New Energy Codes & High-Performance Homes

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Slide Deck 1:
- Top Ten List
- Building Science
- Baseline Study
- Code Envelope Overview

Learning Objectives

- Design priorities for a High-Performance Home
- Identify opportunities resulting from
  Missouri Residential Energy Code Field Study
- Identify standards for insulation requirements and fenestration performance
- Define the building envelope and identify best practices for air sealing (and passing blower door test)
- Identify requirements and best practices for heating and cooling (mechanical and ductwork) and fresh air ventilation systems

Energy Code Resources

Technical assistance or training requests:

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Energy Code Resources

Missouri Residential Building Energy Code Construction Practices Study:
https://energy.mo.gov/energy-codes/missouri-residential-building-codes-study
For additional information on other DOE Field Studies and participating states, please visit https://www.energycodes.gov/compliance/energy-code-field-studies.
Additional education resources are available at www.southfaceonlinetraining.org.

www.southface.org => Resources => GA Energy Code Resources
mikeb@southface.org

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Design Approach for a High-Performance Home

- **Building Science as guide**
  Understand physics of heat air and moisture flow
- **High Performance Enclosure**
  Sound structure, shell is tight, well-insulated and resilient
- **Air Distribution**
  Sealed & insulated ducts – located inside building envelope, intentional fresh air delivery
- **Reduced Equipment & Loads**
  Efficient Heating, Cooling, Hot Water, Lights, Appliances

The Key: It's not necessarily the stuff in the building — it's how it's all put together! (The house is a system)

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High Performance Top Ten List

1. Pay Attention to the Sun
2. Ductwork
3. Thermal Package
4. Equipment
5. Bulk Moisture & Cladding
6. Humidity Control
7. Indoor Air Quality
8. Appropriate Ventilation
9. Lighting and Plug Loads
10. Production for Zero Energy

Use Tools and Technology to help us!

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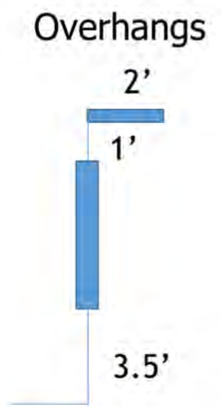
Top Ten List – the Sun

1. **Pay Attention to the Sun**
   Glazing on South and North (minimize East/West) – overhangs, exterior shading
   Glazing – DP low-e with wood, vinyl, Extruded Fiberglass frame
   Sun tubes vs. big skylights.
   Minimize Window Wall Ratio



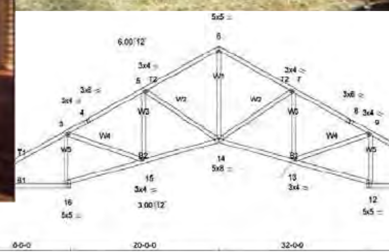
Top Ten List – Ducts

2. Ductwork

Ducts located inside building envelope – sealed with mastic
Returns – path from every room; upsized over supplies







"According to NREL researchers David Roberts and Jon Winkler, moving the ducts from a vented attic to a new location inside the conditioned space will reduce electricity used for cooling by 15% to 20%, and will reduce the size of the needed air conditioning equipment by 0.5 to 1 ton."

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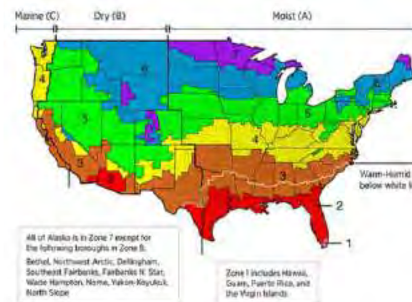
Top Ten List – Insulation

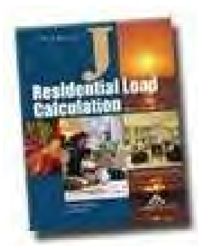
3. **Thermal Package**
   Exceed R-values from 2015/18 IECC prescriptive chart Walls ~R-20+
   – prefer thermal break with rigid insulation (rock wool) & efficient framing
   Insulate foundation walls versus floors – basements, conditioned crawlspaces

