2015 International Energy Conservation Code and Envelope Design

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Hawaii State Energy Office

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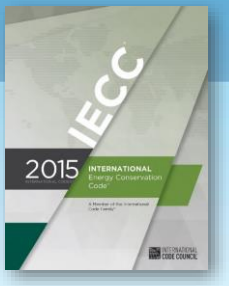


August 5 – 12, 2019

1

Acknowledgment: This material is based upon work supported by the U.S. Department of Energy under Award Number #EE0000811

Sponsor: State of Hawaii, Department of Business, Economic Development and Tourism

2

2

Learning Objectives

- Determine energy code compliance for building envelope designs
- Identify effective envelope heat gain reduction strategies
- Develop fenestration designs that account for thermal and visual comfort
- Select effective opaque envelope construction options
- Identify applicable County amendments to the International Energy Conservation Code

3

3

Sponsors

4

4

Agenda – Morning Session

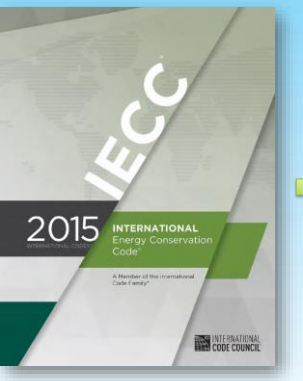
8:00	Registration
8:30	Introduction Fenestration design Fenestration requirements
9:45	BREAK
10:00	Opaque envelope design Opaque envelope requirements
	Hawaii Energy
11:30	Adjourn

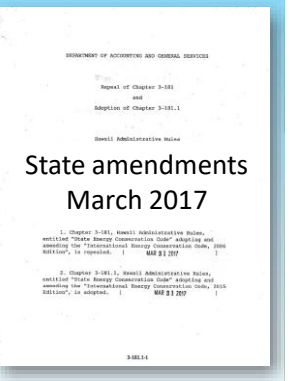
Agenda – Afternoon Session

1:00	Registration
1:30	Hawaii Energy
1:40	Introduction Fenestration design Fenestration requirements
3:00	BREAK
3:15	Opaque envelope design Opaque envelope requirements
4:30	Adjourn

Section 1
Introduction

What is it?





County Adoption Status

Kauai – Nov. 2018
Maui – Mar. 2019
Honolulu } State amendments
Hawaii } apply as of March 2019

What is it?

Table of Contents

Commercial Provisions	Residential Provisions
Chapter 1 – Scope and Administration *	Chapter 1 – Scope and Administration *
Chapter 2 – Definitions	Chapter 2 – Definitions
Chapter 3 – General Requirements	Chapter 3 – General Requirements
Chapter 4 – Commercial Energy Efficiency *	Chapter 4 – Residential Energy Efficiency *
Chapter 5 – Existing Buildings *	Chapter 5 – Existing Buildings *
Chapter 6 – References Standards	Chapter 6 – References Standards

* See also Hawai'i State Energy Conservation Code amendments

Who needs to comply?

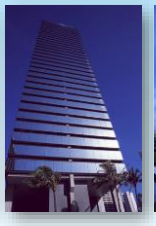
Residential Requirements

- 1- and 2-family dwellings (R-3)
- Multi-family (R-2 ≤ 3 stories)
- Residential care/assisted living (R-4 ≤ 3 stories)

Commercial Requirements

- All other buildings
  - Including R-1 (hotels)






Who needs to comply?

- New construction
- Additions
- Alterations
  - Several exceptions
- Change of occupancy
  - When change results in increase in energy
  - Conversions to dwellings

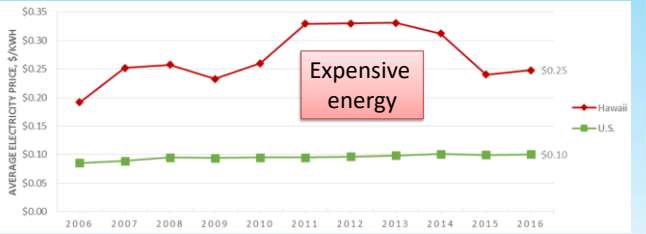
Why should I care?

- Energy savings
  - Lower utility bills
  - Reduced oil imports
  - Lower emissions
- Value
  - Lower life-cycle cost
- Comfort

13

Why should I care?

Electricity Rates ($/kWh)

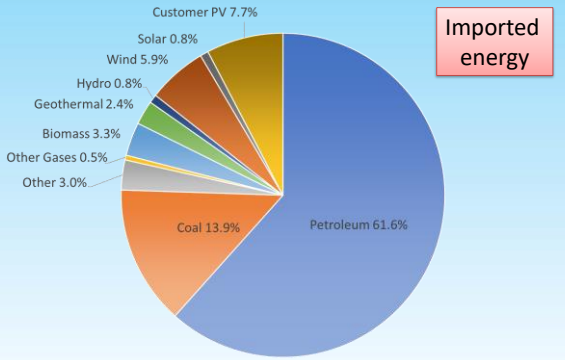


https://energy.hawaii.gov/wp-content/uploads/2011/10/HSEOFactsFigures_May2017_2.pdf

14

Why should I care?

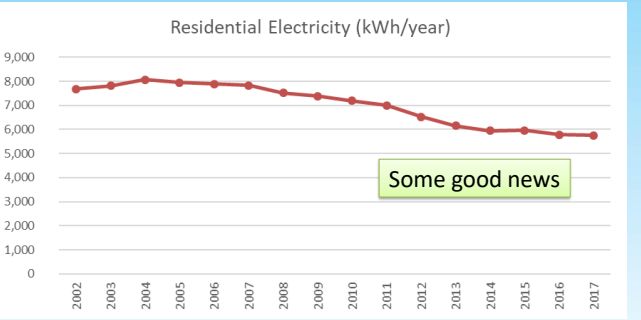
Hawaii Electricity Production by Source (2016)



Source: Eugene Tian, DBEDT

15

Why should I care?



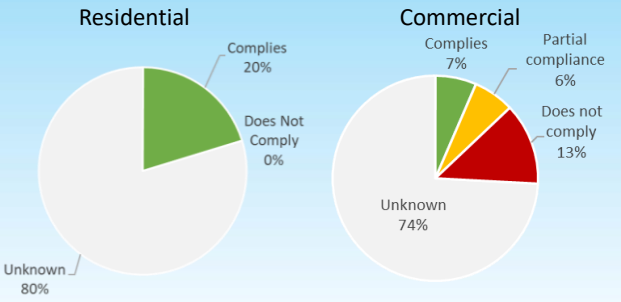
Source: Hawaii Data Book 2017

16

Why are we talking about envelope?

2018 code compliance study

Window compliance



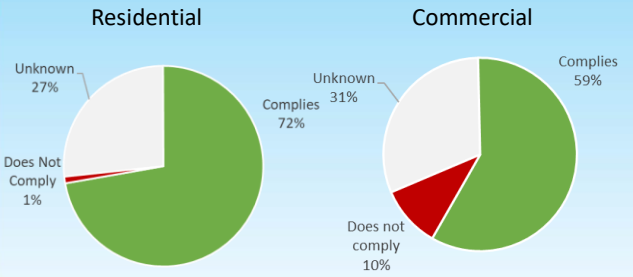
https://energy.hawaii.gov/wp-content/uploads/2018/11/2018-Code-Compliance-Study_Oct2018R.pdf

17

Why are we talking about envelope?

2018 code compliance study

Roof insulation compliance



https://energy.hawaii.gov/wp-content/uploads/2018/11/2018-Code-Compliance-Study_Oct2018R.pdf

18

Section 2
Fenestration Design

- Window impacts
- How windows work
- Window design strategies

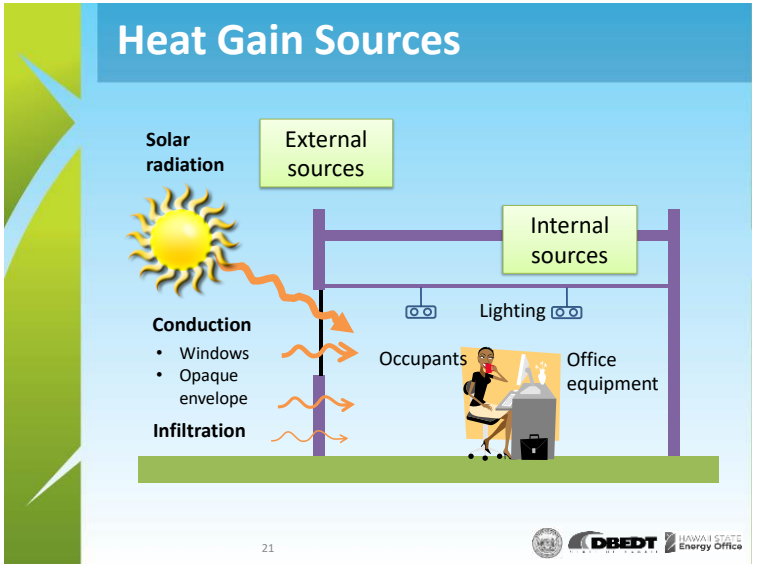
19

Window Impacts

Views, aesthetics, and

- Cooling system size
- Energy - air conditioning and lighting
- Peak electric demand
- Occupant thermal comfort
- Indoor visual comfort
- Outdoor reflected light and heat

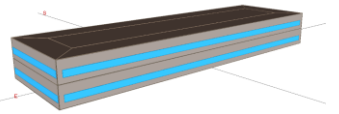
20



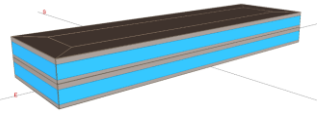
21

Window Impacts

Example office building

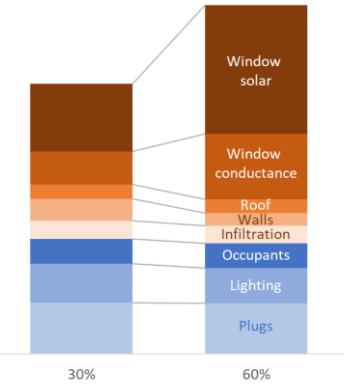


30% window area



60% window area

Peak space cooling load

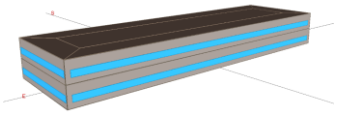


22

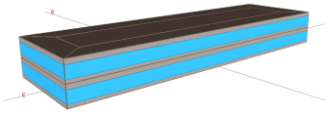
22

Window Impacts

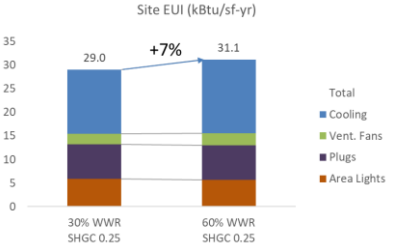
Example office building



30% window area



60% window area

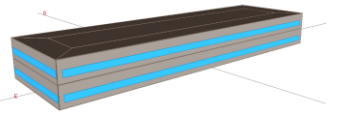


23

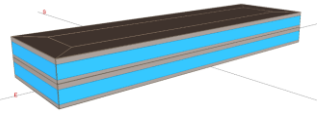
23

Window Impacts

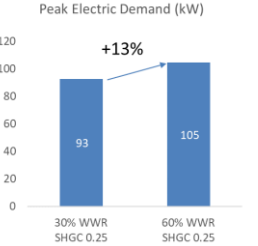
Example office building



30% window area



60% window area

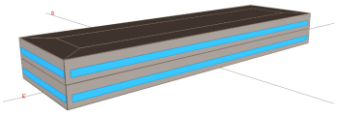


24

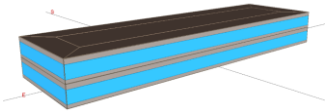
24

Window Impacts

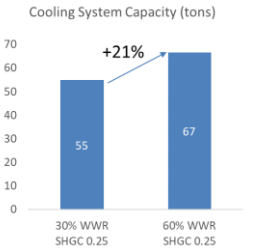
Example office building



30% window area



60% window area



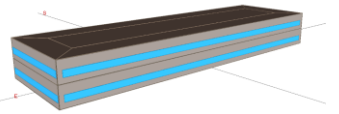
Source: www.carrier.com

25

25

Window Impacts

Example office building



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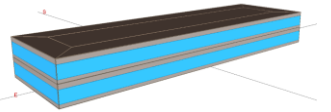
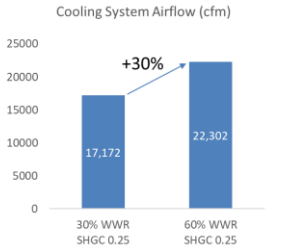


