices[1] linked to the grid providing sensing information and automatically responding to prices/event signals

1. Includes smart meters, energy smart appliances and customer devices, electric vehicles, DR, inverters and storage technologies

Beyond Code Thinking

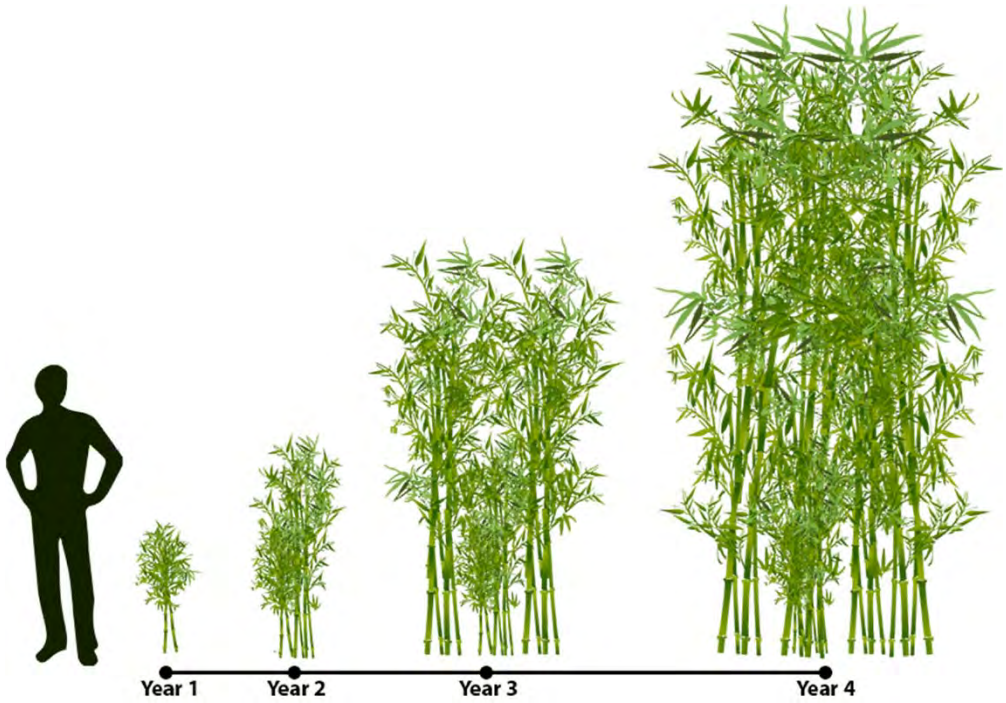
Advanced Third Party Inspections

- NOT Required by 2016 Code ->
  - -GOOD IDEA? YES!
    - **QII Inspection**
    - **Blower Door Infiltration Reductions**
    - **HVAC Balancing, Airflow and IAQ Enhancements**
    - **Whole House Fan Temperature Controls and Night Flush**
    - **Refrigerant Charge Testing**
    - **Solar PV Startup & Inverter Calibration**
    - **Coordinating Advanced Learning Thermostats**

Beyond Code Thinking

Advanced Construction & Green Materials

- NOT Required by 2016 Code ->
  - -GOOD IDEA? YES!
    - **Sustainable Insulation**
    - **Advanced Framing to reduce materials**
    - **Fly Ash Concrete**
    - **Rapidly Renewable Construction Materials like Strawbale, Cork, Bamboo**
    - **Living Future Institute Redlist https://living-future.org/declare/declare-about/red-list/**



Beyond Code Thinking

Decoding * Recovery™
Let's Talk Residential Rebuilding

Insulation Guide

Insulation Material	R-value per inch	Appearance	Advantages	Disac
Batt Type				
Fiberglass	3-3.7		Readily available	Must correctly
Mineral Wool	2.8-3.7		Somewhat better fire resistance and soundproofing than fiberglass; Good for water drainage.	Same
Cotton	3-3.7		Environmentally friendly	Not rea In
Loose Fill				
Fiberglass	3-3.7		Easier to install correctly	Must b (insul
Boxed Netting Fiberglass	3-3.7		Below roof deck insulation; Less expensive than spray insulation	More I than spr
Mineral Fiber	2.8-3.7		Easier to install correctly	Mu (insul
Cellulose Fiber	3-3.7		Provides more resistance to air movement than other loose fill	Mu (insul

Decoding * Recovery™
Let's Talk Residential Rebuilding

Insulation Material	R-value per inch	Appearance	A
Board S			
Type I & II Expanded Polystyrene or EPS	3.6-4.4		
Type III & IV extruded polystyrene or XPS	4.5-5		W
Rigid Fiberglass	4.2-4.5		Dr
Rigid Mineral Fiber	4.2-4.5		Dr
Polyisocyanurate or ISO	5.6-6.7		Cl Va
Expanded Polystyrene Tile Roof Installation Product	R-6 for product		Al
Insulated Roof Tiles	R-7-14 for product		F

Decoding * Recovery™
Let's Talk Residential Rebuilding

Insulation Guide

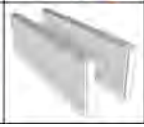
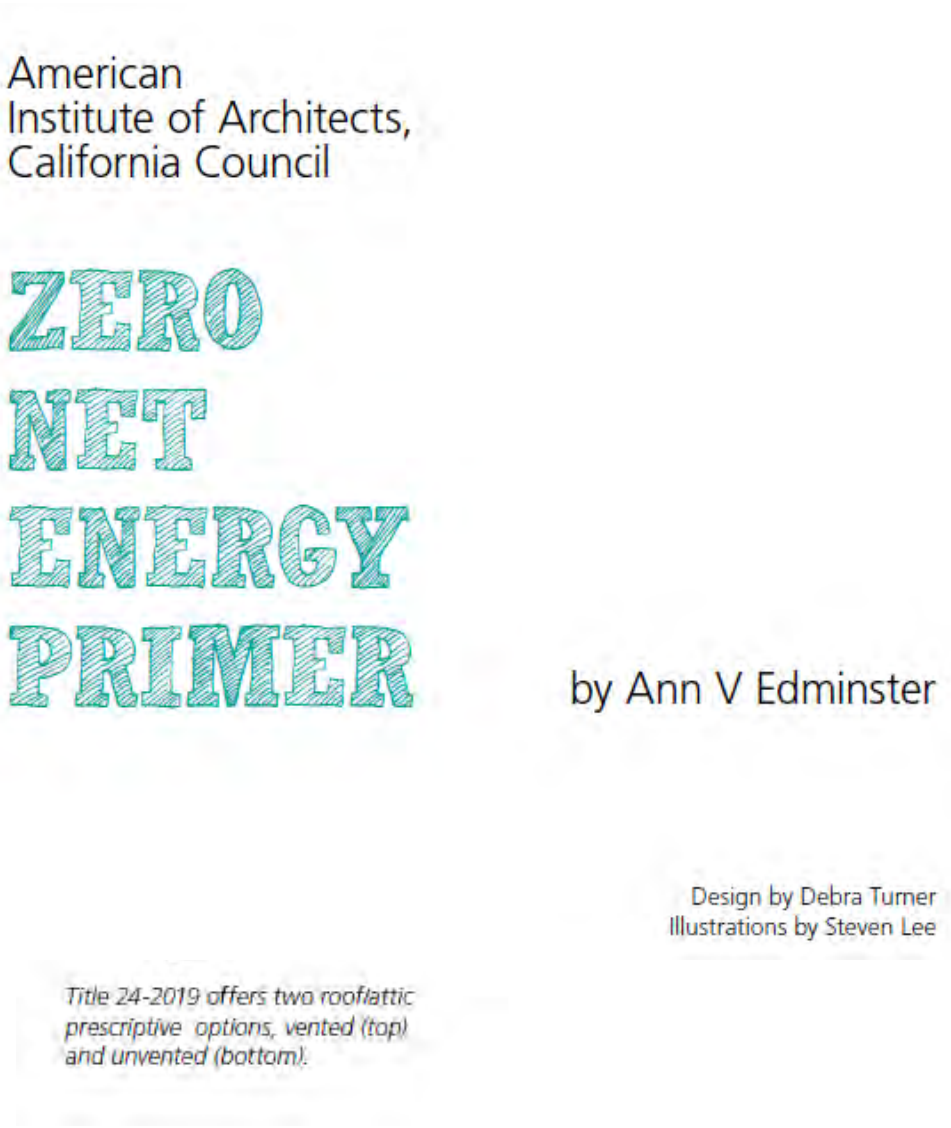
Insulation Material	R-value per inch	Appearance	Advantages	Disadvantages	Product Highlights
Spray Applied					
Wet Spray Cellulose	3-3.7		Low labor costs, environmental benefits, fewer gaps	Adhesive mixed with insulation; must dry before any other sub can enter space	any loose cellulose product fixed with water or adhesive
Spray -applied fiberglass insulation	4.2-4.3		Higher R-value than spray cellulose	Lower recycled content than typical spray cellulose	JM Spider
Open-cell Light Density Polyurethane	3.6		Low labor costs	Must be covered; more expensive than batt	Icynene; Demilec
Closed Cell Medium Density Polyurethane	5.5-6		Can act as the air barrier and vapor retarder.	HFC usually used in production. Must be covered.	Icynene; Demilec
Other					
Structural Insulated Panel Systems (SIPs)	depends on insulation used		Quick installation, good thermal performance and structural integrity	More expensive than alternatives; unfamiliar to builders; building must be designed with product in mind	Thermocore; Structural Insulated Panel Association
Exterior Insulation and Finish Systems (Synthetic Stucco/EIFS)	depends on rigid insulation used		Finish and continuous insulation in one product	Special attention must be paid to drainage detailing	EIFS Industry Members Association (EIMA)
Insulating Concrete Form (ICFs)	depends on the details of the ICF blocks		Fire resistant, durable and energy efficient	More expensive than alternatives; unfamiliar to builders; building must be designed with product in mind	Concrete.org: http://bit.ly/2FkqdDP

Image Credit:
Mineral wool photo from Knauf Insulation
Pink fiberglass winter wonderland (CC BY 2.0) by mikemol
Tile Roof Insulation - Courtesy of CHP - Master Builder Advanced Home Design and Building Practices 2016 Code Readiness Program
Insulating Concrete Form –FEMA News Photo Photo by Kent Baxter - Nov 22, 2001

Beyond Code Thinking

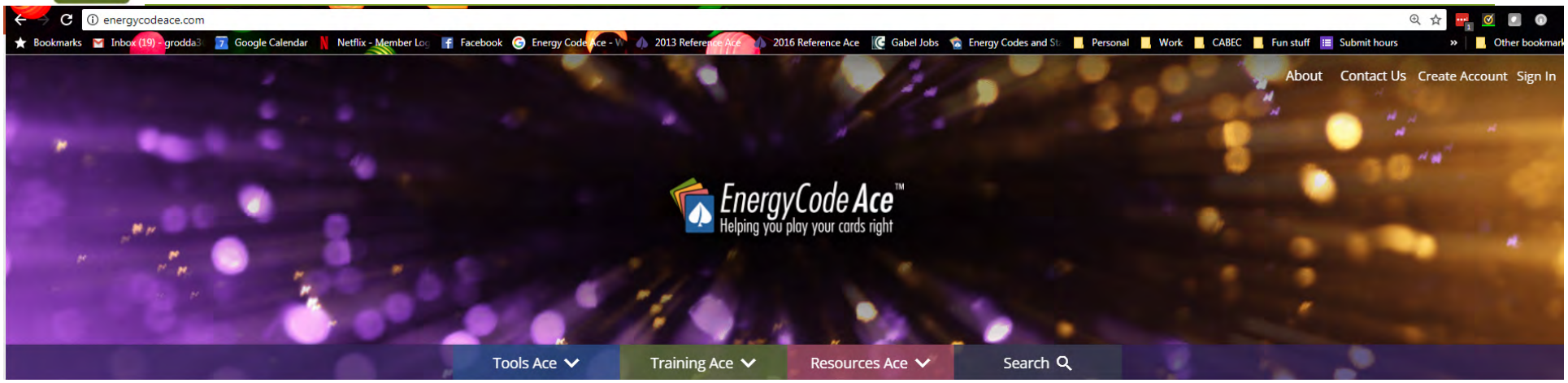
Next Steps to ZERO

- ZNE Best Practices
  - High R-Value Walls, Roof, Floors,
  - Advanced Air Sealing
  - All Electric
  - Solar Installed + Battery Storage
  - Highly Controlled



Next Steps

Other ECA Resources



Ace Resources Trigger Sheets

Quick reference component-by-component summaries of sections of Title 24, Part 6 "triggered" based on project scope.

