



U.S. Department of Energy
**Energy Efficiency
and Renewable Energy**

Bringing you a prosperous future where energy
is clean, abundant, reliable, and affordable

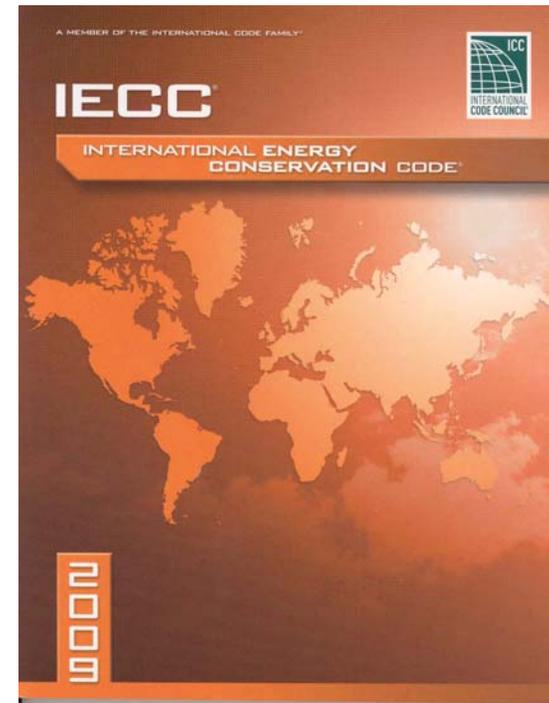
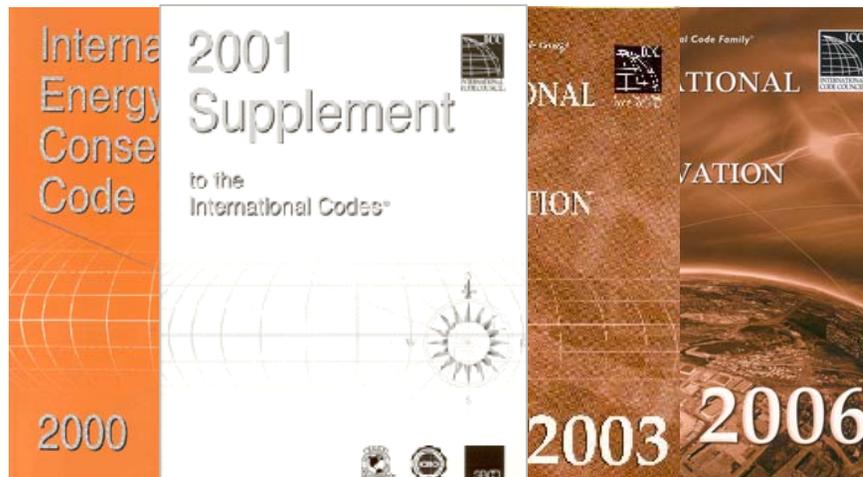
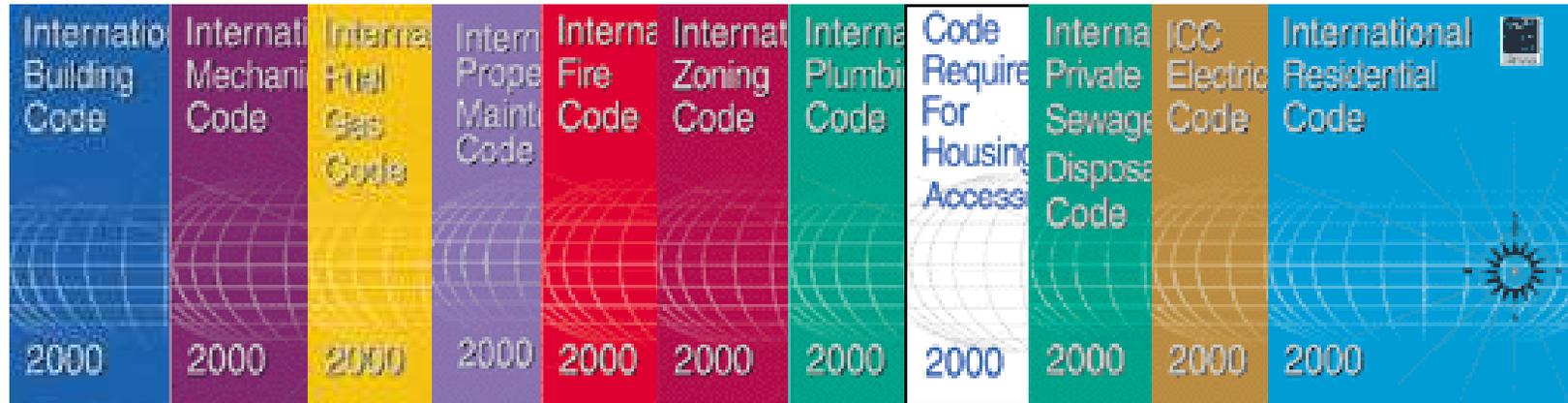


Building Energy Codes

Residential Requirements of the 2009 International Energy Conservation Code

U.S. Department of Energy
Building Energy Codes Program

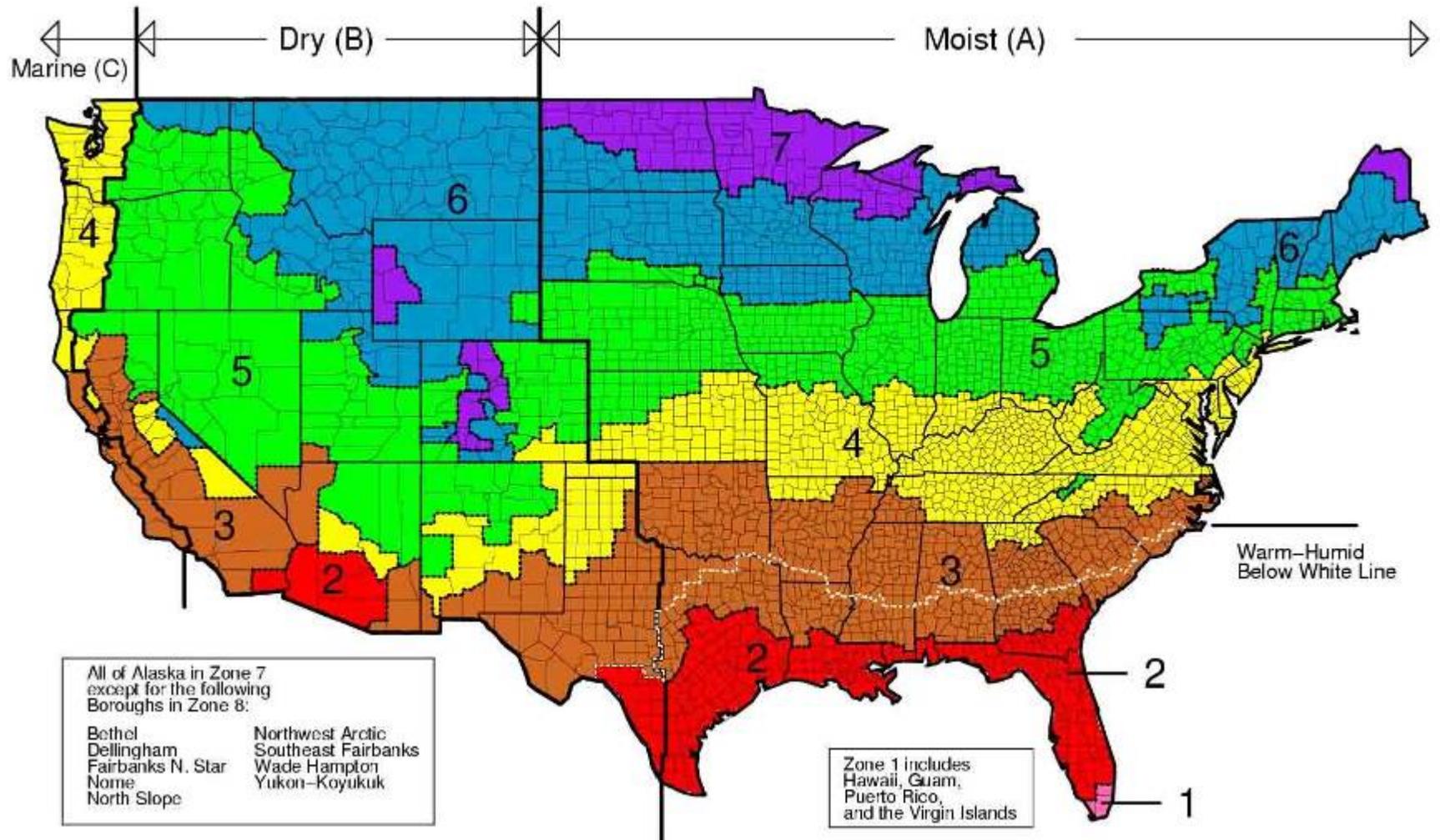
The Family of I-Codes



What's Changed Since IECC 2006?