60% window area

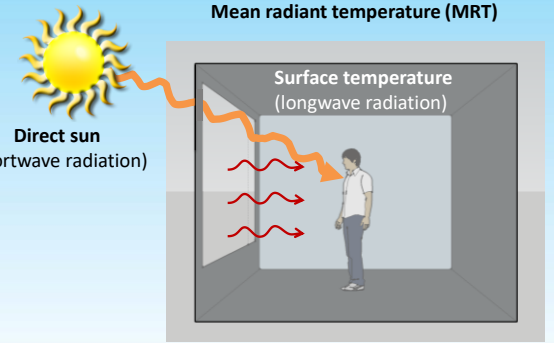


26

26

Window Impacts

Thermal comfort



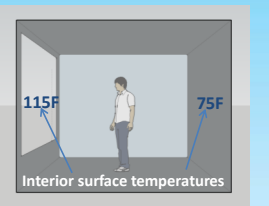
27

27

Window Impacts

Single-pane tinted glass

90F outdoor air
Sun on window

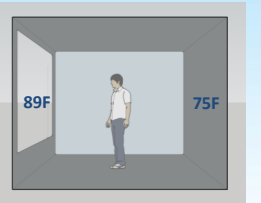


5 feet from window

MRT = 88F
Need 74F air

+ direct sun:
MRT = 91F
Need 67F air

Dual pane low-e, low solar gain



MRT = 77F
Need 78F air

+ direct sun:
MRT = 82F
Need 74F air

28

28

Window Impacts

Visual comfort

Typical indoor lighting targets

Activity	Illuminance (footcandles)
Circulation Orientation	2
Public Areas	5
Simple Tasks	10
Large Tasks Good Contrast	30
Small Tasks Good Contrast	50
Small Tasks Poor Contrast	100

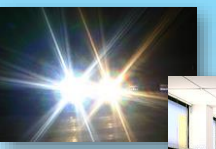
Daylight illuminance

Daylight condition	Illuminance (footcandles)
Clear sky	2,000 to 10,000
Overcast sky	500 to 2,000

Window Impacts

Visual comfort

Glare
- Disability glare
- Discomfort glare
  - Direct glare
  - Veiling glare (reflections)



www.lrc.rpi.edu

Maximum Luminance (Brightness) Ratios	
1 : 3	**task** and adjacent surrounding
1 : 10	**task** and more remote surfaces
1 : 40	within the normal field of view

Window Impacts

Reflected light and heat

Reflective "death ray" torments Vegas sunbathers

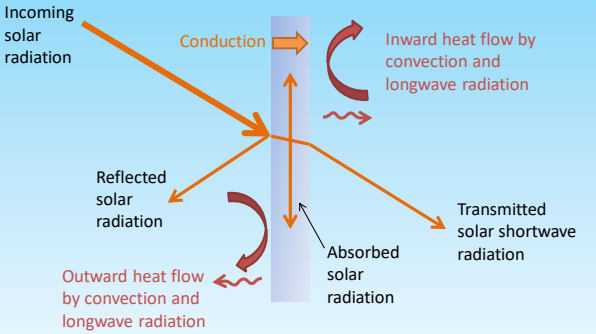
LAS VEGAS (Reuters) - MGM Resorts International is taking the heat for an intense beam of searing desert sunlight, jokingly dubbed the "death ray," that some hotel guests say poses a risk of severe burns to bathers lounging poolside.

'Walkie Scorchie' building developers say they will erect temporary scaffold

Local business owners blame the London skyscraper for starting fires and causing damage by reflecting the sun's rays

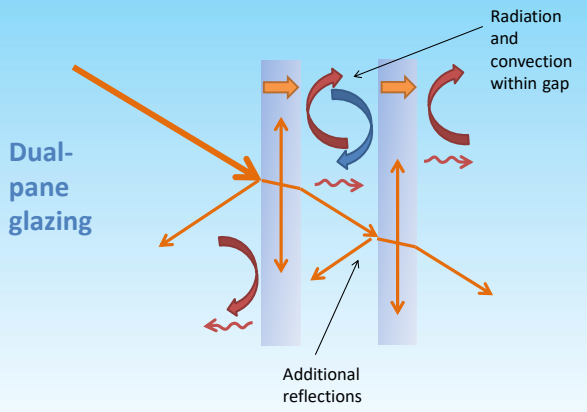
Press Association

How windows work

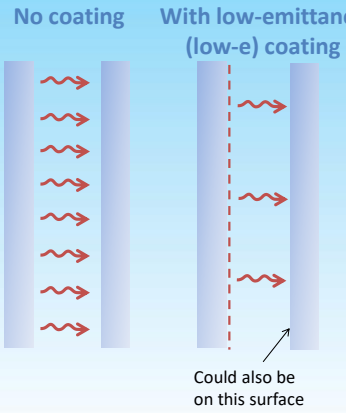


Reflected + Absorbed + Transmitted = 1

How windows work



How windows work



ε = infrared emittance

$$q_{net\ 1\ to\ 2} = \frac{\sigma\left(T_1^4 - T_2^4\right)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

How windows work

- Thermal characteristics
  - Solar heat gain coefficient (SHGC)
  - Thermal conductance (U-factor)
- Optical characteristics
  - Visible light transmittance (VLT)

How windows work

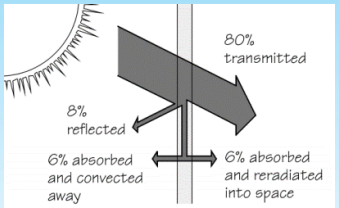
Solar heat gain coefficient

$$\text{SHGC} = \frac{\text{Solar heat gain entering the space}}{\text{Incident solar radiation energy}}$$

How windows work

Solar heat gain coefficient

Clear glass



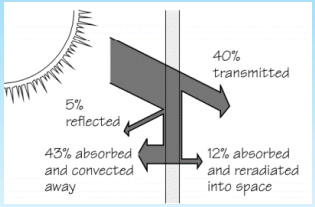
SHGC = 80% + 6% = 86%

http://windows.lbl.gov/software/NFRC/SimMan/NFRCSim6.3-2013-07-Manual.pdf

How windows work

Solar heat gain coefficient

Tinted glass (heat-absorbing)



SHGC = 40% + 12% = 52%

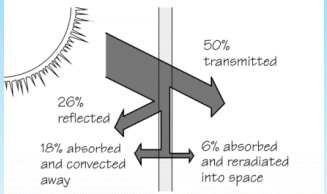
(An example. A range of performance is available)

http://windows.lbl.gov/software/NFRC/SimMan/NFRCSim6.3-2013-07-Manual.pdf

How windows work

Solar heat gain coefficient

Reflective glass coating



SHGC = 50% + 6% = 56%

(An example. A range of performance is available)

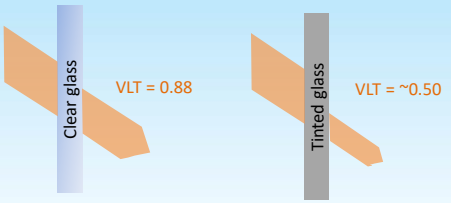
http://windows.lbl.gov/software/NFRC/SimMan/NFRCSim6.3-2013-07-Manual.pdf

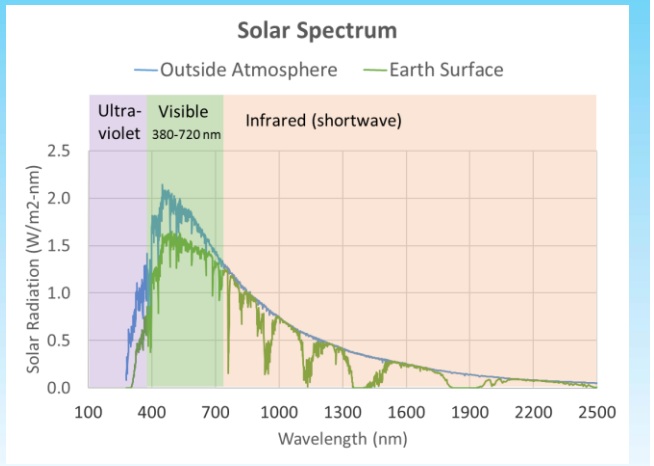
How windows work

Visible light transmittance

$$\text{VLT} = \frac{\text{Visible light entering the space}}{\text{Incident visible light}}$$

Examples



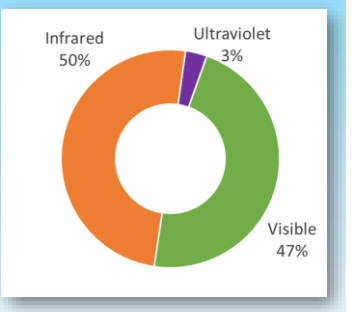


Data source: http://rredc.nrel.gov/solar/spectra/

41

Solar Radiation Power

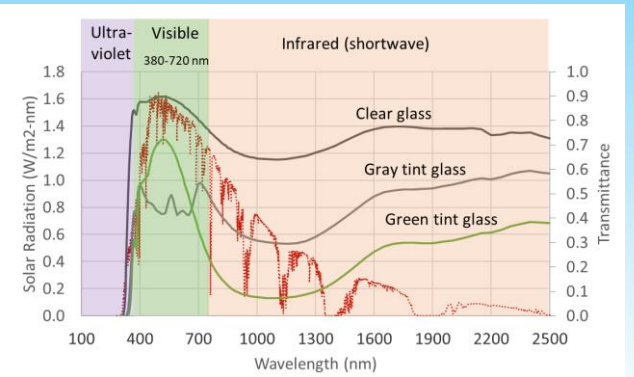
	At Earth Surface
Ultraviolet	10 Btu/hr-ft²
Visible	149 Btu/hr-ft²
Infrared	158 Btu/hr-ft²
Total	317 Btu/hr-ft²



42

How windows work

Tinted glass examples



How windows work

Tinted glass examples

Glass Type (all ¼ in.)	SHGC	VLT	VLT/SHGC ratio
clear	0.82	0.88	1.1
gray	0.60	0.47	0.78
green	0.61	0.77	1.26

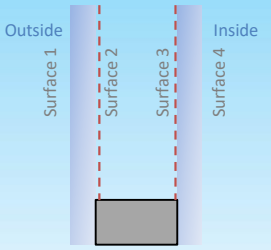
Spectrally selective

44

How windows work

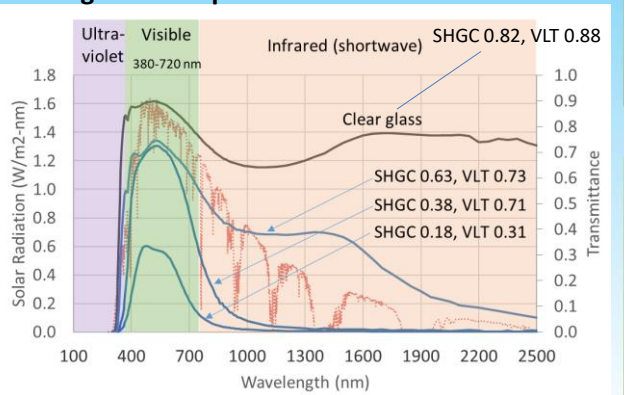
Coated glass

Range of performance
- U-factor (emittance)
- SHGC
- VLT



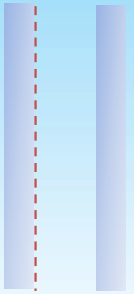
How windows work

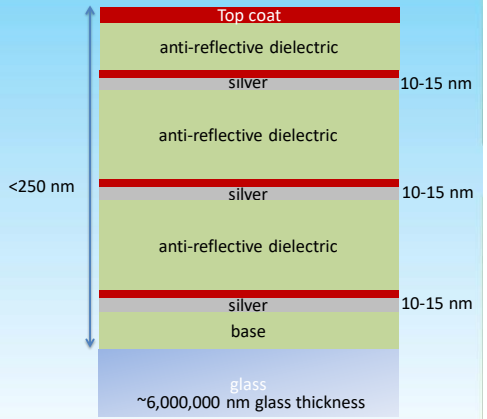
Coated glass examples



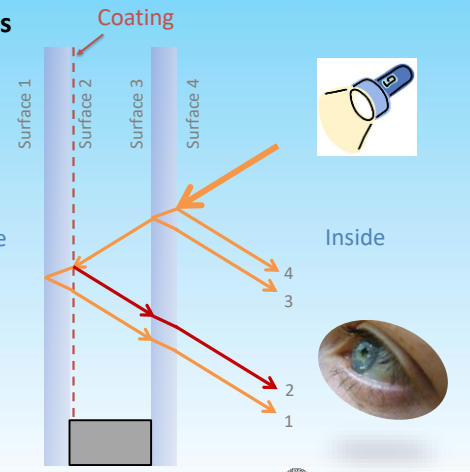
How windows work

Three-layer silver coating





Identifying coated glass



49

Table 10 Visible Transmittance T_v, Solar Heat Gain Coefficient (SHGC), Solar Transmittance T, Front Reflectance R^f, Back Reflectance R^b, and Layer Absorptance A_n^f for Glazing and Window Systems