Ace Resources Fact Sheets

Quick reference summaries of key requirements, forms, definitions and resources for implementing Title 24, Part 6 and Title 20

Ace Resources Checklists

Step-by-step guidance for plans checks and field inspections

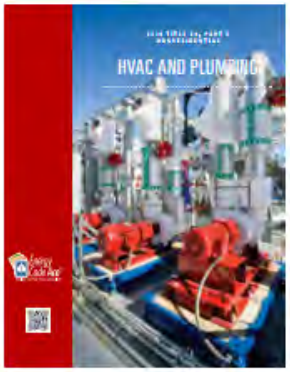
Ace Resources Application Guides

Short manuals including compliance requirements and recommendations for implementing Title 24, Part 6 in new construction, addition and renovation projects.

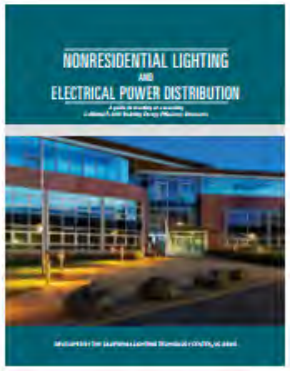
Ace Resources™

Nonresidential Process Equipment and Systems

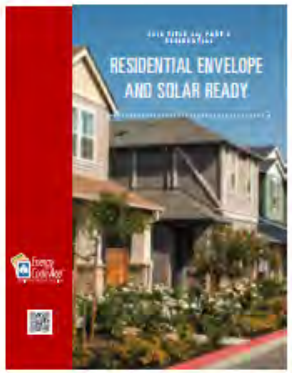
Nonresidential Envelope and Solar Ready



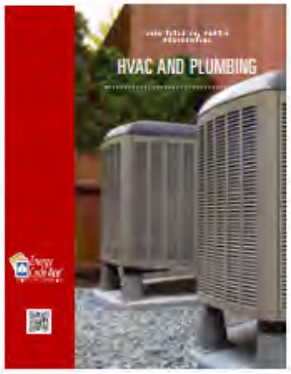
Nonresidential HVAC and Plumbing



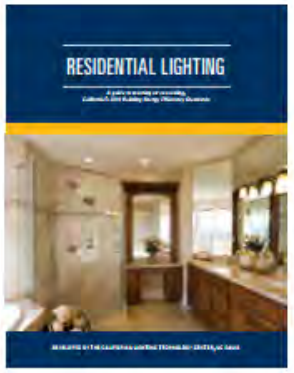
Nonresidential Lighting and Electrical Power Distribution



Residential Envelope and Solar Ready



Residential HVAC and Plumbing



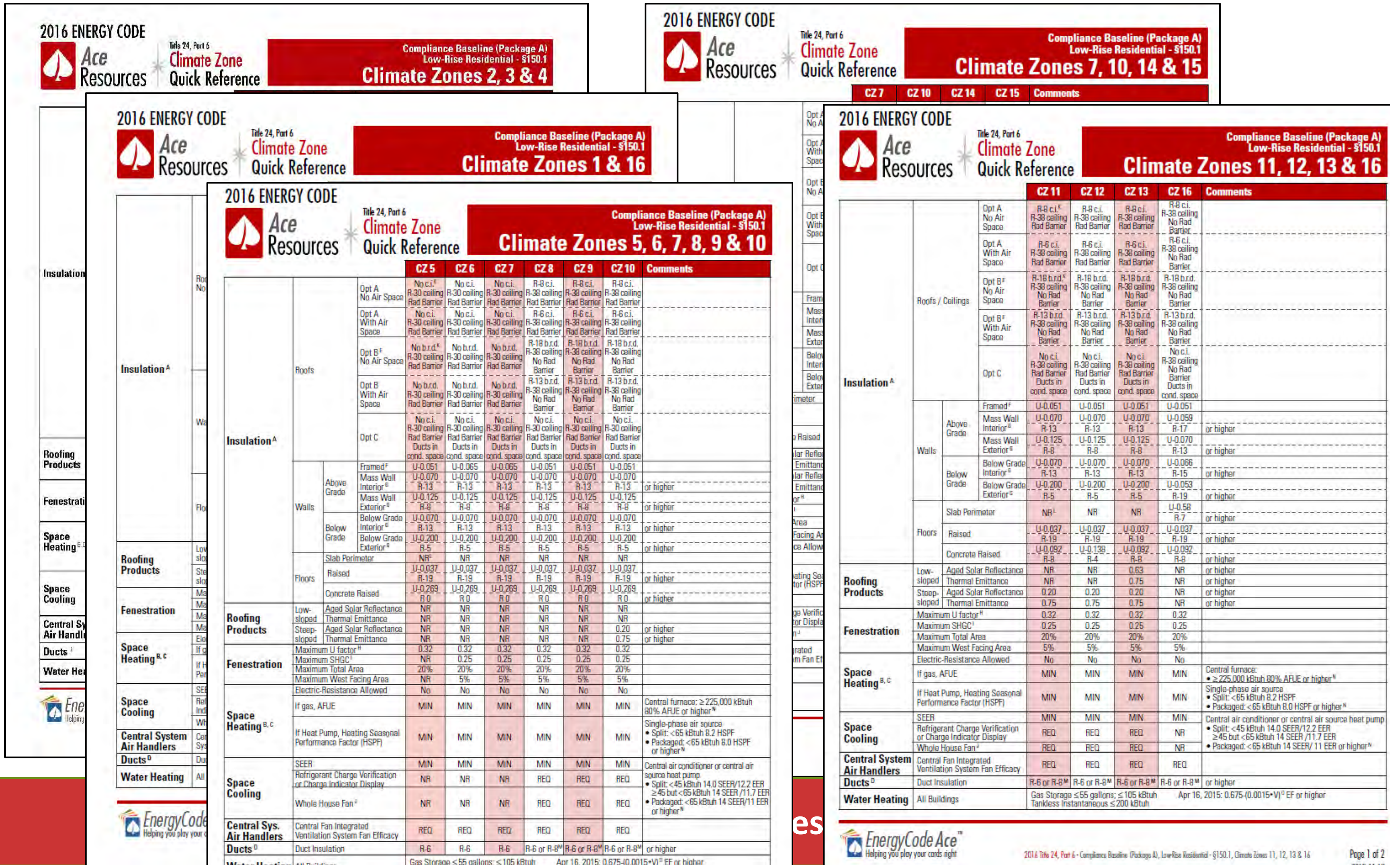
Residential Lighting

Application Guides:

Short manuals including compliance requirements and recommendations for implementing Title 24, Part 6 in new construction, addition and renovation projects.

Also Available through Amazon

Ace Resources | Title 24, Part 6 Climate Zone Quick Reference


2016 ENERGY CODE

Ace Resources | Title 24, Part 6 Climate Zone Quick Reference

Compliance Baseline (Package A) Low-Rise Residential - §150.1

Climate Zones 5, 6, 7, 8, 9 & 10

			CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	Comments
Insulation [A]	Roofs	Opt A No Air Space	No c.i.[K] R-30 ceiling Rad Barrier	No c.i. R-30 ceiling Rad Barrier	No c.i. R-30 ceiling Rad Barrier	R-8 c.i. R-38 ceiling Rad Barrier	R-8 c.i. R-38 ceiling Rad Barrier	R-8 c.i. R-38 ceiling Rad Barrier	
		Opt A With Air Space	No c.i. R-30 ceiling Rad Barrier	No c.i. R-30 ceiling Rad Barrier	No c.i. R-30 ceiling Rad Barrier	R-6 c.i. R-38 ceiling Rad Barrier	R-6 c.i. R-38 ceiling Rad Barrier	R-6 c.i. R-38 ceiling Rad Barrier	
		Opt B [E] No Air Space	No b.r.d.[K] R-30 ceiling Rad Barrier	No b.r.d. R-30 ceiling Rad Barrier	No b.r.d. R-30 ceiling Rad Barrier	R-18 b.r.d. R-38 ceiling No Rad Barrier	R-18 b.r.d. R-38 ceiling No Rad Barrier	R-18 b.r.d. R-38 ceiling No Rad Barrier	
		Opt B With Air Space	No b.r.d. R-30 ceiling Rad Barrier	No b.r.d. R-30 ceiling Rad Barrier	No b.r.d. R-30 ceiling Rad Barrier	R-13 b.r.d. R-38 ceiling No Rad Barrier	R-13 b.r.d. R-38 ceiling No Rad Barrier	R-13 b.r.d. R-38 ceiling No Rad Barrier	
		Opt C	No c.i. R-30 ceiling Rad Barrier Ducts in cond. space	No c.i. R-30 ceiling Rad Barrier Ducts in cond. space	No c.i. R-30 ceiling Rad Barrier Ducts in cond. space	No c.i. R-30 ceiling Rad Barrier Ducts in cond. space	No c.i. R-30 ceiling Rad Barrier Ducts in cond. space	No c.i. R-30 ceiling Rad Barrier Ducts in cond. space	
	Walls, Above Grade	Framed [F]	U-0.051	U-0.065	U-0.065	U-0.051	U-0.051	U-0.051	
		Mass Wall Interior [G]	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	or higher
		Mass Wall Exterior [G]	U-0.125 R-8	U-0.125 R-8	U-0.125 R-8	U-0.125 R-8	U-0.125 R-8	U-0.125 R-8	or higher
	Walls, Below Grade	Below Grade Interior [G]	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	or higher
		Below Grade Exterior [G]	U-0.200 R-5	U-0.200 R-5	U-0.200 R-5	U-0.200 R-5	U-0.200 R-5	U-0.200 R-5	or higher
	Floors	Slab Perimeter	NR[L]	NR	NR	NR	NR	NR	
		Raised	U-0.037 R-19	U-0.037 R-19	U-0.037 R-19	U-0.037 R-19	U-0.037 R-19	U-0.037 R-19	or higher
		Concrete Raised	U-0.269 R-0	U-0.269 R-0	U-0.269 R-0	U-0.269 R-0	U-0.269 R-0	U-0.269 R-0	or higher
Roofing Products	Low-sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	
		Thermal Emittance	NR	NR	NR	NR	NR	NR	
	Steep-sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	0.20	or higher
		Thermal Emittance	NR	NR	NR	NR	NR	0.75	or higher
Fenestration	Maximum U factor [H]		0.32	0.32	0.32	0.32	0.32	0.32	
	Maximum SHGC [I]		NR	0.25	0.25	0.25	0.25	0.25	
	Maximum Total Area		20%	20%	20%	20%	20%	20%	
	Maximum West Facing Area		NR	5%	5%	5%	5%	5%	
Space Heating [B, C]	Electric-Resistance Allowed		No	No	No	No	No	No	
	If gas, AFUE		MIN	MIN	MIN	MIN	MIN	MIN	Central furnace: ≥225,000 kBtuh 80% AFUE or higher [N]
	If Heat Pump, Heating Seasonal Performance Factor (HSPF)		MIN	MIN	MIN	MIN	MIN	MIN	Single-phase air source • Split: <65 kBtuh 8.2 HSPF • Packaged: <65 kBtuh 8.0 HSPF or higher [N]
Space Cooling	SEER		MIN	MIN	MIN	MIN	MIN	MIN	Central air conditioner or central air source heat pump • Split: <45 kBtuh 14.0 SEER/12.2 EER ≥45 but <65 kBtuh 14 SEER /11.7 EER • Packaged: <65 kBtuh 14 SEER/11 EER or higher [N]
	Refrigerant Charge Verification or Charge Indicator Display		NR	NR	NR	REQ	REQ	REQ	
	Whole House Fan [J]		NR	NR	NR	REQ	REQ	REQ	
Central Sys. Air Handlers	Central Fan Integrated Ventilation System Fan Efficacy		REQ	REQ	REQ	REQ	REQ	REQ	
Ducts [D]	Duct Insulation		R-6	R-6	R-6	R-6 or R-8 [M]	R-6 or R-8 [M]	R-6 or R-8 [M]	or higher
Water Heating	All Buildings		Gas Storage ≤55 gallons; ≤105 kBtuh			Apr 16, 2015: 0.675-(0.0015•V) [O] EF or higher			