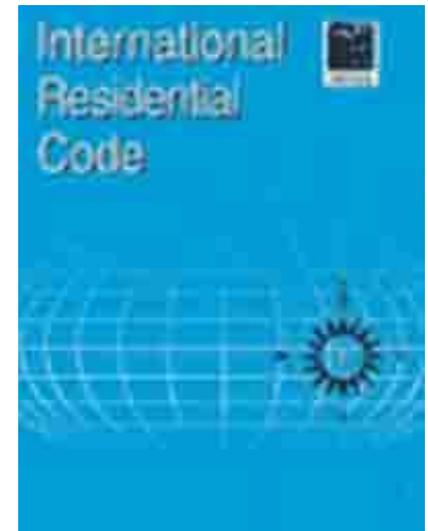
- Stringency – some key differences
- New requirements
 - Building envelope tightness
 - Duct testing
 - Lighting equipment
 - Pool controls and covers
 - Snow melt controls
- Moisture control requirements moved to IRC
- No mechanical trade-offs allowed

Climate Zones—2009 IECC



Relationship Between IRC and IECC

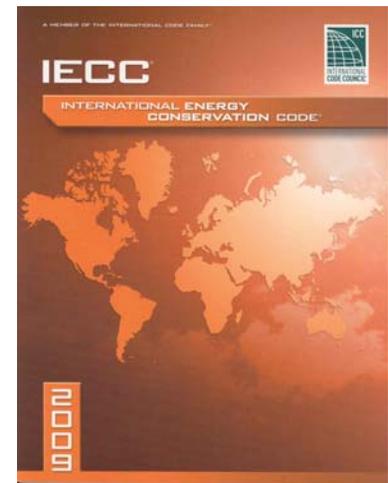
- IECC addresses only energy
- IRC addresses all codes (structural, plumbing, etc.)
 - Allows builder to carry only one code book
 - Chapter 11 has energy
- IECC addresses both residential and commercial; IRC addresses detached one- and two-family dwellings and townhouses
- IRC allows compliance with IECC as an alternative to Chapter 11
- Energy requirements in IRC and IECC almost identical
 - IRC requires 0.35 SHGC in Climate Zones 1-3; IECC requires 0.30



Structure of the IECC

- Chapter 1 Administrative
- Chapter 2 Definitions
- Chapter 3 Climate Zones
- Chapter 4 Residential Energy Efficiency
- Chapter 5 Commercial Energy Efficiency
- Chapter 6 Referenced Standards

Residential
Chapter



Overview of Residential Code Requirements

- Focus is on building envelope
 - Ceilings, walls, windows, floors, foundations
 - Sets insulation levels, window U-factors and solar heat gain coefficients
 - Infiltration control - caulk and seal to prevent air leaks
- Ducts – seal and insulate
- Limited space heating, air conditioning, and water heating requirements
 - Federal law sets most equipment efficiency requirements, not the I-codes
- No appliance requirements
- Lighting equipment – 50% of lamps to be high-efficacy lamps

Scope

Residential Buildings:

- IRC only for single-family, duplex, and townhouses
- IECC has all low-rise (1-3 stories) houses, condos, and apartments [R-2, R-3, R-4], but not hotels/motels [R-1]
- All buildings that are not “residential” by definition are “commercial”

Includes repairs, alterations, and additions

e.g., window replacements



Exceptions to Meeting Thermal Building Envelope Provisions

- Very low energy use buildings (<3.4 Btu/h-ft² or 1 watt/ft²)
- Buildings (or portions of) that are neither heated nor cooled
- Existing buildings (Section 101.4.1)
 - Electrical power, lighting, and mechanical systems still apply
- Buildings designated as historic (Section 101.4.2)



Additions, Alterations, Renovations, Repairs

- Conform as relates to new construction
- Unaltered portions(s) do not need to comply
- Additions can comply alone or in combination with existing building
- Exceptions
 - Storm windows over existing fenestration
 - Glass only replacements
 - Exposed, existing ceiling, wall or floor cavity if already filled with insulation
 - Where existing roof, wall or floor cavity isn't exposed
 - Reroofing for roofs where neither sheathing nor insulation exposed
 - Insulate above or below the sheathing
 - Roofs without insulation in the cavity
 - Sheathing or insulation is exposed

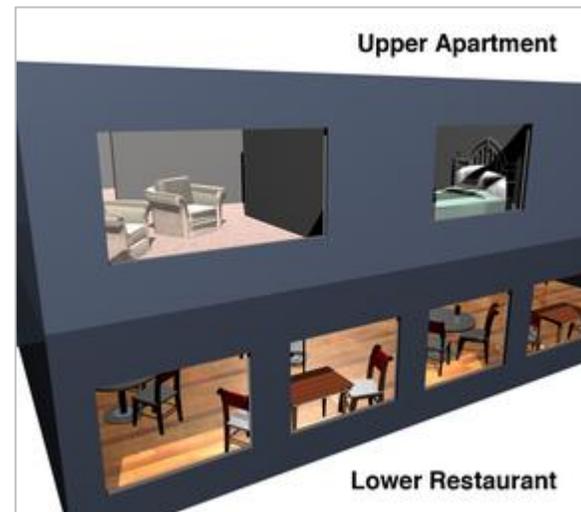


Space Conditioning

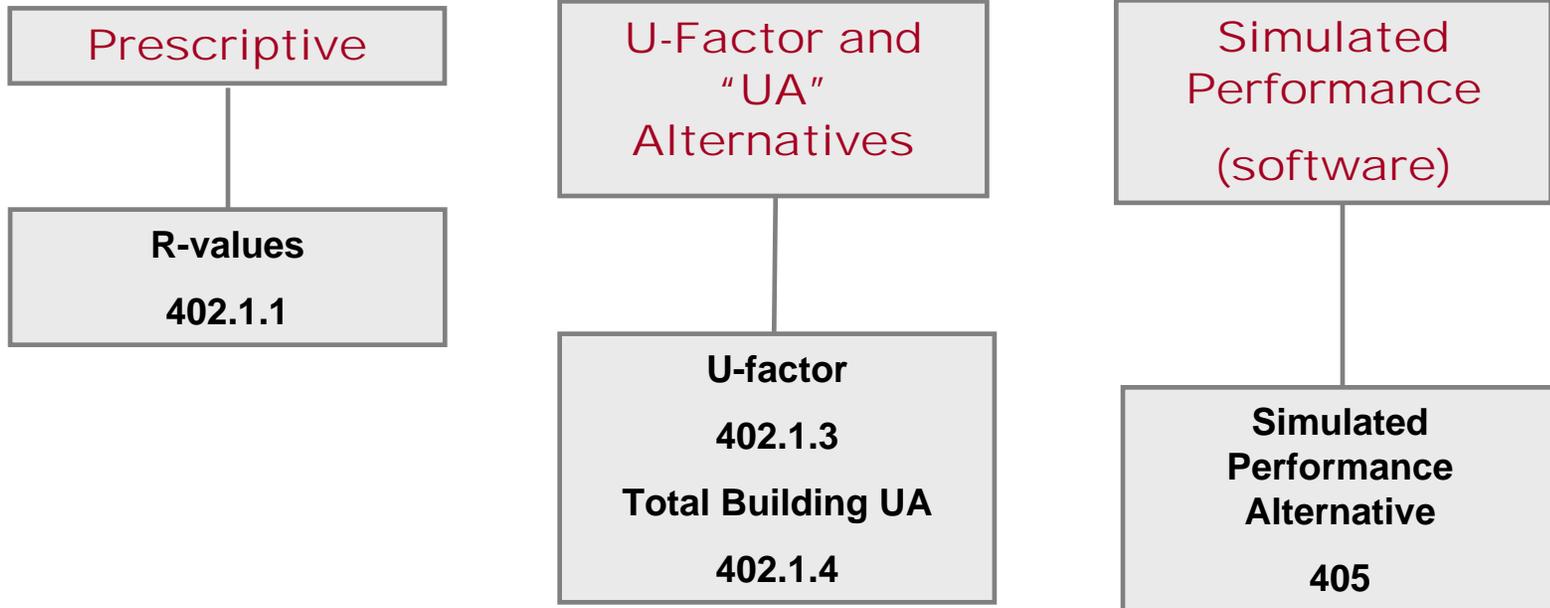
- Any nonconditioned space that is altered to become conditioned space shall be required to be brought into full compliance with this code.