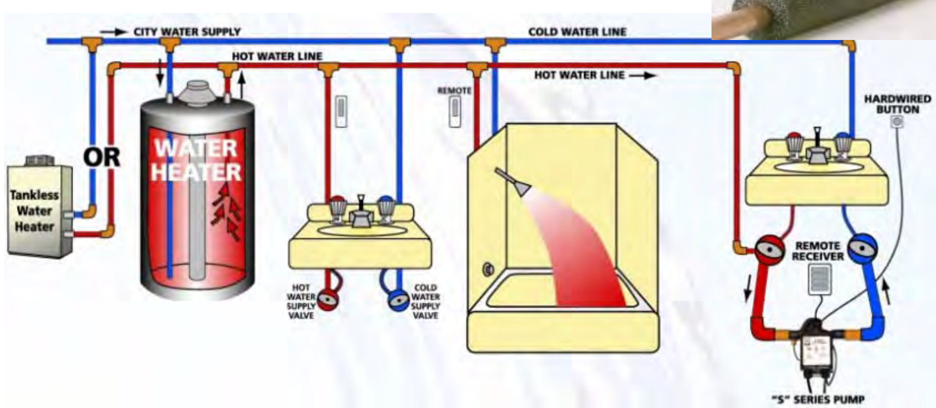


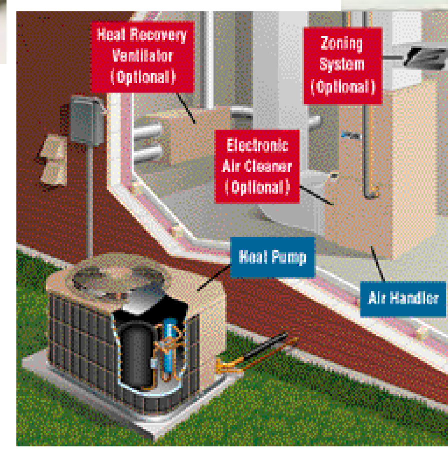
Top Ten List – Mechanical

4. Equipment

Heating – gas 95%, Cooling – Variable Speed – Right Sized furnaces & heat pumps, mini-splits Hot Water – safe gas units, HP electric – insulate lines, distribution





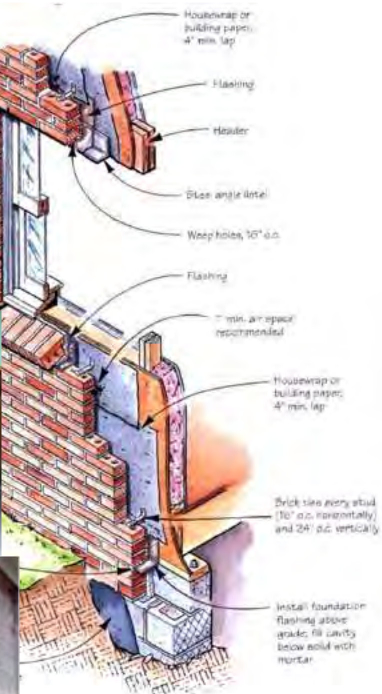


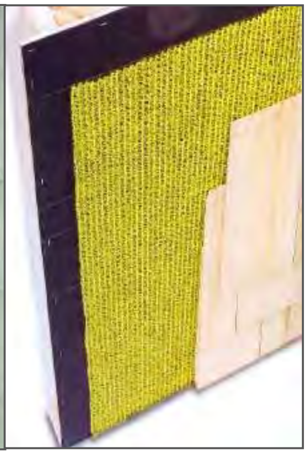
Top Ten List – Water

5. Bulk Moisture and Cladding

Sheathing seams sealed – air barrier and weather barrier – (ZIP)

Drainage plane behind all cladding. Foundation drainage details Flashing integrated with WRB