2016 ENERGY CODE

Ace Resources | Title 24, Part 6 Climate Zone Quick Reference

Compliance Baseline (Package A) Low-Rise Residential - §150.1

Climate Zones 11, 12, 13 & 16

			CZ 11	CZ 12	CZ 13	CZ 16	Comments
Insulation [A]	Roofs / Ceilings	Opt A No Air Space	R-8 c.i.[K] R-38 ceiling Rad Barrier	R-8 c.i. R-38 ceiling Rad Barrier	R-8 c.i. R-38 ceiling Rad Barrier	R-8 c.i. R-38 ceiling No Rad Barrier	
		Opt A With Air Space	R-6 c.i. R-38 ceiling Rad Barrier	R-6 c.i. R-38 ceiling Rad Barrier	R-6 c.i. R-38 ceiling Rad Barrier	R-6 c.i. R-38 ceiling No Rad Barrier	
		Opt B [E] No Air Space	R-18 b.r.d.[K] R-38 ceiling No Rad Barrier	R-18 b.r.d. R-38 ceiling No Rad Barrier	R-18 b.r.d. R-38 ceiling No Rad Barrier	R-18 b.r.d. R-38 ceiling No Rad Barrier	
		Opt B [E] With Air Space	R-13 b.r.d. R-38 ceiling No Rad Barrier	R-13 b.r.d. R-38 ceiling No Rad Barrier	R-13 b.r.d. R-38 ceiling No Rad Barrier	R-13 b.r.d. R-38 ceiling No Rad Barrier	
		Opt C	No c.i. R-38 ceiling Rad Barrier Ducts in cond. space	No c.i. R-38 ceiling Rad Barrier Ducts in cond. space	No c.i. R-38 ceiling Rad Barrier Ducts in cond. space	No c.i. R-38 ceiling No Rad Barrier Ducts in cond. space	
	Walls, Above Grade	Framed [F]	U-0.051	U-0.051	U-0.051	U-0.051	
		Mass Wall Interior [G]	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.059 R-17	or higher
		Mass Wall Exterior [G]	U-0.125 R-8	U-0.125 R-8	U-0.125 R-8	U-0.070 R-13	or higher
	Walls, Below Grade	Below Grade Interior [G]	U-0.070 R-13	U-0.070 R-13	U-0.070 R-13	U-0.066 R-15	or higher
		Below Grade Exterior [G]	U-0.200 R-5	U-0.200 R-5	U-0.200 R-5	U-0.053 R-19	or higher
	Floors	Slab Perimeter	NR[L]	NR	NR	U-0.58 R-7	or higher
		Raised	U-0.037 R-19	U-0.037 R-19	U-0.037 R-19	U-0.037 R-19	or higher
		Concrete Raised	U-0.092 R-8	U-0.138 R-4	U-0.092 R-8	U-0.092 R-8	or higher
Roofing Products	Low-sloped	Aged Solar Reflectance	NR	NR	0.63	NR	or higher
		Thermal Emittance	NR	NR	0.75	NR	or higher
	Steep-sloped	Aged Solar Reflectance	0.20	0.20	0.20	NR	or higher
		Thermal Emittance	0.75	0.75	0.75	NR	or higher
Fenestration	Maximum U factor [H]		0.32	0.32	0.32	0.32	
	Maximum SHGC [I]		0.25	0.25	0.25	0.25	
	Maximum Total Area		20%	20%	20%	20%	
	Maximum West Facing Area		5%	5%	5%	5%	
Space Heating [B, C]	Electric-Resistance Allowed		No	No	No	No	
	If gas, AFUE		MIN	MIN	MIN	MIN	Central furnace: • ≥225,000 kBtuh 80% AFUE or higher [N]
	If Heat Pump, Heating Seasonal Performance Factor (HSPF)		MIN	MIN	MIN	MIN	Single-phase air source • Split: <65 kBtuh 8.2 HSPF • Packaged: <65 kBtuh 8.0 HSPF or higher [N]
Space Cooling	SEER		MIN	MIN	MIN	MIN	Central air conditioner or central air source heat pump • Split: <45 kBtuh 14.0 SEER/12.2 EER ≥45 but <65 kBtuh 14 SEER /11.7 EER • Packaged: <65 kBtuh 14 SEER/ 11 EER or higher [N]
	Refrigerant Charge Verification or Charge Indicator Display		REQ	REQ	REQ	NR	
	Whole House Fan [J]		REQ	REQ	REQ	NR	
Central System Air Handlers	Central Fan Integrated Ventilation System Fan Efficacy		REQ	REQ	REQ	REQ	
Ducts [D]	Duct Insulation		R-6 or R-8 [M]	R-6 or R-8 [M]	R-6 or R-8 [M]	R-6 or R-8 [M]	or higher
Water Heating	All Buildings		Gas Storage ≤55 gallons; ≤105 kBtuh Tankless Instantaneous ≤200 kBtuh		Apr 16, 2015: 0.675-(0.0015•V) [O] EF or higher		

EnergyCode Ace™ Helping you play your cards right

2016 Title 24, Part 6 - Compliance Baseline (Package A), Low-Rise Residential - §150.1, Climate Zones 11, 12, 13 & 16

Page 1 of 2

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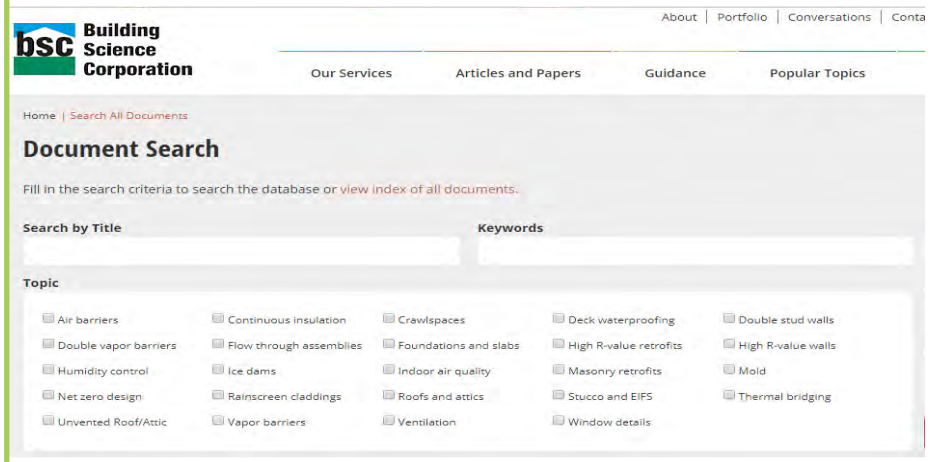

www.rdh.com

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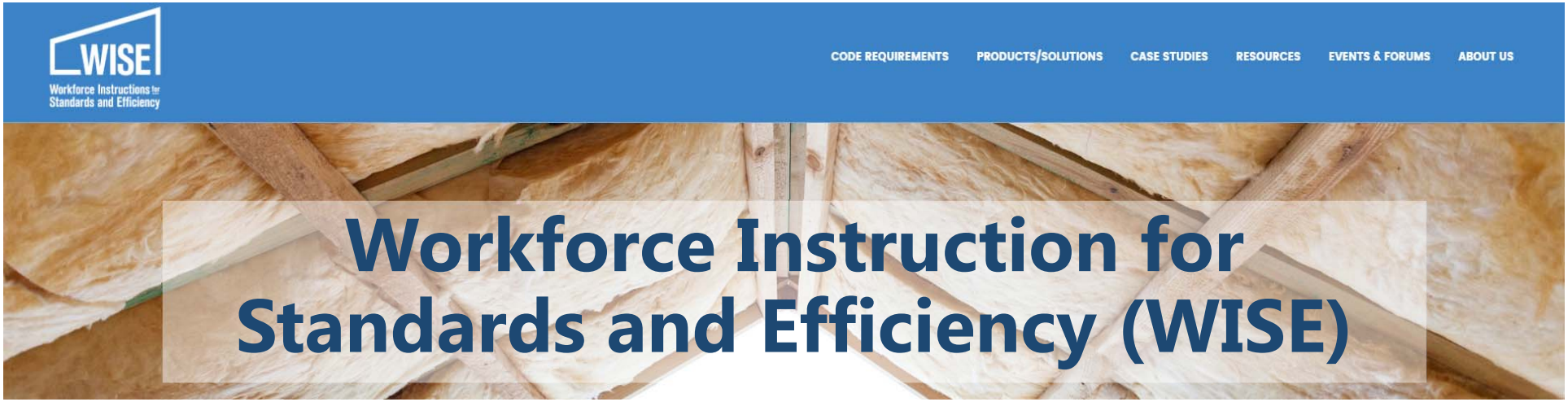

WISE
Workforce Instructions for Standards and Efficiency

- A training and education program sponsored by the California Energy Commission.
- Curates HPA/HPW technical resources and product information on website
- Provides **FREE in-person, one-on-one trainings** to the CA building industry on overcoming barriers to HPA/HPW implementation.
- Contact Dan Krekelberg, WISE Program Manager
  - dkrekelberg@consol.ws

Incentive Programs

https://sonomacleanpower.org/fire-rebuild/

ONCE THE PROGRAM IS ACTIVE, YOU CAN EXPECT THE FOLLOWING PROCESS:

Participate in the program with 6 easy steps! Click on a step below for more information.

- Step 1: Find a Certified Energy Analyst (CEA)
- Step 2: Complete Your Energy Model
- Step 3: Submit Program Application
- Step 4: Receive 50% of Total Incentive
- Step 5: Find a HERS Rater and "Share" Project
- Step 6: Incentive Request Form

Certified Energy Analyst https://cabec.org/find/

Certification as a CEA signifies that a consultant understands the California Building Energy Efficiency Standards (Title 24, Part 6) and has:

- *An understanding of broader energy efficiency issues,*
- *Is committed to providing quality service to clients, and*
- *That he/she has made a commitment to conduct business in an ethical fashion.*

Let's build a more energy efficient California together!

Please Provide Your Feedback!

A survey will pop up on your screen before you leave us today.

- Focus our attentions on your input for further development of training, job aides, tools, etc.
- Fine tune future events
- Let California Statewide Codes & Standards team know how we can improve
- Make your voice heard!

This is how to get a copy of the slide deck

Wrap Up

Residential Recover & Rebuild

California's Building Energy Code (also known as Title 24, Part 6) enables homeowners to save on their electricity and natural gas bills - and by reducing greenhouse gas emissions, helps the environment. If your home needs to be repaired or rebuilt, you may need to comply with this code. This fact sheet includes basic information on the code, but please contact us at info@energycodeace.com if you would like additional assistance.

When is the Building Energy Code Triggered?

Alteration: The home is damaged and part(s) of the home require reconstruction (e.g., new roof being installed to replace a damaged roof).

Addition: The home is being added onto, and the habitable floor area increases (e.g., adding a new family room to the back of an existing house).

New Home: The home must be completely rebuilt.

What Doesn't Trigger the Building Energy Code?

A **repair** does not trigger the Building Energy Code. This is the reconstruction of a building component that does not increase the preexisting energy consumption of that repaired feature. For example, replacing glass in a window is a repair, but replacing the glass and framing of a window is considered an alteration.