Mixed Use Buildings

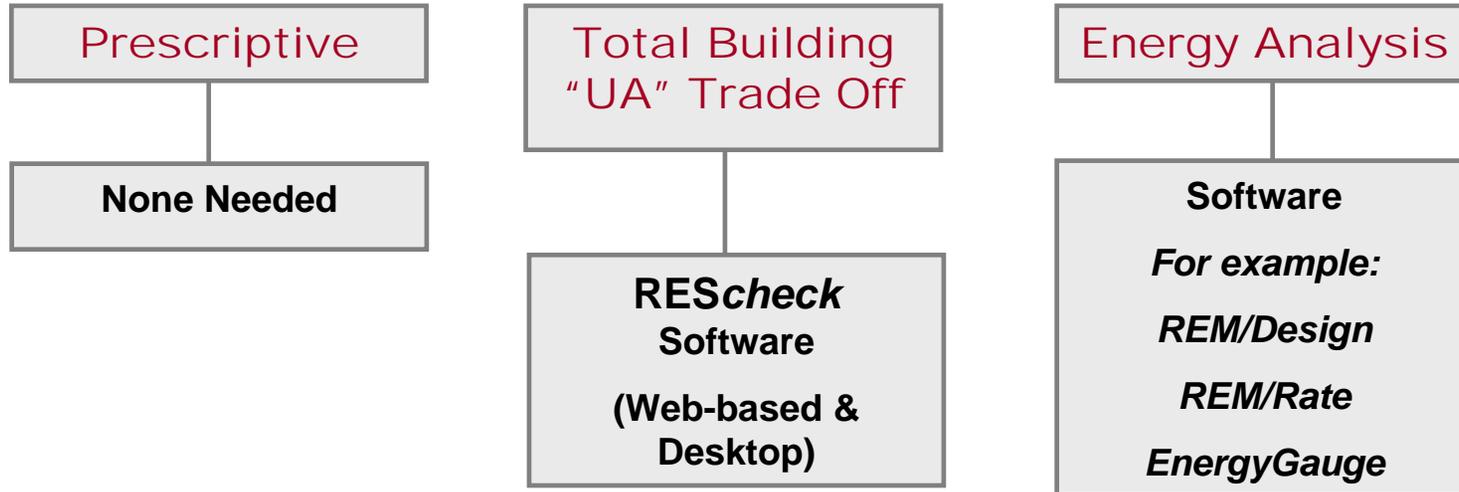
- Mixed occupancies
 - Treat the residential occupancy under the applicable residential code
 - Treat the commercial occupancy under the commercial code



IECC Compliance - Three Options



Code Compliance Tools



Climate-Specific Requirements

Climate-Specific Requirements:

- Foundations
 - Basements
 - Slabs
 - Crawlspace
- Above grade walls
- Skylights, windows, and doors
- Roofs
- Solar Heat Gain Coefficient in warm climates

Universal Requirements (apply everywhere):

- Duct insulation and sealing
- Infiltration control
 - Including recessed cans

Insulation and Fenestration Requirements by Climate Zone

Table 402.1.1
Insulation and Fenestration Requirements by Component^a

CLIMATE ZONE	FENESTRATION U-FACTOR ^b	SKYLIGHT ^b U-FACTOR	GLAZED FENESTRATION ^{b,e} SHGC	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE ⁱ	FLOOR R-VALUE	BASEMENT ^c WALL R-VALUE	SLAB ^d R-VALUE & DEPTH	CRAWL SPACE ^c WALL R-VALUE
1	1.20	0.75	0.30	30	13	3 / 4	13	0	0	0
2	0.65 ^j	0.75	0.30	30	13	4 / 6	13	0	0	0
3	0.50 ^j	0.65	0.30	30	13	5 / 8	19	5 / 13 ^f	0	5 / 13
4 except Marine	0.35	0.60	NR	38	13	5 / 10	19	10 / 13	10, 2ft	10 / 13
5 and Marine 4	0.35	0.60	NR	38	20 or 13+5 ^h	13 / 17	30 ^g	10 / 13	10, 2 ft	10 / 13
6	0.35	0.60	NR	49	20 or 13+5 ^h	15 / 19	30 ^g	15 / 19	10, 4 ft	10 / 13
7 and 8	0.35	0.60	NR	49	21	19 / 21	38 ^g	15 / 19	10, 4 ft	10 / 13

^a *R*-values are minimums, *U*-factors and SHGC are maximums, R-19 batts compressed into a nominal 2 x 6 framing cavity such that the *R*-value is reduced by R-1 or more shall be marked with the compressed batt *R*-value in addition to the full thickness *R*-value.

^b The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

^c "15/19" means R-15 continuous insulated sheathing on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulated sheathing on the interior or exterior of the home. "10/13" means R-10 continuous insulated sheathing on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

^d R-5 shall be added to the required slab edge *R*-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Zones 1 through 3 for heated slabs.

^e There are no SHGC requirements in the Marine Zone.

^f Basement wall insulation is not required in warm-humid locations as defined by Figure 301.1 and Table 301.1.

^g Or insulation sufficient to fill the framing cavity, R-19 minimum.

^h "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

ⁱ The second *R*-value applies when more than half the insulation is on the interior of the mass wall.

^j For impact rated fenestration complying with Section R301.2.1.2 of the *IRC* or Section 1608.1.2 of the *IBC*, maximum *U*-factor shall be 0.75 in Zone 2 and 0.65 in Zone 3.

U-Factor and Total UA (REScheck Approach)

- U-factor Alternative
 - Similar to Prescriptive but uses U-factors instead of R-values
 - Allows for innovative or less common construction techniques such as structural insulated panels or log walls
- Total UA Alternative
 - Same as U-factor alternative but allows trade-offs across all envelope components
 - Approach used in REScheck software

U-Factor Requirements by Climate Zone

**Table 402.1.3
Equivalent U-Factors^a**

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR ^b	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR ^d	CRAWL SPACE WALL U-FACTOR ^c
1	1.20	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.65	0.75	0.035	0.082	0.165	0.064	0.360	0.477
3	0.50	0.65	0.035	0.082	0.141	0.047	0.091 ^c	0.136
4 except Marine	0.35	0.60	0.030	0.082	0.141	0.047	0.059	0.065
5 and Marine 4	0.35	0.60	0.030	0.057	0.082	0.033	0.059	0.065
6	0.35	0.60	0.026	0.057	0.060	0.033	0.050	0.065
7 and 8	0.35	0.60	0.026	0.057	0.057	0.028	0.050	0.065

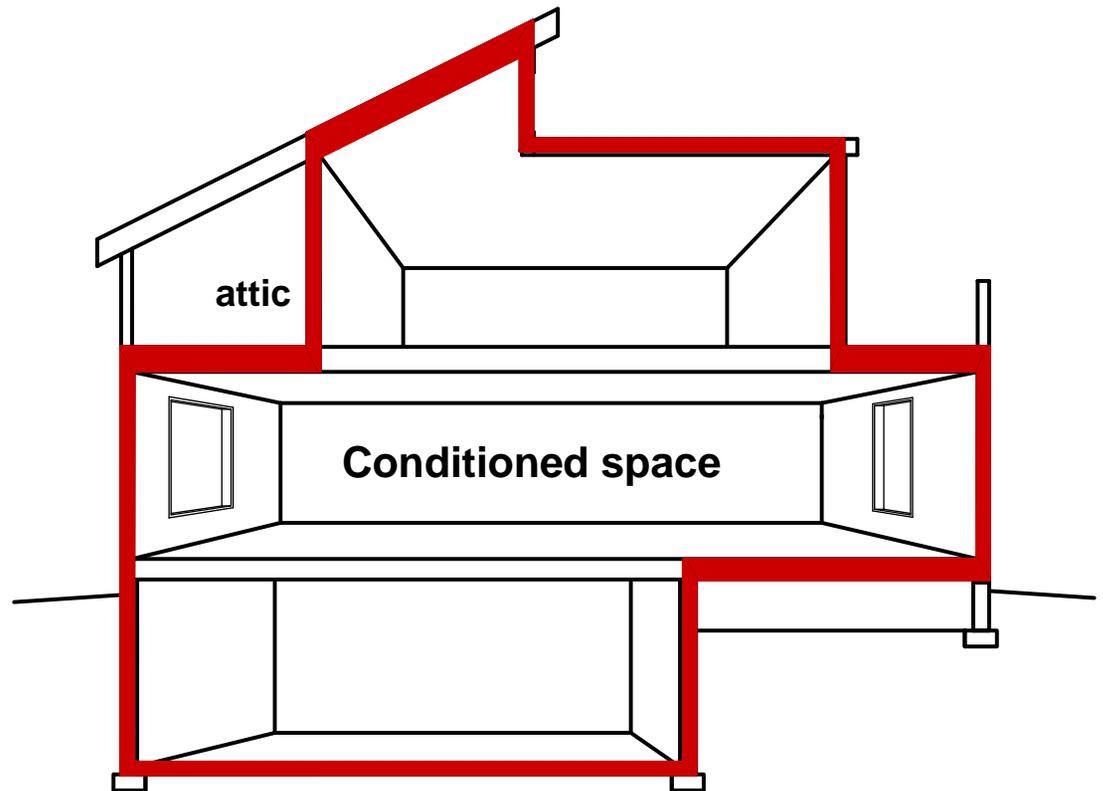
^a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

^b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be a maximum of 0.17 in Zone 1, 0.14 in Zone 2, 0.12 in Zone 3, 0.10 in Zone 4 except Marine, and the same as the frame wall *U*-factor in Marine Zone 4 and Zones 5 through 8.

^c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure 301.1 and Table 301.2.