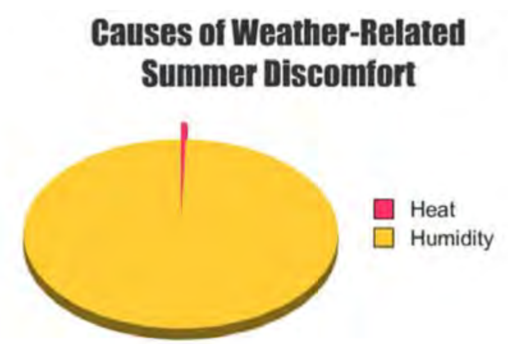


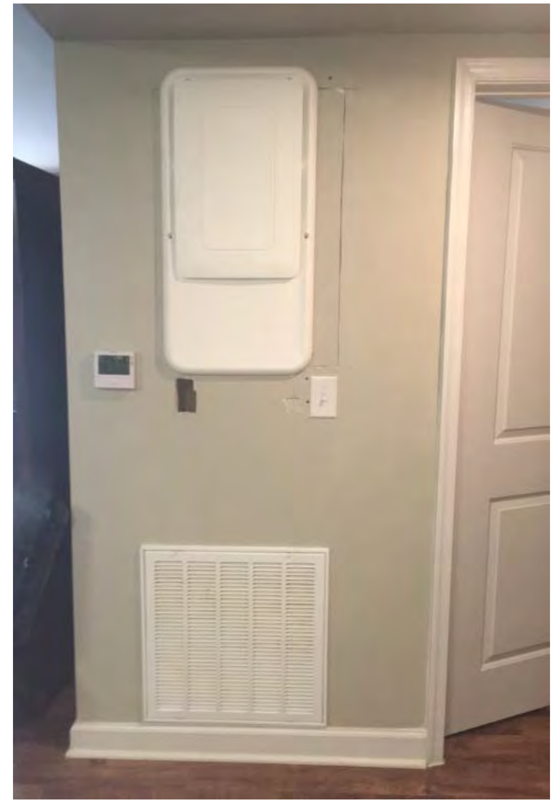
Top Ten - Humidity

6. Humidity Control

Variable speed equipment

Dedicated dehumidifier





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Top Ten List - IAQ

7. Indoor Air Quality

Material selection –
Salvaged, Recycled content
EPP, avoid Red List
Thick, pleated filters
Tight envelope with Fresh Air system

HVI CERTIFIED PERFORMANCE

MODEL	DUCT SIZE	STATIC PRESSURE	SPEED	WATTS
QFAM	6"	0.2	40 CFM	12.9
			50 CFM	13
			60 CFM	15.1
			70 CFM	17.1
			80 CFM	19.5
			90 CFM	21.8
HVI CERTIFIED			100 CFM	26.3
			110 CFM	27.5
			120 CFM	30.1

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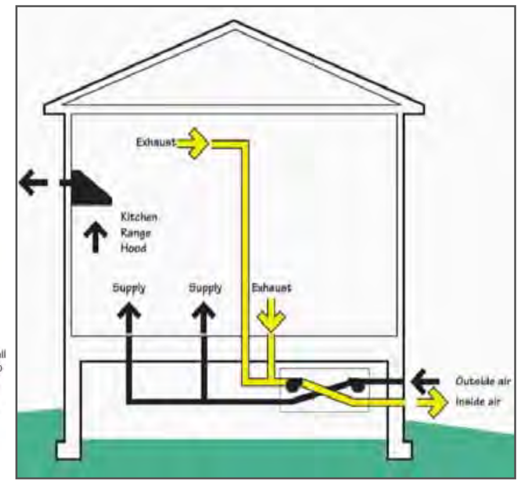
Top Ten List – Fresh Air

8. Appropriate Ventilation

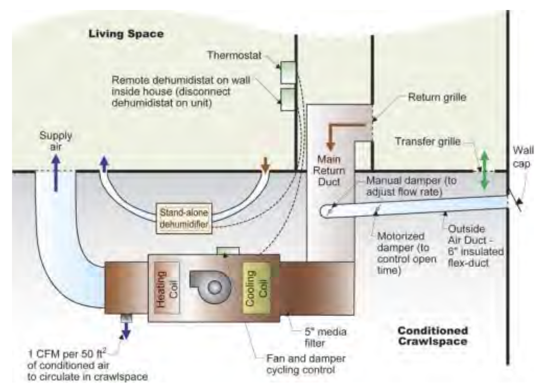
Positive / Balanced versus Exhaust Only
Smart Controls and sensors, ERV,
Ventilation Dehumidifiers