CONDENSED TABLE

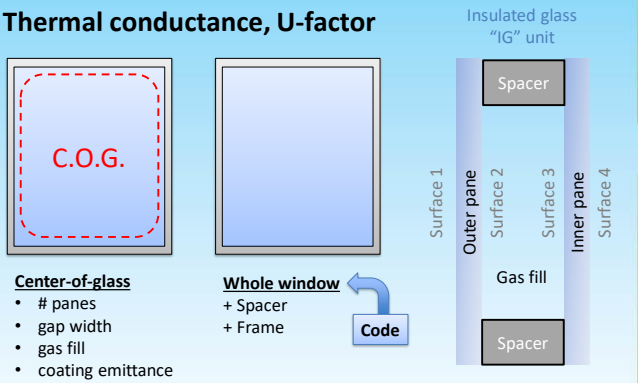
Glazing System				Center-of-Glazing Properties							Total Window SHGC at Normal Incidence				Total Window T_v at Normal Incidence			
				Incidence Angles							Aluminum		Other Frames		Aluminum		Other Frames	
ID	Glass Thick., in.		Center Glazing T_v	Normal 0.00	40.00	50.00	60.00	70.00	80.00	Hemis., Diffuse	Operable	Fixed	Operable	Fixed	Operable	Fixed	Operable	Fixed
Uncoated Single Glazing																		
1b	1/4	CLR	0.88 SHGC	0.81	0.80	0.78	0.73	0.62	0.39	0.73	0.74	0.74	0.66	0.72	0.78	0.79	0.70	0.77
1h	1/4	GRY	0.46 SHGC	0.59	0.57	0.55	0.51	0.44	0.28	0.52	0.54	0.54	0.48	0.52	0.41	0.41	0.37	0.40
1i	1/4	BLUGRN	0.75 SHGC	0.62	0.59	0.57	0.54	0.46	0.30	0.55	0.57	0.57	0.50	0.55	0.67	0.68	0.60	0.66
Reflective Single Glazing																		
1j	1/4	SS on CLR 8%	0.08 SHGC	0.19	0.19	0.19	0.18	0.16	0.10	0.18	0.18	0.18	0.16	0.17	0.07	0.07	0.06	0.07
1n	1/4	TI on CLR 20%	0.20 SHGC	0.29	0.29	0.28	0.27	0.23	0.15	0.27	0.27	0.27	0.24	0.26	0.18	0.18	0.16	0.18
Uncoated Double Glazing																		
5b	1/4	CLR CLR	0.78 SHGC	0.70	0.67	0.64	0.58	0.45	0.23	0.60	0.64	0.64	0.57	0.62	0.69	0.70	0.62	0.69
5h	1/4	GRY CLR	0.41 SHGC	0.47	0.44	0.42	0.37	0.29	0.16	0.39	0.43	0.43	0.38	0.42	0.36	0.37	0.33	0.36
5i	1/4	BLUGRN CLR	0.67 SHGC	0.50	0.47	0.45	0.40	0.32	0.17	0.43	0.46	0.46	0.41	0.44	0.60	0.60	0.54	0.59
5j	1/4	HI-P GRN CLR	0.59 SHGC	0.39	0.37	0.35	0.31	0.25	0.14	0.33	0.36	0.36	0.32	0.35	0.53	0.53	0.47	0.52
Low-e Double Glazing, e = 0.05 on surface 2																		
25b	1/4	LE CLR	0.70 SHGC	0.37	0.36	0.34	0.31	0.24	0.13	0.32	0.34	0.34	0.30	0.33	0.62	0.63	0.56	0.62
25e	1/4	GRY W/LE CLR	0.35 SHGC	0.24	0.23	0.22	0.20	0.16	0.09	0.21	0.23	0.23	0.20	0.21	0.31	0.32	0.28	0.31
25g	1/4	HI-P GRN W/LE CLR	0.53 SHGC	0.27	0.26	0.25	0.23	0.18	0.11	0.23	0.26	0.25	0.22	0.24	0.47	0.48	0.42	0.47

50

50

How windows work

Thermal conductance, U-factor



Center-of-glass
- # panes
- gap width
- gas fill
- coating emittance

Whole window
+ Spacer
+ Frame

51

51

How windows work

Thermal conductance, U-factor

Heat flow = (U-factor)*(window area)*($T_{outdoor}$ – T_{indoor})

$$\frac{\text{Btu}}{\text{hr}\cdot\text{ft}^2\cdot{}^\circ\text{F}}$$

52

52

Window U-factor

Frame Type ID	Glazing Type	Center of Glass	Edge of Glass	Aluminum Without Thermal Break	Aluminum with Thermal Break
	Single Glazing				
1	1/8 in. glass	1.04	1.04	1.23	1.07
2	1/4 in. acrylic/polycarbonate	0.88	0.88	1.10	0.94
3	1/8 in. acrylic/polycarbonate	0.96	0.96	1.17	1.01
	Double Glazing				
4	1/4 in. air space	0.55	0.64	0.81	0.64
5	1/2 in. air space	0.48	0.59	0.76	0.58
6	1/4 in. argon space	0.51	0.61	0.78	0.61
7	1/2 in. argon space	0.45	0.57	0.73	0.56
	Double Glazing, $e = 0.05$ on surface 2 or 3				
24	1/4 in. air space	0.41	0.54	0.70	0.53
25	1/2 in. air space	0.30	0.46	0.61	0.45
26	1/4 in. argon space	0.33	0.48	0.64	0.47
27	1/2 in. argon space	0.25	0.42	0.57	0.41

Source: ASHRAE Handbook Fundamentals 2017

How windows work

Glass samples

Monolithic glass

	SHGC	VLT	VLT/SHGC
gray	0.58	0.44	0.76
blue	0.52	0.68	1.31

Insulated glass

	SHGC	VLT	VLT/SHGC
VE1-48	0.38	0.48	1.26
VNE1-53	0.23	0.49	2.13
VS1-20	0.23	0.18	0.78

Window Design Strategies

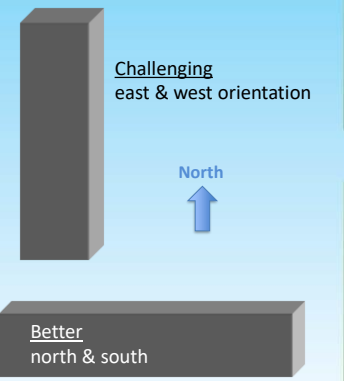
Solar control priorities

1. Orientation
2. Fixed exterior shading
3. Operable exterior shading
4. High performance glazing
5. Interior shading

Window Design Strategies

Solar control priorities

1. **Orientation**
2. Fixed exterior shading
3. Operable exterior shading
4. High performance glazing
5. Interior shading



Window Design Strategies

Solar control priorities

1. Orientation
2. **Fixed exterior shading**
3. Operable exterior shading
4. High performance glazing
5. Interior shading

Window Design Strategies

Solar control priorities

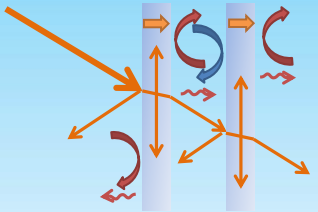
1. Orientation
2. Fixed exterior shading
3. **Operable exterior shading**
4. High performance glazing
5. Interior shading

www.suncontrolers.com

Window Design Strategies

Solar control priorities

1. Orientation
2. Fixed exterior shading
3. Operable exterior shading
4. **High performance glazing**
5. Interior shading

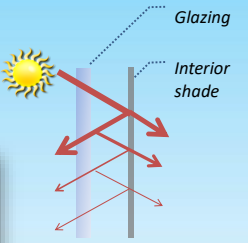


Solar heat gain coefficient (SHGC)
Visible light transmittance (VLT)
Thermal conductance (U-factor)

Window Design Strategies

Solar control priorities

1. Orientation
2. Fixed exterior shading
3. Operable exterior shading
4. High performance glazing
5. **Interior shading**



Window Design Strategies

Additional options to reduce solar heat gain

- Fritted glass
- Laminations
- Retrofit films
- Dynamic glazing

Window Design Strategies

Additional options to reduce solar heat gain

- **Fritted glass**
- Laminations
- Retrofit films
- Dynamic glazing

Window Design Strategies

Additional options to reduce solar heat gain

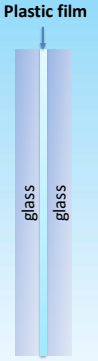
- Fritted glass
- **Laminations**
- Retrofit films
- Dynamic glazing

Common applications

- Security
- Impact safety

Solar performance

- Spectrally selective coatings available



Window Design Strategies

Additional options to reduce solar heat gain

- Fritted glass
- Laminations
- **Retrofit films**
- Dynamic glazing

Common applications

- Security
- Impact safety

Solar performance

- Spectrally selective coatings available

https://www.greenbuildermedia.com/buildingscience/window-film-a-cost-effective-window-retrofit

Window Design Strategies

Additional options to reduce solar heat gain

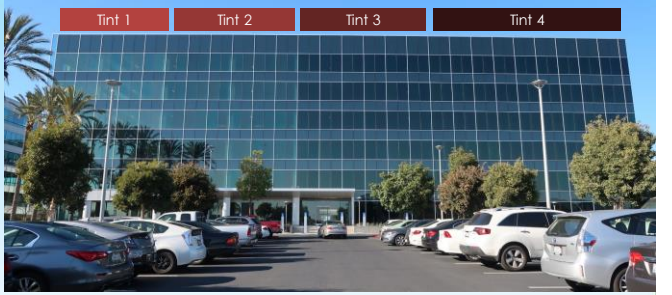
- Fritted glass
- Laminations
- Retrofit films
- **Dynamic glazing**

VLT	58%	40%	6%	1%
SHGC	0.41	0.28	0.11	0.09

Courtesy View Inc.

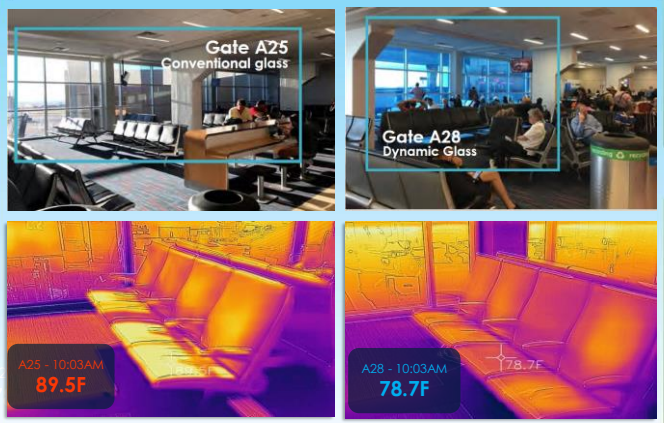
Window Design Strategies

Dynamic glass 4 tint states on a single facade



Courtesy View Inc.

Window Design Strategies



Dallas Fort Worth Airport. Courtesy View Inc.

Window Design Strategies

American Savings Bank Headquarters

11 stories
393,000 ft^2
40,000 ft^2 dynamic glass (View)

Architects : Leo A. Daly, Hi-archy
General Contractor: Nordic PCL

Unobstructed views of ocean & mountains

No window coverings or shades / blinds in the building

Helps increase employee productivity and helps attract and retain talent within the bank

Section 3
Fenestration Requirements

- Checklists
- Residential requirements
- Commercial requirements
- Showing compliance

Checklists - Residential

RESIDENTIAL CHECKLIST
IECC 2015 with Hawaii Amendments

HAWAII STATE Energy Office | Hawaii Energy

SCOPE

Detached one- and two-family dwellings and multiple single-family dwellings (townhouses) as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.

The code applies to new construction, additions and alterations.

See a separate Commercial Checklist for high-rise residential and commercial buildings.

RESIDENTIAL COMPLIANCE OPTIONS

Tropical Zone	Prescriptive	Simulated Performance Alternative	Energy Rating Index Compliance Alternative
Allowed when: 1. ≤50% air conditioned, 2. not heated, and 3. elevation < 2,400 feet.	Includes three options for walls and roof compliance; 1. Prescriptive 2. Total UA (typically with ResCheck software) 3. Points option (added by Hawaii amendment)	Simulated energy performance analysis for heating, cooling and SHW. Proposed design must have annual energy cost less than or equal to energy cost of reference design.	Third-party Home Energy Rating System (HERS) calculation. Allows the designer to pick and choose from many efficiency options. Scores range from 100 to 0. The 100 score indicates compliance with the 2006 IECC. Each efficiency measure beyond 2006 lowers the score. A passing score for Climate Zone 1 is 52.
See Tropical Zone Checklist below	See Prescriptive Checklist below. See Points Option tables below.	See code Section R405	See code Section R406

CHECKLIST CONTENTS	PAGE
Tropical zone checklist	2
Prescriptive checklist	4
Additions and alterations checklist	8
Points option tables	10

Residential Fenestration
Compliance Options

1. Tropical Zone (NEW)
   - ≤50% air conditioned,
   - not heated, and
   - elevation < 2,400 feet
   - requires solar water heating

2. Prescriptive

Climate Zone	Fenestration U-Factor	Skylight U-Factor	Glazed Fenestration SHGC	Ceiling R-Value	Wood Frame Wall R-Value	Mass Wall R-Value	Floor R-Value	Basement Wall R-Value	Slab R-Value	Crawl Space Wall R-Value
1	NR	0.75	0.25	30	13	3/4	NR[1]	0	0	0

3. Simulated performance alternative

4. Energy rating index, ERI (NEW)

Tropical Zone Option
Hawaii Version

R401.2.1

R401.2.1 Tropical zone. *Residential buildings* in the tropical zone at elevations below 2,400 feet (731.5 m) above sea level shall be deemed to comply with this chapter where the following conditions are met:

1. Not more than one-half of the *dwelling unit* is air conditioned
2. The *dwelling unit* is not heated.
3. Solar, wind or other renewable energy source supplies not less than 90 percent of the energy for service water heating.
4. Glazing in *dwelling units* shall have a maximum *solar heat gain coefficient* as specified in Table R402.2.1.