Alterations

Envelope: All walls, floors and roofs must be insulated (even if not previously installed) when opened up (made accessible), or rebuilt in the same exact location, to the minimum insulation requirements of the Building Energy Code. New roofing may need to be a Cool Roof Rating Council (CRRC)-certified cool roof product depending on where the home is located (climate zones 10-15). Title 24, Part 6 Sections 150.0(a-d)

Windows/Glass Doors/Skylights (Fenestration): Replaced fenestration totaling 75 ft^2 or more, must meet the same requirements of a new home, but if under 75 ft^2 is being replaced, there are some exceptions. Title 24, Part 6 Sections 150.0(o)/150.2(b)1A/B/G

Heating/AC/Ventilation (HVAC)/Water Heater: Replaced mechanical system type(s) can match what was there before. New or replaced heating and/or cooling systems require a third-party HERS Rater to test and verify that certain components were installed properly. Title 24, Part 6 Sections 150.0(h-j)(m-o)/150.2(b)C-F

Lighting: Replaced or new lighting must be "high efficacy," which is essentially fluorescent technology or LED that meets quality control requirements (Title 24 Reference Joint Appendix JA8). No screw-based recessed can lights are allowed. In addition, there are simple lighting control requirements. The lighting requirements apply equally to alterations, additions and new construction. Title 24, Part 6 Section 150.0(k)

Addition

Envelope: All new walls, floors and roofs must meet similar requirements of a new home, but with some exceptions dependent on the square footage of the addition or if considered an "extended" wall. Title 24, Part 6 Sections 150.2(a)1 and 2

Windows/Glass Doors/Skylights (Fenestration): There are performance requirements of fenestration product, such as U-Factor (resistance to heat transfer) and SHGC (Solar Heat Gain Coefficient, the ability to limit heat gain into the home from the sun). In addition, there are limitations to the amount of fenestration being used, dependent on the square footage of the addition. Title 24, Part 6 Section 150.2(a)

HVAC/Water Heater: New HVAC system(s) have the same requirements as those being installed in a new home. A new tankless gas water heater (minimum efficiency) may be added as part of an addition (exceptions may apply). Title 24, Part 6 Sections 150.0(h-j)(m-o)/150.2(a) and (b)

Lighting: New lighting has the same requirements for all project types. Title 24, Part 6 Section 150.0(k)

New Home

Envelope: New roof, wall and floor requirements will most likely exceed the building requirements in which the existing home was built. Title 24, Part 6 Section 150.1(c)

Attics: Most areas in California have "high performance" attic requirements which typically means insulation placed on the ceiling AND another layer of insulation at the roof. Title 24, Part 6 Section 150.1(c)1A

Walls: Most areas in California have "high performance" wall requirements which typically means 2"x 6" wood framing using R-19 insulation and an additional 1" of rigid insulation outside the framing. Title 24, Part 6 Section 150.1(c)1B

Fenestration: New fenestration requirements dictate using National Fenestration Rating Council (NFRC)-rated dual-paned vinyl/wood/fiberglass products using Low-E^3 glazing. In addition, there are limitations on the amount used in home. Title 24, Part 6 Section 150.1(c)3-4

HVAC/Water Heater: HVAC system(s) will require third-party testing by a HERS Rater to verify certain components of the system(s). One gas tankless water heater meeting minimum efficiency. Title 24, Part 6 Sections 150.1(c)6-10 and 12-13

Lighting: New lighting has the same requirements for all project types. Title 24, Part 6 Section 150.0(k)

What methods can be used to show compliance with the Building Energy Code?

In addition to mandatory measures (which must always be met), there are two methods:

1. Prescriptive Method: All code requirements can be met or exceeded. Forms used:
   - Alterations: CF1R-ALT-01 through 04-E (or the CF1R-ALT-05-E if no HERS measures)
   - Additions: CF1R-ADD 01-E (or the CF1R-ADD-02-E if no HERS measures)
   - New Home: CF1R-NCB-01-E
2. Performance Method: Flexibility is desired in place of the prescriptive code requirements.
   - CF1R-PRF-01-E is the form used for alteration/addition/new home.

For More Information

California Energy Commission Information & Services

Title 24, Part 6

- Energy Standards Hotline: 1-800-772-3300 (Free) or Title24@energy.ca.gov
- Online Resource Center: energy.ca.gov/title24/orc/
  - The Energy Commission's main web portal for Energy Standards, including information, documents, and historical information
- Home Energy Rating System (HERS) Program Sub-site: energy.ca.gov/HERS/
- What is Your Home Energy Rating booklet energy.ca.gov/HERS/booklet.html
- California Building Climate Zone Map: energy.ca.gov/maps/renewable/building_climate_zones.html

Additional Resources

- National Fenestration Rating Council (NFRC): nfrc.org/
  - NFRC offerings can help facility managers, specifiers, designers and others make informed purchasing and design decisions about fenestration products
- CRRC-Rated Products Directory: coolroofs.org/products/results
  - Search for rated roofing products
- Energy Code Ace: EnergyCodeAce.com
  - An online "one-stop-shop" providing free resources and training to help appliance and building industry professionals decode and comply with Title 24, Part 6 and Title 20. The site is administered by California's investor-owned utilities.

  Of special interest:

  Application Guides
  - Residential Envelope and Solar Ready Areas
  - Residential HVAC and Plumbing
  - Residential Lighting

  energycodeace.com/content/resources-ace/file_type=application-guide

  Fact Sheets
  - Nonresidential & Residential Permit Process 2016
  - Just the Basics: HERS for Residential and Nonresidential Projects
  - Quick Reference Sheet: HERS for Residential and Nonresidential Projects 2016
  - Quick Reference Sheets for Climate Zone Compliance Baselines
  - Residential Cool Roofs
  - Residential Domestic Hot Water (DHW)
  - Residential Fenestration
  - Residential HVAC Alterations
  - Residential Lighting
  - Residential Opaque Envelopes
  - Title 20 Residential Pool Pump Motors

  energycodeace.com/content/resources-fact-sheets/

  Trigger Sheets
  - Residential HVAC Alterations

  energycodeace.com/content/resources-ace/file_type=trigger-sheet

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This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Decoding * Recovery™
Let's Talk Residential Rebuilding

Insulation Guide

Insulation Material	R-value per inch	Appearance	Advantages	Disadvantages	Product Highlights
Batt Type					
Fiberglass	3-3.7		Readily available	Must be installed correctly to achieve full R-value	Widely available
Mineral Wool	2.8-3.7		Somewhat better fire resistance and soundproofing than fiberglass; Good for water drainage.	Same as fiberglass	ROXUL
Cotton	3-3.7		Environmentally friendly	Not readily available; Installation	Ultra Touch
Loose Fill					
Fiberglass	3-3.7		Easier to install correctly	Must be kept in place (insulation dams)	JM; Owens Corning
Boxed Netting Fiberglass	3-3.7		Below roof deck insulation; Less expensive than spray insulation	More labor intensive than spray on insulation	Owens Corning Pro Pink High Performance Attic System
Mineral Fiber	2.8-3.7		Easier to install correctly	Must be kept in place (insulation dams)	Ecofill by Knauf Insulation
Cellulose Fiber	3-3.7		Provides more resistance to air movement than other loose fill	Must be kept in place (insulation dams)	Greenfiber; Green Seal from FiberAmerica

Insulation Guide

Insulation Material	R-value per inch	Appearance	Advantages	Disadvantages	Product Highlights
Board Stock					
Type I & II Expanded Polystyrene or EPS	3.6-4.4		Inexpensive	HC's usually used in production. Must be covered.	Cellofoam Polysheild
Type III & IV extruded polystyrene or XPS	4.5-5		Works well in wet conditions	HFC usually used in production. Must be covered.	Owens Corning FOAMULAR
Rigid Fiberglass	4.2-4.5		Drains away water	Not easily available	Owens Corning FIBERGLASS
Rigid Mineral Fiber	4.2-4.5		Drains away water	More expensive than polystyrene	Thermafiber; ROXUL
Polyisocyanurate or ISO	5.6-6.7		Closed cell, high R-Values compared to polystyrene	HFC usually used in production	RMAX
Expanded Polystyrene Tile Roof Installation Product	R-6 for product		Also helps support roof tile	Limited to tile roof construction	Wedge-it
Insulated Roof Tiles	R-7-14 for product		Insulation and Roofing in One	Replacement	EternaTile; Green Hybrid Roofing;

Insulation Guide

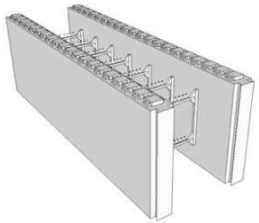
Insulation Material	R-value per inch	Appearance	Advantages	Disadvantages	Product Highlights
Spray Applied					
Wet Spray Cellulose	3-3.7		Low labor costs, environmental benefits, fewer gaps	Adhesive mixed with insulation; must dry before any other sub can enter space	any loose cellulose product fixed with water or adhesive
Spray -applied fiberglass insulation	4.2-4.3		Higher R-value than spray cellulose	Lower recycled content than typical spray cellulose	JM Spider
Open-cell Light Density Polyurethane	3.6		Low labor costs	Must be covered; more expensive than batt	Icynene; Demilec
Closed Cell Medium Density Polyurethane	5.5-6		Can act as the air barrier and vapor retarder.	HFC usually used in production. Must be covered.	Icynene; Demilec
Other					
Structural Insulated Panel Systems (SIPs)	depends on insulation used		Quick installation, good thermal performance and structural integrity	More expensive than alternatives; unfamiliar to builders; building must be designed with product in mind	Thermocore; Structural Insulated Panel Association
Exterior Insulation and Finish Systems (Synthetic Stucco/EIFS)	depends on rigid insulation used		Finish and continuous insulation in one product	Special attention must be paid to drainage detailing	EIFS Industry Members Association (EIMA)
Insulating Concrete Form (ICFs)	depends on the details of the ICF blocks		Fire resistant, durable and energy efficient	More expensive than alternatives; unfamiliar to builders; building must be designed with product in mind	Concrete.org: http://bit.ly/2FkqdDP

Image Credit:
Mineral wool photo from Knauf Insulation
Pink fiberglass winter wonderland (CC BY 2.0) by mikemol
Tile Roof Insulation - Courtesy of CHP - Master Builder Advanced Home Design and Building Practices 2016 Code Readiness Program
Insulating Concrete Form –FEMA News Photo Photo by Kent Baxter - Nov 22, 2001

Additions and Alterations

Existing

Roof:
No Requirements

Walls:
No Requirements

Windows:
No Requirements

Floor:
No Requirements

Altered Features

Skylights:
Altering:
- *U-factor: 0.55/SHGC: 0.30**

Adding ≤ 16 ft²
- *U-factor: 0.55/SHGC: 0.30**

Adding >16 ft²:
- *U-factor: 0.32/SHGC: 0.25**

Altered roof:
R-22 (R-19 if 2x6 rafter)
Cool roof: Required when replacing >50% in CZ 10-15 for sloped roofs >2:12

Windows:
Altering ≤75 ft²:
- *U-factor: 0.40/SHGC: 0.35**

Altering >75 ft²:
- *U-factor: 0.32/SHGC: 0.25**

Adding ≤75 ft²:
- *U-factor: 0.32/SHGC: 0.25**

Adding >75 ft²:
- *U-factor: 0.32/SHGC: 0.25**
- *Total cannot exceed 20% CFA*
- *West facing cannot exceed 5% CFA (except CZ 1, 3, 5)*

Altered Walls:
2x4, R-13
2x6, R-19

Altered Floor:
R-19

Addition

New Skylights:
≤16 ft²:
- *U-factor: 0.55/SHGC: 0.30**

>16 ft²:
- *U-factor: 0.32/SHGC: 0.25**

New Roof Insulation:
≤700 ft²: R-22
>700 ft²: Package A
Cool Roof:
>300 ft² in CZ 10-15, sloped roof
Radiant barrier:
CZ 2-15, vented attic construction when no below roof deck insulation

New Windows:
*U-factor: 0.32/SHGC: 0.25**
Area allowed:
≤400 ft²: *75 ft² or 30% CFA*
>400 ≤700 ft²: *120 ft² or 25% CFA*
>700 ft²: *175 ft² or 20% CFA*

New Extended walls:
2x4, R-15
2x6, R-19
New non-extended walls:
Package A

New Raised Floor:
R-19

**SHGC not required in CZ 1, 3, 5*

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Additions and Alterations

Existing Home	Altered Features		Addition
	Non-Verified	HERS Verified	
Any condition in the existing home that is not changing is considered energy neutral. It does not help or hurt your compliance number. What it does affect is our heating and cooling loads- how much energy will be needed to heat and or cool the home. The better those existing conditions are, the lower the heating and cooling loads will be. It is not necessary to improve existing conditions, but in some cases, it may be beneficial. (See Altered Features.)	Any condition in an existing home that is changed, but not considered a repair, is an alteration which triggers requirements to meet the Energy Code. For compliance purpose in the performance model, these changes are compared to a minimum set standard. If the alteration is only being brought up to these minimums, the performance model does not see this as an energy credit. While these improvements lower the overall heating and cooling loads of the home, they do not offer much help with compliance, unless the improvement exceeds the alteration standard. (See reverse of this sheet for alteration standards.)	Verification of existing conditions allows you to take full credit for the true improvements made to a home. The process includes an inspection completed by a HERS rater before demolition, and before the compliance report is completed. Having an inspection completed when alterations are being made allows the ability to bypass the standard comparison and be compared to the actual existing condition instead, which provides the performance model positive energy "credit" to allow for compliance flexibility. This can only be done with the performance model.	An addition is any added conditioned floor area and volume, either within the existing footprint of the home or built out to expand the footprint of the home. There are two paths to compliance. The prescriptive approach allows for some great exceptions for extended walls, amount of fenestration allowed and options other than high-performance roof. You must meet all of the prescriptive requirements. In the performance approach, each feature of the addition is compared to Package A (except an addition up to 700 sq. ft., the roof is compared to R-22.) If you exceed the minimums in Package A, you will receive an energy credit that can offset any features that do not meet the Package A requirements.