To house

Fresh air

From house



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Top Ten List – Plug Loads

9. Lighting and Plug Loads

100% good quality LED’s – economic no-brainer
ENERGY STAR appliances – manage this (5 refrigerators?!)
Smart power strips and vampire loads

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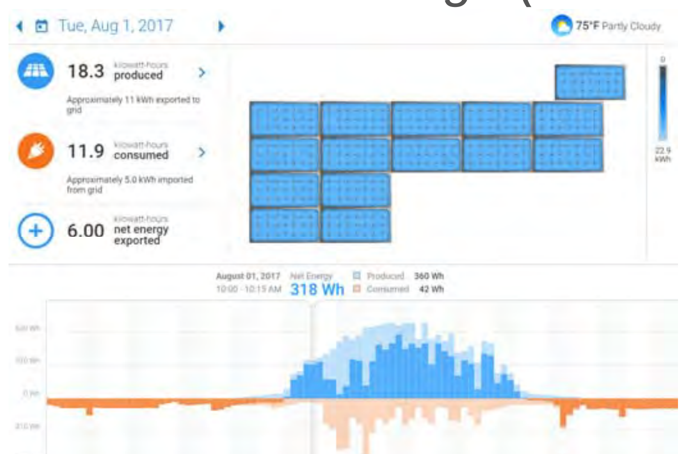
Top Ten List – Renewables

10. Production for Zero Energy

At least make the home solar ready – (structure, conduit)

Solar PV is much more affordable - don't rely on solar to offset poor design

New technologies include on-site storage (PowerWall) and EV's



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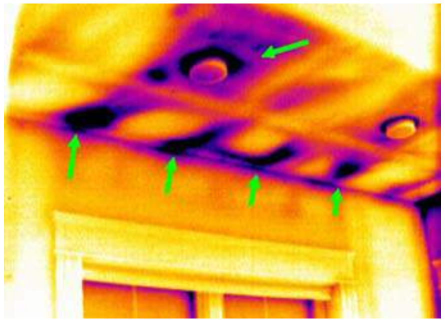
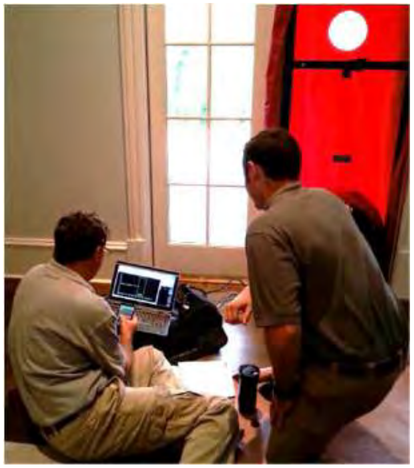




Technology / Programs Can Help

- **Use the Tools**
  - *Energy Modeling – target EUI's, Performance Monitoring, IAQ Sensors, IR Camera, Blower Door and Duct Leakage Testing, Inspections and Certifications*
  - *Beyond Code Programs*

LEED FOR HOMES

PHIUS

NAHB NATIONAL GREEN BUILDING PROGRAM™

energy ENERGY STAR CERTIFIED NEW HOME

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

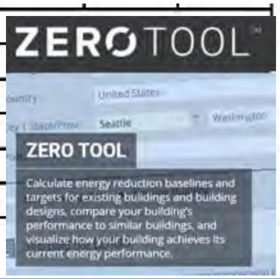
earthcraft A Program of Southface

2030 CHALLENGE Targets: U.S. Residential Regional Averages

architecture 2030

U.S. Regional Averages for Site Energy Use and 2030 Challenge Energy Reduction Targets by Residentail Space/Building Type (RECS 2001)[1]
From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets.

