U.S. Department of Energy
Energy Efficiency and Renewable Energy
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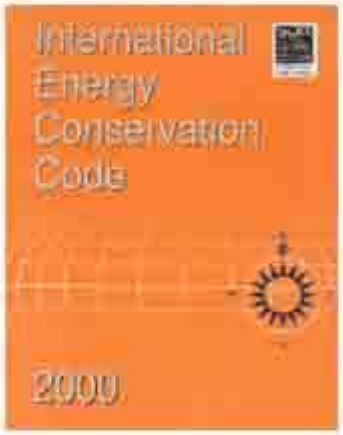
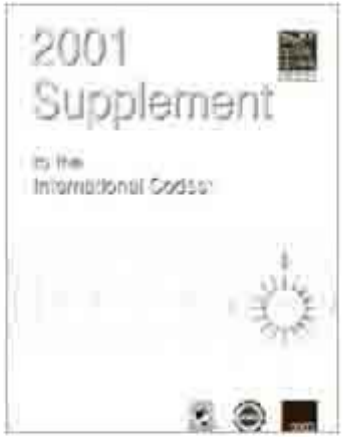
Building Energy Codes

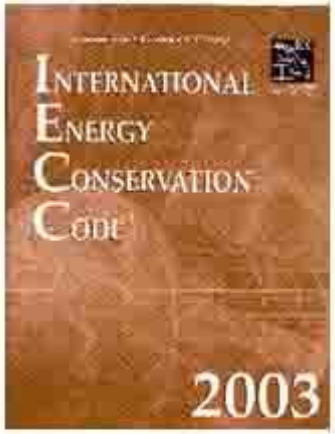
Residential Requirements of the 2006 International Energy Conservation Code

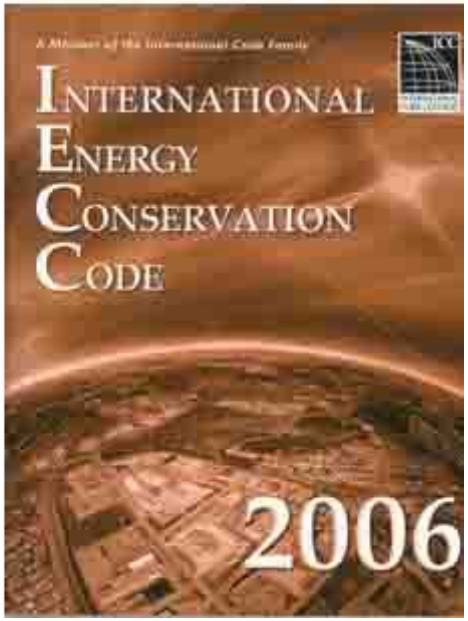
U.S. Department of Energy
Building Energy Codes Program

The Family of I-Codes







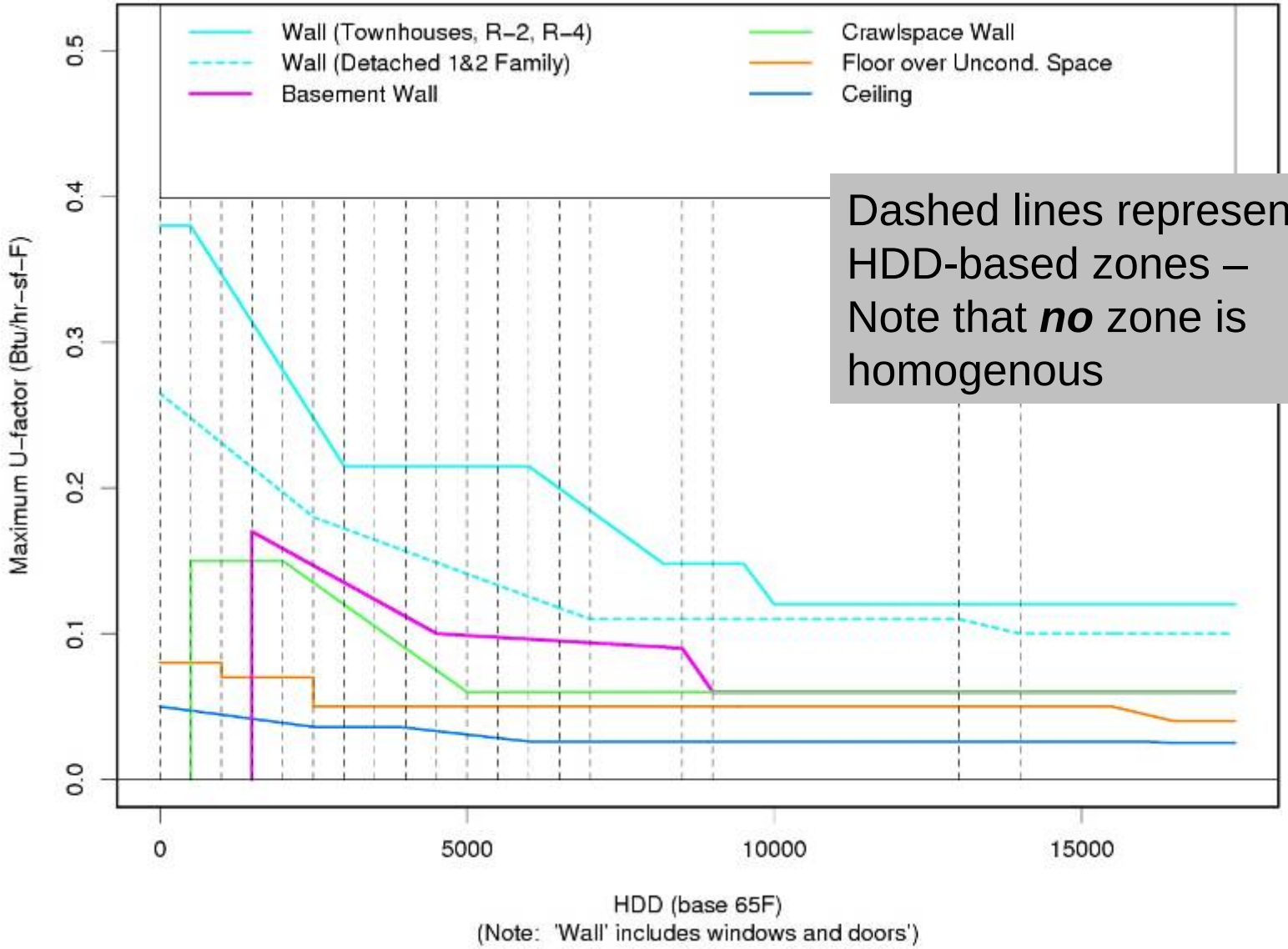


What's Changed Since IECC 2003?

- Stringency—differences are small and local
- Format—completely new
  - New climate basis
    - Strictly geographical (no more HDD)
    - Fewer zones (more homogeneity within jurisdictions)
    - Better climate coverage (zones based on more than HDD)
    - Residential/Commercial use the same zones

Climate "Zones"—2003 IECC

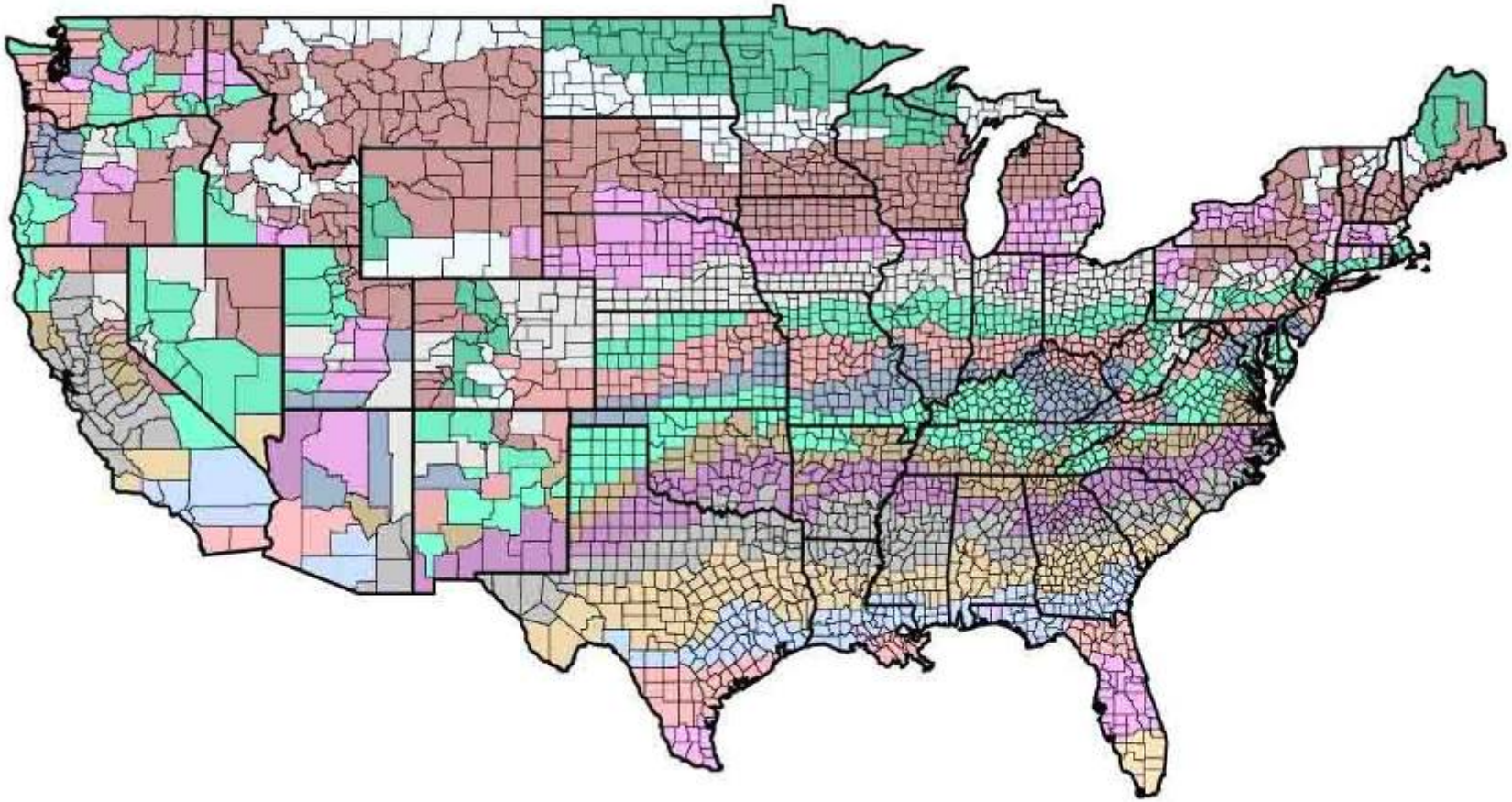
(Requirements varied continuously w/HDD)



Dashed lines represent HDD-based zones – Note that ***no*** zone is homogenous

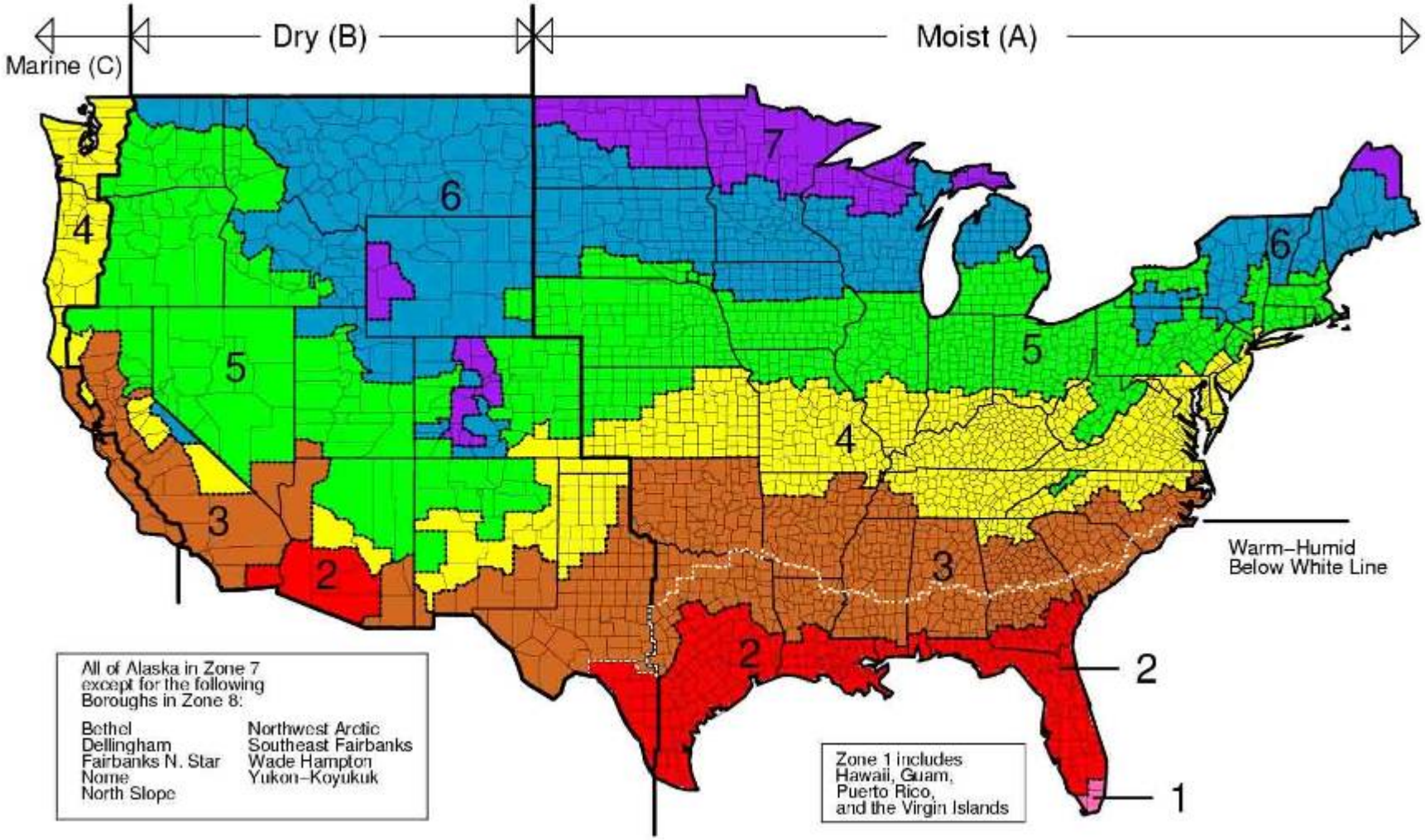
Climate Zones—2003 IECC

(Even aggregated to county level, geographical variations were large)



Note large number of “boundaries” between the 19 unique zones—every boundary is a potential battle

Climate Zones—2006 IECC



What's Changed Since IECC 2003? (cont'd.)