Table R402.2.1. Window SHGC Requirements

Projection Factor of overhang from base of average window sill[b]	SHGC
<.30	.25
.30 – .50	.40
≥.50	N/A

[b]Exception: North-facing windows with pf > .20 are exempt from the SHGC requirement. Overhangs shall extend 2 feet on each side of window or to nearest wall, whichever is less.

5. Skylights in dwelling units shall have a maximum U-factor as specified in Table R402.1.2.
6. Permanently installed lighting is in accordance with Section R404.
7. The roof/ceiling complies with one of the following options:
   1. Comply with one of the roof surface options in Table C402.3 and install R-13 insulation or greater.
   2. Install R-19 insulation or greater.

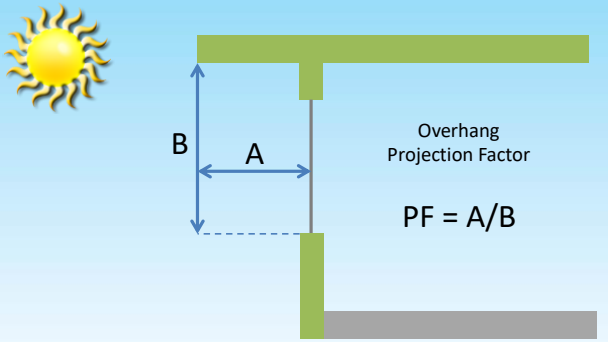
If present, attics above the insulation are vented and attics below the insulation are unvented.

Exception: The roof/ceiling assembly are permitted to comply with Section R407.

8. Roof surfaces have a minimum slope of ¼ inch per foot of run. The finished roof does not have water accumulation areas.
9. Operable fenestration provides ventilation area equal to not less than 14 percent of the floor area in each room. Alternatively, equivalent ventilation is provided by a ventilation fan.
10. Bedrooms with exterior walls facing two different direction have operable fenestration or exterior walls facing two different directions.
11. Interior doors to bedrooms are capable of being secured in the open position.
12. A ceiling fan or ceiling fan rough-in is provided for bedrooms and the largest space that is not used as bedroom.
13. Jalousie windows shall have an air infiltration rate of no more than 1.2 cfm per square foot (6.1 L/s/m^2).
14. Walls, floors and ceilings separating air conditioned spaces from non-air conditioned spaces shall be constructed to limit air leakage in accordance with the requirements in Table R402.4.1.1. [Eff 5/24/10; am and comp MAR 31 2017] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

Residential Fenestration
Tropical Zone Option

R401.2.1



Residential Fenestration
Tropical Zone Option

R401.2.1

Maximum solar heat gain coefficient (SHGC)

Large overhang	Medium overhang	Small overhang
PF ≥ 0.5	0.30 ≤ PF < 0.50	PF < 0.30
No requirement	SHGC ≤ 0.40	SHGC ≤ 0.25

North windows: no requirement if PF > 0.20

Window examples
Dual-pane, low-e, solar control

Double Glazed	Visible Light Trans %	Visible Light Reflect Out %	Visible Light Reflect In %	UV Trans %	SHGC	U-Factor 1/2" Gap Argon	U-Factor 1/2" Gap Air
ClimaGuard 80/70 (#3)	81	13	13	41	0.702	0.271	0.315
HiLightR 802 (80/70 + IS-20)	79	14	14	40	0.678	0.222	0.254
ClimaGuard 72/57 (#3)	71	13	14	27	0.575	0.251	0.298
ClimaGuard 72/57	71	14	13	27	0.468	0.251	0.298
ClimaGuard 70/36	70	11	13	25	0.383	0.248	0.294
ClimaGuard 62/27	62	11	12	8	0.278	0.245	0.292
ClimaGuard 55/27	56	17	19	21	0.277	0.246	0.293
ClimaGuard 53/23	53	13	12	11	0.233	0.243	0.290

SHGC < 0.40

SHGC < 0.25

Source: www.guardian.com

Low UV transmission
is an extra benefit

Overhang size that allows clear glass to comply?

Clear glass complies
in these examples
PF ≥ 0.5

How about on the north side?

R401.2.1

North-facing windows

Clear glass complies in these examples
PF ≥ 0.2

Residential Fenestration
Prescriptive Option

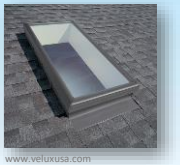
Table R402.1.2 & R402.3

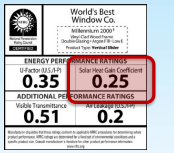
Solar heat gain coefficient (SHGC) ≤ 0.25

- Windows and skylights
- Area weighted average allowed

Exceptions

- Up to 15 ft² exempt
- Skylights can have SHGC ≤ 0.30





National Fenestration Rating Council (NFRC) Label

Checklists - Commercial

COMMERCIAL CHECKLIST
IECC 2015 with Hawaii Amendments

HAWAII STATE Energy Office

Hawaii Energy

SCOPE

Commercial and high-rise residential buildings. More specifically, all buildings except detached one- and two-family dwellings and multiple single-family dwellings (townhouses) as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.

The code applies to new construction, additions and alterations.

See a separate Residential Checklist for low-rise residential buildings.

COMMERCIAL COMPLIANCE OPTIONS

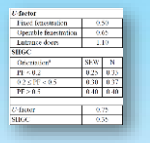
Prescriptive	Total Building Performance Alternative	ASHRAE Standard 90.1-2013
Separate requirements for envelope, mechanical systems, water heating systems, lighting and electrical systems. Also includes "additional efficiency" requirements.	Simulated energy performance analysis for heating, cooling, lighting and SHW. Proposed design must have annual energy cost less than or equal to energy cost of reference design.	Includes both prescriptive and performance compliance options.
See Prescriptive Checklist below	See code Section C407	See separate standard, available from www.ashrae.org

CHECKLIST CONTENTS	PAGE
Envelope	2
Mechanical system	5
Service water heating	8
Lighting and electrical	10
Additional efficiency	14
Additions	16
Alterations	18

Commercial Fenestration
Compliance Options

C402.4

- Prescriptive requirements
  - Windows
    - Maximum area, U-factor & SHGC
  - Skylights
    - Maximum area, U-factor & SHGC
    - Minimum area
- Total Building Performance
- ASHRAE Standard 90.1-2013



Commercial Fenestration - Prescriptive
Maximum Area

C402.4

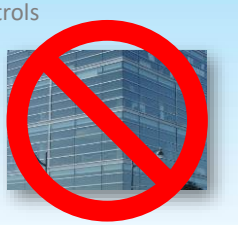
Window area **≤ 30%** of gross wall area

Up to 40% with daylighting controls

Skylight area **≤ 3%** of gross roof area

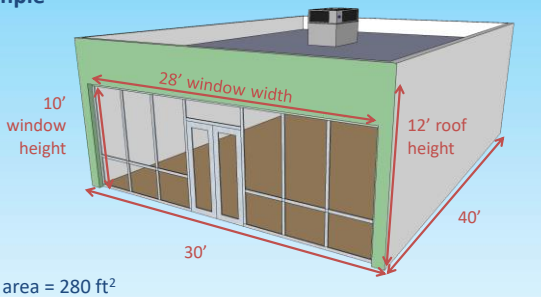
Up to 5% with daylighting controls

Otherwise, use
Total Building Performance
compliance option



Commercial window area limit example

Is window area ≤ 30% gross wall area?



Window area = 280 ft²

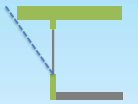
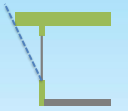
Gross wall area = (30 +40+30+40)*12 = 1,680 ft²

% Window area = 280/1,680 = 17% OK

Commercial Fenestration - Prescriptive
Window SHGC

C402.4

Maximum solar heat gain coefficient (SHGC)

	Large overhang	Medium overhang	Small overhang
			
	PF ≥ 0.5	0.20 ≤ PF < 0.50	PF < 0.20
E/S/W	SHGC ≤ 0.40	SHGC ≤ 0.30	SHGC ≤ 0.25
North	SHGC ≤ 0.40	SHGC ≤ 0.37	SHGC ≤ 0.33

Area-weighted average SHGC allowed by Hawaii amendment

Commercial Fenestration - Prescriptive
Window U-factor

C402.4

Maximum U-factor

- U-0.50 fixed
- U-0.65 operable
- U-1.10 doors

Dual-pane, low-e typical

Single-pane complies

Area-weighted average U-factor allowed

Commercial Fenestration - Prescriptive
Skylight SHGC & U-factor

C402.4

SHGC **≤ 0.35**
(or ≤ 0.60 with daylighting controls)

U-factor **≤ 0.75**
(or U-0.90 with daylighting controls)

Commercial Fenestration - Prescriptive
Skylight – Minimum Area

C402.4

Commercial Fenestration - Prescriptive
Skylight – Minimum Area

C402.4

For spaces under a roof where

- Area > 2,500 ft^2 and
- Ceiling height > 15 ft

≥50% of floor area must be daylighted by skylights

and

Minimum skylight area

1. 3% or roof, or
2. 1% effective aperture

Several exceptions apply

Space types

- office
- lobby
- atrium
- concourse
- corridor
- storage space
- gymnasium/exercise center
- convention center
- automotive service area
- manufacturing
- nonrefrigerated warehouse
- retail store
- distribution/sorting area
- transportation depot
- workshop

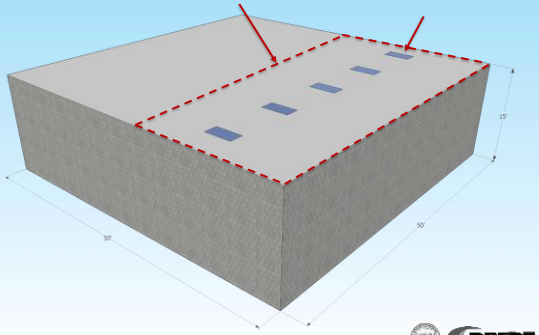
Minimum skylight area example

When
1. Space floor area > 2500 ft^2
2. Ceiling height > 15 ft

Requirements

Daylighted area
≥ 50% of floor area

Skylight area
≥ 3% of daylighted area



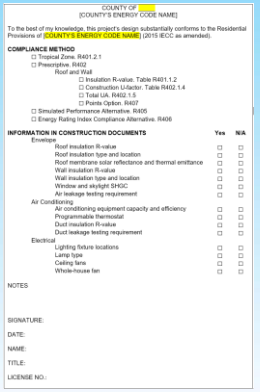
Showing Compliance

Information required on construction documents
(Also shown on checklists)

1. Insulation materials and their *R*-values.
2. Fenestration *U*-factors and solar heat gain coefficients (SHGC).
3. Area-weighted *U*-factor and solar heat gain coefficients (SHGC) calculations.

Excerpt from Sections R103.2 and C103.2

Showing Compliance Residential Certification



COUNTY OF
[COUNTY'S ENERGY CODE NAME]

To the best of my knowledge, this project's design substantially conforms to the Residential Provisions of [COUNTY'S ENERGY CODE NAME] (2015 IECC as amended).

COMPLIANCE METHOD
- ☐ Tropical Zone. R401.2.1
- ☐ Prescriptive. R402
  - Roof and Wall
    - ☐ Insulation R-value. Table R401.1.2
    - ☐ Construction U-factor. Table R402.1.4
    - ☐ Total UA. R402.1.5
    - ☐ Points Option. R407
- ☐ Simulated Performance Alternative. R405
- ☐ Energy Rating Index Compliance Alternative. R406

INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Envelope		
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window and skylight SHGC	☐	☐
Air leakage testing requirement	☐	☐
Air Conditioning		
Air conditioning equipment capacity and efficiency	☐	☐
Programmable thermostat	☐	☐
Duct insulation R-value	☐	☐
Duct leakage testing requirement	☐	☐
Electrical		
Lighting fixture locations	☐	☐
Lamp type	☐	☐
Ceiling fans	☐	☐
Whole-house fan	☐	☐

NOTES

SIGNATURE:

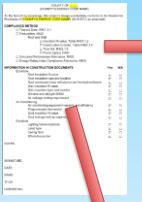
DATE:

NAME:

TITLE:

LICENSE NO.:

Showing Compliance Residential Certification



COMPLIANCE METHOD
- ☐ Tropical Zone. R401.2.1
- ☐ Prescriptive. R402
  - Roof and Wall
    - ☐ Insulation R-value. Table R401.1.2
    - ☐ Construction U-factor. Table R402.1.4
    - ☐ Total UA. R402.1.5
    - ☐ Points Option. R407
- ☐ Simulated Performance Alternative. R405
- ☐ Energy Rating Index Compliance Alternative. R406

INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Envelope		
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window and skylight SHGC	☐	☐
Air leakage testing requirement	☐	☐

Showing Compliance Residential Certification

COUNTY OF MAUI
MAUI COUNTY CODE, CHAPTER 16.16B ENERGY CODE
RESIDENTIAL PROVISIONS

COMPLIANCE METHOD
Check applicable method

☐	R401.2(1) R401.3 through R404 (Prescriptive)
☐	R401.2(2) R405, R401 through R404 labeled Mandatory (Simulated Performance Alternative)
☐	R401.2(3) R406 (Energy Rating Index Compliance Alternative)
☐	R401.2(4) R401.2.1 (Tropical Zone)
☐	R102.1 (Alternative)

To the best of my knowledge, this project's design substantially conforms to the Energy Code.