AIA
California Council

American
Institute of Architects,
California Council

ZERO NET ENERGY PRIMER

The Cottle House
San Jose, CA
One Sky Homes
2012

American
Institute of Architects,
California Council

ZERO NET ENERGY PRIMER

by Ann V Edminster

Design by Debra Turner
Illustrations by Steven Lee

Published: March, 2018

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AIA California Council

All homes depicted in this *Primer* were designed and/or have been reported to be operating at or around zero-net energy

American Institute of Architects,
California Council

ZERO NET ENERGY PRIMER

ACKNOWLEDGEMENTS

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TABLE OF CONENTS

In 2016, the Net Zero Energy Coalition documented 3,137 zero-energy homes in California – 38% of all units in the US and Canada combined.

Net Zero Energy Modern House
Cupertino, CA
Klopf Architecture
Matarozzi Pelsinger Builders
2011

Mariko Reed photo

Zero-energy homes span all architectural styles, sizes, and price points.

The Cottages at Cypress
Fort Bragg, CA
K. Boodjeh Architects
Danco Builders
2014

Brandi Easter photo

Zero net energy homes produce renewable energy onsite and are tied to the electric power grid.

ZETA Townhome
Oakland, CA
ZETA Communities
dsa architects
2009

INTRODUCTION

CALIFORNIA LEADING NORTH AMERICA IN ZNE

In 2006, the State of California targeted 2020 as the date by which all new homes would be required to achieve zero net energy (ZNE). Although that goal will not be fully realized in 2020, Title 24-2019, Part 6, will require the highest level of energy efficiency to date: all new single-family and low-rise multifamily homes submitted for plan check after December 31, 2019, will need to include a Title 24 report showing zero net *electricity use*,[1] and it is very likely that Title 24-2022 will require a ZNE standard for both *electricity and gas*. The State also plans to adopt ZNE standards for non-residential buildings by 2030.

Quite a few cities in California (and elsewhere) already have adopted ZNE or solar energy requirements,[2] and other states are actively considering adopting ZNE. In the meantime, the private sector has taken the lead.

In its *2016 Residential Zero Energy Buildings Study,* the Net Zero Energy Coalition documented more than 8,000 residential units in the US and Canada, with the highest number (3,137) in California. Significantly, more than 90% of these homes are in developer-initiated, multi-unit projects, demonstrating that these pioneering developers believe that ZNE makes solid business sense – and not just at the high end of the market. The inventory includes thousands of units of ZNE workforce housing and production homes, in a wide range of US climates. The takeaway is that ZNE is highly affordable *when you know how to do it.*

This *Primer* was developed to familiarize California architects with the forthcoming residential energy standards, and what those standards mean in practical terms.

Note: The Title 24-2019 energy standards are likely to undergo further changes before they go into effect. Be sure to thoroughly familiarize yourself with them when they are issued.

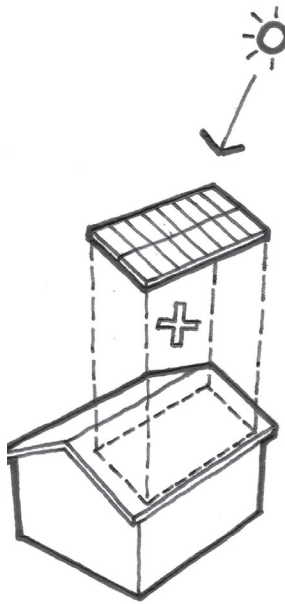
HOW WILL ZNE CHANGE YOUR DESIGN PROCESS?

California's long-time leadership in energy efficiency means that architects who practice here already have gained a lot of practical knowledge that applies directly to achieving ZNE. In simplest terms, ZNE is nothing more than a very efficient building with photovoltaics (PVs) on top. You'll be able to meet the new code by focusing on a few key aspects of design and documentation; each of these topics is discussed in this *Primer*:

- ☐ An excellent thermal enclosure
- ☐ Highly efficient mechanical systems
- ☐ Solar energy systems

In simplest terms, ZNE is nothing more than a very efficient building with photovoltaics (PV) on top.

Sol Lux Alpha Apartments
San Francisco, CA
RG Architecture
Off the Grid Design
2018



Title 24-2019 will require photovoltaics on new homes.

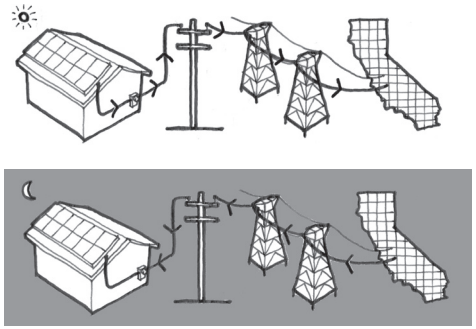
[1] Using California's time-dependent valuation, and excluding plug loads that are not regulated by Title 24, Part 6.
[2] Local ordinances exceeding the [California] 2016 energy efficiency standards.

DEFINITIONS & THE ENERGY CODE

LET'S START WITH DEFINITIONS

Zero net energy, in slightly more technical terms, means that a building has enough onsite renewable energy capacity (typically, a PV array on the roof) to meet its own annual energy needs. The building is tied to the electric power grid, so that at times when the PV array is producing more than the building is using, it feeds into the grid, and when the building needs more than the PVs are producing (e.g., at night), it draws from the grid. At the end of the year, the balance of in- and out-flows is (approximately) zero.

California's ZNE requirements, however, aren't based on conventional units of energy. The State applies hour-by-hour multipliers to energy usage based on the costs of delivering energy at different times. During demand peaks, energy is more expensive to generate because older, less efficient power plants need to be fired up. And so, from the State's perspective, not all units of energy have equal value; instead, they have a 'time-dependent valuation' (TDV), and TDV is the basis for calculating 'energy usage' for purposes of Title 24 compliance.[3]



Top: *Excess energy production feeds into the grid.*
Bottom: *The grid supplies energy when solar production doesn't meet the home's demand.*[1]

There are several other definitions in use in the US, the most widely used of which is the US Department of Energy (DOE) "Common Definition of ZNE." Other definitions have been proposed by the National Renewable Energy Laboratory (NREL).

The procedure for complying with California ZNE requirements will be unchanged from the current procedure for complying with Title 24: you will submit your design along with the Title 24 report, showing compliance with the code, and you're done. There is no requirement to document for the occupants' actual energy use once they are living in the home ("operational ZNE").

WHAT *WILL* CHANGE?

A number of the Title 24 prescriptive requirements and mandatory measures are expected to change with the 2019 code – all of them found by the State to be cost-effective.[4] The anticipated changes from the 2016 code are summarized in the table on the following page and elaborated on later in this *Primer.* As in the past, if you use the performance approach (energy modeling) to comply with code, you may be able to incorporate different performance measures in place of some of the prescriptive requirements. However, because of the increased stringency of the prescriptive requirements, it's likely that the trade-offs will be less effective in improving the modeled performance.

The Cottle House
San Jose, CA
One Sky Homes
2012

California's 2019 code will not require that the home operate at ZNE, only that it be designed to meet the standard.

[3] Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2019 Time Dependent Valuation (TDV) Data Sources and Inputs
[4] Presentation - Proposed 2019 Building Energy Efficiency Standards ZNE Strategy

Proposed Changes from 2016 to 2019 Standards

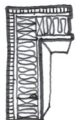
(prescriptive and tradeable except HVAC, as noted below)[5]

Attics

Two options:

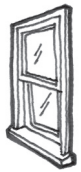
- ☐ Vented, high-performance attic with increased insulation requirements, or
- ☐ Directly conditioned attic

Walls



U-factor reduced from 0.051 to 0.048 (e.g., R-21 cavity insulation plus R-7 exterior continuous insulation) in single-family new construction in all CA Climate Zones (CZ) except CZ 6 and 7, where it remains at 0.065; and all homes must meet QII (Quality Insulation Installation)

Windows & Solid Doors



Windows:

- ☐ Maximum U-factor 0.30 in all climate zones
- ☐ No solar heat gain coefficient (SHGC)[6] requirement in CZ 1, 3, 5 and 16
- ☐ Maximum SHGC 0.23 in CZ 2, 4, and 6-15

Solid Doors:

- ☐ Maximum U-factor requirement of 0.20, and NFRC-rated

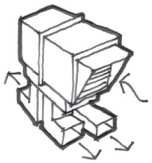
DHW

If using a tank water heater, then drain water heat recovery and either HERS verified compact hot water design or HERS verified pipe insulation; added provisions for electric resistance and heat pump water heaters.

PVs

Required in all climate zones (with certain exceptions, e.g., inadequate solar access) – sized to meet the electric load only, not gas; may NOT be used to trade off efficiency measures

HVAC & Whole House Fans



Mandatory changes, not tradeable:

- ☐ Gas furnace air handling systems – fan efficacy maximum 0.45 W/cfm systems.
- ☐ Air filter increased to minimum MERV 13
- ☐ Range hoods to be HERS verified as Home Ventilation Institute (HVI) certified

Whole House Fans:

- ☐ Products must be certified through Modernized Appliance Efficiency Database System (MAEDBS)

[5] Because the 2019 code is still being formulated, some of these requirements may change somewhat from what is shown here.
[6] The lower a window's SHGC, the less solar heat it transmits.

Spring Lake Apartments
Woodland, CA
Kuchman Architects
Mutual Housing
2015
Frank Domin photo

If you use a performance-based approach to compliance, you may have quite a few other options.

PHOTOVOLTAICS AND BATTERIES

The most notable and obvious change from the 2016 code is the added **requirement to include PV in your design;** it will no longer be available for trade-off with efficiency measures. Regardless of whether the house is all-electric or dual-fuel (using electricity and natural gas or propane), only the electric load will be factored into the required size of the PV array; and for all-electric homes, the required PV system size will be based on the electric use of a similar, code-compliant, dual-fuel house.

The new code compliance software will provide two different "Energy Design Ratings" (EDRs) – one for the efficiency measures alone and another for the renewable energy system. Each one, independently, will need to meet a minimum (climate zone-specific) threshold to achieve compliance.

WHAT IF MY PROJECT DOESN'T SEE THE SUN?

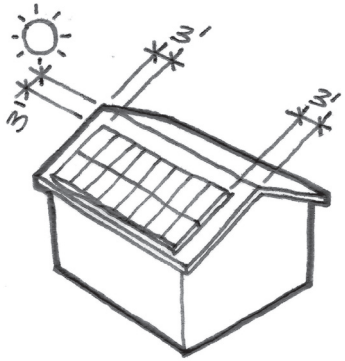
There will be exceptions to the PV requirements in situations where it's simply not feasible to meet them; for example:

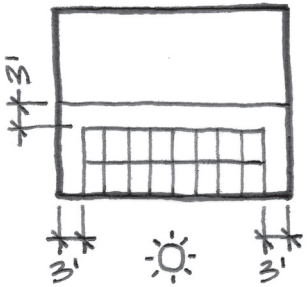
- ☐ The PV requirement may be waived entirely if the structure is shaded by other structures or offsite landscape features
- ☐ Three-story or taller homes may require a smaller PV array
- ☐ Projects that include battery storage may require a smaller PV array

DO I NEED TO INCLUDE BATTERY STORAGE?