- Format—completely new
  - Key differences
    - Single-family and multifamily consolidated
    - Envelope requirements independent of window-wall ratio (except in performance path)
    - Performance path cleaner, more complete, closer to prescriptive
    - Additions much simpler
  - Small but notable differences
    - New "hard limits" (aka "trade-off limits") for glazing U-factor/SHGC
    - Duct R-value (8) cannot be traded off
    - Prescriptive requirements given in "purchasable" units (e.g., R-value, not U-factor)
    - Requirement to seal air handler

Relationship Between IRC and IECC

- IECC addresses only energy

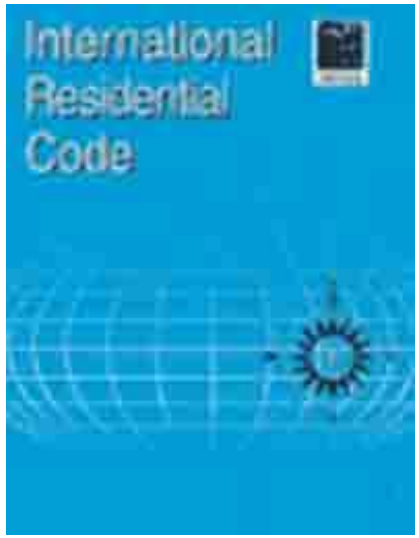
- IRC addresses all codes (structural, plumbing, etc.)
  - Allows builder to carry only one code book
  - Chapter 11 has energy

- IECC addresses both residential and commercial; IRC only residential, excludes most apartments

- IRC references IECC

- Energy requirements in IRC and IECC almost identical

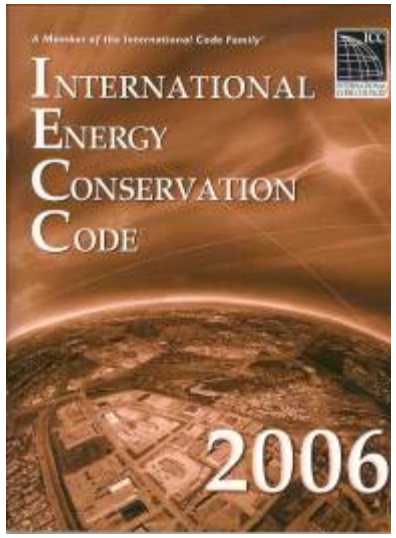
  Some minor differences:
  - IRC has different “hard limits” for fenestration U-factor
  - IRC has no SHGC “hard limit”



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 lighting or appliance requirements

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

Changes to Occupancy

- Applies if change increases energy use
- Alterations to existing spaces
- Applies to only portions of the systems being altered
- Alterations must meet the requirements applying to the altered component
- New systems in the alterations must comply

Additions, Alterations, Renovations, Repairs

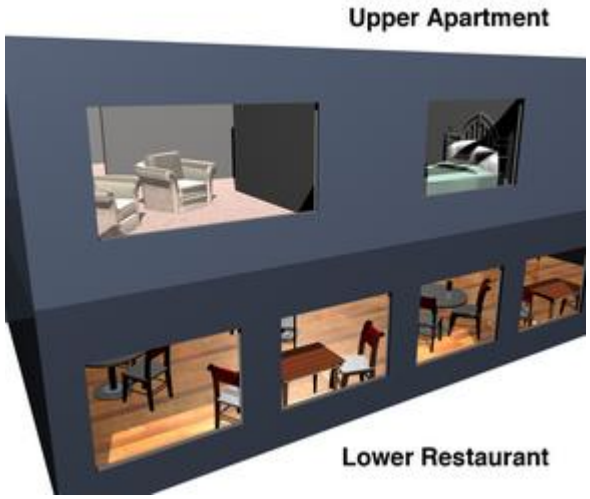
- Conform to code as new construction
- Exceptions
  - Storm windows installed over existing fenestration
  - Glass only replacements in an existing sash and frame
  - Existing ceiling, wall or floor cavities exposed during construction provided the cavities are filled with insulation
  - Construction where existing roof, wall or floor cavity is not exposed

Exceptions

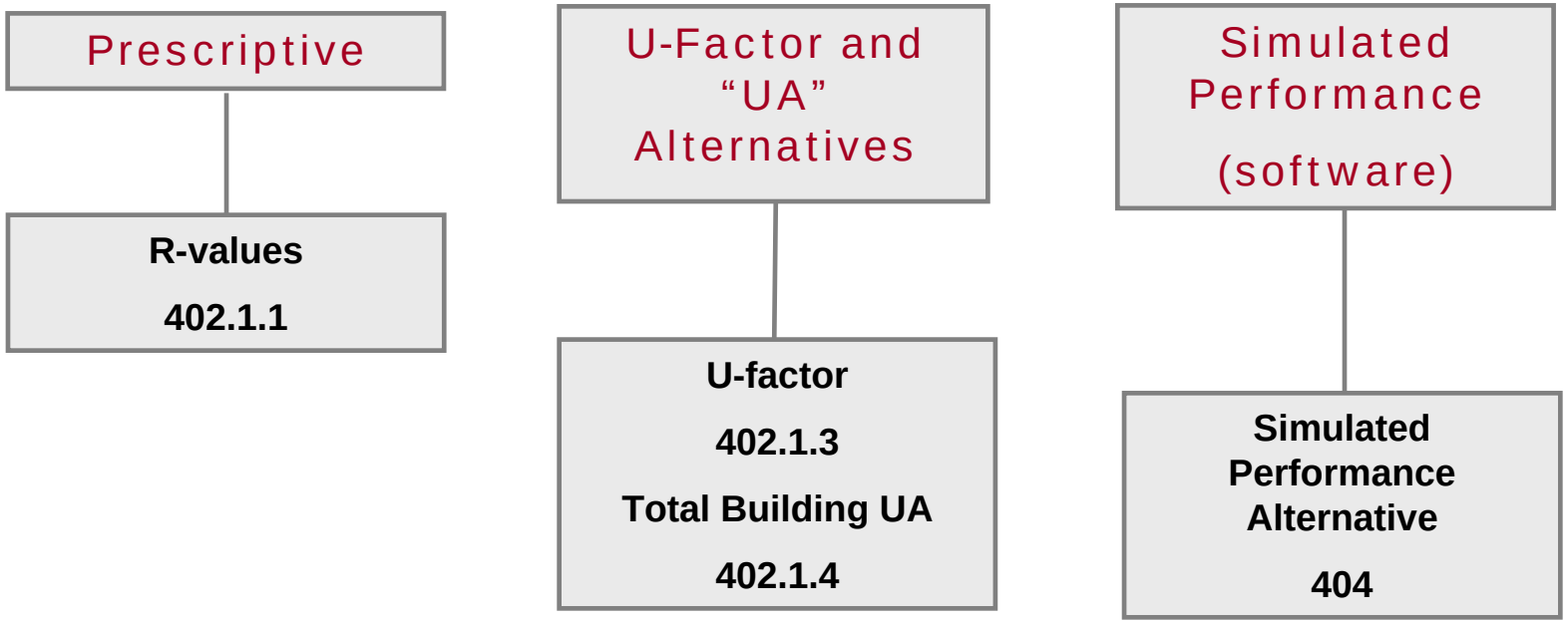
- Very low energy use buildings (<3.4 Btu/h-ft^2 or 1 watt/ft^2)
- Buildings (or portions of) that are neither heated nor cooled
- Buildings designated as historic (Section 101.4.2)

Mixed Use Buildings

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



IECC Code Compliance–Three Options



Code Compliance Tools

Prescriptive	Total Building "UA" Trade Off	Energy Analysis
None Needed	**RES*check* Software** **(Web-based & Desktop)**	**Software** ***For example:*** ***REM/Design*** ***REM/Rate*** ***EnergyGauge***

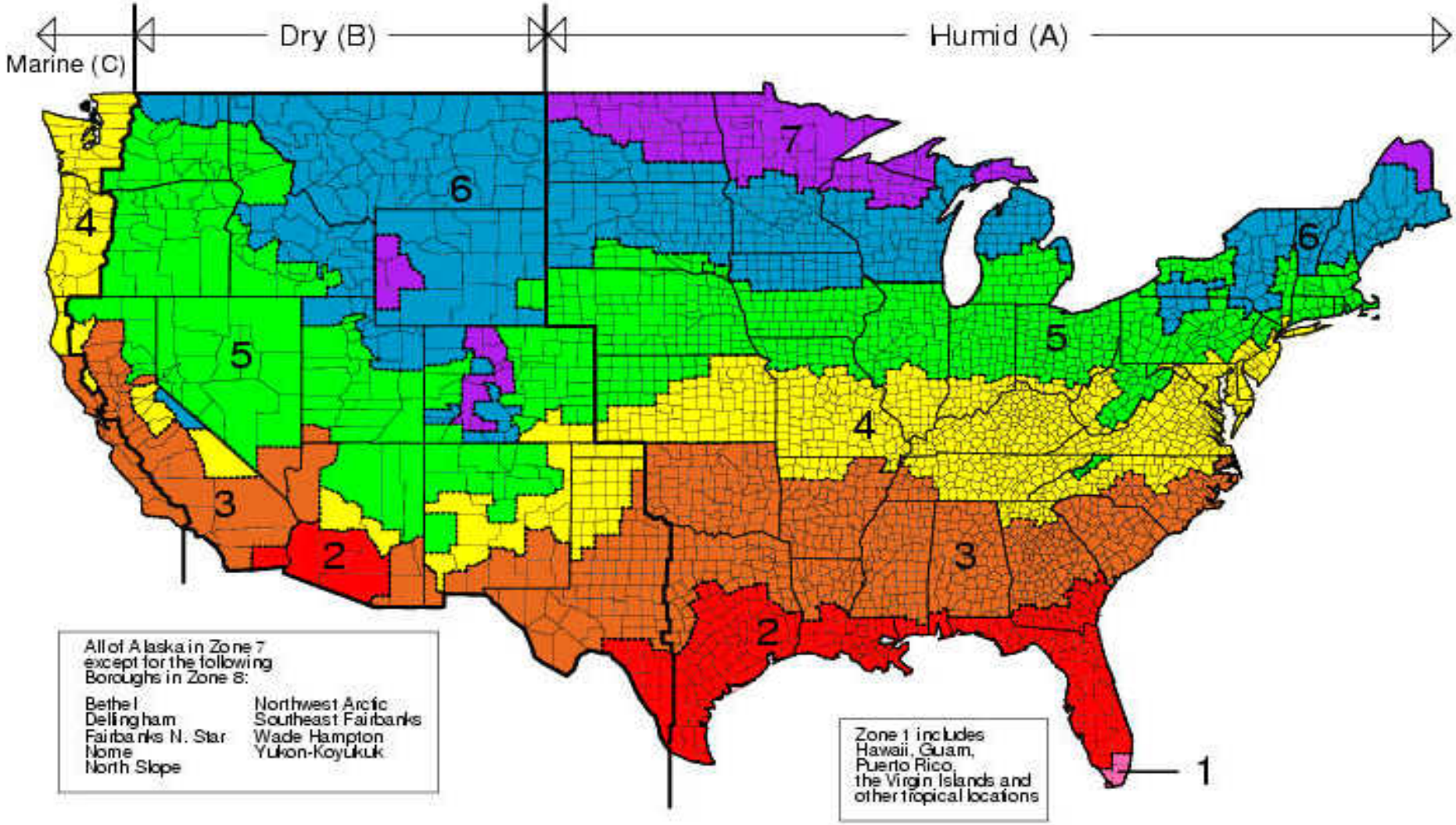
Climate Specific Requirements

Climate Specific Requirements:

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

Universal Requirements (apply everywhere):

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


Marine (C)
Dry (B)
Humid (A)
7
6
4
5
3
2
1
All of Alaska in Zone 7
except for the following
Boroughs in Zone 8:
Bethel
Dellingham
Fairbanks N. Star
Nome
North Slope
Northwest Arctic
Southeast Fairbanks
Wade Hampton
Yukon-Koyukuk
Zone 1 includes
Hawaii, Guam,
Puerto Rico,
the Virgin Islands and
other tropical locations

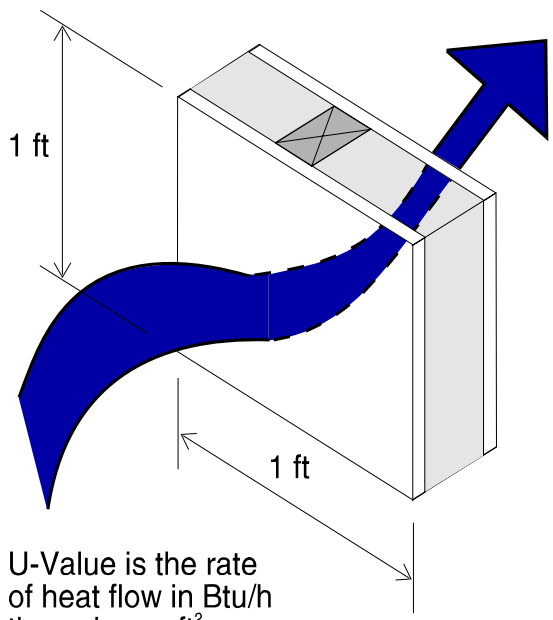
R-Values

- Thermal resistance to heat flow
- The larger the number the better
- The R-value of layers in an assembly can be added together

U-Factors

- The amount of heat in Btu (British thermal units) that flows each hour through one square foot, when there is a 1ºF temperature difference across the surface
- The smaller the number the better

$$U\text{-}Factor = \frac{1}{R\text{-}Value}$$



U-Value is the rate of heat flow in Btu/h through one ft^2 area when one side is 1° F warmer

Insulation and Fenestration Requirements by Climate Zone

Table 402.1.1
Insulation and Fenestration Requirements by Component

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 & DEPTH	CRAWL SPACE WALL R-VALUE
1	1.20	0.75	0.40	30	13	3	13	0	0	0
2	0.75	0.75	0.40	30	13	4	13	0	0	0
3	0.65	0.65	0.40	30	13	5	19	0	0	5 / 13
4 except Marine	0.40	0.60	NR	38	13	5	19	10 / 13	10, 2ft	10 / 13
5 and Marine 4	0.35	0.60	NR	38	19 or 13+5	13	30	10 / 13	10, 2 ft	10 / 13
6	0.35	0.60	NR	49	19 or 13+5	15	30	10 / 13	10, 4 ft	10 / 13
7 and 8	0.35	0.60	NR	49	21	19	30	10 / 13	10, 4 ft	10 / 13

U-Factor and Total UA (RES*check* 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 RES*check* software

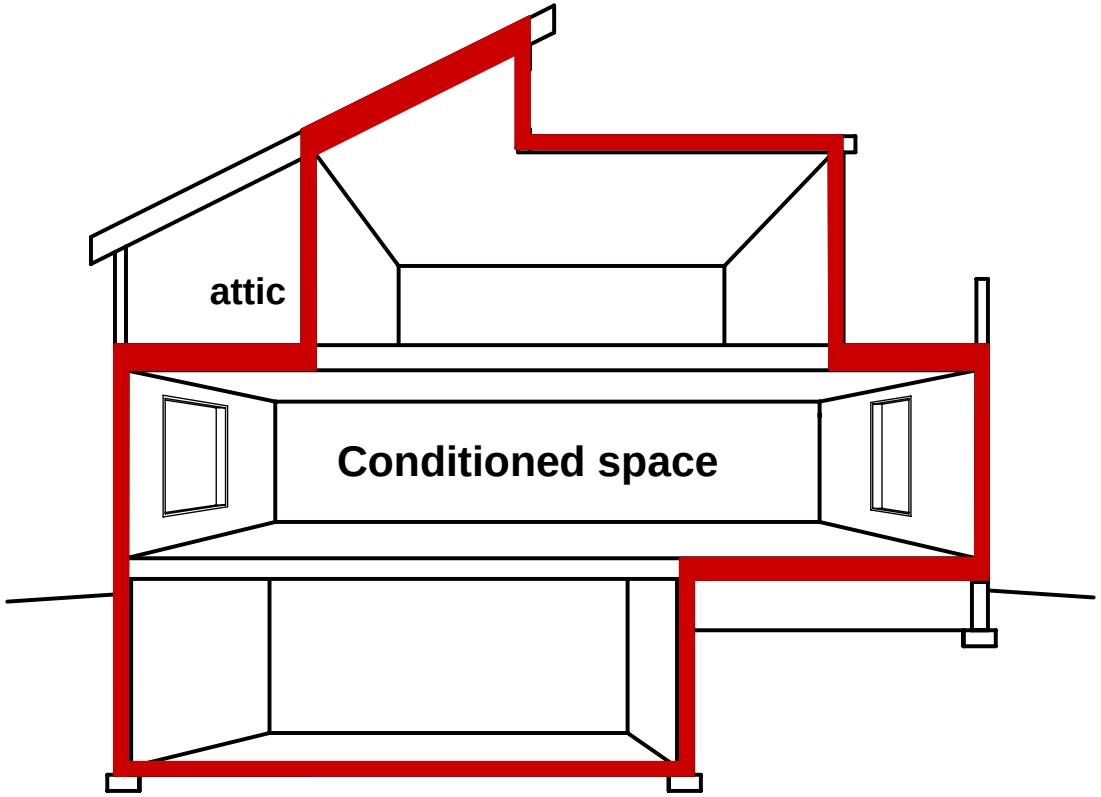
U-Factor Requirements by Climate Zone

Table 402.1.3
Equivalent U-Factors

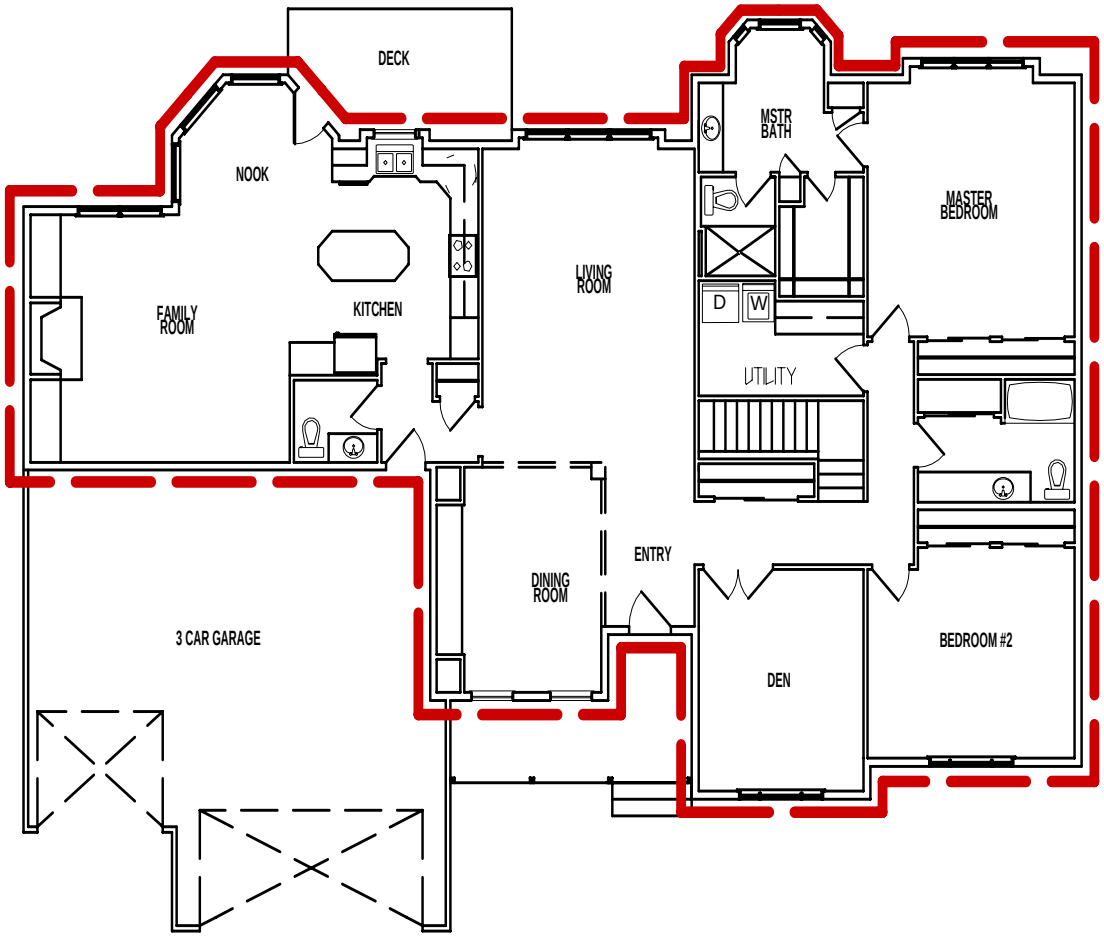
CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	1.20	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.75	0.75	0.035	0.082	0.165	0.064	0.360	0.477
3	0.65	0.65	0.035	0.082	0.141	0.047	0.360	0.136
4 except Marine	0.40	0.60	0.030	0.082	0.141	0.047	0.059	0.065
5 and Marine 4	0.35	0.60	0.030	0.060	0.082	0.033	0.059	0.065
6	0.35	0.60	0.026	0.060	0.06	0.033	0.059	0.065
7 and 8	0.35	0.60	0.026	0.057	0.057	0.033	0.059	0.065