Signature: _____ Date: _____
Name: _____
Title: _____
License No.: _____

Showing Compliance Commercial Certification

COUNTY OF [COUNTY'S ENERGY CODE NAME]

To the best of my knowledge, this project's design substantially conforms to the [CODE NAME] (2015 IECC as amended) for **building envelope components** (Section C402).

COMPLIANCE METHOD
- ☐ 2015 IECC as amended. Mandatory & Prescriptive
- ☐ 2015 IECC as amended. Mandatory & Total Building Performance
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Prescriptive
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Energy Cost Budget Method

INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window SHGC	☐	☐
Window U-factor	☐	☐
Skylight SHGC	☐	☐
Skylight U-factor	☐	☐

NOTES

SIGNATURE:

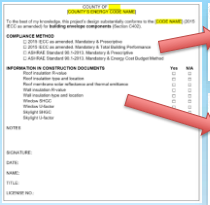
DATE:

NAME:

TITLE:

LICENSE NO.:

Showing Compliance Commercial Certification



COMPLIANCE METHOD
- ☐ 2015 IECC as amended. Mandatory & Prescriptive
- ☐ 2015 IECC as amended. Mandatory & Total Building Performance
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Prescriptive
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Energy Cost Budget Method

INFORMATION IN CONSTRUCTION DOCUMENTS
- Roof insulation R-value
- Roof insulation type and location
- Roof membrane solar reflectance and thermal emittance
- Wall insulation R-value
- Wall insulation type and location
- Window SHGC
- Window U-factor
- Skylight SHGC
- Skylight U-factor

Showing Compliance Commercial Certification

COUNTY OF MAUI
MAUI COUNTY CODE, CHAPTER 16.16B ENERGY CODE
COMMERCIAL PROVISIONS

COMPLIANCE METHOD
Check applicable method

☐	C401.2(1) ANSI/ASHRAE/IESNA 90.1
☐	C401.2(2) Sections C402 through C406
☐	C401.2(3) Sections C402.5, C403.2, C404, C405.2, C405.3, C405.4, C405.6 & C407
☐	C102.1 Alternative

To the best of my knowledge, this project's design substantially conforms to the Energy Code.

Signature: _____ Date: _____
Name: _____
Title: _____
License No.: _____

One more thing

Solar control vs.transparency

- Kakaako Mauka Area Rules
  - VLT ≥ 70% on ground floor
  - VLT ≥ 50% other floors

```
(k)  Windows:
(1)  Highly-reflective, mirrored, and opaque
     window glazing are prohibited;
(2)  Window glazing shall be transparent with
     clear or limited UV tint so as to provide
     views out of and into the building.  Visible
     light transmission level of windows on the
     ground floor shall be seventy per cent or
     greater and on all other floors the visible
     light transmission level shall be fifty per
     cent or greater;
```

https://dbedt.hawaii.gov/hcda/files/2012/11/Chapter-217-Mauka-Area-Rules-EFF-2011.11.11.pdf

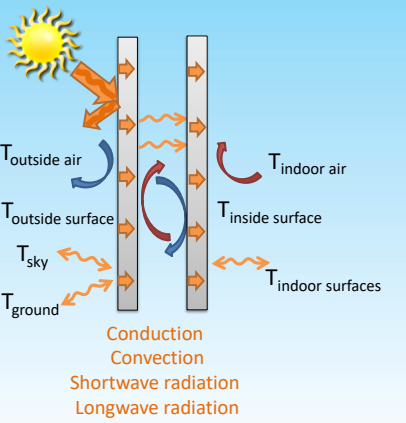
Fenestration compliance quiz

1. Does a non-AC home need to meet window requirements?
2. Can a home with 90% glass walls comply?
3. Can an office with 90% glass walls comply?
4. Can a retail storefront use clear glass?
5. Is a new gym without AC required to have skylights?
6. Does an auto repair shop without AC have to meet window requirements?

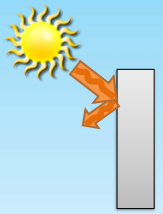
Section 4
Opaque Envelope Design

- Heat transfer
- Opaque envelope options
  - Insulation
  - Radiant barriers
  - Cool roofs
  - Cool walls

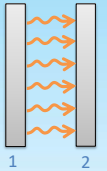
Opaque Envelope Heat Transfer



Opaque Envelope Heat Transfer



Short-wave
solar radiation



Long-wave
infrared radiation

Opaque Envelope Heat Transfer

Longwave Infrared Radiation

$$W = \varepsilon \sigma T^4$$

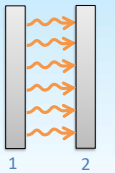
$$q_{net\ 1\ to\ 2} = \frac{\sigma\left(T_1^4 - T_2^4\right)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

W = emissive power, Btu/hr·ft^2
ε = thermal emittance of material
σ = 0.1712 x 10^{-8} (Btu/h·ft^2 ·°R^4)
T = temperature, °R

$q_{net\ 1\ to\ 2}$ = net radiant heat transfer between two planar surfaces (Btu/h·ft^2)

$$\varepsilon = \frac{\text{Radiation emitted by a given material}}{\text{Radiation emitted by a black body at the same temperature}}$$

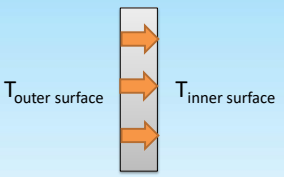
ε = 0.8 – 0.9 typical
ε < 0.1 for "low-e" surfaces, polished metal



Opaque Envelope Heat Transfer

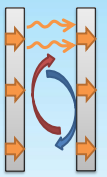
Heat transfer <u>within</u> an assembly

Solid material



Conduction

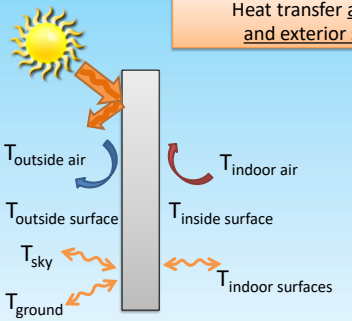
Assembly with air gap



Conduction
Convection
Longwave radiation

Opaque Envelope Heat Transfer

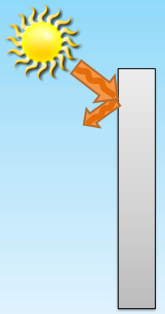
Heat transfer <u>at interior and exterior surfaces</u>



Convection
Shortwave radiation
Longwave radiation

Opaque Envelope Heat Transfer

Heat transfer at interior and exterior surfaces

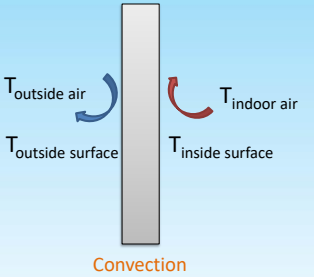


Shortwave radiation factors
- Sun position
- Sky condition
- **Solar reflectance**

105

Opaque Envelope Heat Transfer

Heat transfer at interior and exterior surfaces

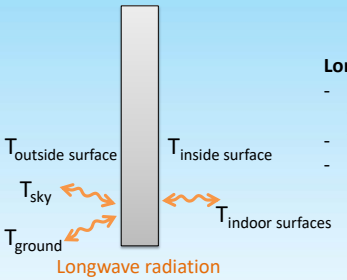


Convection factors
- Air temperature
- Surface temperatures
- Air speed
- Surface roughness

106

Opaque Envelope Heat Transfer

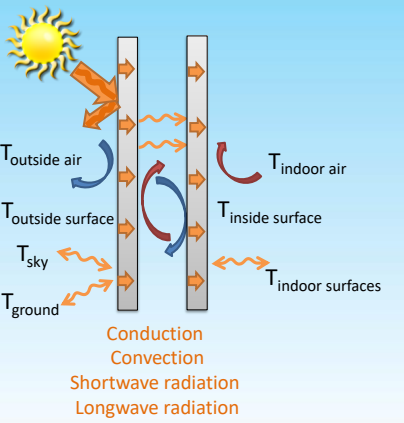
Heat transfer at interior and exterior surfaces



Longwave radiation factors
- Surface and sky temperatures
- View factors
- **Infrared (thermal) emittance**

107

Opaque Envelope Heat Transfer



108

Opaque Envelope Heat Transfer

- Simplified assembly properties
  - Thermal transmittance (U-factor)
  - Solar reflectance, exterior surface
  - Infrared emittance, exterior and interior surfaces

Opaque Envelope Options

Opaque envelope options

- Insulation
- Radiant barriers
- Cool roofs
- Cool walls

Opaque Envelope Options

Insulation Materials	Typical R-value per inch of thickness
Batt - fiberglass, cellulose, cotton	R-3 – R-4
Loose fill - fiberglass, cellulose, cotton	R-3 – R-4
Foam board - polyisocyanurate	R-6
Foam board - extruded polystyrene	R-5
Foam board - expanded polystyrene	R-4
Spray foam - polyurethane	R-6
Spray foam - "Icynene"	R-3.6
Spray foam – soy based	R-3.6
Aerogel	Up to R-20

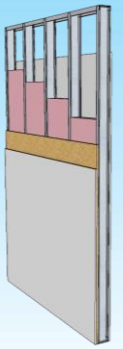
113

114

Opaque Envelope Options

Thermal Bridging – Metal Framing

Assembly	Insulation R-value	Correction Factor	Effective R-value
2x4, 16 in. spacing	11	0.50	5.5
	13	0.46	6.0
	15	0.43	6.4
2x4, 24 in. spacing	11	0.60	6.6
	13	0.55	7.2
	15	0.52	7.8
2x6, 16 in. spacing	19	0.37	7.1
	21	0.35	7.4
2x6, 24 in. spacing	19	0.45	8.6
	21	0.43	9.0



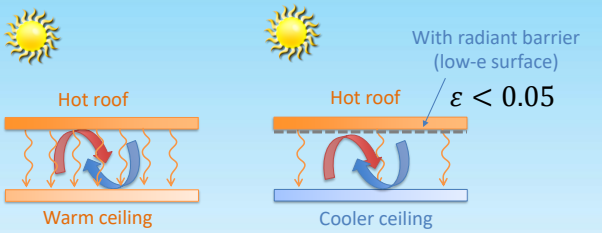
Source: ASHRAE Handbook Fundamentals 2017

115

115

Opaque Envelope Options

Radiant Barrier



$$q_{net\ 1\ to\ 2} = \frac{\sigma\left(T_1^4 - T_2^4\right)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

116

116

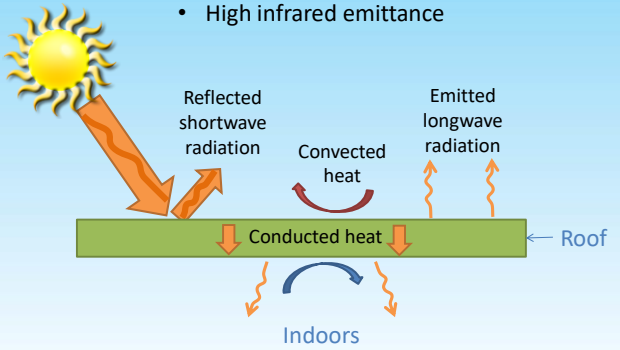
Source: www.radiantbarrierguru.com

Source: www.radiantbarrier.com

Opaque Envelope Options

Cool Roof

- High solar reflectance
- High infrared emittance



Opaque Envelope Options

Roof Temperature Examples

Sacramento, CA - 89°F ambient

EPDM single-ply	Built up roof with aggregate	Built up roof with capsheet
173°F	**159°F**	**158°F**