Residential Space/Building Type[2]	Average Source EUI[3] (kBtu/Sq.Ft./Yr)	Average Site EUI[3,4] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr) 50% Target	60% Target	70% Target	80% Target	90% Target
South							
Single-Family Detached	86.0	41.5	20.8	16.6			
Single-Family Attached	82.5	38.8	19.4	15.5			
Multi-Family, 2 to 4 units	113.6	46.9	23.5	18.8			
Multi-Family, 5 or more units	122.4	47.9	24.0	19.2			
Mobile Homes	162.0	63.3	31.6	25.3			



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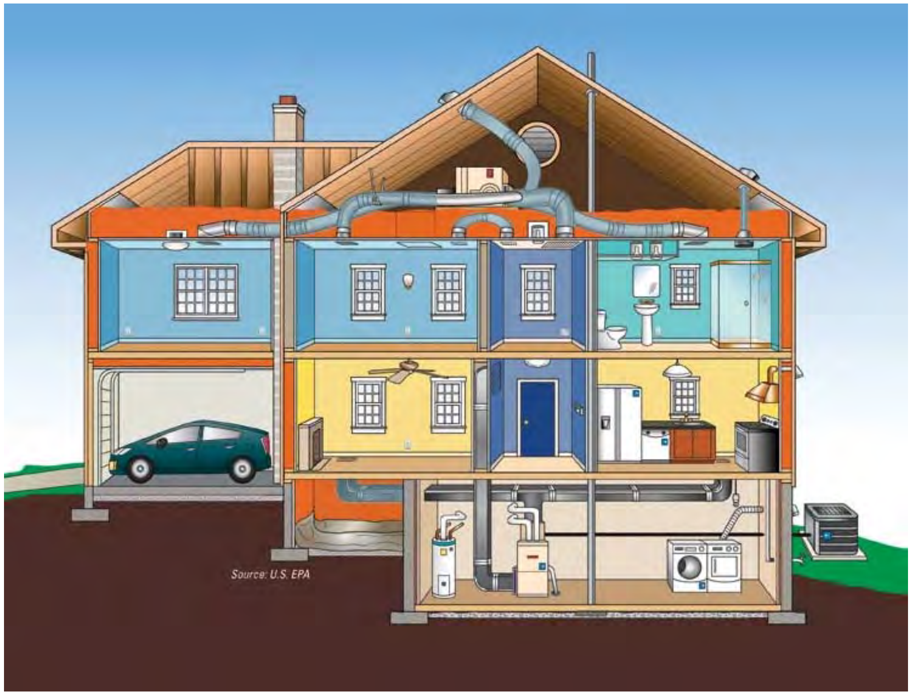
Part I

Building Science

A house is a system made up of interrelated parts:

- The building thermal envelope
- Systems
  - Heat and air conditioning
  - Ventilation
  - Water heating and distribution
- Lighting & appliances



Building Thermal Envelope

IECC Definition

The basement walls, exterior walls, floor, roof and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

What parts of this house are enclosed by the thermal envelope?

Heat Transfer

- Heat is a form of energy
- Heat moves from hot to cold
- 3 types of heat transfer:
    - **Conduction** – heat moves through a material
    - **Convection** – heat energy carried by a fluid (including air)
    - **Radiation** – heat emits from a hot surface to a cooler surface

Heat Transfer Problem

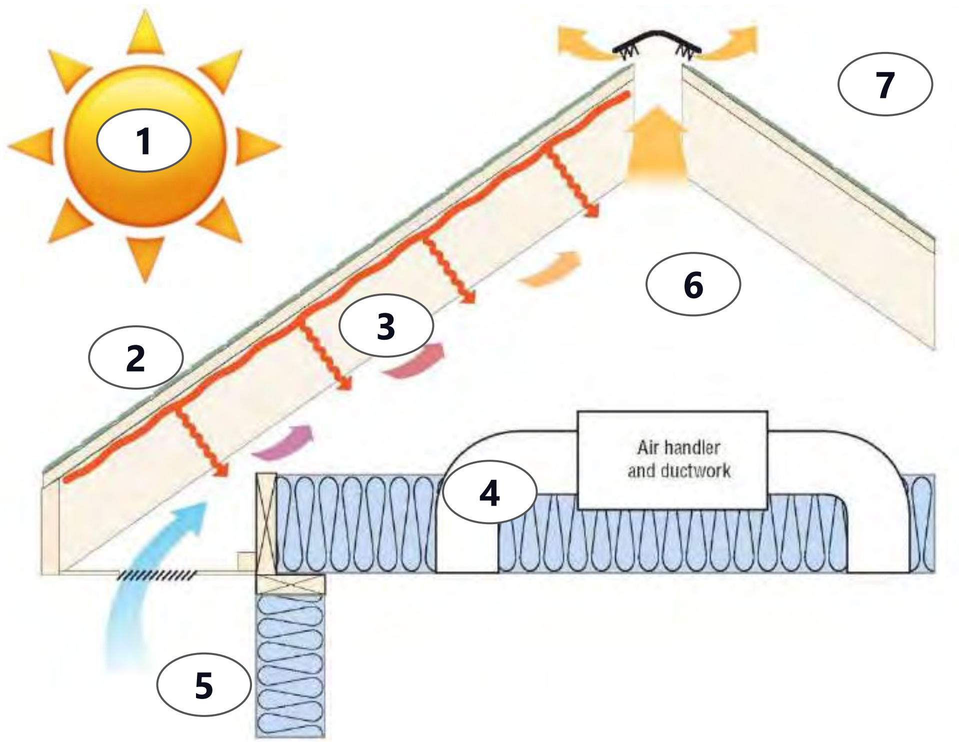
Your Choices:
- **Radiation**
- **Conduction**
- **Convection**