Building Envelope Specific Requirements

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



Building Envelope



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 (more on that later)
- NFRC rated and certified

  Exceptions:
  - Unrated single-paned products comply in Zone 1
  - Unrated double-pane with thermal break comply in Zones 2 and 3
- 15 sq. ft. of glazing (and one opaque door) may be exempted (prescriptive path only)
  - For example, decorative glass on/near front door
- Fenestration replacement must meet the 0.40 SHGC requirement in Climate Zones 1-3 and the U-factor requirements in all zones

Fenestration Defaults, Tables 102.1.3 (1-3)

Glazed Fenestration U-factor

Frame Type	Single Pane	Double Pane	Skylight Single	Skylight Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

Door U-factors

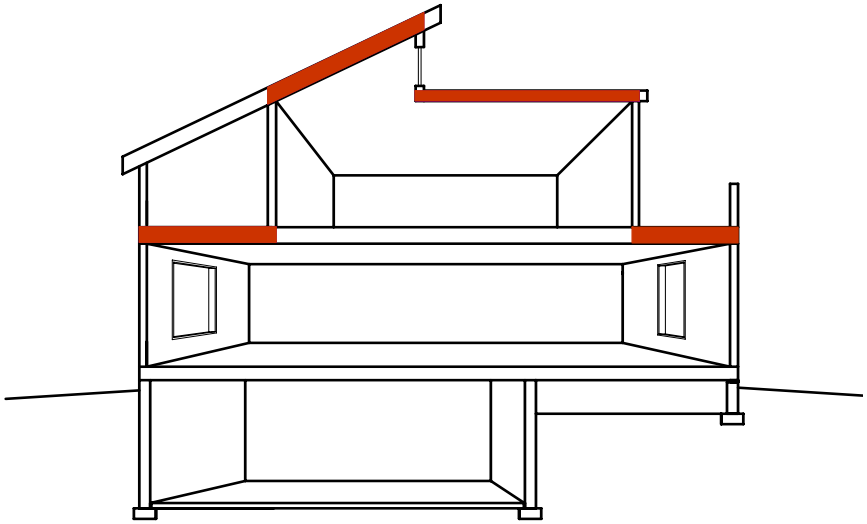
Door Type	U-factor
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

Glazed Fenestration SHGC

Single Glazed		Double Glazed		Glazed Block
Clear	Tinted	Clear	Tinted	
0.8	0.7	0.7	0.6	0.6

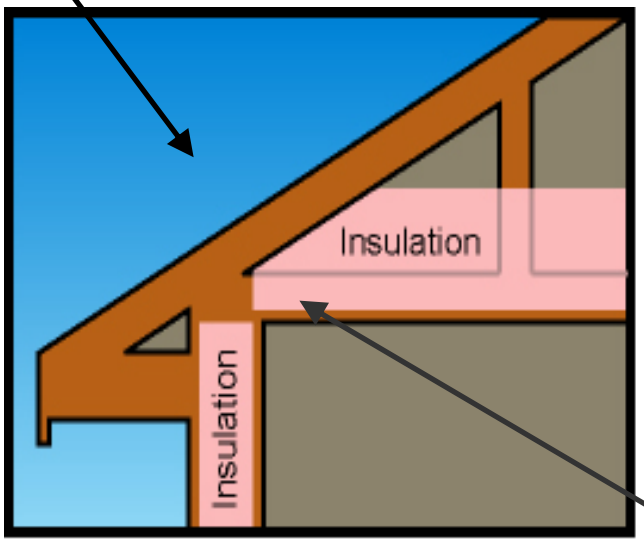
Ceilings

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



Standard Roof Truss

Possibility of ice dam formations

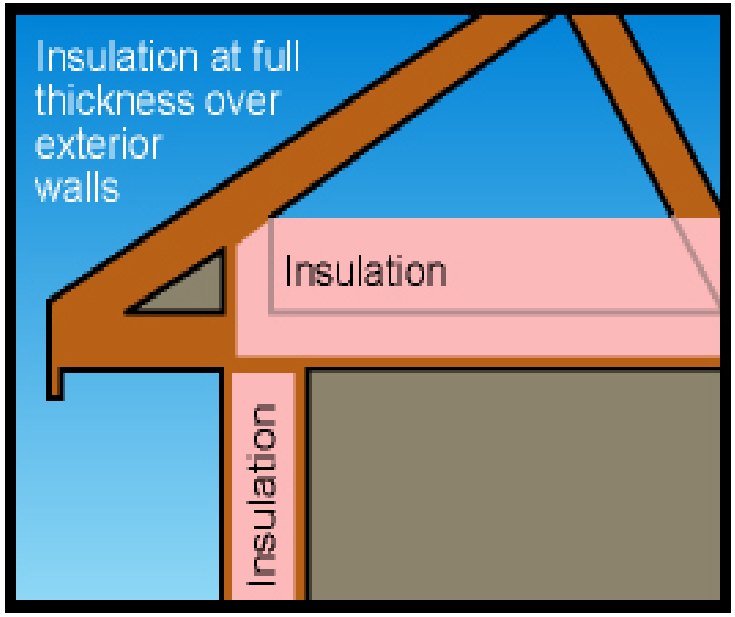


Cold corners contribute to condensation and mold growth

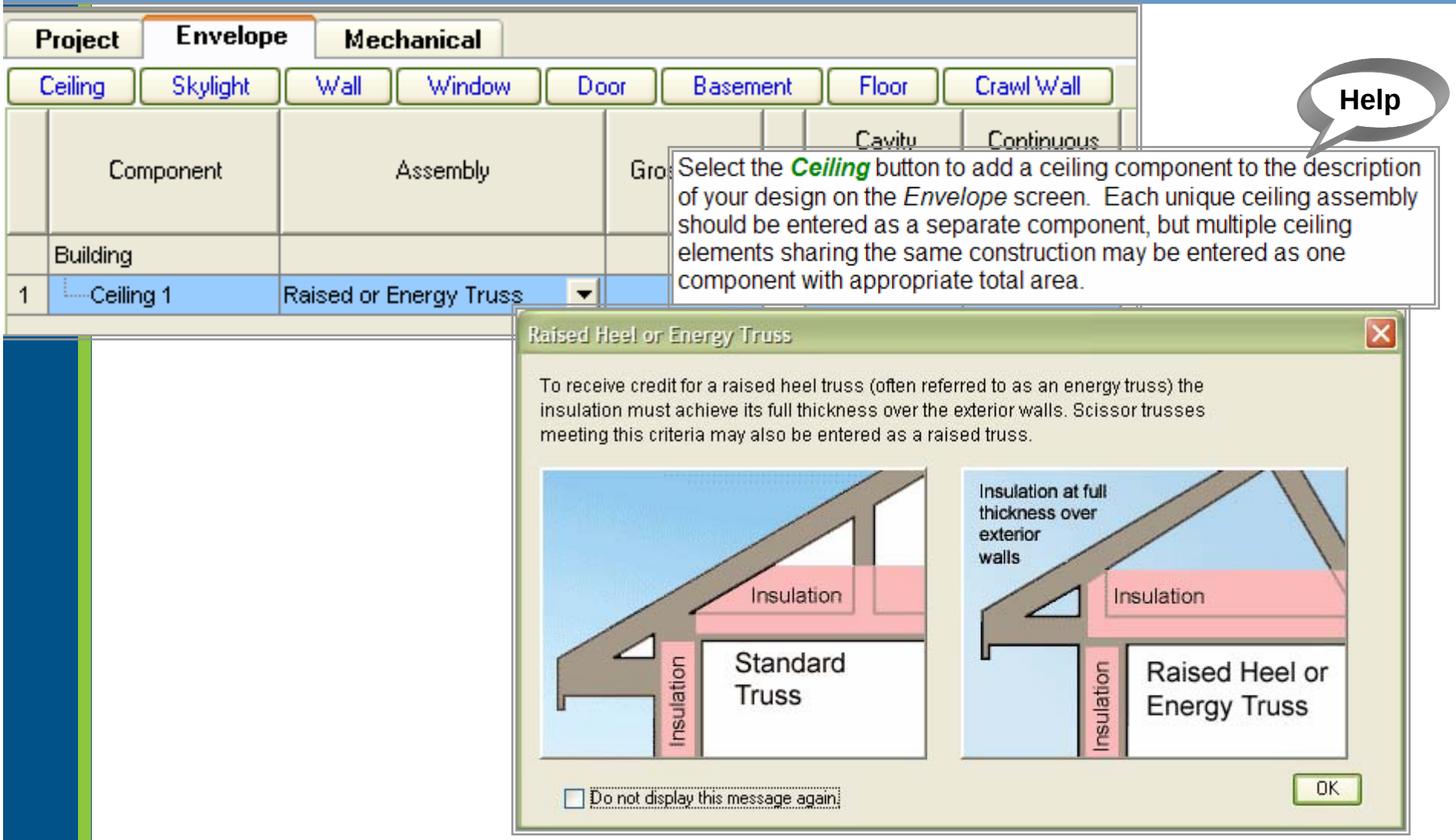
- Ceiling insulation code requirements assume standard truss systems