Courtesy Dan Varvais, Applied Polymer Systems

Opaque Envelope Options

Cool Roof

Types
- Single ply plastic
- Metal
- Liquid applied
- Tile (clay or concrete)
- Composite shingle

http://coolroofhawaii.com

http://www.whirlwindsteel.com

121

Opaque Envelope Options

	Solar Reflectance	Emittance
Asphalt shingles	5% – 30%	0.91
Liquid coating - white	65% - 78%	0.86 – 0.91
Liquid coating - silver	54%	0.42
Painted metal – white	60% - 67%	~0.90
Painted metal – other	8% - 66%	~0.90
Concrete tile – unpainted	25%	0.90
Concrete tile – white	73%	0.90
Single ply – grey	23%	~0.90
Single ply – white	80%	~0.90
Unpainted galvanized steel	61%	0.25

http://www.fsec.ucf.edu/en/publications/html/FSEC-CR-670-00/

122

CRRC
COOL ROOF RATING COUNCIL

CRRC PROD. ID	MANUFACTURER: BRAND MODEL	PRODUCT TYPE	COLOR	SOLAR REFLECTANCE initial	SOLAR REFLECTANCE 3 year	THERMAL EMITTANCE initial	THERMAL EMITTANCE 3 year	SRI initial	SRI 3 year	MORE INFO
0808-0001	**Burkeline Roofing**: M-358 CSPE White	Membrane: Single Ply Thermoplastic and Thermoset Roofing	Bright White	0.83	0.71	0.88	0.87	104	87	+
0628-0011	**Carlisle Construction Materials Incorporated**: Spectro-Weld TPO White	Membrane: Single Ply Thermoplastic and Thermoset Roofing	Bright White	0.88	0.75	0.89	0.90	111	93	+
0628-0017	**Carlisle Construction Materials Incorporated**: Sure-Flex KEE HP Gray	Membrane: Single Ply Thermoplastic and Thermoset Roofing	Grey	0.57	0.50	0.88	0.85	67	57	+
0628-0016	**Carlisle Construction Materials Incorporated**: Sure-Flex KEE HP Tan	Membrane: Single Ply Thermoplastic and Thermoset Roofing	Tan	0.74	0.63	0.88	0.84	91	75	+
0628-0015	**Carlisle Construction Materials Incorporated**: Sure-Flex KEE HP White	Membrane: Single Ply Thermoplastic and Thermoset Roofing	Bright White	0.82	0.71	0.89	0.84	103	86	+

http://www.coolroofs.org/products/search.php

123

CRRC Product Label Example

CRRC
COOL ROOF RATING COUNCIL ®

	Initial	Weathered
Solar Reflectance	0.88	0.68 3 year aged
Thermal Emittance	0.87	0.89 3 year aged

Rated Product ID Number	0001
Licensed Seller ID Number	0896
Classification	Production Line

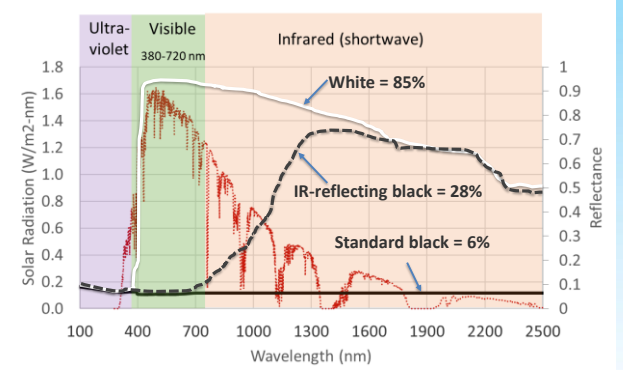
Cool Roof Rating Council ratings are determined for a fixed set of conditions, and may not be appropriate for determining seasonal energy performance. The actual effect of solar reflectance and thermal emittance on building performance may vary.

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

124

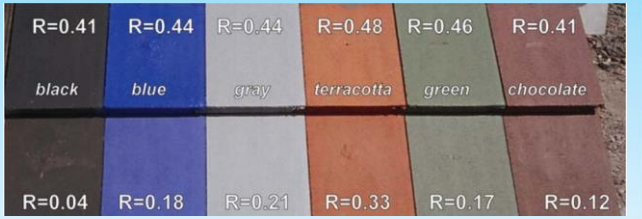
Opaque Envelope Options

Infrared reflecting pigments



Opaque Envelope Options

Infrared reflecting pigments



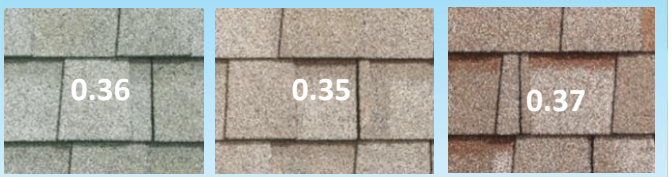
Opaque Envelope Options

Asphalt shingle examples

http://www.owenscorning.com/NetworkShare/Roofing/10019919-Cool-ROOF-Colors-Shingles-Data-Sheet.pdf

Opaque Envelope Options

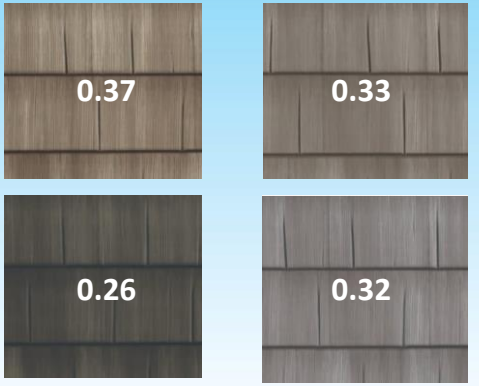
Asphalt shingle examples



https://www.certainteed.com/residential-roofing/products/landmark-solaris-platinum/

Opaque Envelope Options

Metal shingle examples



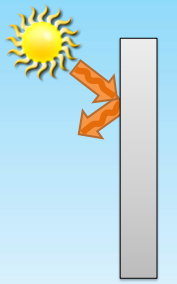
https://www.certainteed.com/resources/SolarReflectiveBrochure-SW.pdf

129

Opaque Envelope Options

Cool Walls

- Light color paint
- Infrared-reflective paint
- Pigments with fluorescence
  - Effective solar reflectance > solar reflectance

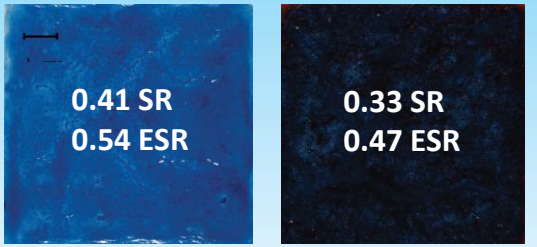


https://heatisland.lbl.gov/projects/cool-walls

130

Opaque Envelope Options

Fluorescence



SR = solar reflectance
ESR = effective solar reflectance

https://heatisland.lbl.gov/projects/cool-walls

131

Opaque Envelope Options

Summary

Reducing heat gain

- Insulation
- Thermal bridge mitigation
- Radiant barriers
- Solar reflectance
- Infrared emittance

132

Opaque Envelope Quiz

I want to keep my home cool.
Do I want high or low infrared emittance?

1. On top of the roof
2. Under the roof
3. On the exterior wall surface
4. On the interior wall surface

Section 5
Opaque Envelope Requirements

- Residential
- Commercial
- Compliance documentation

Residential Opaque Envelope
Compliance Options

1. Tropical Zone (NEW)
   - ≤50% air conditioned,
   - not heated, and
   - elevation < 2,400 feet
   - requires solar water heating

2. Prescriptive

   Wall and roof options:
   1. Prescriptive
   2. Total UA
   3. Points option (Hawaii amendment)

Climate Zone	Fenestration U-Factor	Skylight U-Factor	Glazed Fenestration SHGC	Ceiling R-Value	Wood Frame Wall R-Value	Mass Wall R-Value	Floor R-Value	Basement W R-Value	Slab R-Value	Crawl Space Wall R-Value
1	NR	0.75	0.25	30	13	3/4	NA[1]	0	0	0

3. Simulated performance alternative

4. Energy rating index, ERI (NEW)

Residential Opaque Envelope
Tropical Zone Option

R401.2.1

Roof options
1. R-19 roof insulation
2. Cool roof + R-13 insulation
3. Points option (R407)

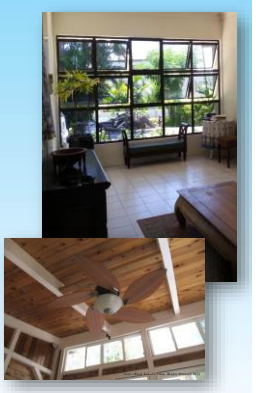
If there is an attic
- Vented if attic above insulation
- Unvented if attic below insulation

Residential Opaque Envelope
Tropical Zone Option

R401.2.1

Natural ventilation requirements

- Operable windows
  - Area ≥ 14% of floor area
- Bedrooms
  - Interior doors can be secured open
  - Openings on two different sides if exterior walls face two different directions
- Ceiling fans or rough-ins in
  - Bedrooms
  - Largest space that is not a bedroom
- Jalousie windows
  - Air infiltration rate ≤ 1.2 cfm/ft^2



Residential Opaque Envelope
Tropical Zone Option

R401.2.1

Wall requirements

None

Residential Opaque Envelope
Prescriptive Option

Table R402.1.2

	R-value (hr-ft^2-°F/Btu)	U-factor (Btu/hr-ft^2-°F)
Ceiling	R-30	0.035
Wood frame wall	R-13	0.084
Mass wall	R-3 – exterior R-4 – interior	0.197
Floor	R-13	0.064
Basement wall	0	0.360
Slab on grade	0	NA
Crawl space wall	0	0.477

R-0 (Kauai and Maui)

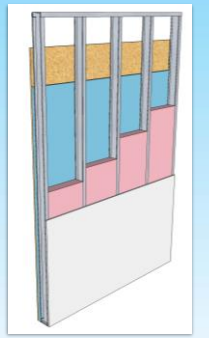
R-0 (Kauai) with:

- Reflectance ≥ 0.64 or
- Overhang PF ≥ 0.3

Residential Opaque Envelope
Prescriptive Option

Table R402.1.2

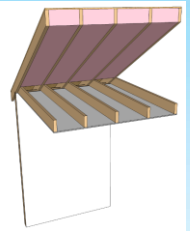
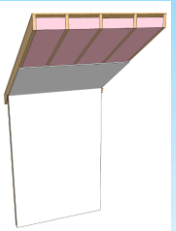
	Insulation R-value (hr-ft^2-°F/Btu)
Steel frame wall, 16 in. o.c.	R-0 + 9.3 R-13 + 4.2 R-15 + 3.8 R-19 + 2.1 R-21 + 2.8
Steel frame wall, 24 in. o.c.	R-0 + 9.3 R-13 + 3.0 R-15 + 2.4
Steel truss ceiling	R-38 R-30 + 3 R-26 + 5
Steel joist ceiling	R-38 R-49 if framing > 2x8



Residential Opaque Envelope
Prescriptive Option

Table R402.1.2

Wood-frame Ceilings

Some R-30 insulation options

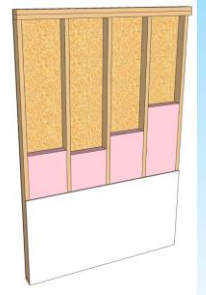
- 10 in. batt
- ~10 in. blown-in
- ~8 in. open-cell spray foam
- ~5 in. closed-cell spray foam

Or use the points option for compliance

Residential Opaque Envelope
Prescriptive Option

Table R402.1.2

Wood-frame Walls



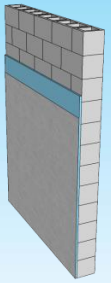
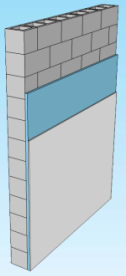
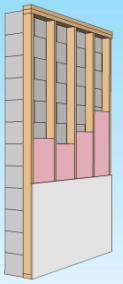
Some R-13 insulation options

- 3.5 in. batt
- 3.5 in. blown-in
- 3.5 in. open-cell spray foam
- ~2 in. closed-cell spray foam

Residential Opaque Envelope
Prescriptive Option

Table R402.1.2

Mass Walls Kauai amendment, next slide

R-3 exterior
≥ 0.50 in. polyisocyanurate
≥ 0.60 in. polystyrene

R-4 interior
≥ 0.67 in. polyisocyanurate
≥ 0.80 in. polystyrene

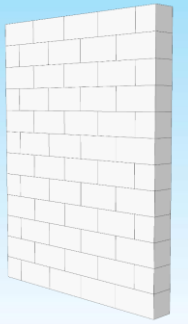
U-factor ≤ 0.197
≥ R-4 in wood furring
≥ R-11 in metal furring

Residential Opaque Envelope
Prescriptive Option

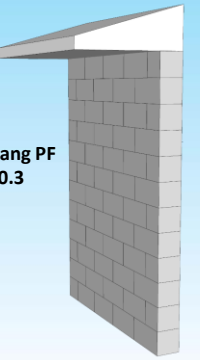
Table R402.1.2

Mass Walls **Kauai Amendment**

Reflectance ≥ 0.64



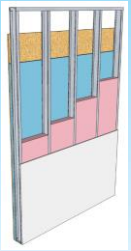
Overhang PF ≥ 0.3



Residential Opaque Envelope
Prescriptive Option

Table R402.1.2

Metal-frame walls



Framing 16 in. o.c.	Framing 24 in. o.c.
R-0 + 9.3	R-0 + 9.3
R-13 + 4.2	R-13 + 3.0
R-15 + 3.8	R-15 + 2.4

Rigid foam board thickness

R-value	Extruded Polystyrene (R-5/in.)	Poly-isocyanurate (R-6/in.)
2.4	≥ 0.48 in.	≥ 0.40 in.
3.0	≥ 0.60 in.	≥ 0.50 in.
3.8	≥ 0.76 in.	≥ 0.63 in.
4.2	≥ 0.84 in.	≥ 0.70 in.
9.3	≥ 1.86 in.	≥ 1.55 in.