Building Envelope Specific Requirements

- Building Envelope consists of:
 - Fenestration
 - Ceilings
 - Walls
 - Above grade
 - Below grade
 - Mass walls
 - Floors
 - Slab
 - Crawl space



Fenestration

- An area weighted average of fenestration can be used to satisfy the U-factor & SHGC requirements
 - Area-weighted average U-factor and SHGC are subject to hard limits, even in trade-offs
 - NFRC rated and certified
- Exceptions:
- Unrated U-factor for single-paned products comply in Zone 1
 - Unrated U-factor for double-pane with thermal break comply in Zone 2

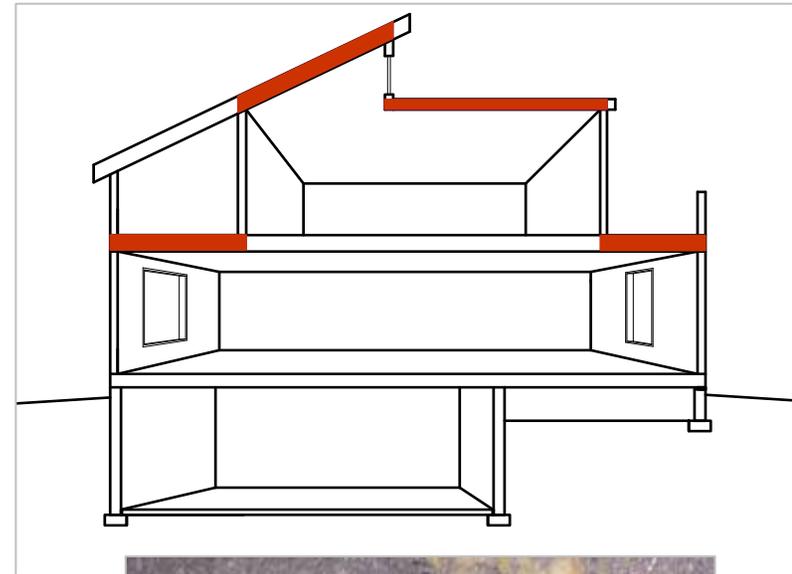
Fenestration (cont'd)

Prescriptive Path Only

- Exemptions
 - 15 ft² of glazing (Section 402.3.3)
 - 24 ft² of one side-hinged opaque door assembly (Section 402.3.4)
- Replacement fenestration must meet
 - 0.30 SHGC in Climate Zones 1-3
 - U-factors in all Zones

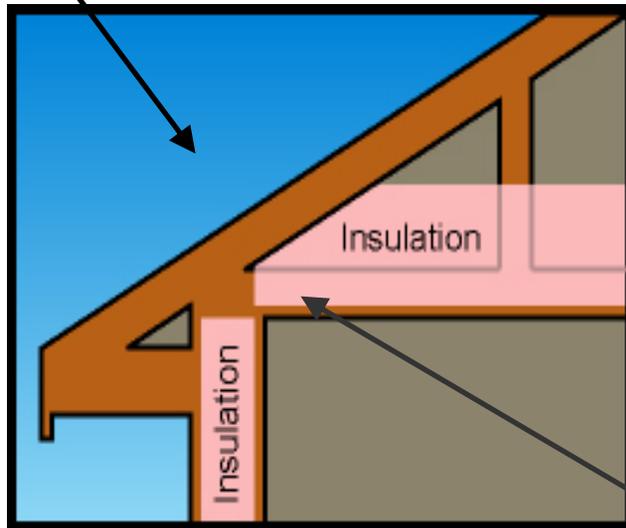
Ceilings

- Requirements based on
 - Assembly type
 - Continuous insulation
 - Insulation between framing
- Meet or exceed R-values



Standard Roof Truss

Possibility of ice dam formations



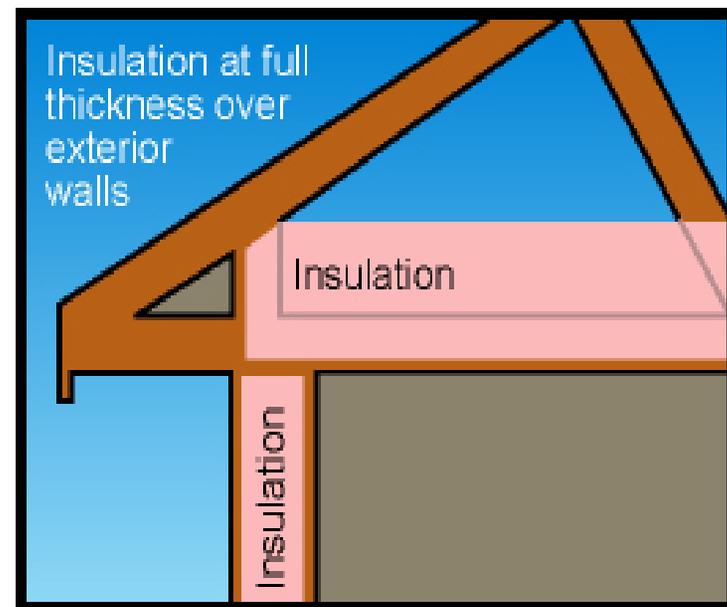
- Ceiling insulation code requirements assume standard truss systems

Cold corners contribute to condensation and mold growth

Raised Heel Truss



- Raised Heel/Energy Truss credit if insulation is full height over exterior wall (*Prescriptive*)
 - R-30 instead of R-38
 - R-38 instead of R-49



Ceilings without Attic Spaces (Prescriptive)

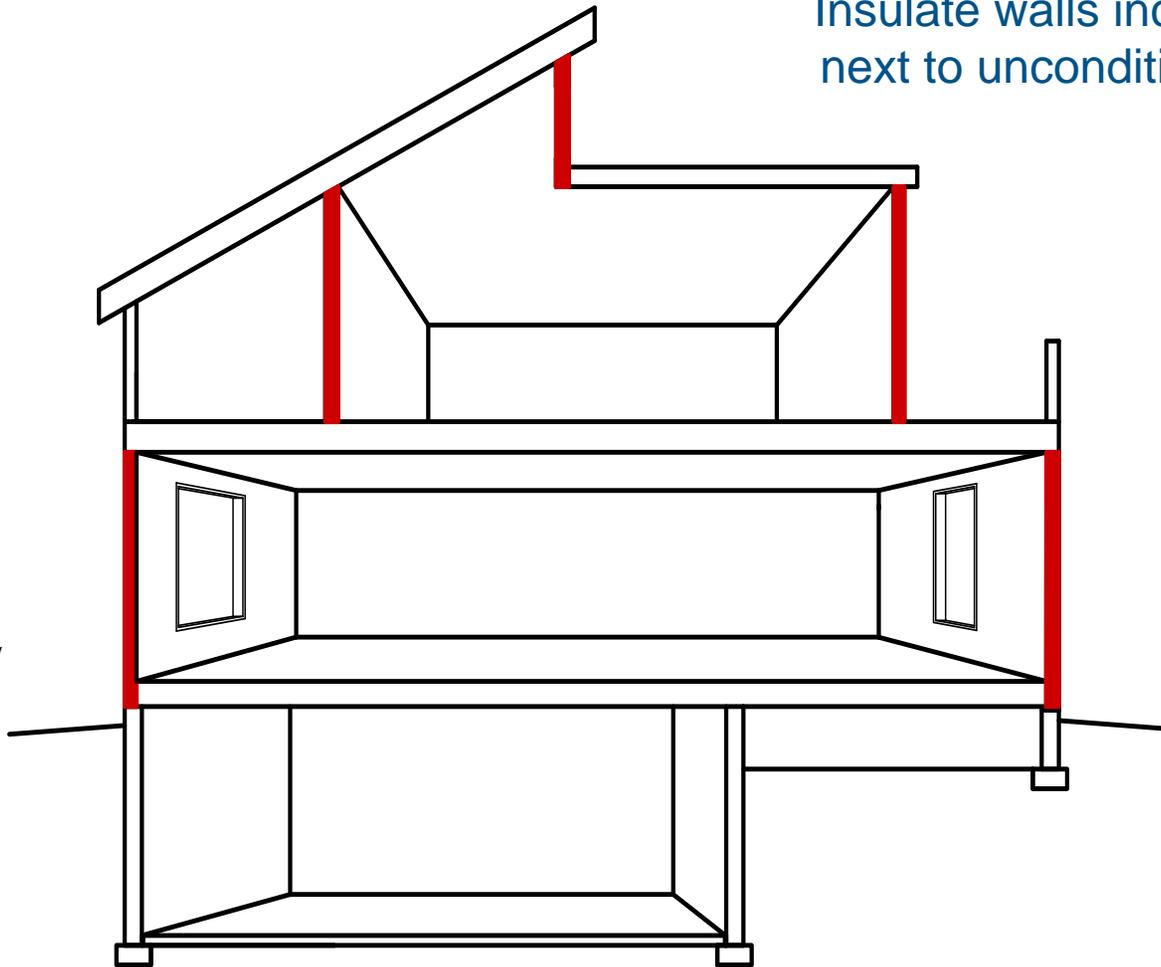
- Where
 - Insulation levels are required $> R-30$ and
 - Not sufficient amount of space to meet higher levels
 - $R-30$ allowed for 500 ft^2 or 20% total insulated ceiling area, whichever is less