Raised Heel Truss

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

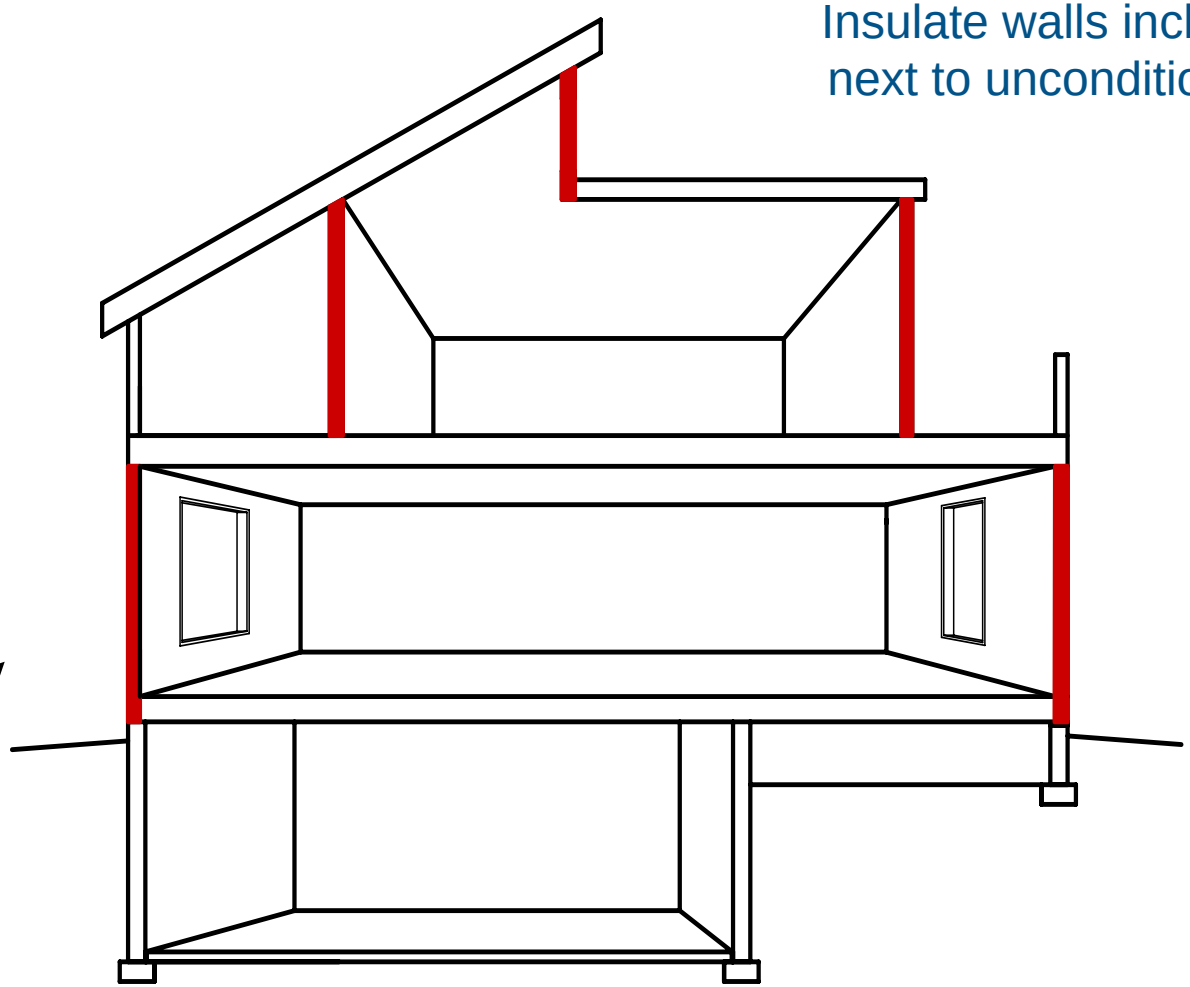


Roofs in RES*check*



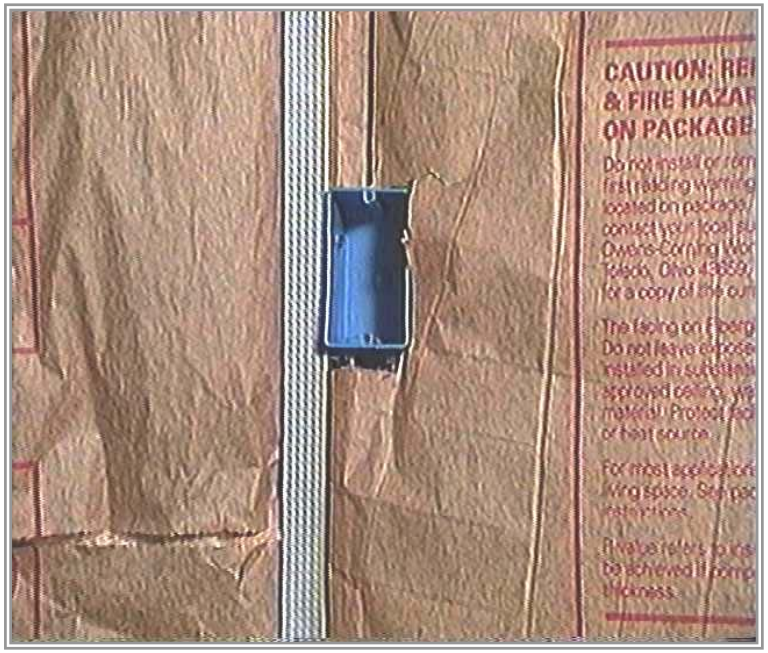
Above Grade Walls

Insulate walls including those next to unconditioned spaces

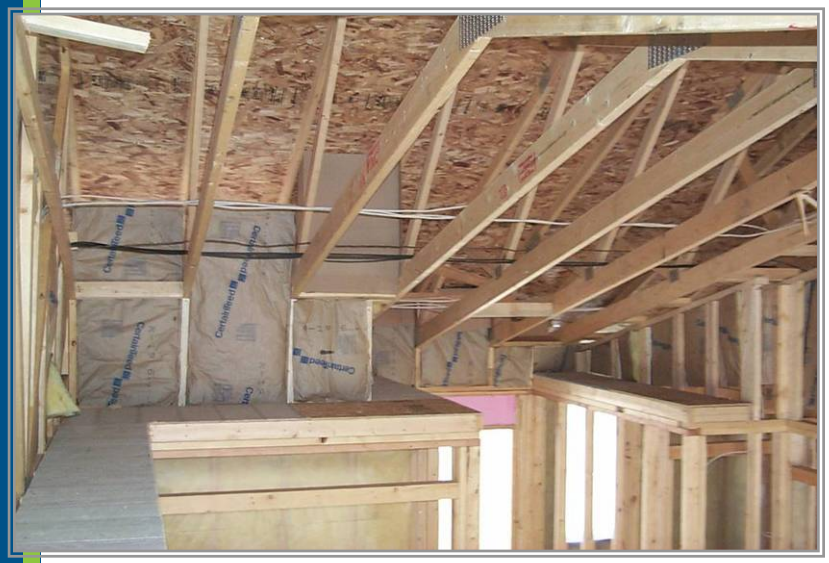


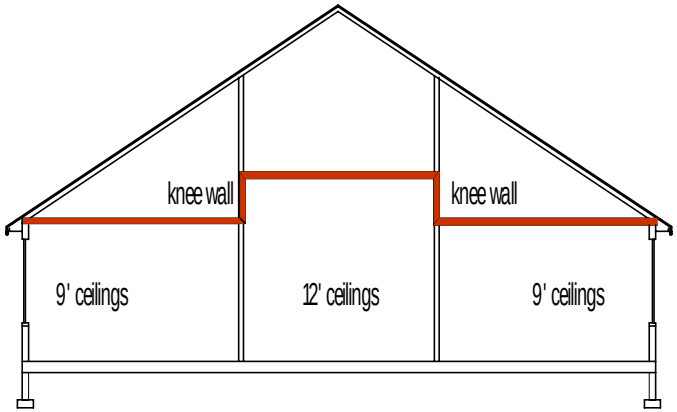
Don't forget to insulate rim joists

Wall Insulation



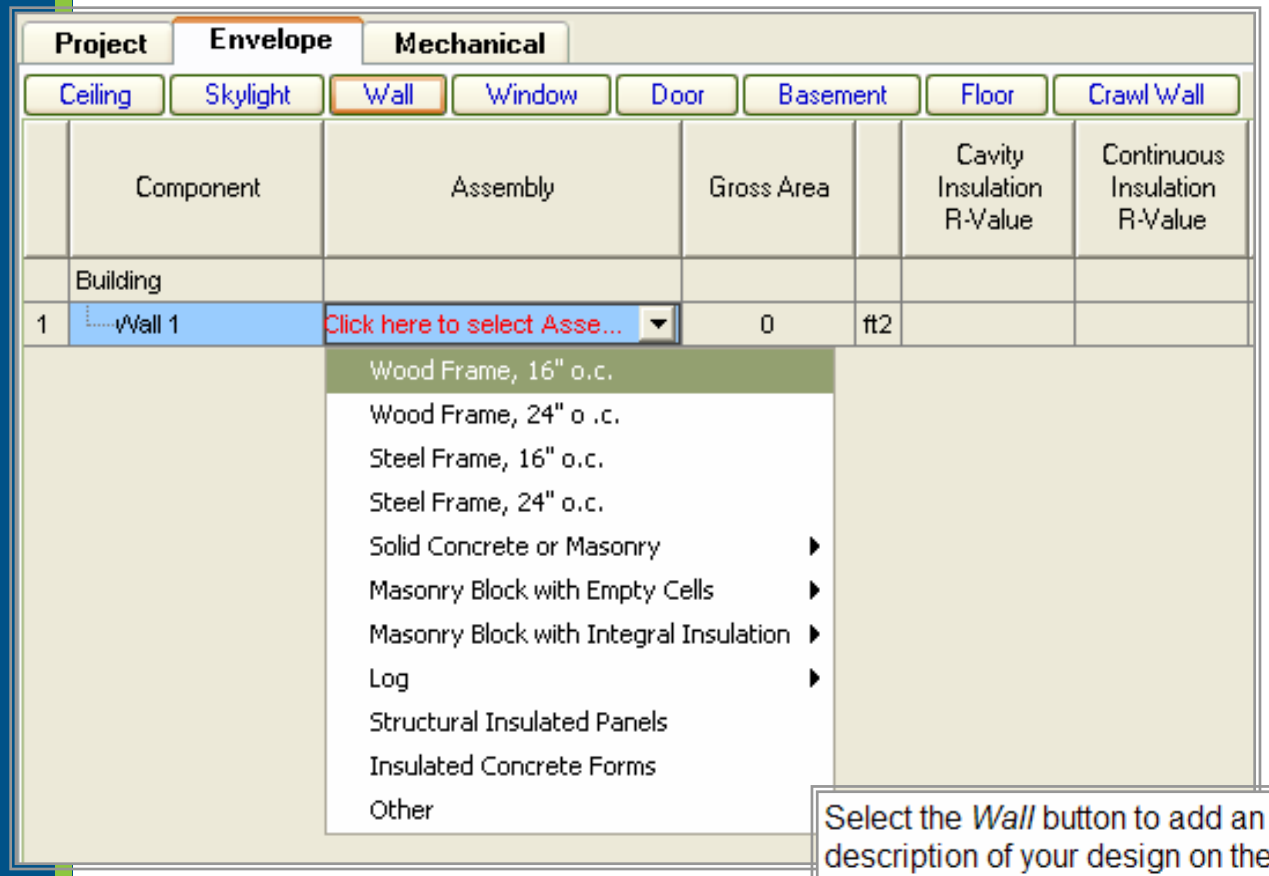
Knee Wall Insulation





No, No… Never cut the batts too short

Above-Grade Walls in RES*check*



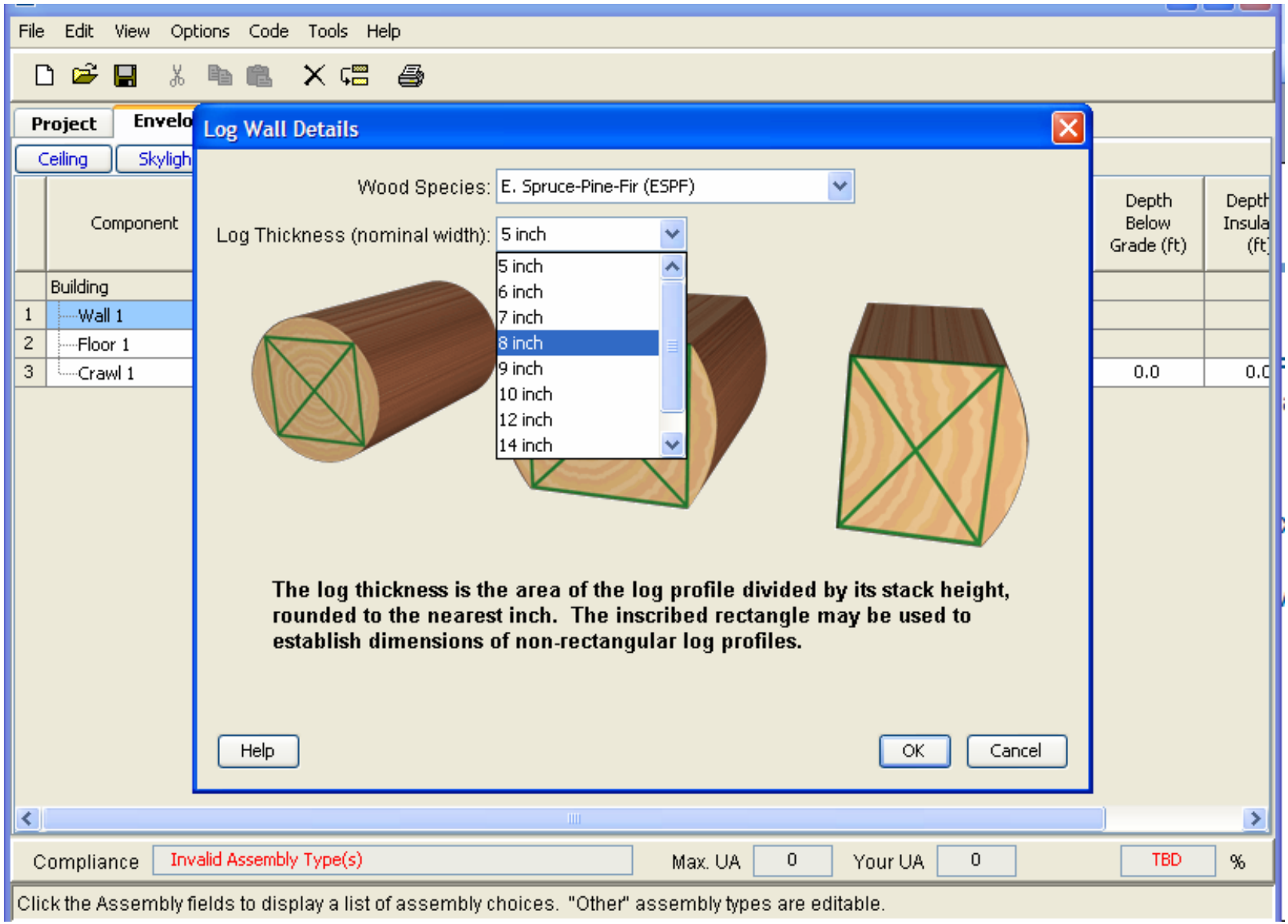
Help

Select the *Wall* button to add an above-grade wall component to the description of your design on the *Envelope* screen. Each unique above-grade wall assembly should be entered as a separate component, but multiple wall elements sharing the same construction may be entered as one component with appropriate total area.

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
  - If insulation placement cannot be met, provisions for wood frame wall insulation requirements apply (with specific U-factor and R-value exceptions in zones 1-3)

Log Walls


File Edit View Options Code Tools Help
Project
Envelo
Ceiling
Skyligh
Component
Building
1 Wall 1
2 Floor 1
3 Crawl 1
Depth Below Grade (ft)
Depth Insula (ft)
0.0
Log Wall Details
Wood Species: E. Spruce-Pine-Fir (ESPF)
Log Thickness (nominal width): 5 inch
5 inch
6 inch
7 inch
8 inch
9 inch
10 inch
12 inch
14 inch
The log thickness is the area of the log profile divided by its stack height, rounded to the nearest inch. The inscribed rectangle may be used to establish dimensions of non-rectangular log profiles.
Help
OK
Cancel
Compliance
Invalid Assembly Type(s)
Max. UA
0
Your UA
0
TBD
%
Click the Assembly fields to display a list of assembly choices. "Other" assembly types are editable.

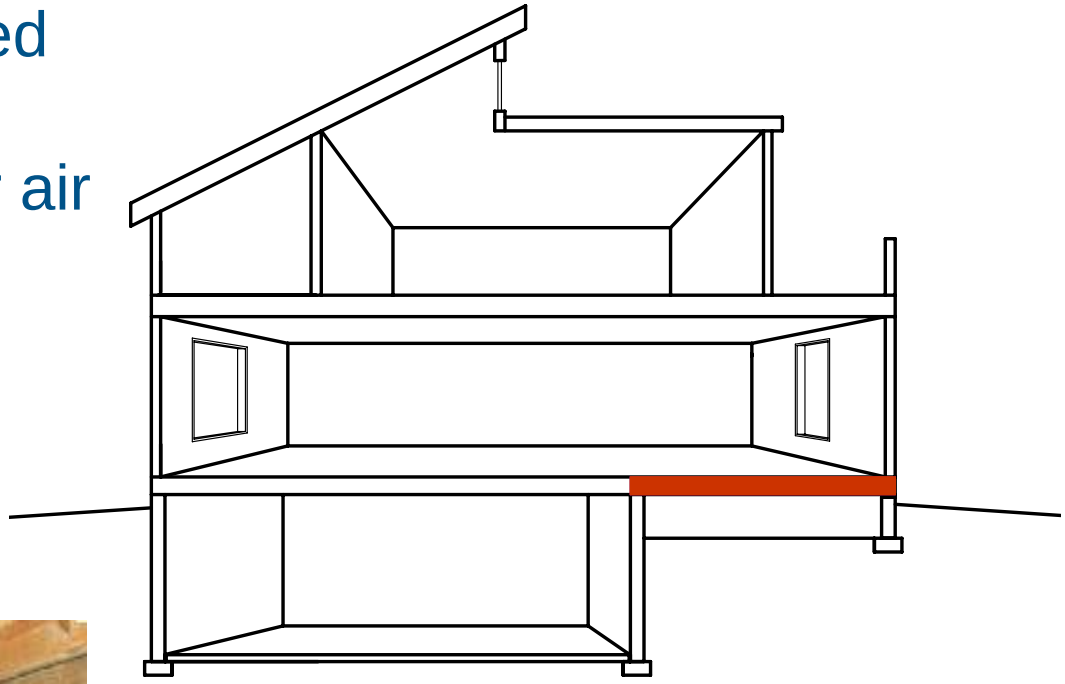
Steel-frame

- Ceilings, walls, and floors

Wood Frame R-value	Cold-Formed Steel Equivalent R-value
Steel Truss Ceilings	
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	
R-30	R-38 in 2x4, 2x6, or 2x8 R-49 any framing
R-38	R-49 2x4, 2x6, 2x8, or 2x10
Steel Framed Wall	
R-13	R-13 +5 or R-15 +4, or R-21 +3
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, 2x6 R-19 +12 in 2x8 or 2x10

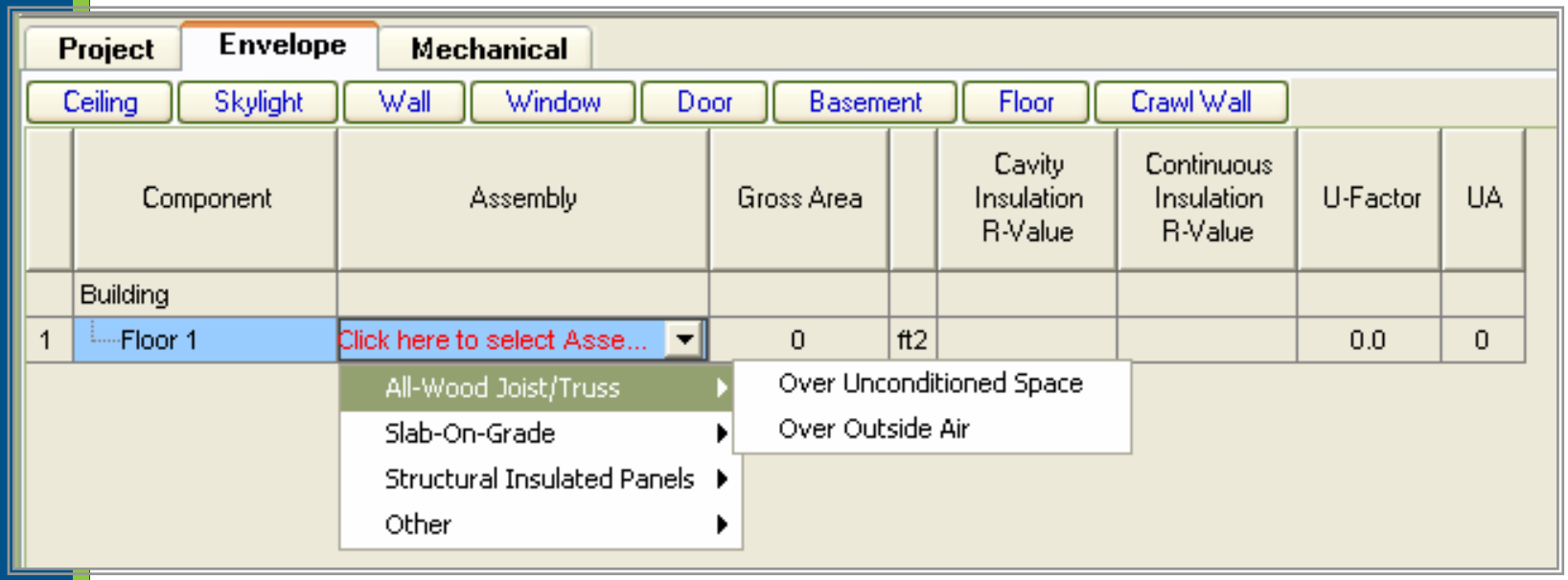
Floors over Unconditioned Space

- Space can be unheated basement or a crawlspace or outdoor air
- Zones 1-2: R-13
- Zones 3-4ab: R-19
- Zones 4c-8: R-30