1 → 2 = Radiation

2 → 3 = Conduction

3 → 4 = Radiation

5 → 6 → 7 = Convection



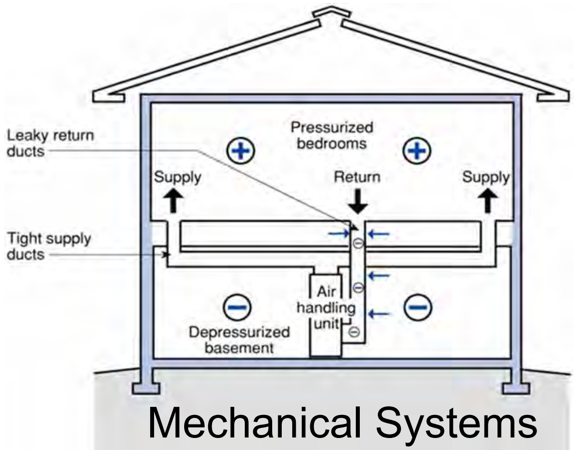
Why Foamed Houses?

The energy code allows for multiple ways of defining the building thermal envelope. This home's envelope is defined by the roof, not the ceiling. What's the advantage of this?

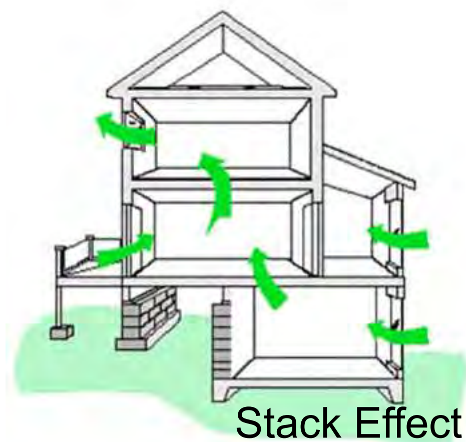
Air Flow

- Air moves from areas of higher pressure to areas of lower pressure.
- Natural and man-made forces that can create pressure differences cause air to flow.
- Whenever air moves out of a home, an equal amount of air enters the home (CFMin = CFMout).