Access Hatches and Doors (Prescriptive)

- Weatherstrip and insulate doors from conditioned spaces to unconditioned spaces (e.g., attics and crawl spaces)
 - Insult to level equivalent to surrounding surfaces
 - e.g., required ceiling insulation = R-38; attic hatch insulated to R-38
- Provide access to all equipment that prevents damaging or compressing the insulation
- Install a wood framed or equivalent baffle or retainer when loose fill insulation is installed

Above Grade Walls

Insulate walls including those next to unconditioned spaces



Don't forget to insulate rim joists

Mass Walls

- What type
 - Concrete block, concrete, insulated concrete form (ICF), masonry cavity, brick (other than brick veneer), earth, and solid timber/logs
- Provisions
 - At least 50% of the required R-value must be on the exterior or integral to the wall
 - When more than half the insulation is on the interior, the mass wall U-factors:

Climate Zones	U-Factor Maximum
1	0.17
2	0.14
3	0.12
4 except Marine	0.10
4 Marine	same as above grade frame wall
5-8	same as above grade frame wall



Steel-frame

- Ceilings, walls, and floors
- Exceptions
 - Climate Zones 1 and 2 ci can be reduced to R-3 for 24" o.c. walls

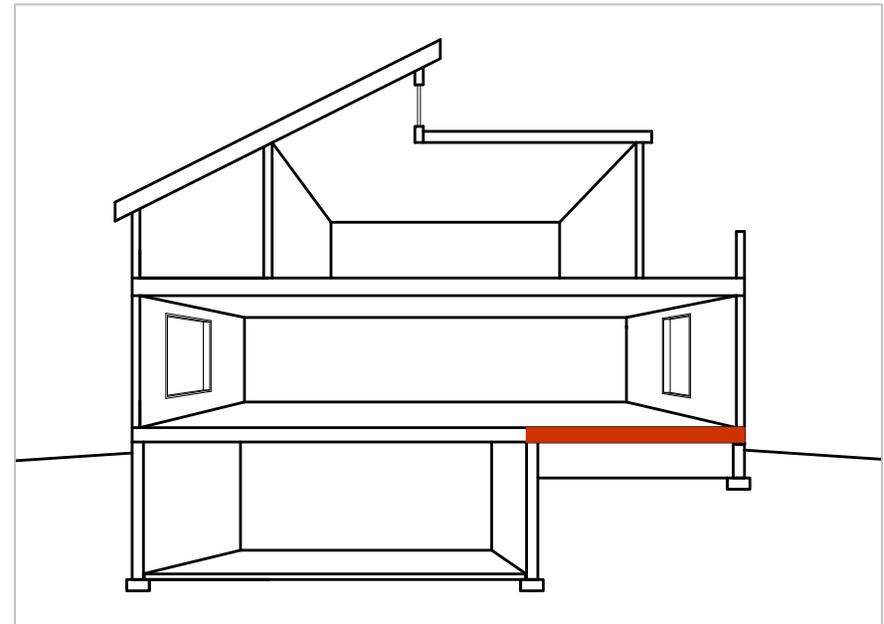
**Table 402.2.5
Steel-Frame Ceiling, Wall and Floor Insulation
(R-Value)**

Wood Frame R-value	Cold-Formed Steel Equivalent R-value ^a
Steel Truss Ceilings^b	
R-30	R-38 or R-30 + 3 or R-26 + 5
R-38	R-49 or R-38 + 3
R-49	R-38 + 5
Steel Joist Ceilings^b	
R-30	R-38 in 2x4, or 2x6, or 2x8 R-49 any framing
R-38	R-49 2x4, or 2x6, or 2x8, or 2x10
Steel Framed Wall	
R-13	R-13 + 5 or R-15 +4, or R-21 +3 or R-0+10
R-19	R-13 + 9 or R-19 +8 or R-25 +7
R-21	R-13 +10 or R-19 +9 or R-25 +8
Steel Joist Floor	
R-13	R-19, 2x6 R-19 + 6 in 2x8 or 2x10
R-19	R-19 + 6 in 2x6 R-19 +12 in 2x8 or 2x10

Floors over Unconditioned Space

- Space can be unheated basement or a crawlspace or outdoor air

Climate Zones	R-Value
1-2	13
3-4ab	19
4c-6	30*
7-8	38*



- Insulation must maintain permanent contact with underside of subfloor

*Exception:

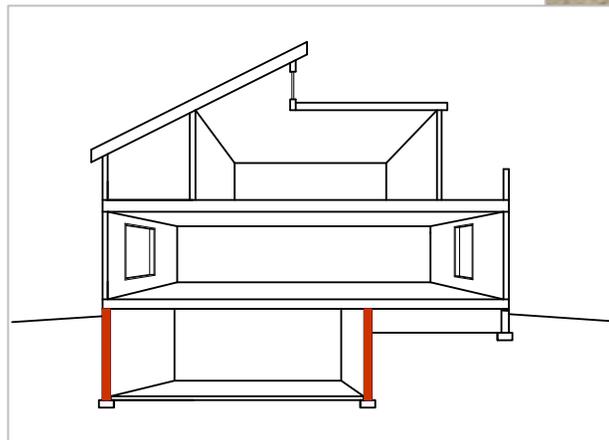
Climate Zones 4c-8

R-19 permitted if cavity completely filled

Below-Grade Walls

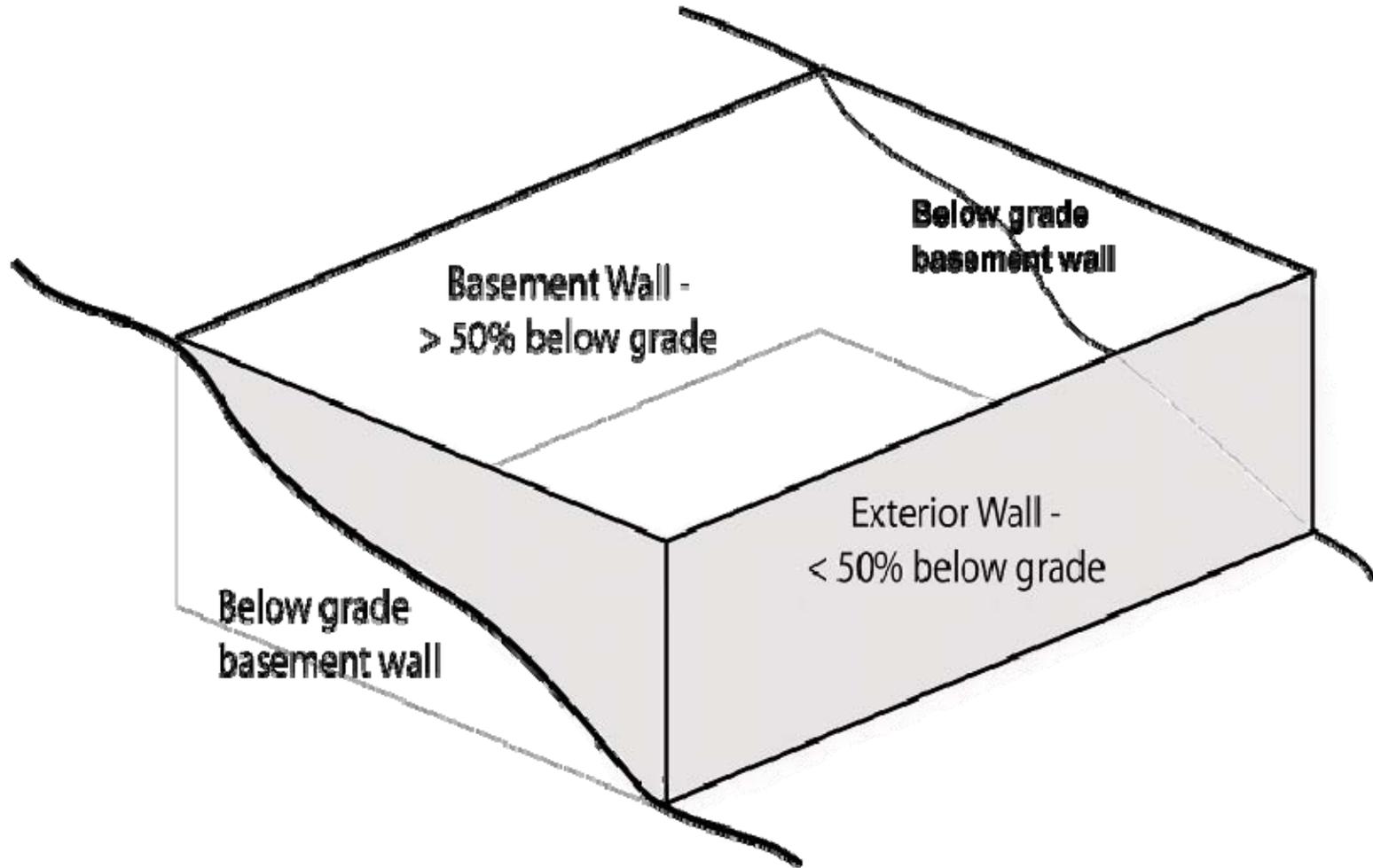
- $\geq 50\%$ below grade

Climate Zones	R-Value
1-2	0
3	5/13
4-5	10/13
6-8	15/19



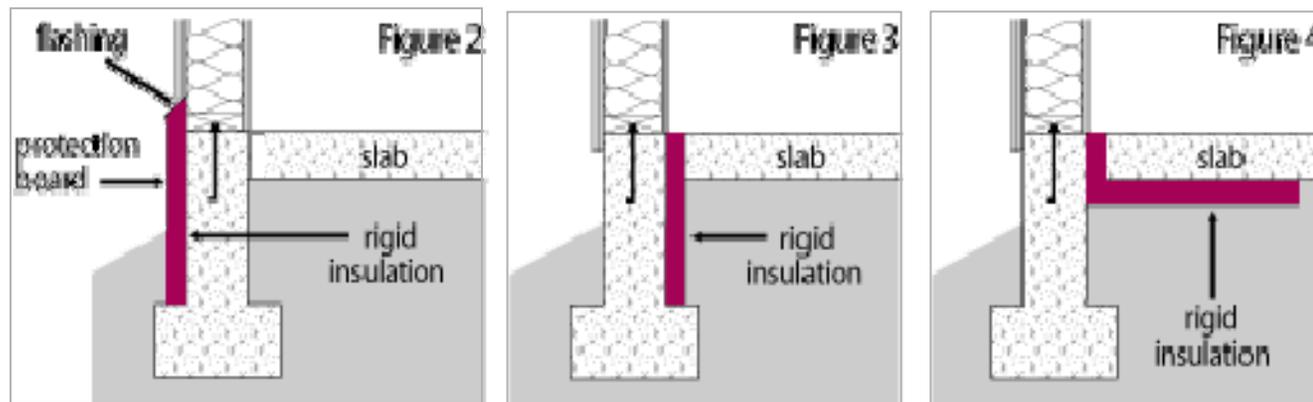
Insulated from top of basement wall down to 10 ft below grade or basement floor, whichever is less

Defining Below-Grade Walls

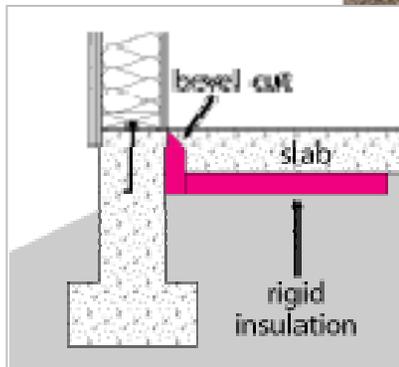


Slab Edge Insulation

- Slabs with a floor surface < 12 inches below grade
 - R-10 (typically 2 inches) insulation in Zones 4 and above
 - Downward from top of slab a minimum of 24" (Zones 4 and 5) or 48" (Zones 6, 7, and 8)
 - Insulation can be vertical or extend horizontally under the slab or out from the building (must be under 10 inches of soil)

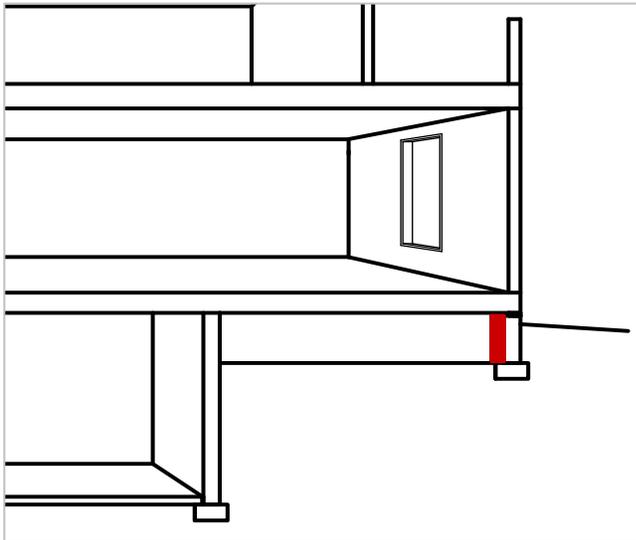


Slab Edge Insulation



Crawlspace Wall Insulation

- Unvented Crawlspaces
 - Space should be mechanically vented or conditioned (See Section R408 of the IRC)
 - Cover exposed earth with a continuous Class I vapor retarder



Vented & Unvented Crawlspace

Vented Crawlspace Requirements:

- The raised floor over the crawlspace must be insulated.
- A vapor retarder may be required as part of the floor assembly.
- Ventilation openings must exist that are equal to at least 1 square foot for each 150 square feet of crawlspace area and be placed to provide cross-flow (*IRC 408.1, may be less if ground vapor retarder is installed*).
- Ducts in crawlspace must be sealed and have R-8 insulation.

Unvented Crawlspace Requirements:

- The crawlspace ground surface must be covered with an approved vapor retarder (*e.g., plastic sheeting*).
- Crawlspace walls must be insulated to the R-value requirements specific for crawlspace walls (*IECC Table 402.1.1*).
- Crawlspace wall insulation must extend from the top of the wall to the inside finished grade and then 24" vertically or horizontally.
- Crawlspace must be mechanically vented (*1 cfm exhaust per 50 square feet*) or conditioned (*heated and cooled as part of the building envelope*).

Additions

- Treat as a stand-alone building
- Additions must meet the prescriptive requirements in Table 402.1.1



Sunrooms

Less stringent insulation
R-value and glazing
U-factor requirements

Sunroom definition:

- Glazing area >40% glazing of gross exterior wall and roof area
- Separate heating or cooling system or zone
- Must be thermally isolated (closeable doors or windows to the rest of the house)



Sunroom Requirements

- Ceiling Insulation

- Zones 1-4 R-19
- Zones 5-8 R-24

- Wall Insulation

- All zones R-13

- Fenestration U-Factor

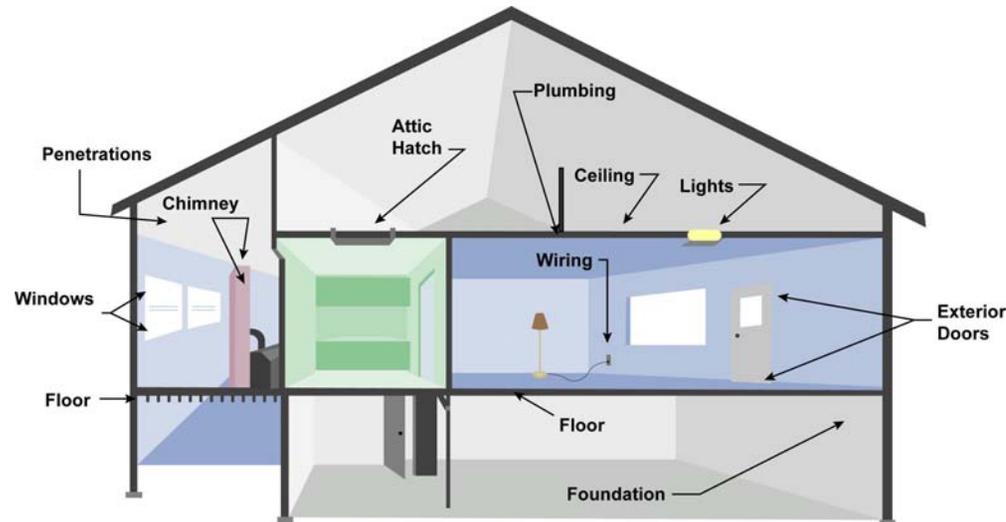
- Zones 4-8 0.50

- Skylight U-Factor

- Zones 4-8 0.75

Mandatory Requirements Building Envelope

- Air leakage
- Recessed lighting
- Maximum fenestration U-factor and SHGC
- Fireplaces