Battery storage systems will not be required in the 2019 code; however, the State may require them in future versions of the code, and they may be a helpful feature to consider including in new homes, to allow surplus energy generated by onsite PV systems to be stored for onsite use during periods when the home's demand exceeds the PV production at that time. Energy storage systems will likely earn credit towards Title 24 compliance.

Church Hill Townhomes
Fortuna, CA
K. Boodjeh Architects
Danco Builders
2013
Brandi Easter photo





Only the electric load will be factored into the required size of the PV array.

DESIGN PRINCIPLES

EARLY DESIGN CONSIDERATIONS

Some of the factors that make it easiest to achieve ZNE – and to keep it affordable for your client – can also be easy to overlook, and need to be factored into the early stages of design. Not all of them are necessarily captured effectively in the energy modeling, but they will affect how well the home operates with people living there, so they do matter! At right is a checklist of things to keep in mind as you begin your design.

Early Design Checklist

- ☐ Plan for efficient framing – walls @ 24" o.c., openings aligned with framing, etc.
- ☐ Provide enough space for all the HVAC equipment and ducts (with required insulation) in conditioned space.
- ☐ Work with an HVAC system designer who really understands high performance (few do, so pick yours carefully).
- ☐ Run an energy model very early in design to get a sense of how much PV you're going to need – that will be important as you design the roof form.
- ☐ Avoid complexity in your roof design; simplicity carries multiple benefits:
  - + easier to detail so as to reduce risk of water intrusion
  - + easier to air-seal and insulate
  - + less costly to build
  - + more space for PVs
- ☐ Reduce overall complexity. Changes of plane and complicated intersections add cost; compromise thermal performance; are harder to build while maintaining continuity of water, air, and thermal barriers, and therefore increase risk of defects.
- ☐ Build in flexibility to accommodate changes over the building's life span, such as fuel switching (gas to electricity), addition of electric vehicle charging, etc.

RESOURCES

- Pacific Gas and Electric Company Zero Net Energy Production Builder Demonstration: Habitat for Humanity of San Joaquin County
- PVWatts® Calculator, National Renewable Energy Laboratory (NREL) – allows a quick, early calculation of energy generating potential
- *Residential Envelope and Solar Ready* – Energy Code Ace resource on California 'solar-ready roof' requirements
- Berkeley Deep Green Building Initiative solar roof recommendations (more comprehensive than building code requirements) – see Appendix A, Section 3 (pg. 17 in PDF)

Some of the factors that make it easiest to achieve ZNE can also be easy to overlook, and need to be factored into the early stages of design.

CLIMATE-SPECIFIC & PASSIVE DESIGN STRATEGIES

California's energy code recognizes 16 climate zones, which fall into five general types: north and mid-coast, southern coast, inland valley, mountain, and desert. However, these differences have relatively minor implications for designing ZNE homes; heating and cooling loads may dictate slightly different space conditioning specifications or a somewhat different set of passive design strategies.

Because different people mean different thing by 'passive' design, some definitions and guidance are provided at right.

Passive design as a generic term refers to ways of achieving a comfortable, healthy indoor environment that aren't mechanized and will function even in a power outage. A robust, well-sealed thermal enclosure is a cornerstone of passive design, as are shading strategies that respond to solar geometry.

Passive solar design, 1970s-style, was popularized in a context of drafty, poorly-insulated enclosures. It emphasized thermal mass and large expanses of south-facing glazing. A moderate amount of thermal mass can sometimes be helpful but should be used with great caution – it works better in some climates than others, and can be overdone. Too much south-facing glass can be a HUGE liability in a ZNE home, as it can cause catastrophic overheating, particularly in spring and fall when sun angles are low and bypass overhangs.

Passive House is a design system (including proprietary software) based on very stringent efficiency requirements for the building enclosure. There are two variants in use in the US, one affiliated with Passiv Haus International (PHI, headquartered in Germany) and the other an adaptation developed by Passive House Institute US (PHIUS, headquartered in Illinois) to align with North American climates. Both systems have devoted California ZNE practitioners.

D'Souza De La Torre Residence
Belmont, CA
Arkin Tilt Architects
2005
Edward Caldwell photo

RESOURCES

- "California Supreme Court Rules Against SOM" – cautionary tale about overheating in mild climates
- International Passive House Association
- Passive House Institute US
- *Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting and More Using Natural Flows*, David Bainbridge & Ken Haggard, 2011

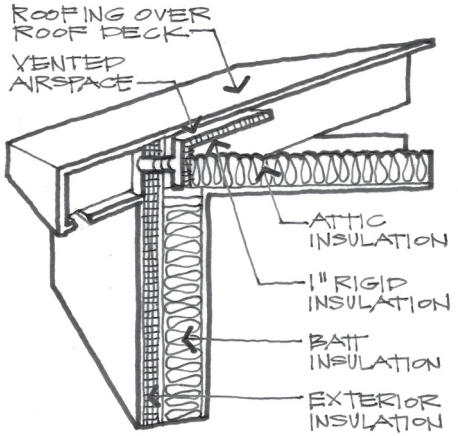
WALL & ROOF ASSEMBLIES

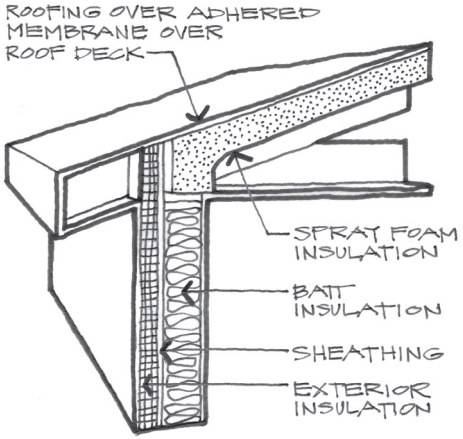
A high-quality enclosure is the bedrock of efficient construction, thus well-designed, well-detailed, and well-constructed wall and roof assemblies are critical to achieving ZNE. Key elements in high-performance assembly design include the framing, cavity insulation, exterior insulation, barriers, and air leakage control. Each of these elements is discussed below, and extensive relevant resources are listed on page 16.

FRAMING

Framing acts as a "thermal bridge" between interior and exterior surfaces; incorporating "advanced framing" or "optimum value engineering" features will reduce thermal bridging, thereby improving thermal performance while also saving the builder money on lumber. Although only a few specific advanced framing measures (e.g., 24" o.c. framing instead of 16") can be modeled in Title 24 software, all of them will reduce your project's framing factor, improving operating energy performance. Several advanced framing references are listed in the RESOURCES section on page 16.

Raised-heel trusses are another particularly valuable efficiency measure; while they require a bit more lumber, they allow the full depth of insulation to be installed all the way to the edge of the roof.





Title 24-2019 offers two roof/attic prescriptive options, vented (top) and unvented (bottom).

Plaza Point
Arcata, CA
K. Boodjeh Architects
2012
Brandi Easter photo

A high-quality enclosure is the bedrock of efficient construction.

CAVITY INSULATION

Several variables affect the ultimate thermal performance of insulation – not just R-values. The types and location of the insulation you use and the quality of installation also are extremely important in terms of energy efficiency, occupant comfort, and health.

Quality insulation installation (QII) is a prescriptive measure in the draft 2019 code, and should be utilized in all ZNE projects. Insulation, especially batt insulation, has commonly been poorly installed, with many defects including air gaps and compression around wires, pipes, and electrical boxes. Meeting the QII requirement entails field verification by a HERS rater. Achieving a high-quality installation that will pass a rigorous HERS verification requires that you write explicit installation specifications and review them with the general contractor and the insulation sub.

In general, blown rather than batt insulation is easier to install and will yield the best results. It is difficult, though not impossible, for installers to meet QII standards (and pass inspections) when using batts. Blown insulation types include:

- ☐ Fiberglass
- ☐ Cellulose
- ☐ Wool
- ☐ Spray foam (low- and high-density)

EXTERIOR INSULATION

In the past you may have avoided exterior insulation by trading off the prescriptive requirement for exterior insulation for another efficiency measure. Under the 2019 code, due to the overall increases in efficiency requirements, that trade-off will become more difficult in most CA climate zones (1-5 and 8-16), where the 2019 code includes a decrease in the prescriptive value for wall assembly U-factor, from 0.051 to 0.048. This translates to an increase in both cavity insulation (from R-19 to R-21) and continuous, rigid board, exterior insulation (from R-5 to R-7).

Options for exterior insulation include:

- ☐ Expanded polystyrene (EPS)
- ☐ Extruded polystyrene (XPS)
- ☐ Polyisocyanurate ("polyiso")
- ☐ Cork
- ☐ Mineral wool

Each insulation type has a unique set of characteristics (e.g., installation method, vapor permeability, aged R-value, global warming potential, and others). Before specifying your assemblies, research the pros and cons of the available options. Whatever product you select, incorporate the appropriate wall assembly details in your drawings – in particular, transition points such as window header and sill details and wall-to-roof transitions – to maintain continuity of moisture, air, and thermal barriers. See RESOURCES on page 16.

BARRIERS

With buildings getting more and more airtight and well-insulated, there also is more concern about making sure that air, vapor, and moisture barriers are correctly specified, appropriately placed within the building assembly, well-detailed, and properly installed.

These topics are well beyond the scope of this document to address in depth, but several excellent resources to help you address these issues successfully are listed on page 16.

Changing QII from a credit to a prescriptive requirement means that it will be included in the baseline ("standard" home) energy model, so omitting QII from the "proposed" home will reduce the modeled performance.

Quality insulation installation (QII) should be utilized in all ZNE projects.

AIR LEAKAGE CONTROL

AIR LEAKAGE CONTROL

Controlling air leakage is a critical aspect of building a ZNE home and is required in Title 24-2016, Residential Appendix 3. Air sealing is an uncommon skill and not yet well-established as a trade in California (or in many other parts of the US). As a result, this is among the most challenging aspects of building ZNE homes – and thus requires considerable attention by architects as well as builders.

Uncontrolled air leakage can compromise comfort, substantially reduce thermal performance, and increase risks of condensation, dry rot, and mold growth – and associated liability. Wall and ceiling assemblies do not need to 'breathe' – they need to be tight, while also designed to permit drying. Building Science Corporation has conducted extensive research on this topic (and many others) for the US Department of Energy, much of which is available free of charge at www.buildingscience.com.

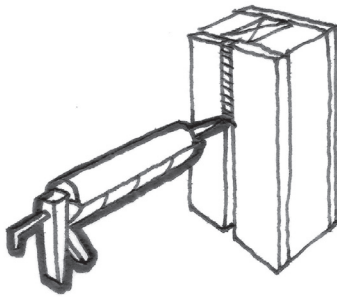
To aid in achieving successful air sealing, include the following information in the contract documents:

- ☐ Specification for airtightness with other enclosure specifications; (PG&E recommends an air leakage rate of 1.5 to 2.0 ACH_{50} for its ZNE demonstrations, although lower rates are possible with good detailing and careful construction)
- ☐ Section drawing showing a continuous air barrier around the entire building section – the icon at right links to an example drawing created by Coldham & Hartman Architects
- ☐ Architectural details showing the correct means of air-sealing specific areas – also shown in drawing linked at right
- ☐ Accountability for outcomes

Because of the current level of experience with the practice in California, successful air sealing also requires both communication about the intent of air sealing with the contractor and subcontractors and vigilance during construction. Consider including the following requirements for the general contractor in your specifications:

- ☐ Assign specific responsibility for air sealing to one individual (air sealing manager, or ASM) who reports to the site superintendent or project manager – this is typically the insulation subcontractor
- ☐ Ensure that the ASM receives specific training in effective air sealing techniques and in blower door testing
- ☐ Brief all affected workers/subs (e.g., framing, windows, plumbing, electrical, drywall) on the importance of air sealing to the ZNE goal, and inform them that they are answerable to the ASM for their specific contributions to the overall air sealing strategy
- ☐ Demonstration by the ASM of specific techniques the subs will use
- ☐ Frequent inspections by the ASM as trade work involving air sealing proceeds
- ☐ A preliminary blower door test conducted by the ASM as soon as the house is fully closed in, i.e., after all exterior windows and doors are installed; after rough plumbing, electrical, and all other penetrations in the pressure boundary are complete; and preferably before any materials cover the exterior sheathing and/or shear walls and before any insulation or drywall is installed
- ☐ Use of appropriate diagnostic techniques (e.g., smoke testing) to identify leak sources
- ☐ Correction of air sealing defects
- ☐ Additional blower door testing by the ASM during and post-correction activities until the targeted airtightness is achieved

In a ZNE home, it is important to include a mechanical ventilation system to supply fresh, filtered air at an appropriate rate for the size of the home. Mechanical ventilation avoids air quality problems and greatly reduces the energy penalty of uncontrolled air leakage – even factoring in the fan energy. Most California ZNE homes are now using heat-recovery or energy-recovery ventilators (HRVs or ERVs).