Wind



Mechanical Systems



Stack Effect

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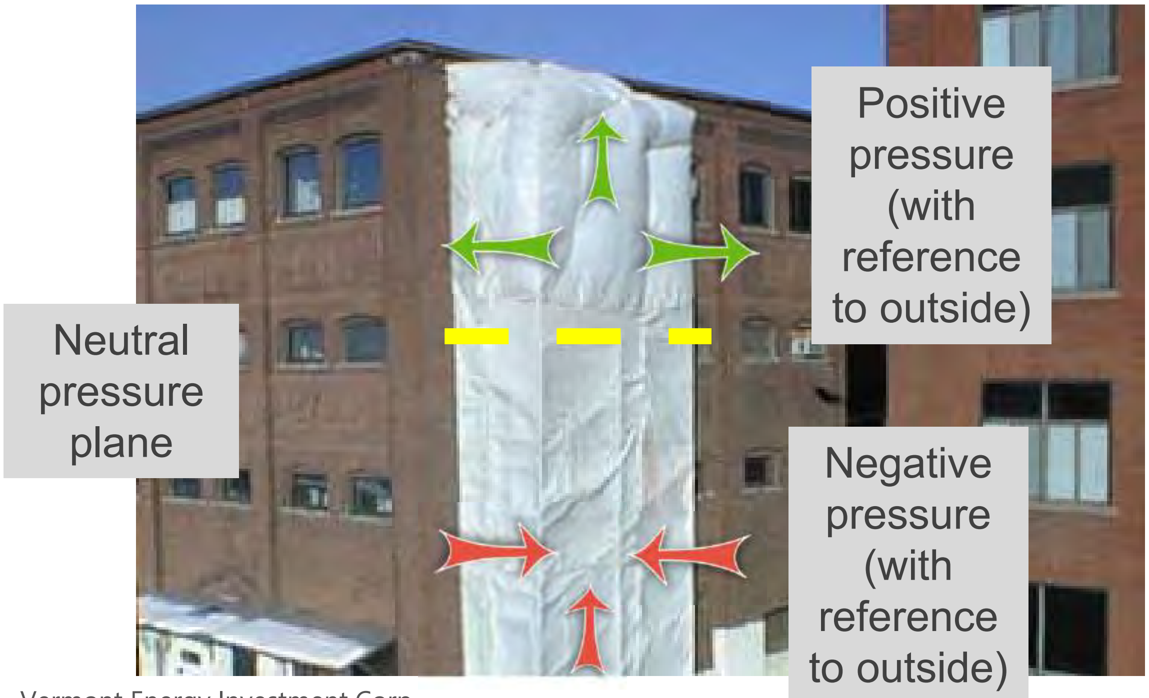
Stack Effect



Vermont Energy Investment Corp.

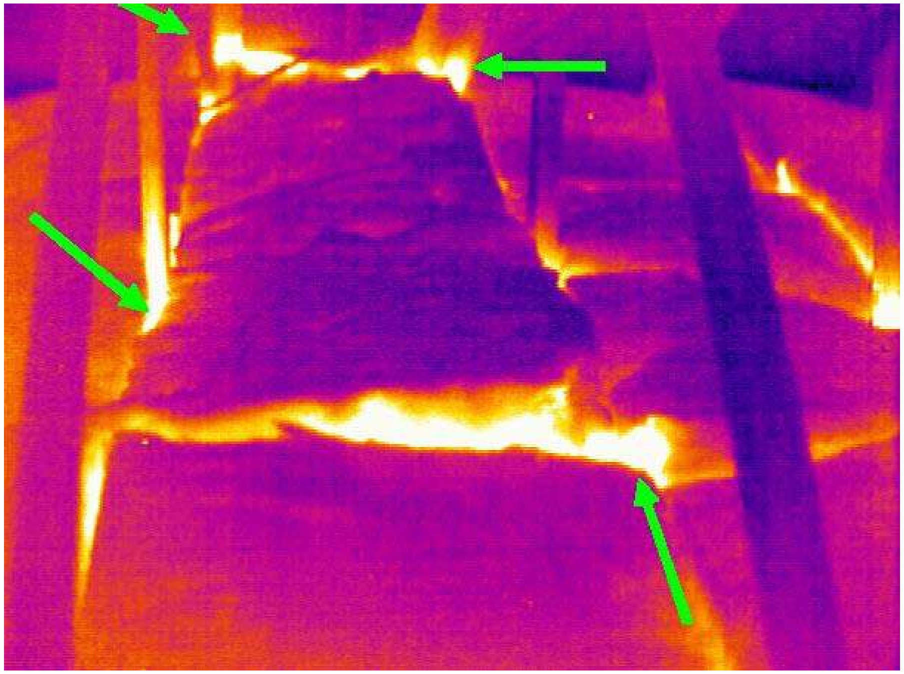
Thermal and Air Barriers

The thermal and pressure boundaries in the building envelope must be **complete** and **aligned.**

- Insulation products such as fiberglass batts must be completely enclosed on all sides.
- Insulation is most effective when it is continuous and located outside the structure.