Air Leakage Control

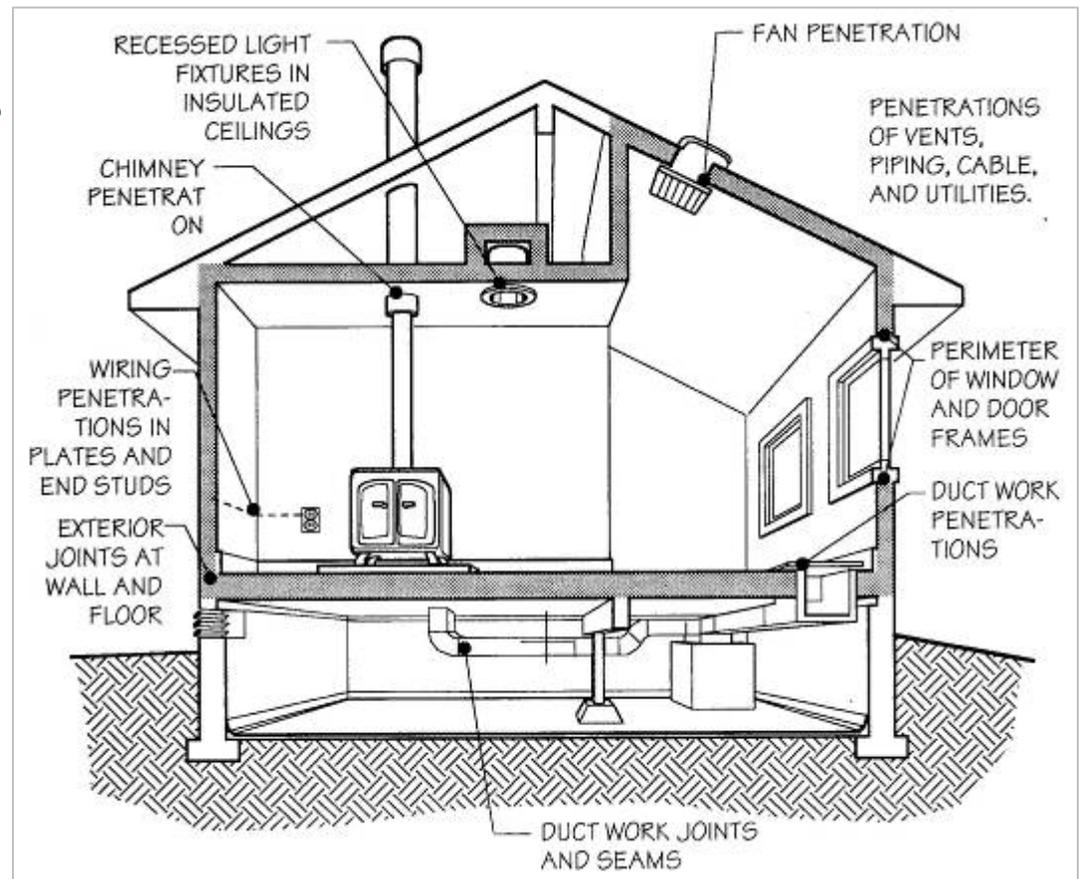
Mandatory Requirements

- Building envelope
 - Sealed with caulking materials or
 - Closed with gasketing systems
 - Joints and seams sealed or taped or covered with a moisture vapor-permeable wrapping material



Areas for Air Leakage (Infiltration)

- Windows and doors
- Between sole plates
- Floors and exterior wall panels
- Plumbing
- Electrical
- Service access doors or hatches
- Recessed light fixtures
- Rim joist junction



Recessed Lighting Fixtures

Mandatory Requirements

- Type IC rated and labeled in a sealed or gasketed enclosure
- Type IC rated and labeled as meeting ASTM E 283 when tested at 1.57 psf (75 Pa) pressure differential with no more than 2.0 cfm of air movement
- Sealed with a gasket or caulk between the housing and interior wall or ceiling covering



Air Sealing and Insulation

- 2 options to demonstrate compliance
 - When tested air leakage is <7 ACH when tested with a blower door at pressure of 33.5 psf (Section 402.4.2.1)
 - Testing after rough in and installation of building envelope penetrations
 - When items listed in Table 402.4.2, applicable to the method of construction, are field verified (Section 402.4.2.2)

Windows – U-Factors

- Strict limits on U-factor in northern U.S. (cannot be traded off)

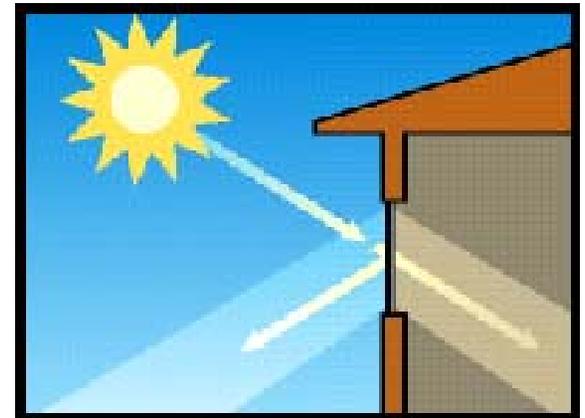
Climate Zones	U-Factor Maximum
4-5	0.48
6-8	0.40

- U-0.75 for skylights in Zones 4-8
- These are based on building average; individual windows or skylights can be worse if area-weighted average meets these requirements

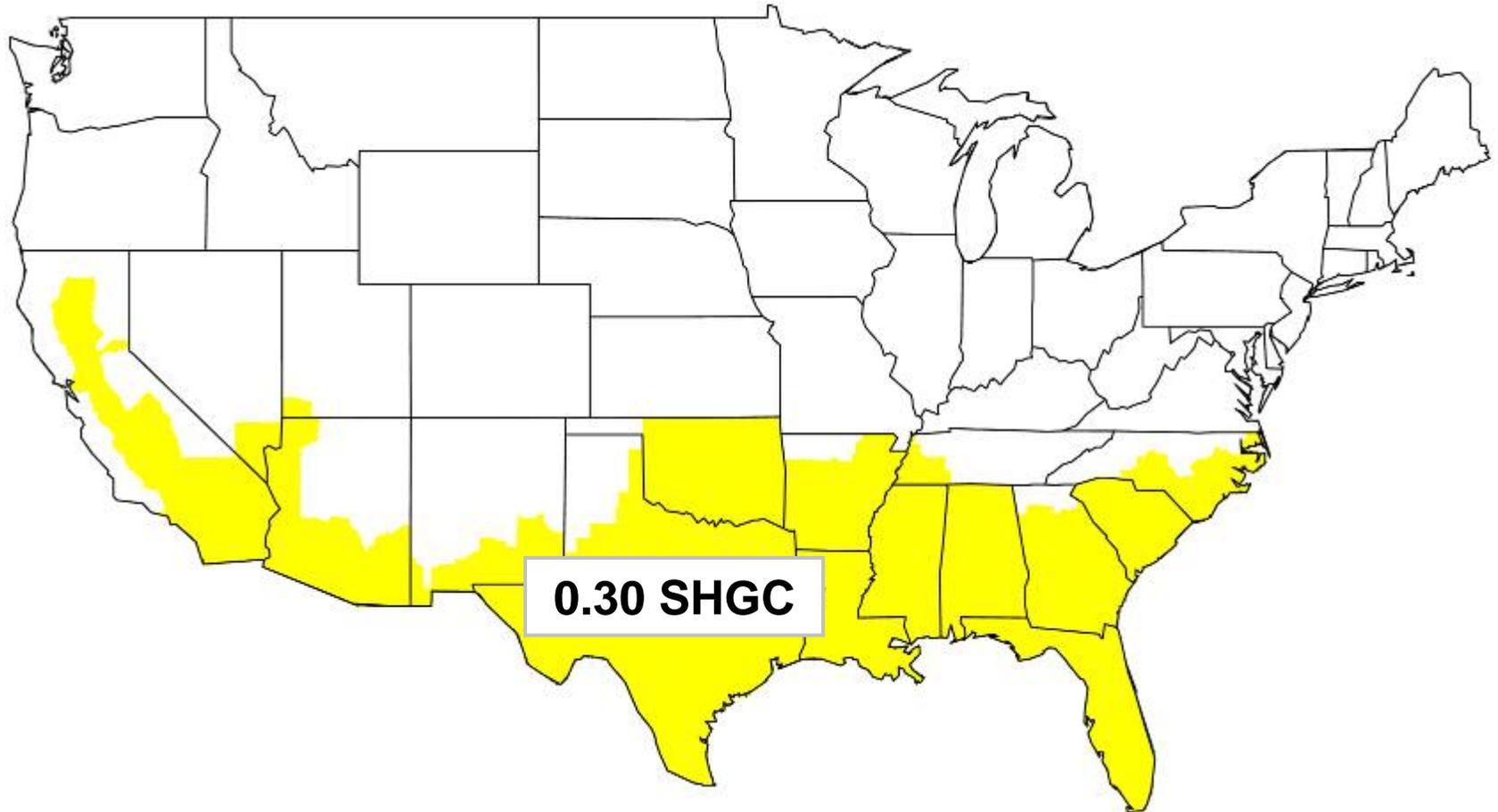
Windows - SHGC

- Solar Heat Gain Coefficient
 - Climate Zones 1-3
 - 0.30 or lower (area-weighted average)
 - Cannot exceed 0.50 even if performance path trade-offs are used (area-weighted average)
 - National Fenestration Rating Council (NFRC) tested