Air sealing drawing by Coldham & Hartman Architects

RESOURCES

(Note: some of these are free, others available for purchase)

HIGH-PERFORMANCE ASSEMBLIES (GENERAL)

- *Guide for Designing Energy-Efficient Building Enclosures for Wood-Frame Multi-Unit Residential Buildings in Marine to Cold Climate Zones in North America,* FP Innovations and RDH Building Engineering Ltd., Graham Finch, et al.
- *Illustrated Guide - R22+ Effective Walls in Residential Construction in B.C.,* BC Housing
- *Field Test of Hygrothermal Performance of Highly Insulated Wall Assemblies,* M. Fox, et al.
- *Hygrothermal Analysis of California Attics,* Building Science Corporation, Joseph Lstiburek and Christopher Schumacher
- Building Science Corporation case studies – in the search window, select "Designs That Work" as the document type, and the appropriate US climate zone[7] (or "Any")
- *Building Science Corporation assembly guidance documents,* e.g., "ETW: Walls - 2x6 Advanced Frame Wall Construction High R-Value" – in the search window, select "Enclosures That Work" as the document type and select "Any" as the climate zone
- Residential High Performance Walls, California Energy Codes & Standards
- Building America Solution Center, U.S. Department of Energy – Energy Efficiency & Renewable Energy – *Ceilings Guide* and many other relevant guides
- *Construction Guide, Next Generation High Performance Walls, Climate Zones 3-5 Part 1: 2x6 Walls.* Home Innovation Research Labs, V. Kochkin and J. Wiehagen
- Several listed at Workforce Instructions for Standards and Efficiency (WISE), e.g., *Illustrated Guide: R22+ Effective Walls in Wood-Frame Construction in British Columbia,* Homeowner Protection Office, BC Housing

FRAMING

- *Advanced Framing Construction Guide,* APA – The Engineered Wood Association

INSULATION

- The BuildingGreen Guide to Insulation – each insulation type analyzed, including thermal performance (R-value), response to aging, performance in extreme temperatures, off-gassing, global warming potential, health impacts, and other key factors
- *Builder's Guide to Continuous Insulation,* Dow, Building Science Corporation
- *Measure Guideline: Incorporating Thick Layers of Exterior Rigid Insulation on Walls,* US Department of Energy, Building Science Corporation
- *Residential Insulated Sheathing – Design Guide,* Roxul, Building Science Consulting, John Straube

AIR SEALING

- "Fact Sheet: Envelope Air Sealing 2013 California Energy Efficiency Building Standards," California Energy Commission
- Coldham & Hartman Architects continuous air barrier drawing
- Hammer and Hand Best Practices Manual
- *Forty Years of Air Barriers,* Building Science Corporation
- *Passive House Design,* Gonzalo Roberto
- *Details for Passive Houses,* Österreichisches Institut für Baubiologie und -ökologie

INSULATION SPECIFICATIONS AND SCOPES OF WORK

- State of California Quality Insulation Installation specifications
- HERS fact sheet
- *Ace Installation Residential,* Energy Code Ace
- Energy Code Ace Quality Insulation Installation resources – a sample plan set including air sealing details, a QII note block to be added to architectural plans, and a contractor's QII checklist
- *Revisions to Quality Management Products: Four Scopes of Work for High Performance Homes* – NREL, National Association of Home Builders Research Center – covers excavation, foundations, framing, and HVAC

Valley Glen Apartments
Dixon, CA
Pacific West Communities
2014
Glen McDowell photo

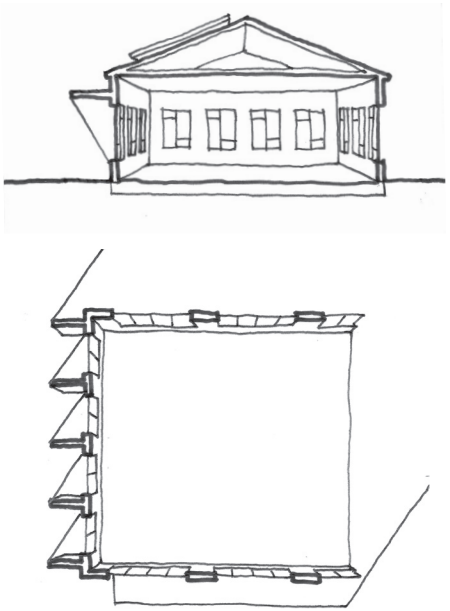
[7] See https://energy.gov/eere/buildings/climate-zones for definitions of US climate zones, which are distinct from California climate zones.

FENESTRATION

Windows are important to many aspects of occupant satisfaction and comfort, as well as having a potentially profound effect on energy performance. Key design measures to consider in ZNE homes include:

- ☐ Holding glass area in check. The most efficient window is considerably less efficient than the most inefficient wall, *and* the more glass you have, the more challenging protection from overheating becomes. (Tip: avoid floor-to-ceiling glass; your clients' kneecaps and feet won't enjoy the view at floor level, it's a thermal liability, and the lower the glass is on the wall, the harder it is to shade)
- ☐ Incorporate shading and glare protection. While especially critical in cooling-dominated climates, shading is important in *all* ZNE homes – if the SHGC is too high or shading is inadequate, they can overheat quite easily compared with homes built to earlier standards.
- ☐ Use skylights judiciously. They typically result in both unwanted heat gain during daylight hours and heat loss at night.

As shown on page 8, while the draft 2019 code calls for a maximum SHGC of 0.23 in climate zones with higher cooling loads (CZ 2, 4, and 6-15), there is no SHGC requirement in CZ 1,3, 5 and 16. However, many CA ZNE demonstration projects have adopted a specification of U 0.27 or less and SHGC 0.20 or less to further improve comfort and enclosure efficiency, and reduce overheating risks.



Top: *Overhangs provide shading on south facades when the sun is high in the sky.*
Bottom: *Vertical fins provide shading on east and west facades when the sun is low in the sky.*

RESOURCES

- Efficient Windows Collaborative
- *Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting and More Using Natural Flows,* David Bainbridge & Ken Haggard, 2011

Many CA ZNE demonstration projects have adopted a specification of U 0.27 or less and SHGC 0.20 or less to further improve comfort and enclosure efficiency, and reduce overheating risks.

HEATING AND COOLING

Designing a highly efficient enclosure yields big benefits: it creates a more comfortable home for your clients while reducing the size, complexity, and thus the cost of the heating and cooling systems. However, realizing those benefits requires that you work with an HVAC design professional who really understands high performance, will calculate heating and cooling loads that accurately reflect the high-performance enclosure, and then will select, size, and locate the system components accordingly. Assumptions and 'rules of thumb' commonly used by HVAC contractors don't apply to a home with a superior enclosure. If loads and sizing aren't calculated using accurate information, they will not be correct.

Variables that affect the overall efficiency of heating and cooling systems include fuel selection, air handler and distribution system locations, proper sizing, equipment efficiency, distribution system design, installation quality, and commissioning.

California Energy Commission (CEC) research shows that good design and installation of heating and cooling systems can increase system performance by 80% and that this is the most cost-effective opportunity for improvement in residential buildings.[8]

Achieving high-performance heating and cooling solutions is complicated by infinite possible combinations of system variables, with each variable affecting others. For example, larger ducts require less fan energy to push air through them, but have more heat loss due to their larger surface area. And larger supply grilles are quieter because they reduce air velocity – but air velocity that is too low cannot mix air in the room, resulting in uncomfortable temperature stratification. To successfully address all these variables, it is imperative to select an HVAC contractor who commissions all installations and whose testing results will align with the "ZNE Quality Heating and Cooling Specification Guidelines" above. These specifications are achievable with experienced high-performance trades people.

ZNE QUALITY HEATING AND COOLING SPECIFICATION GUIDELINES[9]

Air conditioner sizing	2,000+ sq.ft. per ton (even in warmer climates – valley, inland empire, and desert)
Heating system sizing	Less than or equal to 12 Btu/sq.ft. (even in cold climates)
Duct leakage	zero (too small to measure)
Duct conductive losses	R-6.0 insulation, ducts in conditioned space, and as short as possible
Fan energy	less than 0.2 watts per CFM
Cooling air flow	550+ CFM per ton
Subcooling	low end of manufacturer's acceptable range
Superheat	less than 8°F

LOCATION

Locating the air handling equipment and ducts within conditioned space is critical to minimize air handler and distribution system losses.

Good design and installation of heating and cooling systems can increase system performance by 80%.

[8] *Efficiency Characteristics and Opportunities for New California Homes* (ECO), March 2011, CEC Project 500-2012-062, J. Proctor, R. Chitwood, B. Wilcox.
[9] Developed by Rick Chitwood, Chitwood Energy Management.

PROPER SIZING

Design of the HVAC system is closely related to the building form and to the quality of the thermal enclosure. The ratio of surface area to volume is an important variable in the architect's control – a smaller ratio (a simpler form) reduces unwanted heat loss and gain. An excellent thermal enclosure (low air leakage rate, QII, etc.) also substantially reduces heating and cooling loads. As a result, much lower-capacity heating and cooling equipment can – and should – be used. However, too often, HVAC systems are sized using 'rules of thumb' that are completely inappropriate for efficient ZNE enclosures.

As a result, oversizing equipment is very common, and it is problematic because oversized systems compromise comfort – for example, an oversized furnace will provide a short blast of heat (typically creating higher-than-desired temperatures in some parts of the home) and then shut off until the thermostat drops again; and then this will repeat, so the occupants are alternately too warm and too cool. Furthermore, oversized, rapidly cycling equipment fails prematurely because it is designed to run continuously, not in short cycles.

ZNE homes in California require much smaller equipment than is typical in standard construction. The industry standard for sizing in California is 500 to 800 square feet of conditioned floor area per ton of cooling capacity. Several examples of ZNE homes are shown below, with sizing ranging from 1,600 to 3,400 square feet per ton. These examples demonstrate that equipment capacities 3 to 5 times lower than are typically specified will meet the heating and cooling needs of highly-efficient, ZNE homes.

In modestly-sized ZNE homes in many California climates, the heating and cooling loads may be low enough that the only equipment option that has a small enough capacity is a single, ducted, mini-split electric heat pump (which provides both heating and cooling).

EQUIPMENT EFFICIENCY

Title 24 minimum required equipment efficiencies in most cases will be completely adequate for ZNE homes – if the system is properly designed and installed.

DISTRIBUTION SYSTEM DESIGN

As with water heating systems, a compact layout will contribute to efficient performance. Keep ducts as short as possible – in your well-insulated ZNE enclosures, there is no need to run ducts to exterior walls. Sizing system components using the applicable Air Conditioning Contractors of America (ACCA) manuals, in compliance with CALGreen requirements (Title 24, Part 11), is also very important. Passing the new HVAC mandatory tests (listed on page 8) will be very hard if duct systems are not designed and installed correctly.

INSTALLATION QUALITY/ COMMISSIONING

Installation shortcomings can greatly reduce system performance, so include specifications requiring commissioning of all elements of the heating and cooling systems – e.g., duct blaster, blower door, and room-by-room air flow testing.

Most residential building features and performance are verified visually, e.g., inspecting a header size or noting the insulation R-value stamped on fiberglass batts. Heating and cooling performance can only be verified with performance measurements. The performance goals are not the same as the HERS verification, which simply checks for code-minimum performance. More appropriate performance goals for ZNE homes are shown in the "ZNE Quality Heating and Cooling Specification Guidelines" table on page 18.

Be very selective about who you work with, and require that the HVAC system designer submit load calculations, equipment sizing based on load calculations, and all specifications, for your approval.