- Insulation must maintain permanent contact with underside of subfloor

Floors in RES*check*

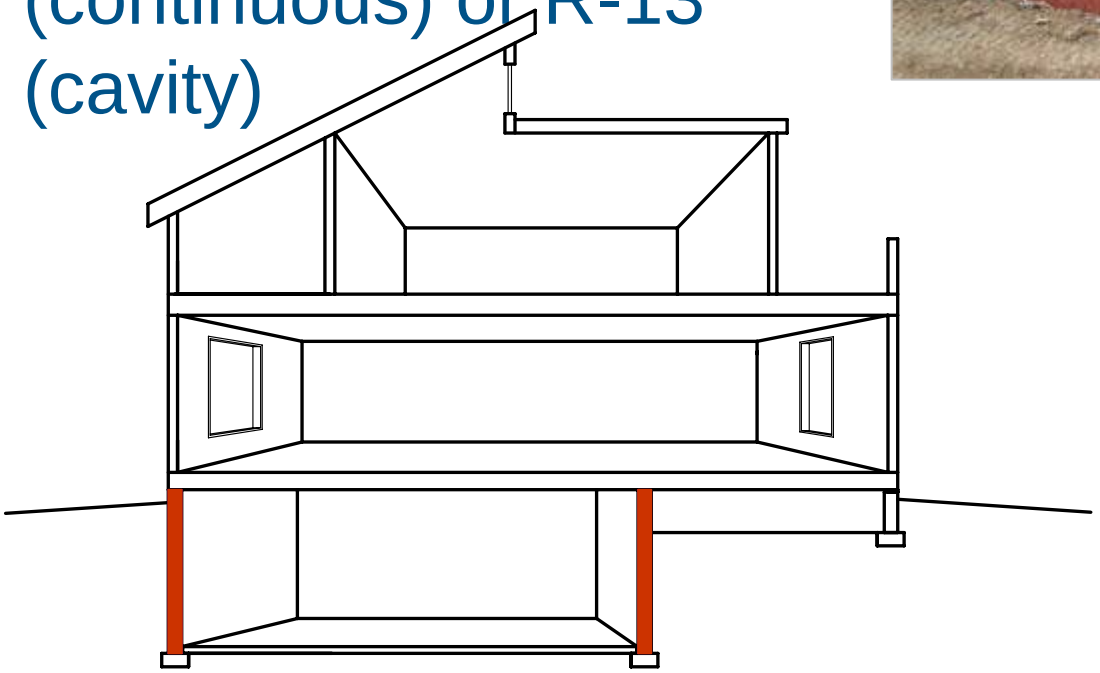


Help

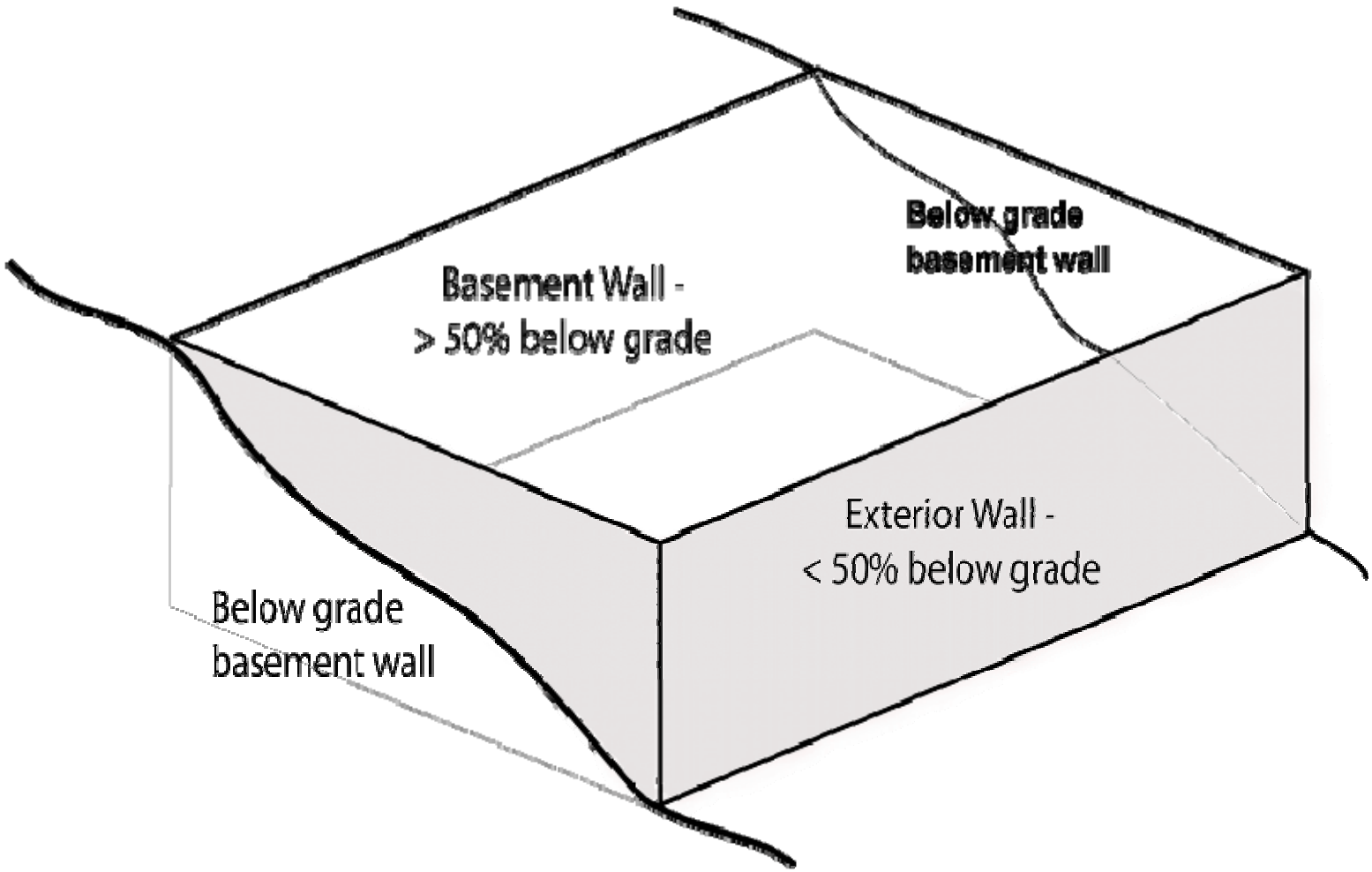
- Floor Location - For some floor types you must also indicate whether the floor is located over an unconditioned space or over outside air. Floors over unconditioned space include all floors over unconditioned (neither heated nor **cooled**) basements, crawl spaces, and garages. Floors over outside air include floor cantilevers, floors of an elevated home, and floors over overhangs (such as the floor directly above a recessed entryway or open carport). Floors over heated spaces are not part of the building envelope and should not be included.

Below-Grade Walls

- Greater than or equal to 50% below grade
- Zones 1-3: R-0
- Zones 4-8: R-10 (continuous) or R-13 (cavity)



Defining Below-Grade Walls

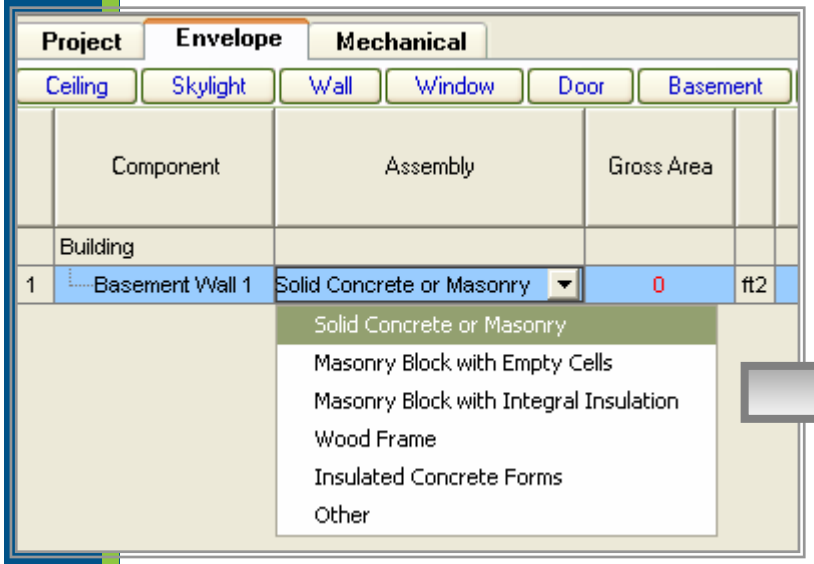


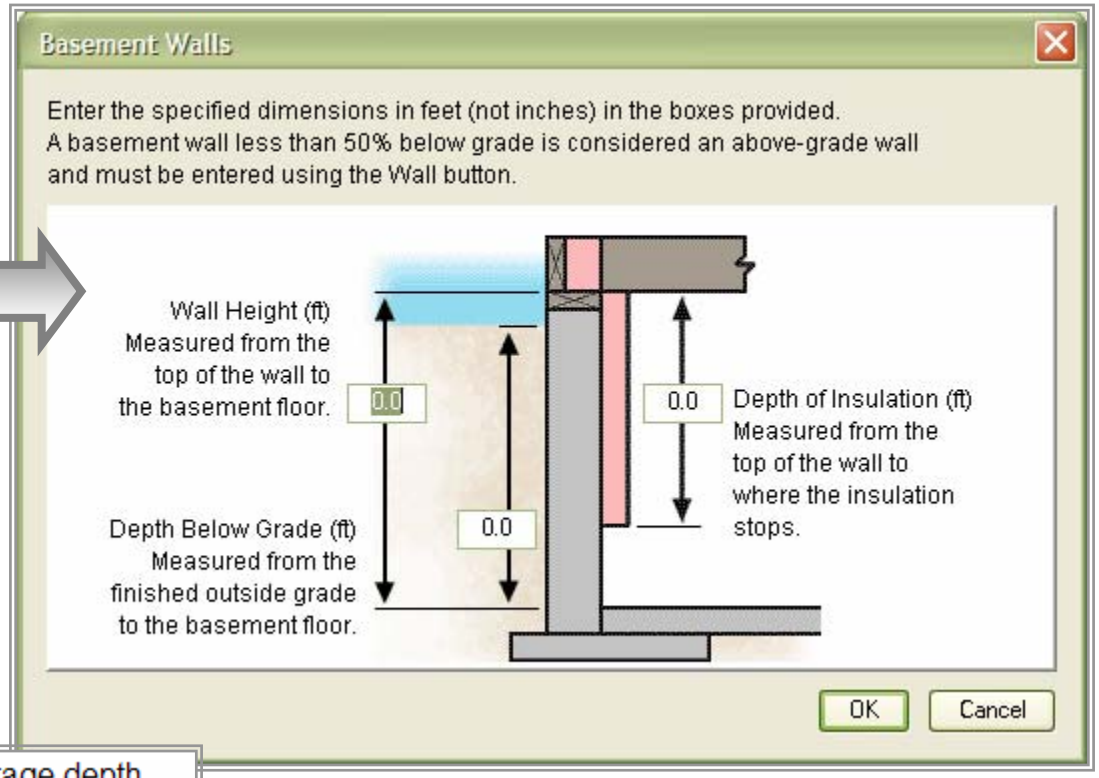
Ways to Insulate Basement Walls

Interior Studs w/batts

Exterior Rigid Foam

Below-Grade Walls in RES*check*



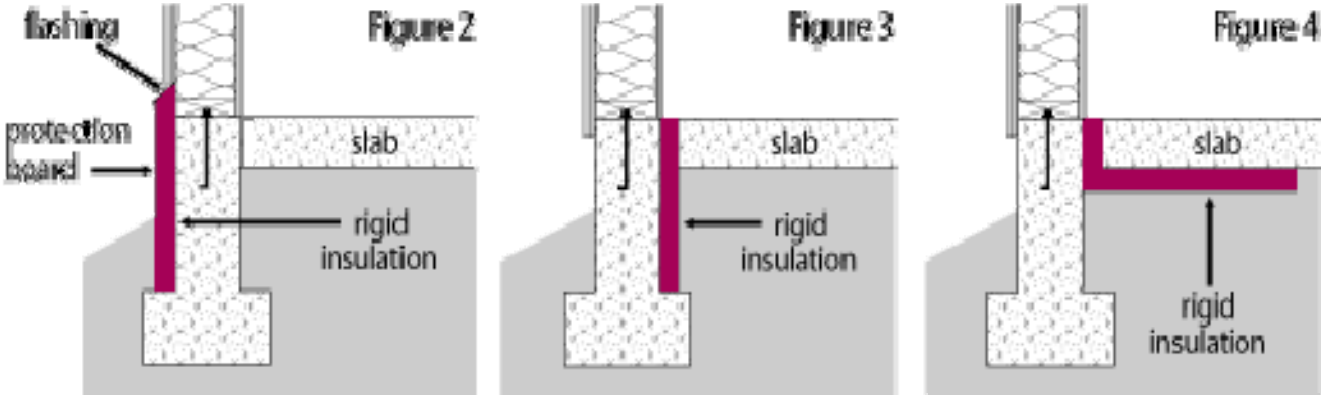


Help

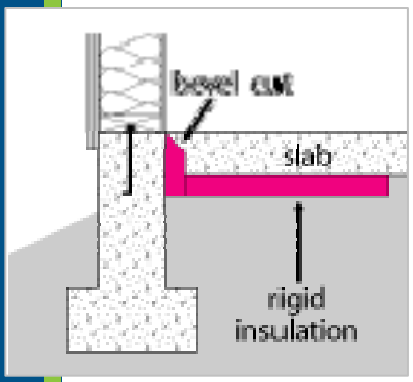
Any individual wall of a conditioned basement with an average depth 50% or more below grade should be entered using the *Basement* button. Walls of conditioned basements with an average depth LESS than 50% below grade should be entered as an above-grade wall using the *Wall* button.