**Solar Heat
Gain Coefficient**

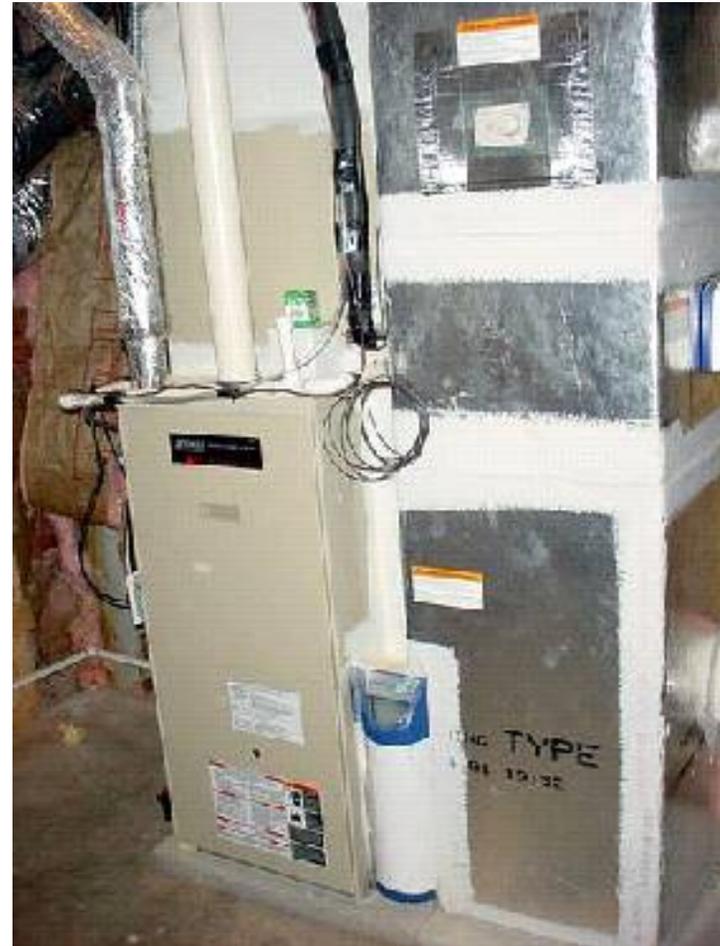


Locations with Window SHGC Requirements



Mechanical Systems & Equipment

- Equipment efficiency set by Federal law, not the I-Codes



Mandatory Requirements Systems (Section 403)

- Controls
- Heat pump supplementary heat
- Ducts
 - Sealing (Mandatory)
 - Insulation (Prescriptive)
- HVAC piping insulation
- Circulating hot water systems
- Ventilation
- Equipment sizing
- Systems serving multiple dwelling units
- Snow melt controls
- Pools

Programmable Thermostat - Controls

Mandatory Requirements

- If primary heating system is a forced-air furnace
 - At least one programmable thermostat/dwelling unit
 - Capability to set back or temporarily operate the system to maintain zone temperatures
 - down to 55°F (13°C) or
 - up to 85°F (29°C)
 - Initially programmed with:
 - heating temperature set point no higher than 70°F (21°C) and
 - cooling temperature set point no lower than 78°F (26°C)

Heat Pump Supplementary Heat - Controls

Mandatory Requirements

- Prevent supplementary electric-resistance heat when heat pump can meet the heating load
- Exception
 - During defrost

Ducts

- Insulation (Prescriptive)
 - Ducts outside the building envelope: R-8
 - All other ducts: R-6
- Sealing (Mandatory)
 - Joints and seams shall comply with IRC, Section M1601.4.1
- Building framing cavities shall not be used as supply ducts



Duct Tightness Tests

Mandatory Requirements

- All ducts, air handlers, filter boxes and building cavities used as ducts shall be sealed (Section 403.2.2)
- Duct tightness shall be verified *by either* –
 - Post construction test
 - Leakage to outdoors: ≤ 8 cfm/per 100 ft² of conditioned floor area **or**
 - Total leakage: ≤ 12 cfm/per 100 ft² of conditioned floor area
 - tested at a pressure differential of 0.1 in w.g. (25Pa) across entire system, including manufacturer's air handler enclosure
 - All register boots taped or otherwise sealed
 - OR** • Rough-in test
 - Total leakage ≤ 6 cfm/per 100 ft² of conditioned floor area
 - tested at a pressure differential of 0.1 in w.g. (25Pa) across roughed-in system, including manufacturer's air handler enclosure
 - all register boots taped or otherwise sealed
 - if air handler not installed at time of test
 - Total air leakage ≤ 4 cfm/per 100 ft²

Exceptions: Duct tightness test is not required if the air handler and all ducts are located within conditioned space

Piping Insulation

Mandatory Requirements

- R-3 required on
 - HVAC systems
 - Exception: Piping that conveys fluids between 55 and 105°F
- R-2 required on
 - All circulating domestic hot water systems
 - Systems also require a readily accessible manual switch



Ventilation and Equipment Sizing

Mandatory Requirements

- Ventilation
 - Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating
- Equipment Sizing
 - IECC references Section M1401.3 of the IRC
 - Load calculations determine the proper capacity (size) of equipment
 - Goal is big enough to ensure comfort but no bigger
 - Calculations shall be performed in accordance with ACCA Manual J or other approved methods



Snow Melt System Controls

Mandatory Requirements

- Snow- and ice-melting system controls
 - pavement temperature $> 50^{\circ}\text{F}$ and no precipitation is falling and when the outdoor temperature is $> 40^{\circ}\text{F}$

Pools

Mandatory Requirements

- Pool heaters
 - with a readily accessible on-off switch
 - fired by natural gas not allowed to have continuously burning pilot lights
- Time switches to automatically turn off and on heaters and pumps according to a preset schedule installed on swimming pool heaters and pumps.
 - Exceptions
 - Public health standards require 24-hour pump operation
 - Pumps operating pools with solar-waste-heat recovery heating systems

Pool Covers

Mandatory Requirements

- On heated pools
 - If heated to $>90^{\circ}\text{F}$, vapor-retardant pool cover at least R-12

Exception: If $>60\%$ of energy from site-recovered or solar energy source

Fireplaces

- New wood-burning fireplaces shall have gasketed doors and outdoor combustion air.



Systems

Mandatory Requirements

- Systems serving multiple dwelling units shall comply with Sections 503 and 504 in lieu of Section 403

Lighting Equipment (Prescriptive)

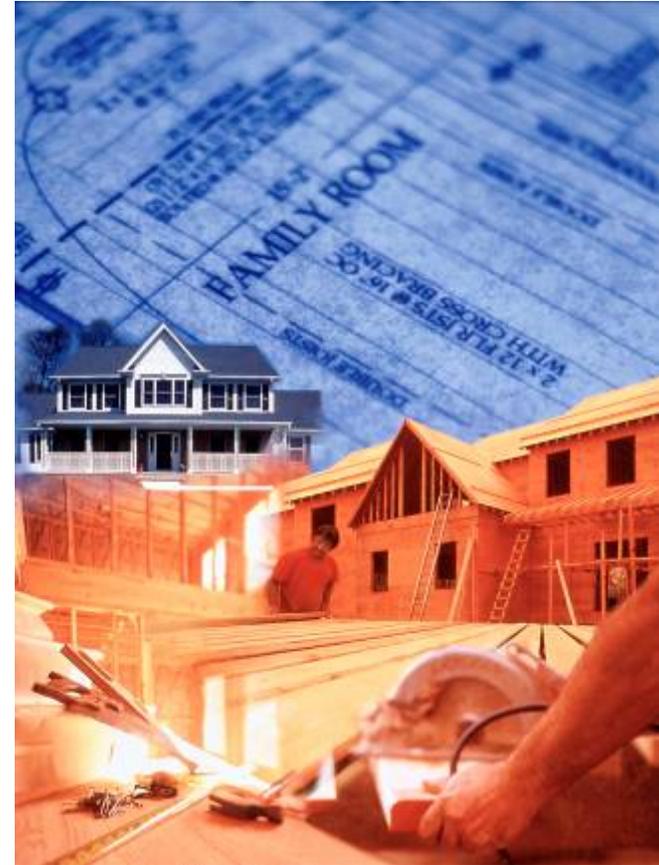
- A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps

Simulated Performance Alternative

- Requires computer software with specified capabilities (local official may approve other tools)
- Includes both envelope and equipment
- Allows greatest flexibility. Credits features such as:
 - High efficiency furnaces, air-conditioners, etc.
 - Tight ducts (must be leak tested) or hydronic systems
 - Exterior shading, favorable orientation, thermal mass, SHGC, etc.
- Section 405 specifies “ground rules”
 - These will generally be “hidden” in compliance software calculation algorithms
 - Very similar ground rules are used in home federal tax credits and ENERGY STAR Home guidelines

Compliance/Documentation/Inspections

- Code Official has final authority
 - Software, worksheets
 - Above Code Programs
- Electronic media can be used
- Construction work for which a permit is required is subject to inspection
- Certificate is required



Compliance/Documentation/Inspections

- Code Officials Inspection
 - Successive and final inspections, and reinspections if necessary
- Code Validity
 - Code deemed to be illegal or void shall not affect the remainder of the code
- Codes and standards considered part of the requirements of the code
 - Provisions take precedence
- Fees
 - Must be paid before permit is issued
 - Required in accordance with schedule

Certificate

- Permanently posted on the electrical distribution panel
- Don't cover or obstruct the visibility of other required labels
- Includes the following:
 - R-values of insulation installed for the thermal building envelope including ducts outside conditioned spaces
 - U-factors for fenestration
 - SHGC for fenestration
 - HVAC efficiencies and types
 - SWH equipment

Certificate (cont'd)

- If a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed
 - Certificate lists gas-fired unvented room heater, electric furnace or baseboard electric heater
- No efficiency listed for the above systems