Builder	Location	CA Climate Zone	CDD	Home Size (Sq. Ft.)	Cooling Load (Btu/Hr)	Cooling Capacity Need (tons)	Standard Sizing (tons)	Square Feed per Ton
Habitat for Humanity of San Joaquin Valley[10]	Stockton, CA	12	1,470	1,200	6,000	3/4	2	1,600
CHISPA	Greenfield, CA	4	257	1,167				
PG&E Redding Demo [builder?]	Redding, CA	11	1,132	2,550	9,000	3/4	3.5	3,400

[10] "House 10" in *Final Report,* March 2017, Pacific Gas and Electric Company Zero Net Energy Production Builder Demonstration, Habitat for Humanity of San Joaquin County Dream Creek Subdivision, Stockton, CA.

WATER HEATING

To minimize the energy needed for water heating, think about the layout of hot water draws throughout the house, and the water heater location, in the very early stages of design, and locate them as compactly as possible. A compact system also may allow you to incorporate drain water heat recovery. An efficient water heater is also important, as are efficient appliances and fixtures.

LOCATION & DISTRIBUTION

Locate the water heater in conditioned space. To the extent possible, design hot water draws close to one another and to the water heater, to minimize heat loss through the pipes. When a compact system is not practicable, install an on-demand recirculation loop; an excellent guidance document is available from the EPA (listed on page 21 under RESOURCES).

DRAIN WATER HEAT RECOVERY

Drain water heat recovery (DWHR) may be a beneficial feature to incorporate – in the draft 2019 code, this is an option with a tank water heater and a credit with a tankless unit. DWHR systems transfer heat from outflowing hot water in drain lines (e.g., from shower stalls) to the incoming cold water line, as shown at right – the coil is the incoming cold water line.

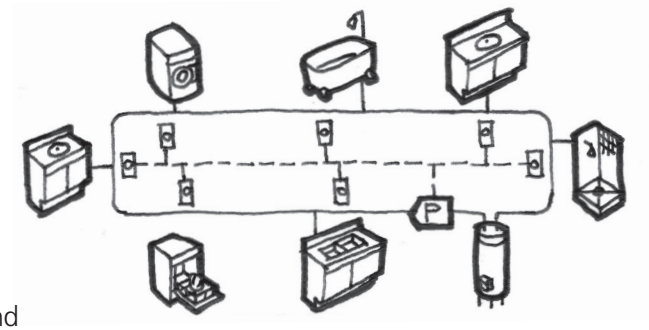
WATER HEATER EFFICIENCY

Title 24-2019 offers three prescriptive water heating options; those options, along with a comparison of their pros and cons, is shown in the table on page 21.

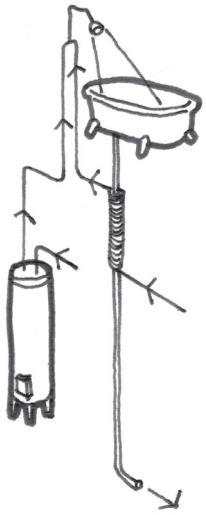
APPLIANCE AND FIXTURE PERFORMANCE

Showers, dishwashers, and clothes washers have significant impacts on household energy use (as well as water use). Particularly in relatively mild climates and in multifamily buildings, they may represent a very high fraction of overall energy consumption. Appliance selection is often heavily influenced by clients, particularly when aesthetics are a major concern. Nevertheless, you can provide your clients with some excellent guidance in choosing high-efficiency options. While Energy Star is a reasonable starting point, higher standards include Energy Star "Most Efficient," CEE1.org 'Tier 3' listings, and models rated 90+ on Enervee.com.

Specify showerheads with the lowest practicable flow rate (gallons per minute, or gpm) that will provide acceptable performance. CALGreen requires that the combined flow rate of all showerheads controlled by a single valve may not exceed 2.0 gpm @ 80 psi; however, it's important to note that flow rate isn't a good predictor of a satisfactory shower experience, and showerheads with lower flow rates can provide greater energy savings without compromising performance. Be sure to consult credible, current reviews (e.g., on BuildingGreen.com) to assist in specifying models. Another important variable in shower performance is the height of the showerhead relative to the height of the person showering; if too great a distance between the two, the water droplets will cool too much before hitting the person. A good solution to ensure a happy shower for everyone is to specify adjustable-height fixtures whenever possible.



When a compact layout is not feasible, install an on-demand recirculating hot water loop.



Drain water heat recovery diagram

SOLAR WATER HEATING

In multifamily buildings, solar water heating (a.k.a. solar thermal) systems are a prescriptive requirement under Title 24. In single-family homes, solar water heating earns performance credit. However, many ZNE practitioners believe that for single-family homes, 'solar thermal is dead,' because comparable results are achieved with an electric heat pump water heater in combination with a modest increase in the size of the PV array – while also being simpler and cheaper, and requiring less maintenance.[11]

[11] See articles on this topic by Martin Holladay at http://www.greenbuildingadvisor.com/blogs/dept/musings/solar-thermal-dead and http://www.greenbuildingadvisor.com/blogs/dept/musings/solar-thermal-really-really-dead.

Water Heater Pros and Cons[12]

Factor	Heat Pump (Gas or Electric)	Gas or Propane Tankless ("instantaneous")	Gas or Propane Storage Tank
Space	■ Relatively large (6+ square feet of floor space) and relatively tall, and require air space around them.	■ Relatively small, wall-mounted	■ Relatively large (4-6 square feet of floor space).
Location	■ Can be installed in a closet only if both supply and return air are ducted.	■ Condensing (higher efficiency) units can be located in conditioned space, closer to fixtures and with shorter delivery time.	■ Condensing (higher efficiency) units can be located in conditioned space, closer to fixtures and with shorter delivery time.
Hot Water Delivery	■ Recovery rate (time to reheat a new tank) is relatively slow.	■ Can provide endless hot water at typical flow rates; may not be able to meet several simultaneous demands (which are are relatively uncommon). ■ Most models are not "instantaneous" as they start out with cold water; delivery time also depends on distance to fixture.	■ Can provide hot water for typical flow rates and meet several simultaneous demands. ■ When water in the tank is below desired temperature, flow rate is limited.
Maintenance	■ Manufacturers recommend yearly valve check. ■ Anodes and flush tank should be checked at least every 5 years. ■ Efficiency drops when the air filter is dirty.	■ Manufacturers recommend yearly service for cleaning filters and flushing heat exchangers.	■ Controls are simpler and less prone to malfunction than those of tankless models. ■ Manufacturers recommend yearly valve check. ■ Anodes and flush tank should be checked at least every 5 years.
Other	■ Best choice for all-electric homes. ■ 1.5 to 2.5 times more efficient than tankless or traditional storage water heaters when well maintained. ■ Grid-connected models can be programmed to heat when electric rates are low, for later use. ■ Relatively new technology, shorter track record.	■ Good for intermittent uses such as vacation homes (water doesn't age and become smelly).	

RESOURCES

- Energy Star Water Heaters – select Energy Star "Most Efficient"
- Consortium for Energy Efficiency – the most efficient models are designated as Tier 3
- Enervee.com
- *WaterSense New Home Specification Guide for Efficient Hot Water Delivery Systems,* US Environmental Protection Agency – on-demand hot water recirculation system design guidance
- Drain Water Heat Recovery Characterization and Modeling, Natural Resources Canada
- Drain-water heat recovery energy efficiency ratings, Natural Resources Canada
- "Drain Water Heat Recovery Systems are Energy Efficient and Economical," EcoBuilding Pulse, Heidi Moore

[12] Table developed with extensive input from Gary Klein and Larry Weingarten, hot water experts extraordinaire.

ELECTRIC LOADS

LIGHTING

Title 24 has stringent regulations governing choice of lighting fixtures, lamps, and lighting controls. All residential lighting requirements are prescriptive. That means going above and beyond those requirements won't affect your energy model, but it can reduce operating energy use. Many homes have excess numbers of fixtures or ill-placed fixtures. "Better" lighting includes going 100% LED, focusing on lighting quality that addresses functional needs and reinforces the architectural design while reducing the fixture count, and avoiding recessed cans in insulated

APPLIANCES AND ELECTRONICS

The 2019 code is expected to include credit for Energy Star appliances. For best operating energy performance, specify or recommend best-in-class (Energy Star Most Efficient, CEE1.org Tier 3, or Enervee.com 90+) for all appliances and electronics – refrigerators are at the top of the list!

MONITORING

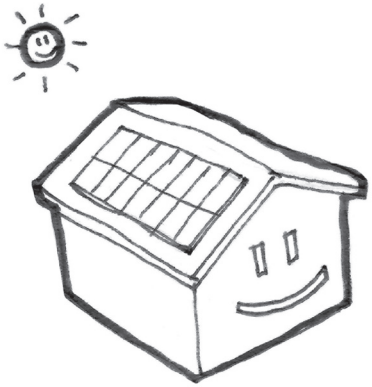
Performance monitoring devices and dashboards are increasingly common, heightening occupant awareness of their energy-using behaviors.

RESOURCES

- *Residential Lighting,* California Lighting Technology Center, UC Davis (this document may require some updates to reflect 2019 code)
- Consortium for Energy Efficiency – the most efficient models are designated as Tier 3
- *Liberty Lighting Guidelines for Zero Net Energy Communities,* California Lighting Technology Center, UC Davis
- Enervee.com – models are rated on a 100-point scale; choose ratings of 90+

TOP TEN RESOURCES

- California Energy Commission, 2019 Title 24, Part 6 draft code language
- Building Science Corporation
- Building America Solution Center
- Net Zero Energy Coalition case study database
- Energy Code Ace
- Green Building Advisor
- DOE Tour of Zero
- National Renewable Energy Laboratory
- Zero Energy Project
- *Energy Free: Homes for a Small Planet*



KEYS TO SUCCESS

START WITH THE END IN MIND

Set ZNE as a project goal from the very beginning, to calibrate your mindset (and your client's). Then you'll figure out how to do it and stay on budget!

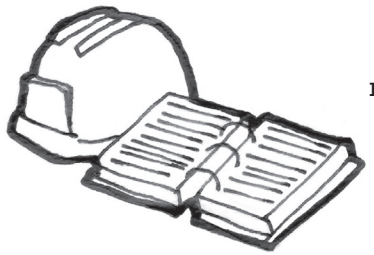
Learn from the pioneers – research how other architects have tackled the ZNE challenge.

Pick a rock star team, and involve all of them from early in the design process – include a really great mechanical system designer, a really great energy modeler, and a really great general contractor! The ideal qualifications are:

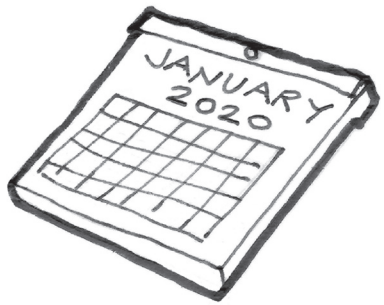
- **Commitment** to the ZNE goal
- **Creativity** to go beyond business-as-usual
- **Experience** with high-performance/ZNE projects
- **Engagement** ("plays well with others")

Focus on the enclosure – it's the key to success with ZNE. Dedicate time to developing a comprehensive set of air sealing and air-vapor-water barrier continuity details that you can use over and over again.

Control what happens in the field as much as you can – develop a rigorous set of quality management specifications to include in your CDs (every time); include field diagnostics (blower door testing, duct blaster testing, infrared imaging, etc.) and commissioning.



Make a checklist of the new things you will need to accommodate now (and should plan for in the future), and their space needs: shading, PVs, more PVs for electric vehicles, mechanical equipment in conditioned space, etc.



HAVE FUN!

RESOURCES

"Making Choices Instead of Paying Premiums," Northeast Sun, Bruce Coldham – excellent article on the relationship between goals and budget

Net Zero Energy Coalition/NESEA case study database

Tour of Zero, US Department of Energy project profiles

California Association of Building Energy Consultants (CABEC) listing of Certified Energy Analysts

You'll be able to meet California's new ZNE code

by focusing on a few key aspects of

design and documentation;

each of these topics is discussed

in this ZERO NET ENERGY PRIMER:

- ☐ An excellent thermal enclosure
- ☐ Highly efficient mechanical systems
- ☐ Solar energy systems