Slab Edge Insulation

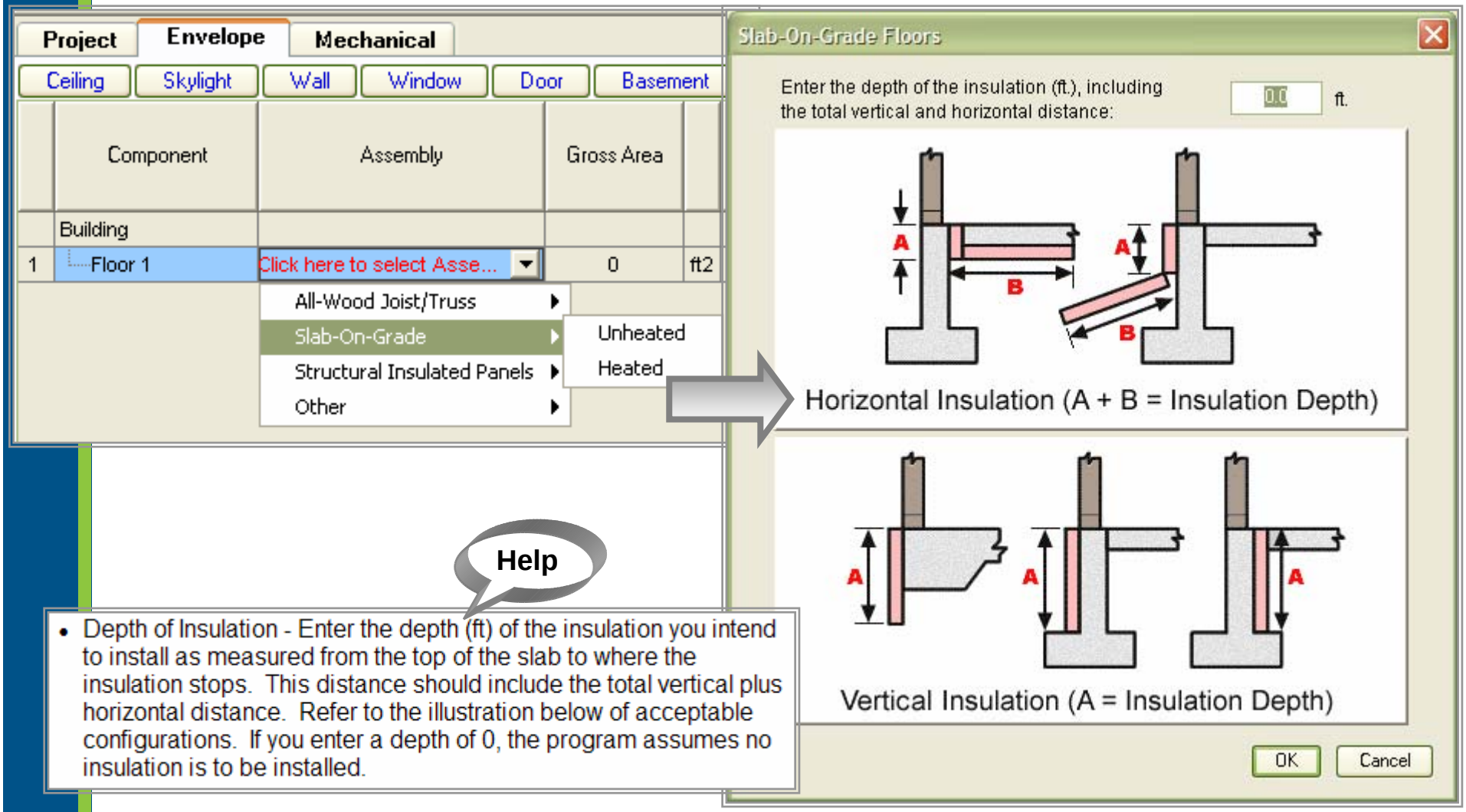
- R-10 (typically 2 inches) insulation in Zones 4 and above
- Downward from top of slab a minimum of 24” (Zones 4 and 5) or 48” (Zones 6, 7, and 8)
- Insulation can be vertical or extend horizontally under the slab or out from the building (must be under 10 inches of soil)



Slab Edge Insulation



Slabs in RES*check*

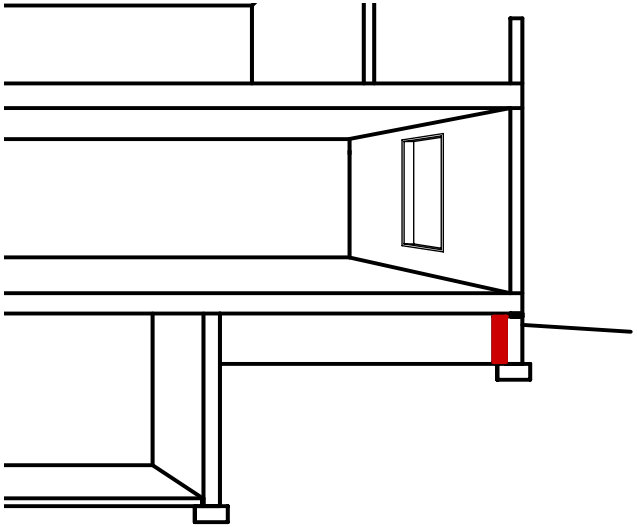


Help

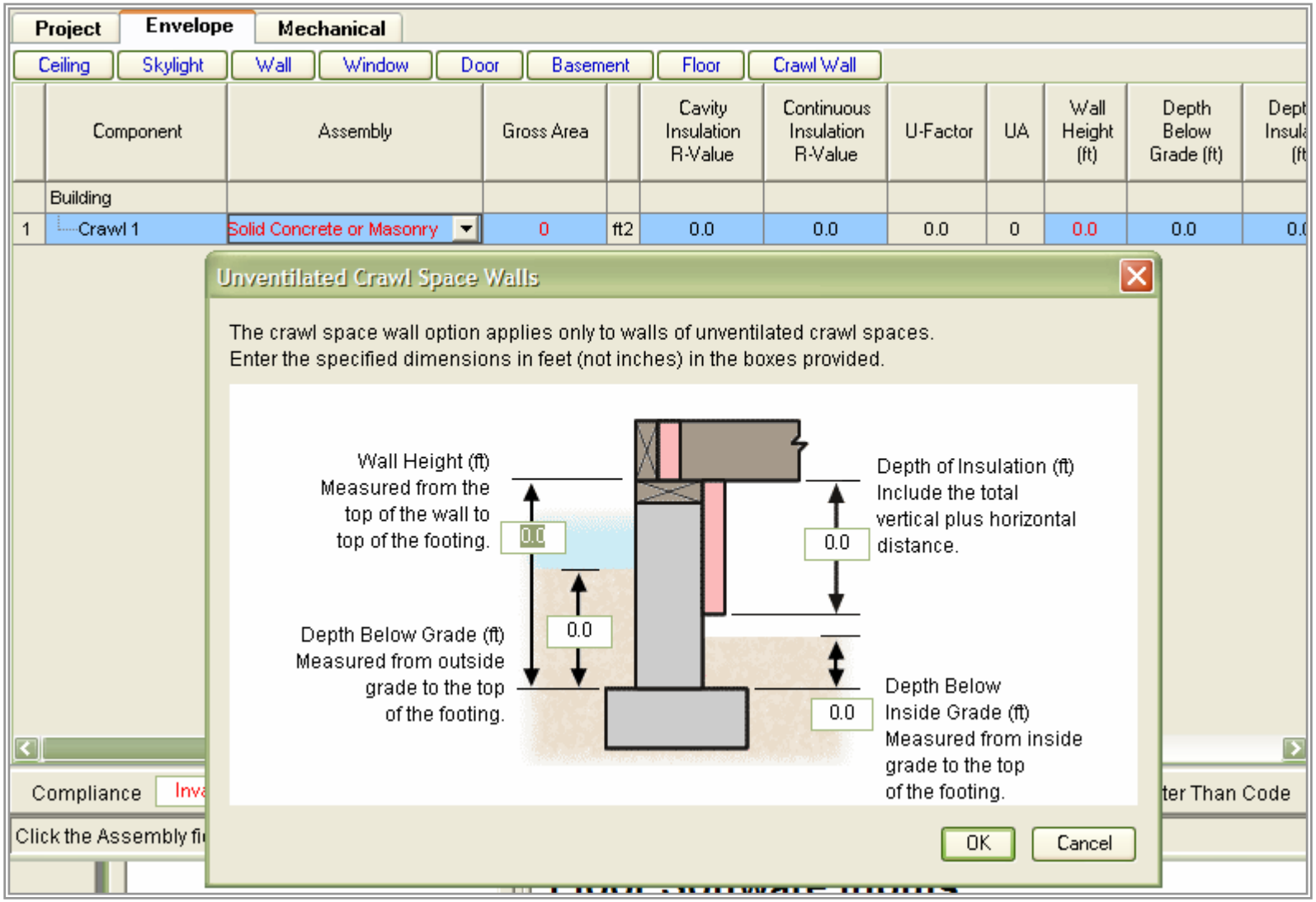
- Depth of Insulation - Enter the depth (ft) of the insulation you intend to install as measured from the top of the slab to where the insulation stops. This distance should include the total vertical plus horizontal distance. Refer to the illustration below of acceptable configurations. If you enter a depth of 0, the program assumes no insulation is to be installed.

Crawlspace Wall Insulation

When crawlspace walls are insulated, the space should be mechanically vented or conditioned. See Section R408 of the IRC.



Crawlspace Walls in RES*check*



Vented & Unvented Crawlspaces

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:

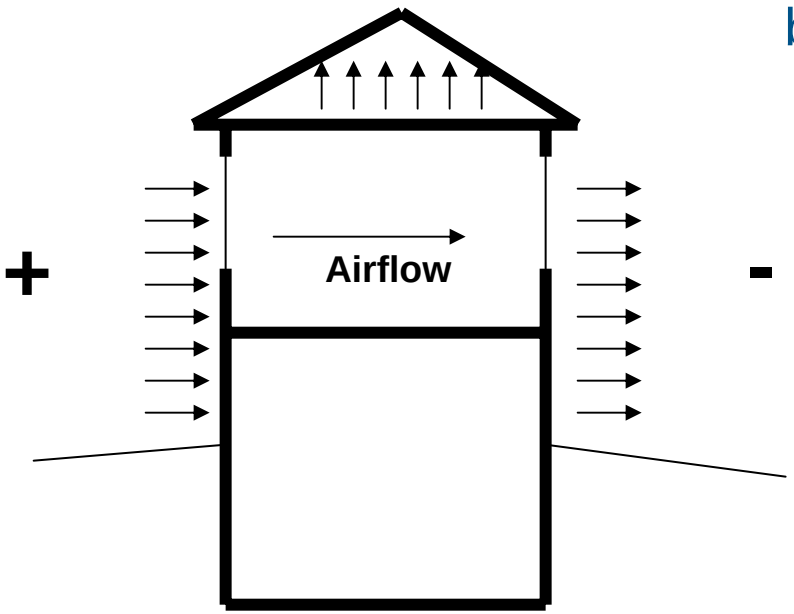
- The crawlspace ground surface must be covered with an approved vapor retarder *(e.g., plastic sheeting).*
- Crawlspace walls must be insulated to the R-value requirements specific for crawlspace walls *(IECC Table 402.1).*
- Crawlspace wall insulation must extend from the top of the wall to the inside finished grade and then 24” vertically or horizontally.
- Crawlspaces must be mechanically vented *(1 cfm exhaust per 50 square feet)* or conditioned *(heated and cooled as part of the building envelope).*

Bottom Plate

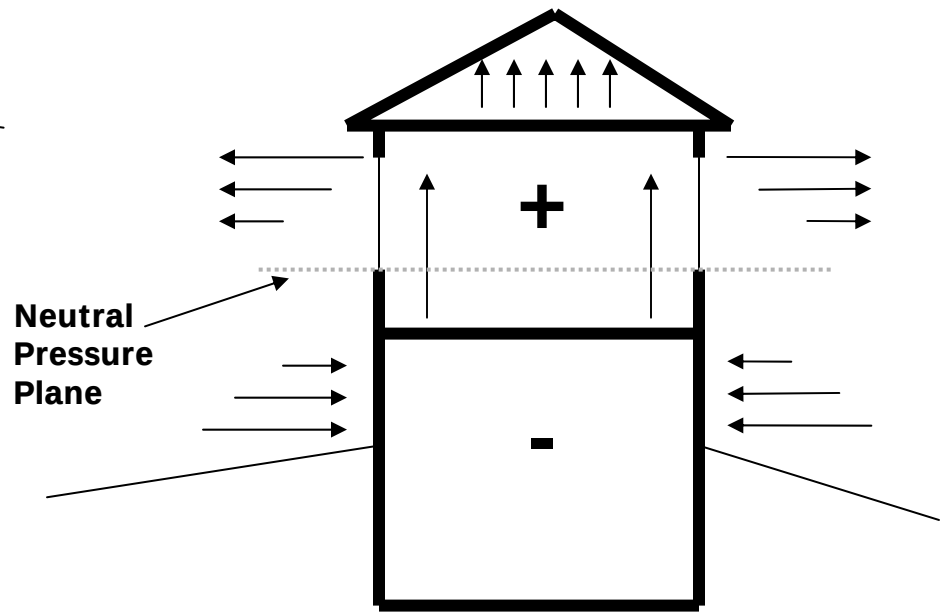
Dryer Vent

What is Infiltration?

- Unwanted air movement through a building
  - Caused by a pressure difference (air moves from high pressure to a lower pressure)



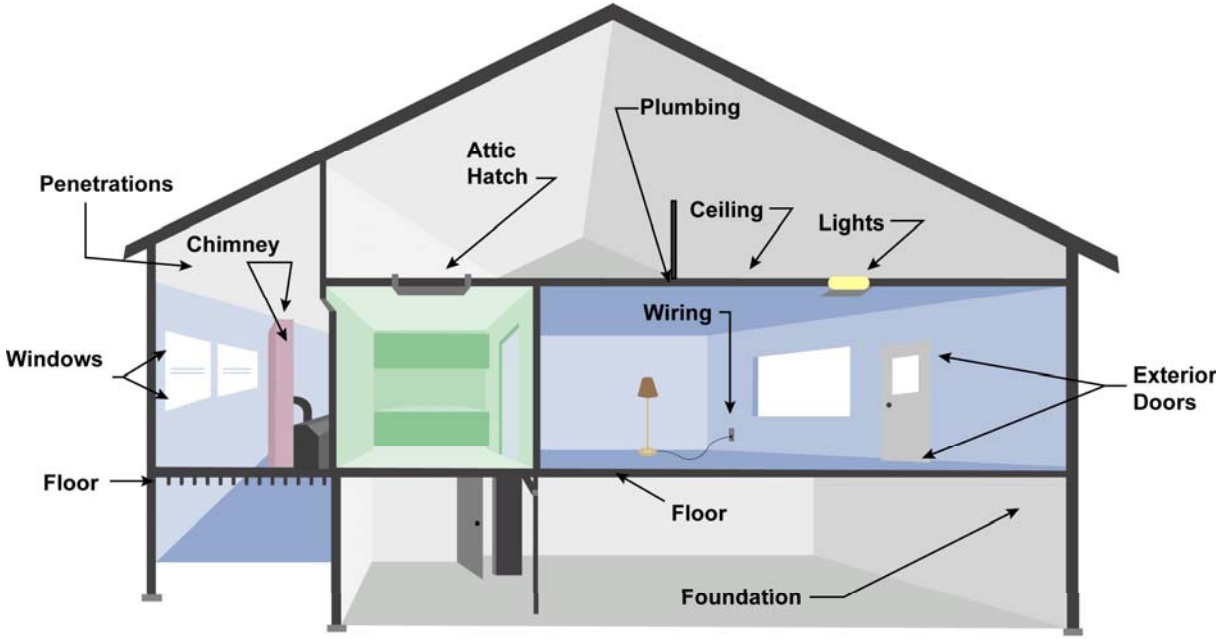
Wind



Stack

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



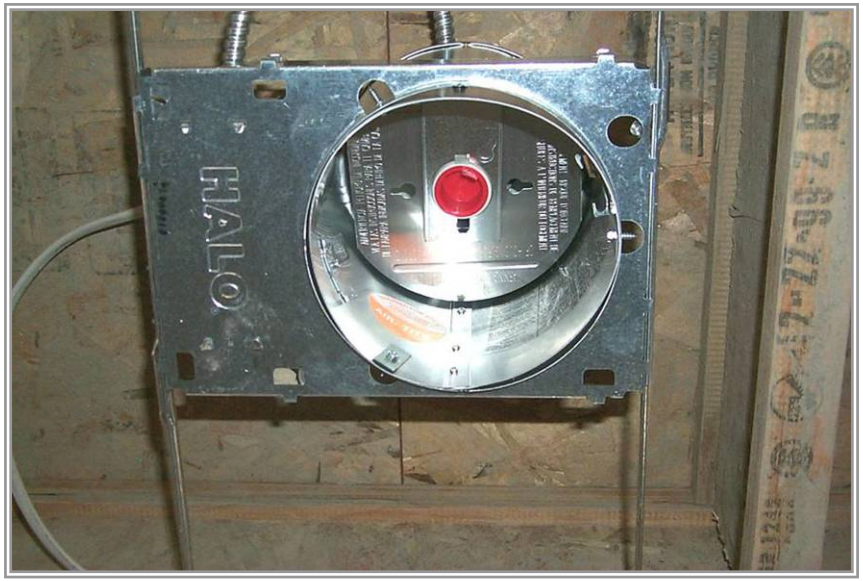
Infiltration Points
Typical Sources of Air Leakage in the Home