Or use the points option for compliance

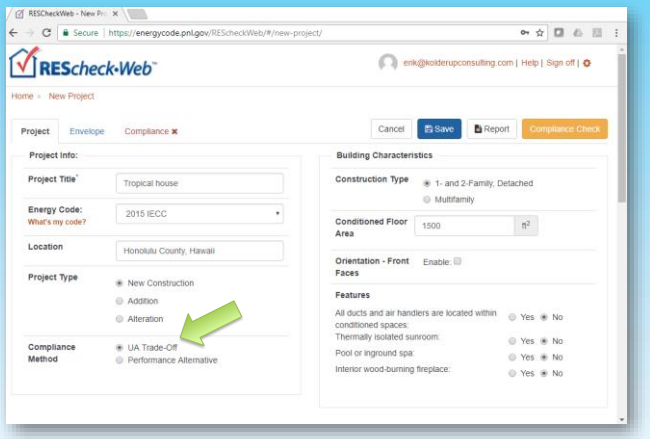
145

Residential Opaque Envelope
Total UA Option

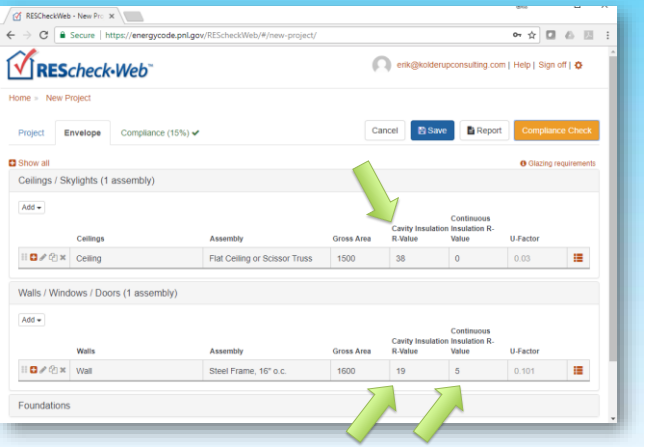
R402.1.5

- Calculate total U-factor x Area for walls and roof
- Typically use REScheck software
  - Desktop or Web version
  - https://energycode.pnl.gov/REScheckWeb

146



147



148

Generated by RESCheck-Web Software

Compliance Certificate

Project Tropical house

Energy Code: **2015 IECC**
Location: **Honolulu, Hawaii**
Construction Type: **Single-family**
Project Type: **New Construction**
Conditioned Floor Area: **1,500 ft2**
Climate Zone: **1 (0 HDD)**
Permit Date:
Permit Number:

Construction Site: Owner/Agent: Designer/Contractor:

Compliance: Passes using UA trade-off

Compliance: **15.0% Better Than Code** Maximum UA: **187** Your UA: **159** Maximum SHGC: **0.25** Your SHGC: **0.00**

The % Better or Worse Than Code Index reflects how close to compliance the house is based on code trade-off rules.
It DOES NOT provide an estimate of energy use or cost relative to a minimum-code home.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	U-Factor	UA
Ceiling: Flat Ceiling or Scissor Truss	1,500	38.0	0.0	0.030	45
Wall: Steel Frame, 16" o.c.	1,600	19.0	5.0	0.071	114

Compliance Statement: The proposed building design described here is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2015 IECC requirements in RESCheck Version : REScheck-Web and to comply with the mandatory requirements listed in the REScheck Inspection Checklist.

Name - Title Signature Date

Project Title: Tropical house Report date: 04/08/18
Data filename: Page 1 of 1

Residential Opaque Envelope
Points Option

Section R407
Hawaii Specific

- Total points ≥ 0
  - Roof and walls, or
  - Roof alone and wall alone
- Options for credit
  - Insulation
  - Cool roof
  - Radiant barrier
  - Wall reflectance
  - More efficient lighting
  - Efficient appliances
  - Wall shading
  - Ductless AC
  - High efficiency AC
  - No AC
  - Small dwelling
  - Energy Star fans
  - Solar electric

Measure	Standard Home Points	Tropical Home Points
R-13 Cavity Wall Insulation	0	1
R-19 Roof Insulation	-1	0
R-19 Roof Insulation + Cool roof membrane[1] or Radiant Barrier[3]	0	1
R-19 Roof Insulation + Attic Venting[2]	0	1
R-30 Roof Insulation	0	1
R-13 Wall Insulation + high reflectance walls[4]	1	2
R-13 Wall + 90% high efficacy lighting and Energy Star Appliances[5]	1	2
R-13 Wall Insulation + exterior shading wpf=0.3[6]	1	2
Ductless Air Conditioner[7]	1	1
1.071 X Federal Minimum SEER for Air Conditioner	1	1
1.142 X Federal Minimum SEER for Air Conditioner	2	2
No air conditioning installed	NA	2
House floor area ≤ 1,000 ft²	1	1
House floor area ≥ 2,500 ft²	-1	-1
Energy Star Fans[8]	1	1
Install 1 kW or greater of solar electric	1	1

Reasons to use the Points Option
1. Want <R-30 roof insulation
2. Have metal-framed walls and don't want to add foam board insulation

Points Option - Wood Framed Walls

Measure	Standard Home Points	Tropical Zone Points
R-13 cavity wall insulation	0	1
R-19 roof insulation	-1	0
R-19 roof insulation + cool roof membrane[1] or radiant barrier[3]	0	1
R-19 roof insulation + attic venting[2]	0	1
R-30 roof insulation	0	1
R-13 wall insulation + high reflectance walls[4]	1	2
R-13 wall + 90% high efficacy lighting and Energy Star appliances[5]	1	2
R-13 wall insulation + exterior shading wpf=0.3[6]	1	2
Ductless air conditioner[7]	1	1
1.071 X Federal minimum SEER for air conditioner	1	1
1.142 X Federal minimum SEER for air conditioner	2	2
No air conditioning installed	NA	2
House floor area ≤ 1,000 ft²	1	1
House floor area ≥ 2,500 ft²	-1	-1
Energy Star fans[8]	1	1
Install 1 kW or greater of solar electric	1	1

Points Option - Metal Framed Walls

Measure	Standard Home Points	Tropical Zone Points
R-13 + R-3 wall insulation	0	1
R-13 cavity wall insulation + R-0	-1	0
R-13 wall insulation + high reflectance walls[4]	0	1
R-13 wall + 90% high efficacy lighting and Energy Star Appliances[5]	1	2
R-13 wall insulation + exterior shading wpf=0.3[6]	0	1
R-30 roof insulation	0	1
R-19 roof insulation	-1	0
R-19 + cool roof membrane[1] or radiant barrier[3]	0	1
R-19 roof insulation + attic venting[2]	0	1
Ductless air conditioner[7]	1	1
1.071 X Federal minimum SEER for air conditioner	1	1
1.142 X Federal minimum SEER for air conditioner	2	2
No air conditioning installed	NA	2
House floor area ≤ 1,000 ft²	1	1
House floor area ≥ 2,500 ft²	-1	-1
Energy Star Fans[8]	1	1
Install 1 kW or greater of solar electric	1	1

Points Option - Footnotes

POINTS OPTION

[1] Cool roof with three-year aged solar reflectance of 0.55 and 3-year aged thermal emittance of 0.75 or 3-year aged solar reflectance index of 64.

[2] One cfm/ft^2 attic venting.

[3] Radiant barrier shall have an emissivity of no greater than 0.05 as tested in accordance with ASTM E-408. The radiant barrier shall be installed in accordance with the manufacturer's installation instructions.

[4] Walls with covering with a reflectance of ≥ 0.64.

[5] Energy Star rated appliances include refrigerators, dishwashers, and clothes washers and must be installed for the Certificate of Occupancy

[6] The wall projection factor is equal to the horizontal distance from the surface of the wall to the farthest most point of the overhang divided by the vertical distance from the first floor level to the bottom most point of the overhang.

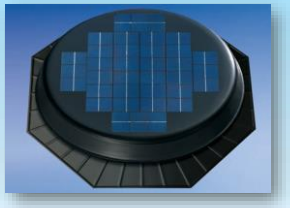
[7] All air conditioning systems in the house must be ductless to qualify for this credit.

[8] Install ceiling fans in all bedrooms and the largest space that is not used as a bedroom.

POINTS OPTION

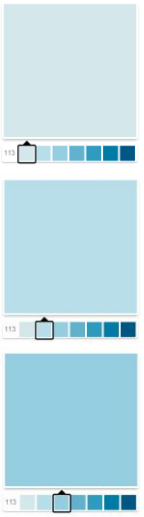
Attic Venting

≥1 cfm/ft^2 for credit



Source: www.solatube.com

POINTS OPTION



SW 6784 Bravo Blue
Interior/Exterior

Color Collection	SW Color
Color Family	Blues
Color Strip	113
RGB Value	R-212 | G-231 | B-234
Hexadecimal Value	#D4E7EA
LRV	78

SW 6785 Quench Blue
Interior/Exterior

Color Collection	SW Color
Color Family	Blues
Color Strip	113
RGB Value	R-184 | G-222 | B-233
Hexadecimal Value	#B8DEE9
LRV	69

SW 6786 Cloudless
Interior/Exterior

Color Collections	SW Color , Teen Space
Color Family	Blues
Color Strip	113
RGB Value	R-149 | G-206 | B-224
Hexadecimal Value	#95CEE0
LRV	57

Example
Light
Reflectance Value
(LRV) for exemption ≥ 64%

OK, LRV 78

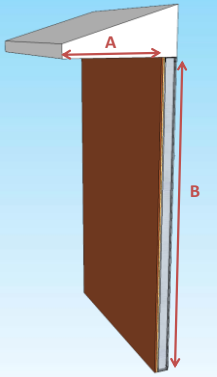
OK, LRV 69

Not complying, LRV 57

Source: www.sherwin-williams.com

POINTS OPTION

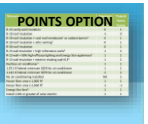
Wall Overhang Shading



Wall Projection Factor (WPF) ≥ 0.30

$$WPF = \frac{A}{B}$$

Points Option Example



- Single family home
  - 3000 ft^2
  - Metal-framed construction
  - Air conditioned with split-system AC
- Want
  - R-19 insulation in cathedral ceiling (instead of R-30)
  - R-13 wall cavity insulation (no continuous insulation)
- Questions
  1. How many points behind?
  2. What are the options that can be used for compliance?