Recessed Lighting Fixtures

Mandatory Requirements

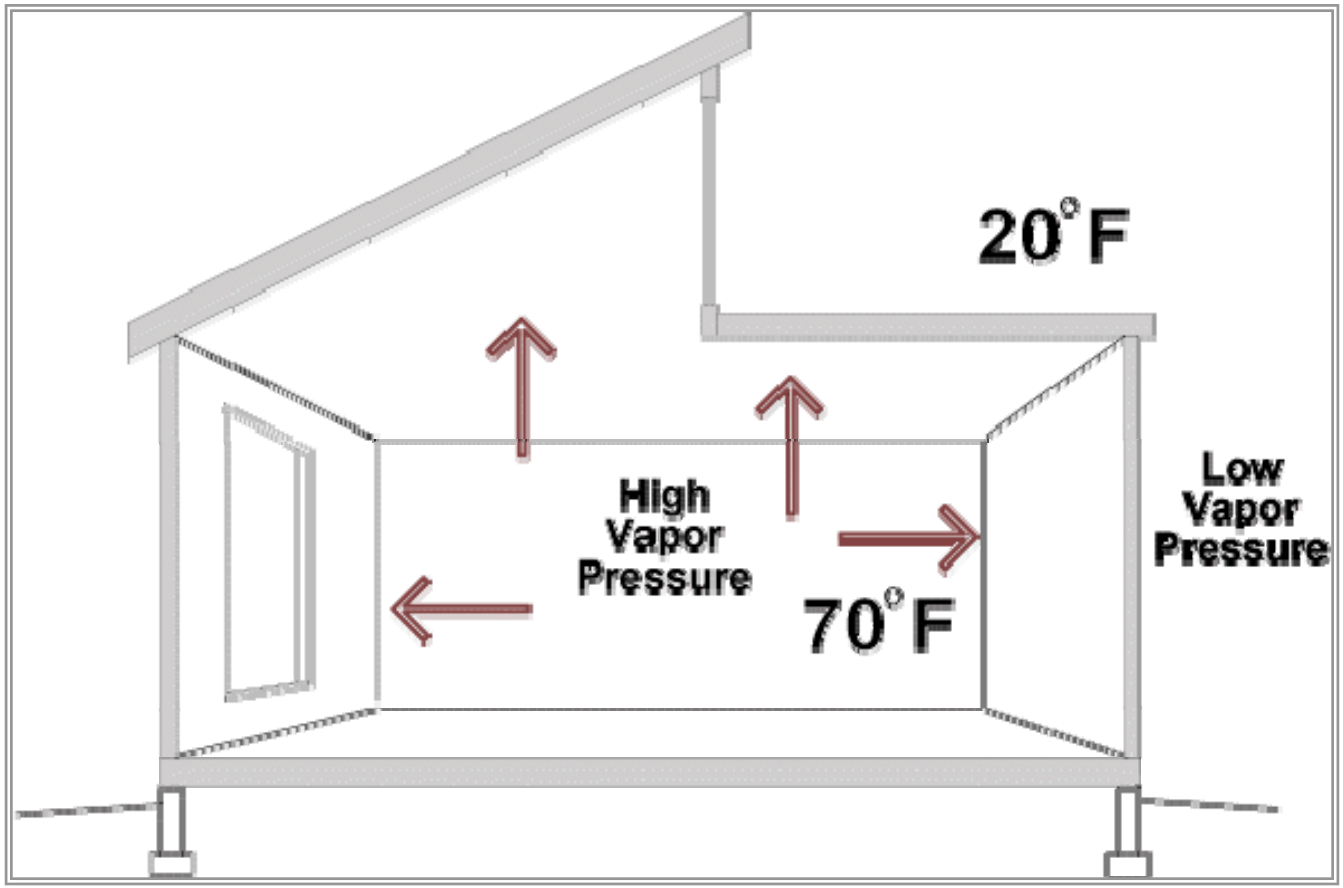
- Type IC rated and labeled in a sealed or gasketed enclosure
- Type IC rated and labeled as meeting ASTM E 283 with no more than 2.0 cfm of air movement
- Located inside an airtight box with clearances of at least 0.5 inch from combustible material and 3 inches from insulation

Recessed Lighting Fixtures



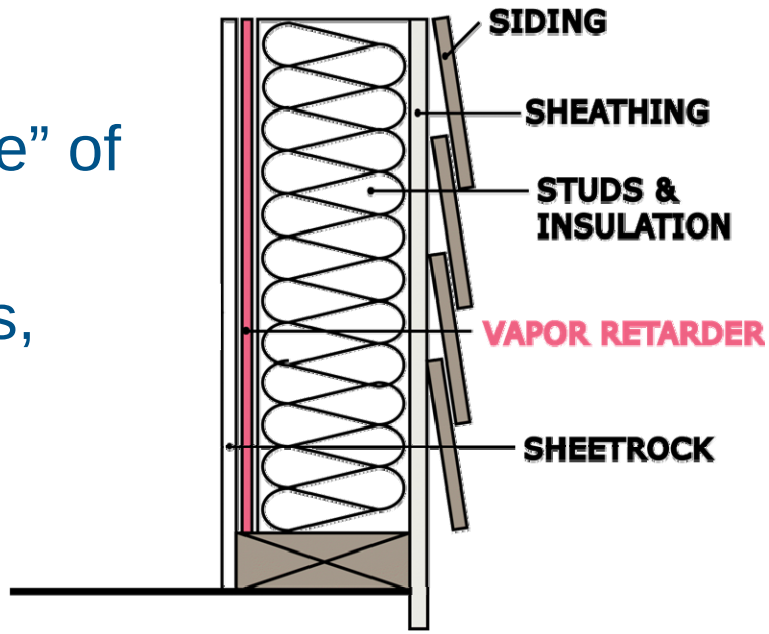
Moisture Control

Why a Vapor Retarder?



Vapor Retarders – Code Requirements

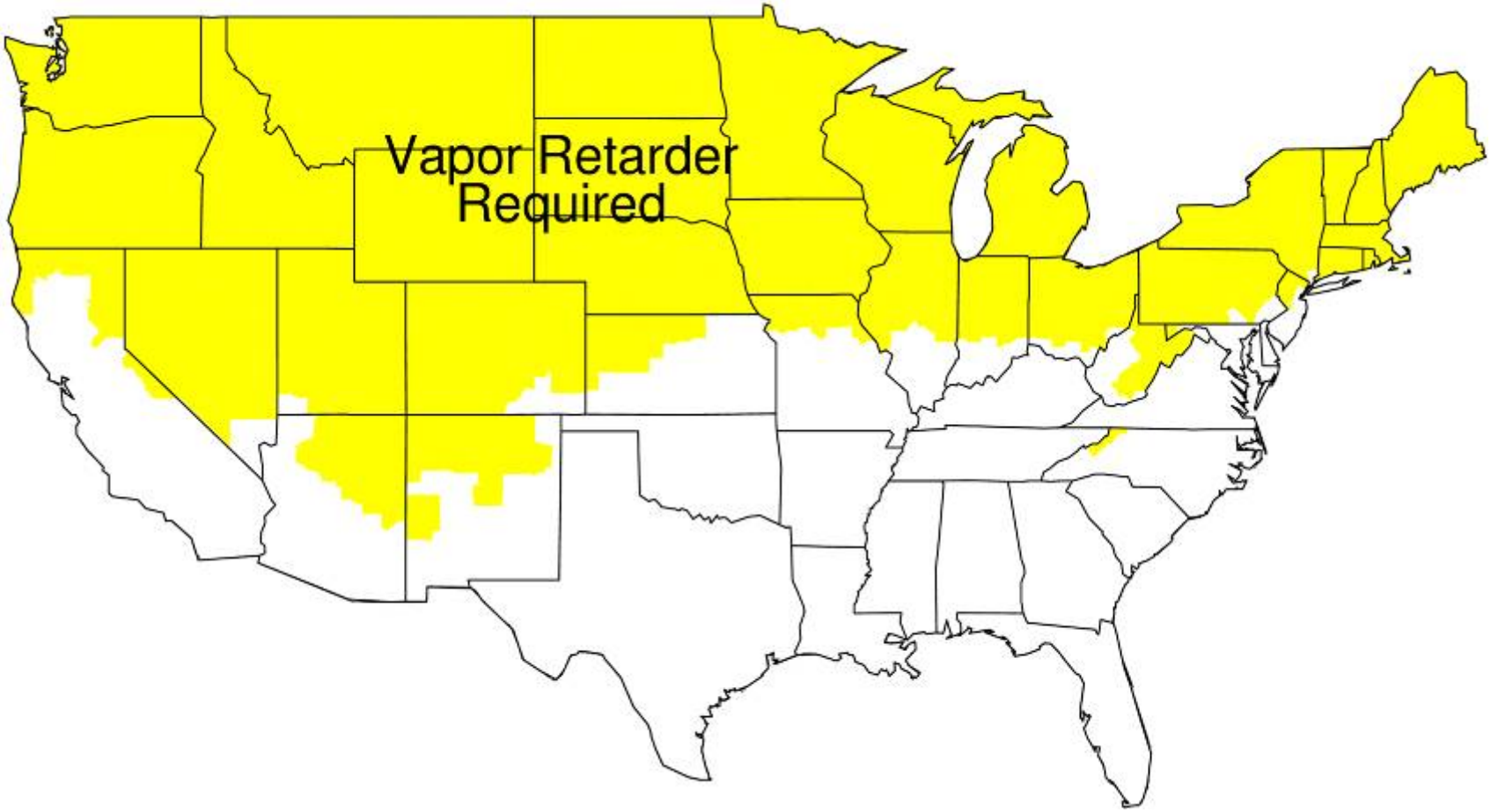
- Requirements
  - Install on “warm-in-winter side” of insulation
  - Use in unvented framed walls, floors, and ceilings
- Exceptions
  - In construction where moisture or its freezing won’t damage materials
  - If other approved means to avoid condensation are provided



Vapor Retarders - Examples

Vapor Retarder

Mandatory Requirements



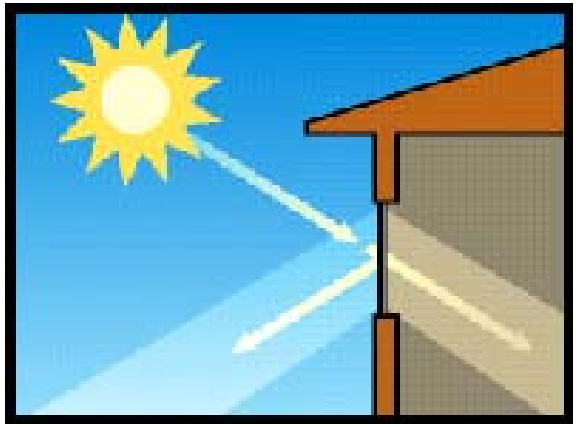
Windows – U-Factors

- Strict limits on U-factor in northern U.S. (cannot be traded off)
  - U-0.48 maximum in Zones 4 and 5, U-0.40 maximum in Zones 6-8
  - U-0.75 for skylights in Zones 4-8
  - These are based on building average; individual windows or skylights can be worse if average meets these requirements

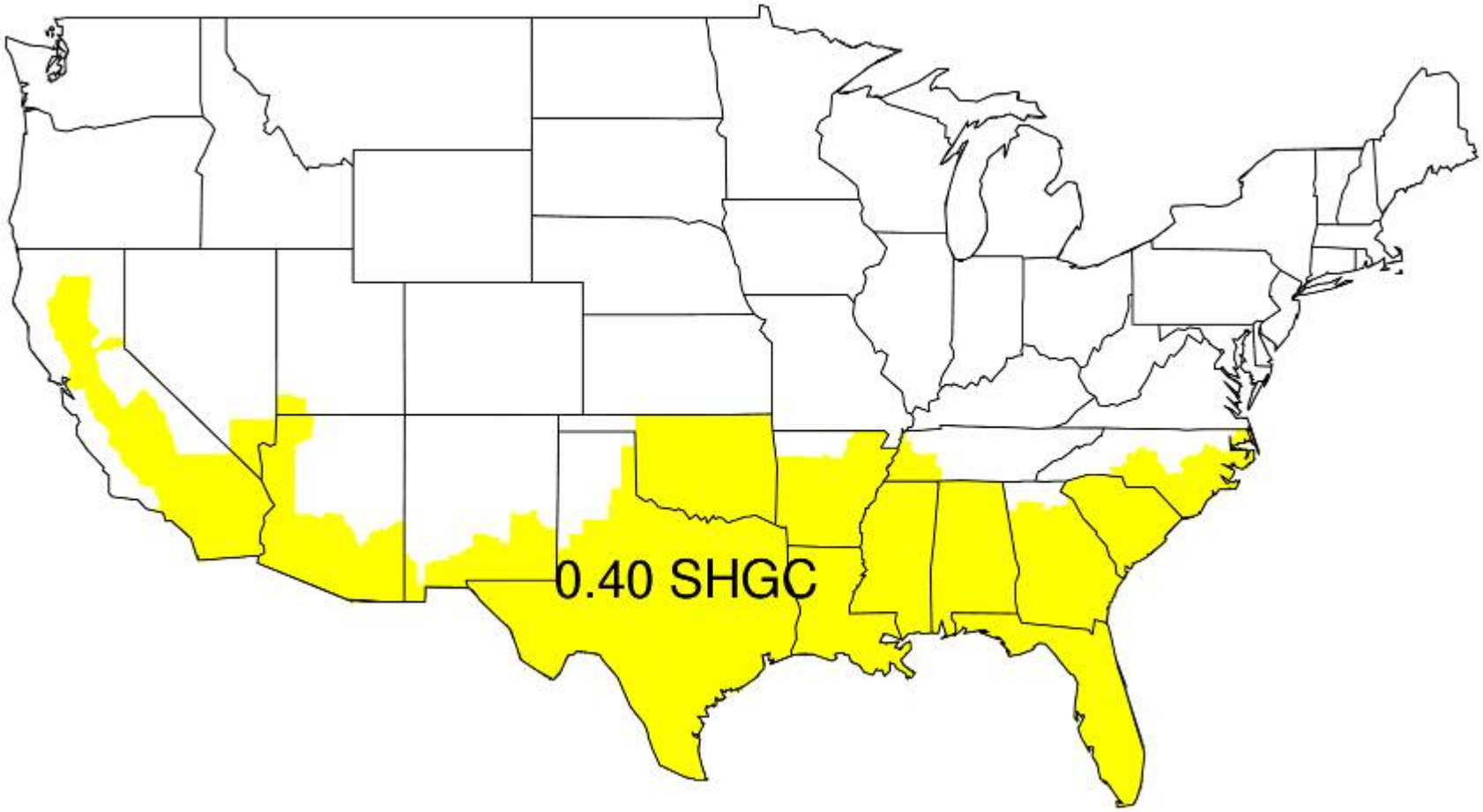
Windows - SHGC

- Solar Heat Gain Coefficient
  - SHGC of 0.40 or lower required in the southern U.S. (area-weighted average)
  - SHGC cannot exceed 0.50 even if performance path trade-offs are used (area-weighted average)
  - National Fenestration Rating Council (NFRC) tested

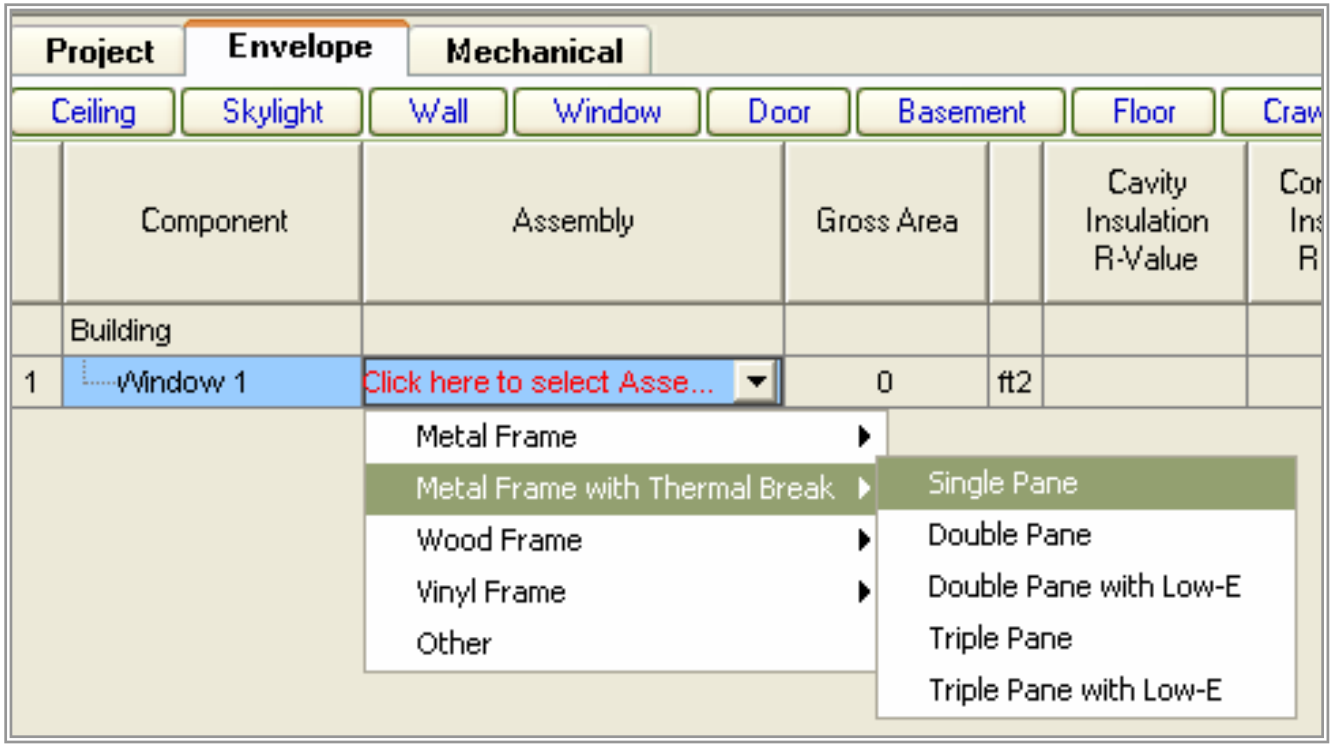
Solar Heat Gain Coefficient



Locations with Window SHGC Requirements



Windows in RES*check*



Help

Windows are defined as any transparent or translucent section in an exterior building wall including glass block but excluding glass doors (which are entered using the ***Door*** button). **Glazing** having a slope greater than 60 degrees from horizontal is considered a window while glazing having a slope less than 60 degrees from horizontal is considered a **skylight**.

Mechanical Systems & Equipment

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

Efficiency Terms

Part Load Performance

AFUE – Annual Fuel Utilization Efficiency

- Gas heating equipment

HSPF – Heating Seasonal Performance Factor

- Residential heat pumps

SEER – Seasonal Energy Efficiency Ratio

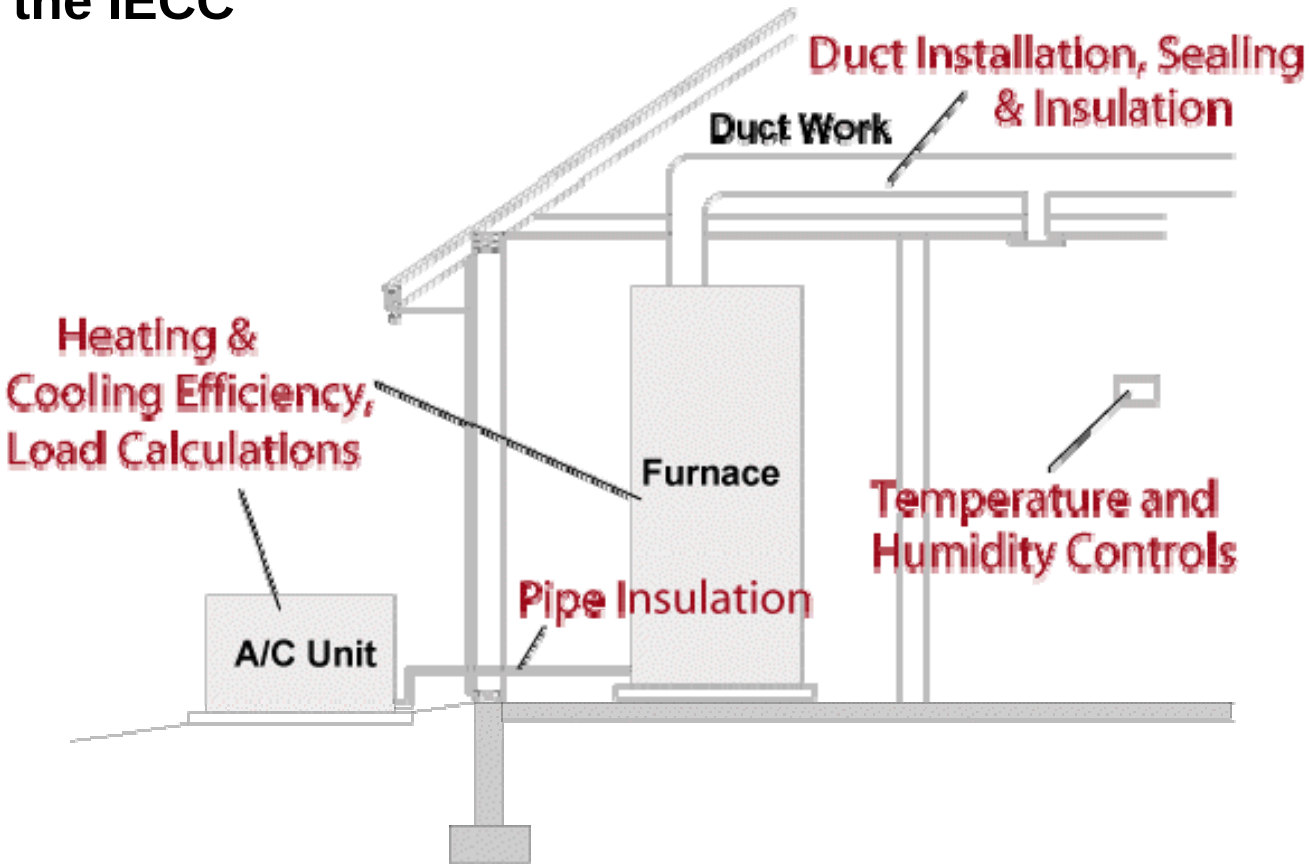
- Residential air conditioners

Mandatory Requirements Systems

- Controls
- Heat pump supplementary heat
- Ducts
  - Sealing
  - Insulation
- HVAC piping insulation
- Circulating hot water systems
- Ventilation
- Equipment Sizing

Mechanical Systems Overview

Major mechanical systems covered by the IECC



Ducts

- Insulation
  - Ducts outside the building envelope shall be insulated to R-8
  - R-6 allowed for ducts in floor trusses

- Sealing
  - Joints and seams shall comply with IRC, Section M1601.3.1
- Building framing cavities shall not be used as supply ducts

Duct Sealing

Piping Insulation

- R-2 required on
  - HVAC systems
    - Exception: Piping that conveys fluids between 55 and 105°F

Auto-Circulating Systems

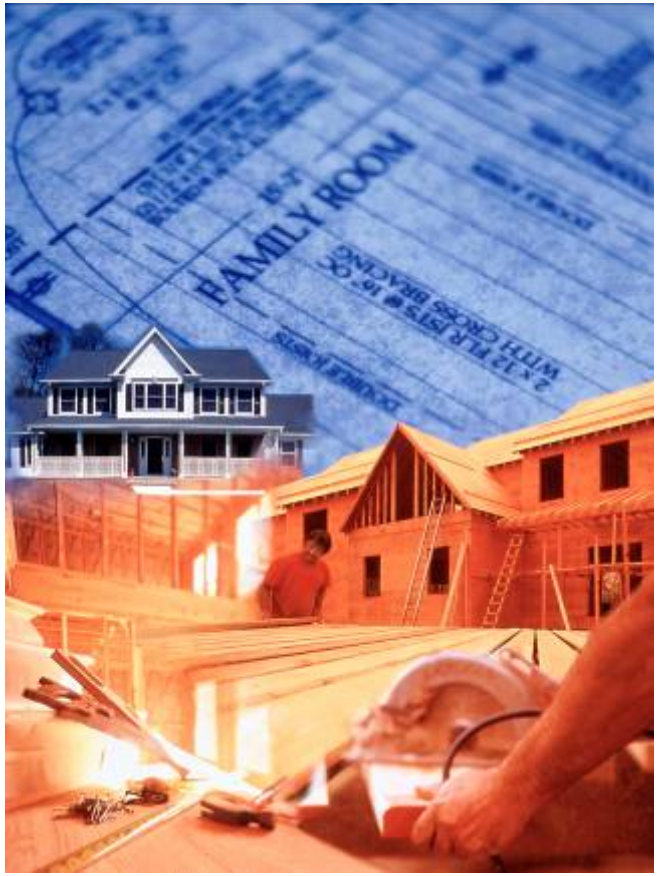
- Auto-circulating systems
  - R-2 required

Ventilation and Equipment Sizing

- 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

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



Certificate

- Permanently posted on the electrical distribution panel
- Shall include 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
  - SWH equipment

Proposed RES*check* Certificate

REScheck™

Residential Energy Efficiency Certificate

Address: **Date:**

Envelope R-Values	R-Value
Ceiling/Roof:	
Wall:	
Foundation:	

Fenestration U-Factors & SHGCs	U-Factor	SHGC
Window:		
Skylight:		
Door:		

Heating & Cooling Equipment	Type	Efficiency
Heating:		
Cooling:		
Water Heater:		

	R-Value
Duct Insulation: (in unconditioned space)	

▼ I certify that the above information is correct.

Signature:

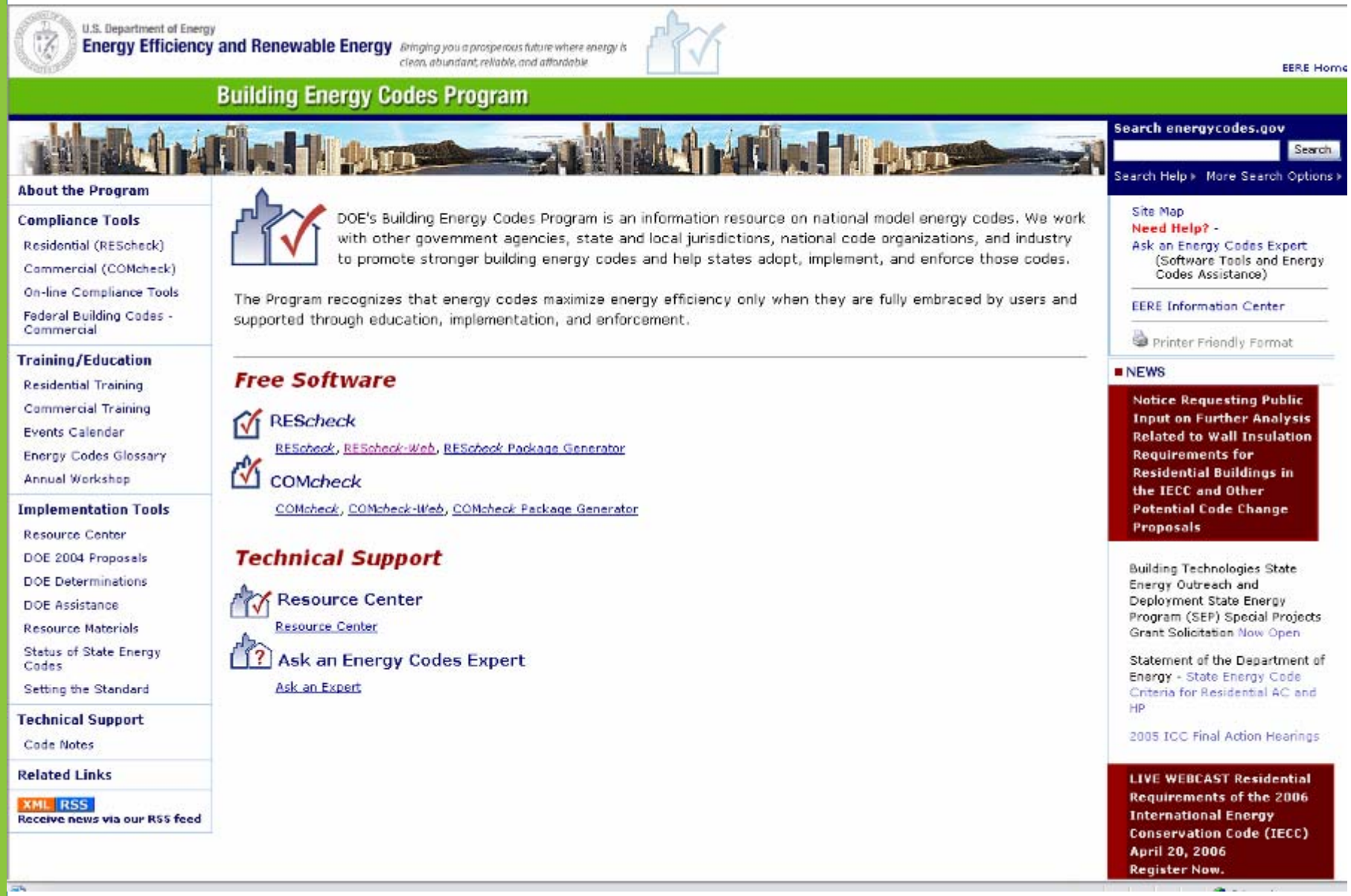
Name and Title:

Comments

Simulated Performance

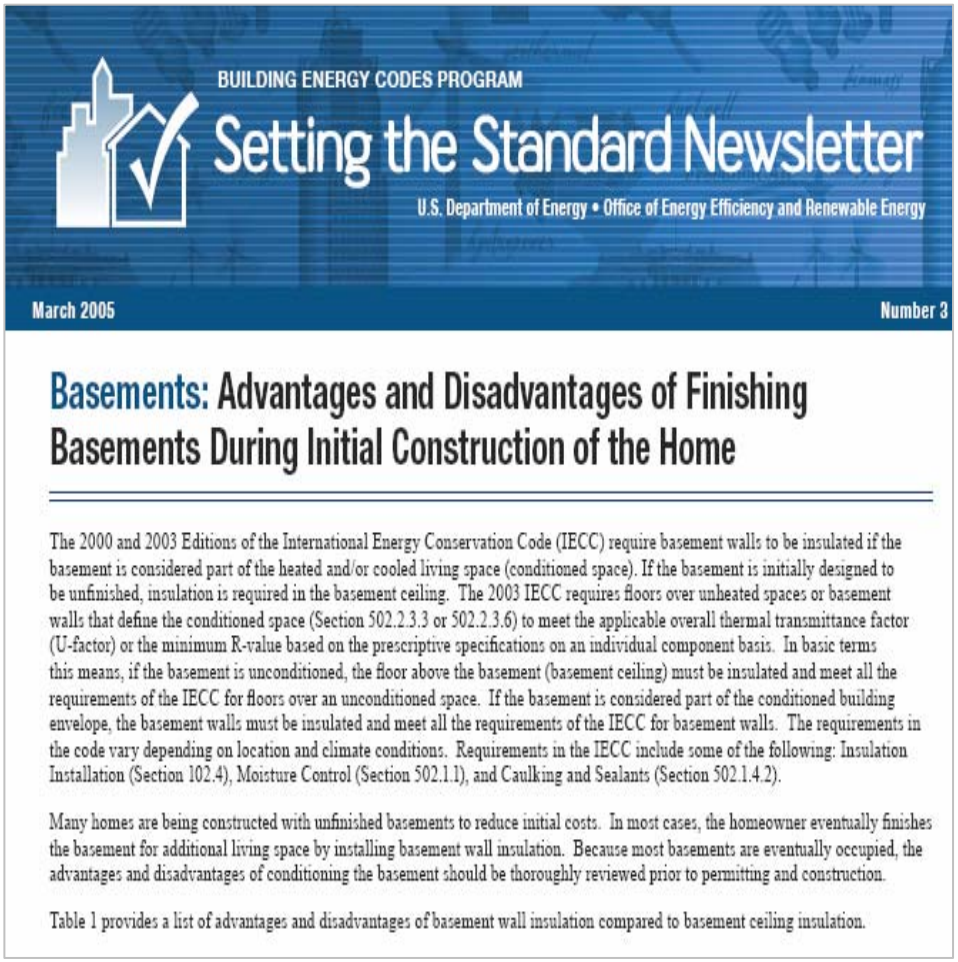
- Requires computer software with specified capabilities (local official may approve other tools)
- Includes both envelope and equipment
- Allows greatest flexibility. Credits features such as:
  - High efficiency furnaces, air-conditioners, etc.
  - Tight ducts (must be leak tested) or hydronic systems
  - Exterior shading, favorable orientation, thermal mass, SHGC, etc.
- Section 404 specifies “ground rules”
  - These will generally be “hidden” in compliance software calculation algorithms
  - Very similar ground rules are used in new home federal tax credits and ENERGY STAR Home guidelines

www.energycodes.gov
techsupport@becp.pnl.gov



Setting the Standard Newsletter

- Register on-line to receive the latest up-to-date information on energy code related issues



BUILDING ENERGY CODES PROGRAM

Setting the Standard Newsletter

U.S. Department of Energy • Office of Energy Efficiency and Renewable Energy

March 2005 Number 3

Basements: Advantages and Disadvantages of Finishing Basements During Initial Construction of the Home

The 2000 and 2003 Editions of the International Energy Conservation Code (IECC) require basement walls to be insulated if the basement is considered part of the heated and/or cooled living space (conditioned space). If the basement is initially designed to be unfinished, insulation is required in the basement ceiling. The 2003 IECC requires floors over unheated spaces or basement walls that define the conditioned space (Section 502.2.3.3 or 502.2.3.6) to meet the applicable overall thermal transmittance factor (U-factor) or the minimum R-value based on the prescriptive specifications on an individual component basis. In basic terms this means, if the basement is unconditioned, the floor above the basement (basement ceiling) must be insulated and meet all the requirements of the IECC for floors over an unconditioned space. If the basement is considered part of the conditioned building envelope, the basement walls must be insulated and meet all the requirements of the IECC for basement walls. The requirements in the code vary depending on location and climate conditions. Requirements in the IECC include some of the following: Insulation Installation (Section 102.4), Moisture Control (Section 502.1.1), and Caulking and Sealants (Section 502.1.4.2).

Many homes are being constructed with unfinished basements to reduce initial costs. In most cases, the homeowner eventually finishes the basement for additional living space by installing basement wall insulation. Because most basements are eventually occupied, the advantages and disadvantages of conditioning the basement should be thoroughly reviewed prior to permitting and construction.

Table 1 provides a list of advantages and disadvantages of basement wall insulation compared to basement ceiling insulation.

Newsletter: http://www.energycodes.gov/news/

Questions/Comments

- Help Desk – on-line electronic form
  http://www.energycodes.gov/support/helpdesk.php

- Email
  Techsupport@becp.pnl.gov

U.S. Department of Energy's
Building Energy Codes Program