Three points behind
- R-19 roof = -1 point
- R-13 wall = -1 point
- Area ≥2500 ft^2 = - 1 point

Options
1 point: high reflectance walls
1 point: 90% HE lighting + ES appliances
1 point: wall shading
1 point: ductless AC
1 point: 13.9 SEER
2 points: 14.8 SEER
1 point: ES ceiling fans
1 point: ≥1 kW solar electric

Residential Opaque Envelope
Summary

- Wall and roof, four options
  1. Tropical zone option
  2. Prescriptive Table R402.1.2
  3. Total UA
  4. Points option

Commercial Opaque Envelope
Compliance Options

C402.4

- Prescriptive requirements
  - Walls
    - R-value or U-factor
  - Roof
    - R-value or U-factor
    - Cool roof membrane
- Total Building Performance
- ASHRAE Standard 90.1-2013

CLIMATE ZONE	1	
	All other	Group R
Insulation entirely above roof deck	R-20ci	R-25ci
Metal buildings[b]	R-10 + R-11 LS	R-19 + R-11 LS
Attic and other	R-38	R-38
Mass	R-5.7ci[d]	R-5.7ci[d]
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20
Below-grade wall[d]	NR	NR
Mass[e]	NR	NR
Joist/framing	NR	NR
Unheated slabs	NR	NR
Heated slabs	R-7.5 for 12" below	R-7.5 for 12" below
Nonswinging	R-4.75	R-4.75

Commercial Opaque Envelope
Roof Insulation

Table C402.1.3

State version

	Type	Min. Insulation	
		Group R	Other
Roof	Insulation entirely above deck	R-25ci	R-20ci
	Metal building	R-19 + R-11 LS	R-19 + R-11 LS
	Attic and other	R-38	R-38

ci = continuous insulation
LS = layer system

Commercial Opaque Envelope
Roof Insulation

Table C402.1.3

Kauai version

	Type	Min. Insulation	
		Group R	Other
Roof	Insulation entirely above deck	R-25ci	R-20ci
	Metal building	~~R-19 + R-11 LS~~ R-30 R-19+cool roof	~~R-19 + R-11 LS~~ R-30 R-19+cool roof
	Attic and other	~~R-38~~ R-30 R-19+cool roof	~~R-38~~ R-30 R-19+cool roof

ci = continuous insulation

Commercial Opaque Envelope
Roof Insulation

Table C402.1.3

Maui version

	Type	Min. Insulation	
		Group R	Other
Roof	Insulation entirely above deck	~~R-25ci~~ R-12.5ci	~~R-20ci~~ R-10ci
	Metal building	~~R-19 + R-11 LS~~ R-30 R-19+cool roof	~~R-19 + R-11 LS~~ R-30 R-19+cool roof
	Attic and other	~~R-38~~ R-30 R-19+cool roof	~~R-38~~ R-30 R-19+cool roof

ci = continuous insulation

Roof Insulation
Entirely Above Deck

R-25 for group R buildings
R-20 for other buildings

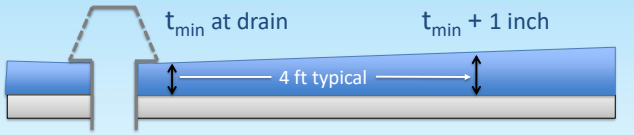
Polyisocyanurate	R-6/inch
Extruded polystyrene	R-5/inch

Photos courtesy of PIMA (Polyisocyanurate Insulation Manufacturers Association), via www.energycodes.gov

Roof Insulation
Entirely Above Deck

Tapered insulation exception (C402.2.2)

Meet minimum R-value here
- R-25 for group R buildings
- R-20 for other buildings

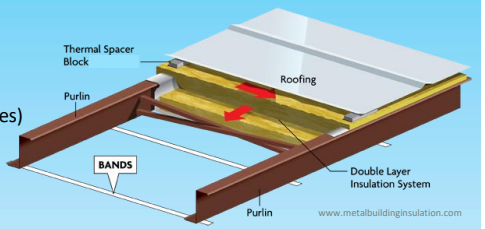


Minimum can be 3 inches

Example:
R-20 polystyrene = 4 inches

Roof Insulation
Metal Building

R-19 + R-11 LS
& thermal block
(6 inches + 3.5 inches)



Source: http://armstrongsteel.com

Roof Insulation Below Deck
"Attic and Other"

R-38 for all buildings
(12-inch thickness)

Or U-factor ≤ 0.027

Source: www.energycodes.gov

Commercial Opaque Envelope
Low-sloped Roofs

C402.3

Cool roof required

1. solar reflectance ≥0.55
   + thermal emittance ≥ 0.75, or
2. solar reflectance index ≥ 64

3-year aged values

Typical products
- Single-ply membrane
- Liquid applied

Commercial Opaque Envelope
Wall Insulation

Table C402.1.3

State version

	Type	Min. Insulation	
		Group R	Other
Walls	Mass	R-5.7ci	R-5.7ci
	Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci
	Metal framed	R-13+ R-5ci R-13*	R-13+ R-5ci R-13*
	Wood framed and other	R-13+ R-5ci R-20 R-13*	R-13+ R-5ci R-20 R-13*

ci = continuous insulation

* R-13 alone with:
- Reflectance ≥ 0.64, or
- Overhang PF ≥ 0.3

Commercial Opaque Envelope
Wall Insulation

Table C402.1.3

Maui and Kauai version

	Type	Min. Insulation	
		Group R	Other
Walls	Mass	R-5.7ci R-0*	R-5.7ci R-0*
	Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci
	Metal framed	R-13+ R-5ci R-13**	R-13+ R-5ci R-13**
	Wood framed and other	R-13+ R-5ci R-20 R-13**	R-13+ R-5ci R-20 R-13**

ci = continuous insulation

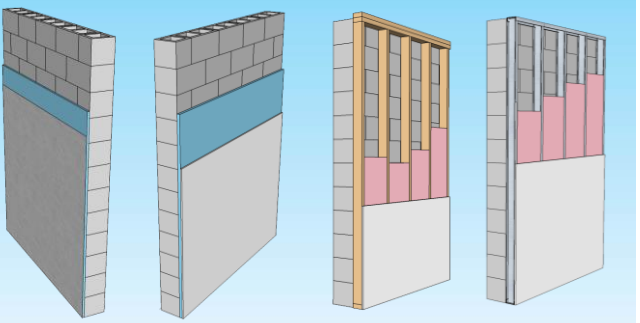
* No insulation for mass wall with:
- Reflectance ≥ 0.64,
- Overhang PF ≥ 0.3, or
- Thickness ≥ 6 in.

** R-13 alone with:
- Reflectance ≥ 0.64, or
- Overhang PF ≥ 0.3

169

169

Commercial Mass Wall Options



exterior interior

R-5.7 insulation
(1 in. polyisocyanurate or
1.25 in. polystyrene)

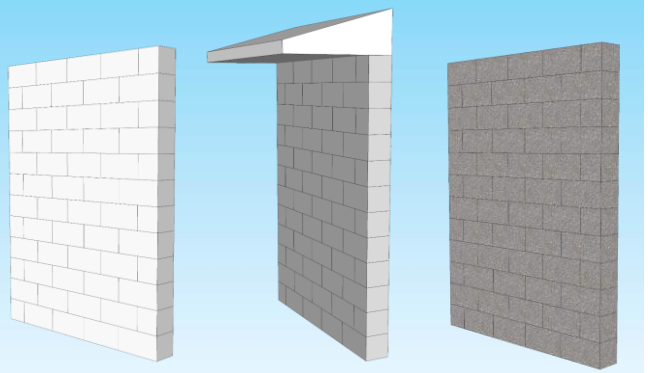
U-factor ≤ 0.151
Interior furring
R-6 in wood or **R-13** in metal

170

170

Commercial Mass Wall Options

Kauai & Maui Amendments



Reflectance ≥ 0.64

Overhang PF ≥ 0.3

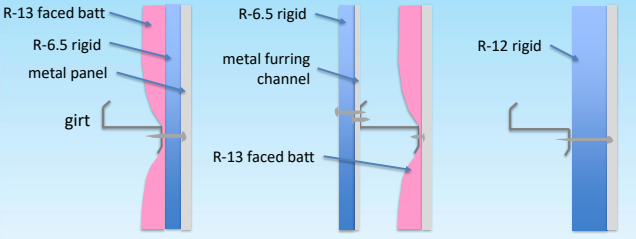
Thickness ≥ 6 inches

171

171

Commercial Metal-building Wall Options

Source: http://armstrongsteel.com



R-13 + **R-6.5** continuous

R-12 continuous

172

172

Commercial Wood-framed Wall Options

R-13 +
R-3.8 continuous

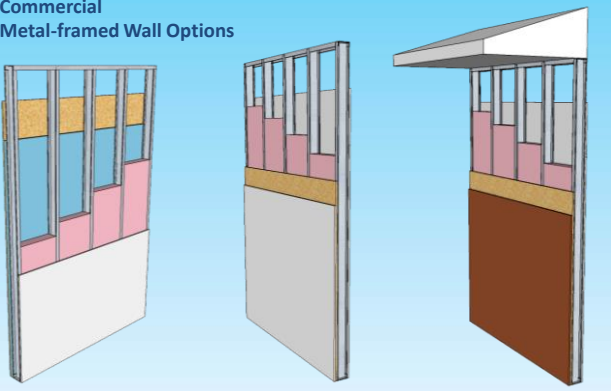
R-20

R-13 +
Reflectance
≥ 0.64

R-13 +
Overhang
PF ≥ **0.3**

173

Commercial Metal-framed Wall Options



R-13+
R-5 continuous

R-13+
Reflectance ≥ **0.64**

R-13 +
Overhang
PF ≥ 0.3

174

Commercial Opaque Envelope Summary

C402.4

- Prescriptive requirements
  - Walls
    - R-value or U-factor
  - Roof
    - R-value or U-factor
    - Cool roof membrane
- Total Building Performance
- ASHRAE Standard 90.1-2013

CLIMATE ZONE	1	
	All other	Group R
Insulation entirely above roof deck	R-20ci	R-25ci
Metal buildings[b]	R-10 + R-11 LS	R-10 + R-11 LS
Attic and other	R-38	R-38
Mass	R-5.7ci[d]	R-5.7ci[d]
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20
Below-grade wall[d]	NR	NR
Mass[e]	NR	NR
Joist/framing	NR	NR
Unheated slabs	NR	NR
Heated slabs	R-7.5 for 12" below	R-7.5 for 12" below
Nonswinging	R-4.75	R-4.75

175

Showing Compliance

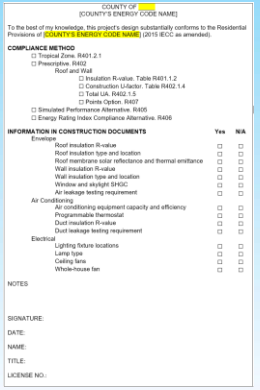
Information required on construction documents
(Also shown on checklists)

1. Insulation materials and their *R*-values.
2. Fenestration *U*-factors and solar heat gain coefficients (SHGC).
3. Area-weighted *U*-factor and solar heat gain coefficients (SHGC) calculations.

Excerpt from Sections R103.2 and C103.2

176

Showing Compliance Residential Certification



COUNTY OF
[COUNTY'S ENERGY CODE NAME]

To the best of my knowledge, this project's design substantially conforms to the Residential Provisions of [COUNTY'S ENERGY CODE NAME] (2015 IECC as amended).

COMPLIANCE METHOD

- ☐ Tropical Zone. R401.2.1
- ☐ Prescriptive. R402
  - Roof and Wall
    - ☐ Insulation R-value. Table R401.1.2
    - ☐ Construction U-factor. Table R402.1.4
    - ☐ Total UA. R402.1.5
    - ☐ Points Option. R407
- ☐ Simulated Performance Alternative. R405
- ☐ Energy Rating Index Compliance Alternative. R406

INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Envelope		
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window and skylight SHGC	☐	☐
Air leakage testing requirement	☐	☐
Air Conditioning		
Air conditioning equipment capacity and efficiency	☐	☐
Programmable thermostat	☐	☐
Duct insulation R-value	☐	☐
Duct leakage testing requirement	☐	☐
Electrical		
Lighting fixture locations	☐	☐
Lamp type	☐	☐
Ceiling fans	☐	☐
Whole-house fan	☐	☐

NOTES

SIGNATURE:

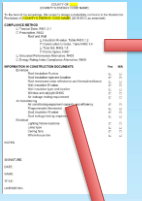
DATE:

NAME:

TITLE:

LICENSE NO.:

Showing Compliance Residential Certification



COMPLIANCE METHOD

- ☐ Tropical Zone. R401.2.1
- ☐ Prescriptive. R402
  - Roof and Wall
    - ☐ Insulation R-value. Table R401.1.2
    - ☐ Construction U-factor. Table R402.1.4
    - ☐ Total UA. R402.1.5
    - ☐ Points Option. R407
- ☐ Simulated Performance Alternative. R405
- ☐ Energy Rating Index Compliance Alternative. R406

INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Envelope		
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window and skylight SHGC	☐	☐
Air leakage testing requirement	☐	☐

Showing Compliance Commercial Certification

COUNTY OF
[COUNTY'S ENERGY CODE NAME]

To the best of my knowledge, this project's design substantially conforms to the [CODE NAME] (2015 IECC as amended) for **building envelope components** (Section C402).

COMPLIANCE METHOD

- ☐ 2015 IECC as amended. Mandatory & Prescriptive
- ☐ 2015 IECC as amended. Mandatory & Total Building Performance
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Prescriptive
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Energy Cost Budget Method

INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window SHGC	☐	☐
Window U-factor	☐	☐
Skylight SHGC	☐	☐
Skylight U-factor	☐	☐

NOTES

SIGNATURE:

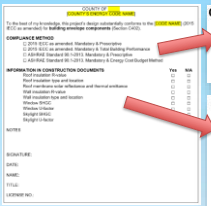
DATE:

NAME:

TITLE:

LICENSE NO.:

Showing Compliance Commercial Certification



COMPLIANCE METHOD

- ☐ 2015 IECC as amended. Mandatory & Prescriptive
- ☐ 2015 IECC as amended. Mandatory & Total Building Performance
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Prescriptive
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Energy Cost Budget Method

INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window SHGC	☐	☐
Window U-factor	☐	☐
Skylight SHGC	☐	☐
Skylight U-factor	☐	☐

Please fill out the evaluation forms

Thank you!

181

181

For more information

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2015 IECC available:
- http://iccsafe.org/publications

State energy code website
- http://energy.hawaii.gov/hawaii-energy-building-code

County websites
- Kauai: https://www.kauai.gov/PublicWorks/Building
- Maui: https://www.mauicounty.gov/1308/Building-Plan-Review-Section

Hawaii Energy code information website
- https://hawaiienergy.com/codes

182

182