Continuous Insulation & Air Barrier

Air barrier and insulation must be in contact.



Moisture Transport

Moisture moves…

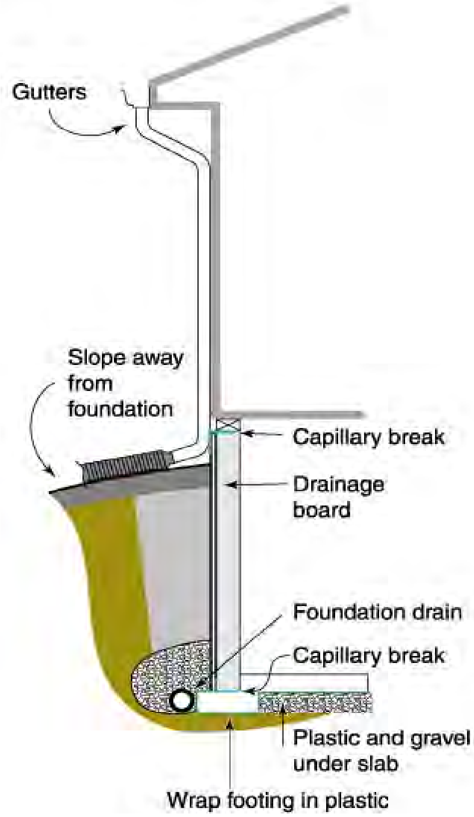
- From wet to dry
- As liquid or vapor
- By capillary action (wicking)

Geography matters! What works in one region may not work in another.

Appropriate measures for moisture control are essential!

Bulk Moisture Control

- Proper site drainage
- Foundation waterproofing
- Plastic ground cover
- Gutters channel water away from foundation



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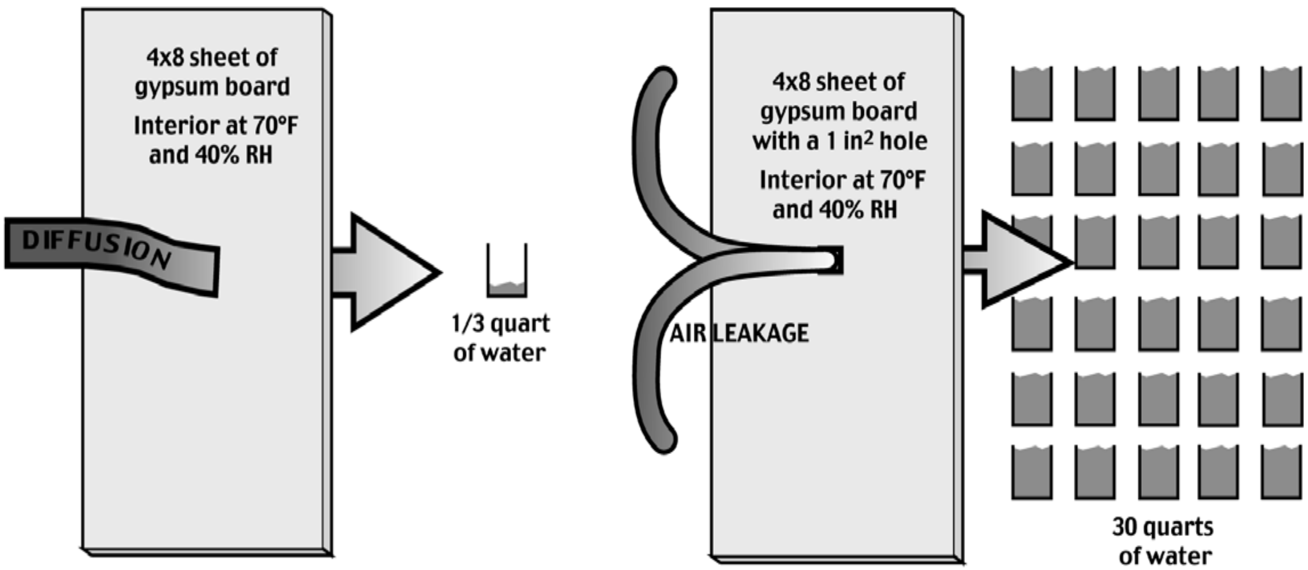
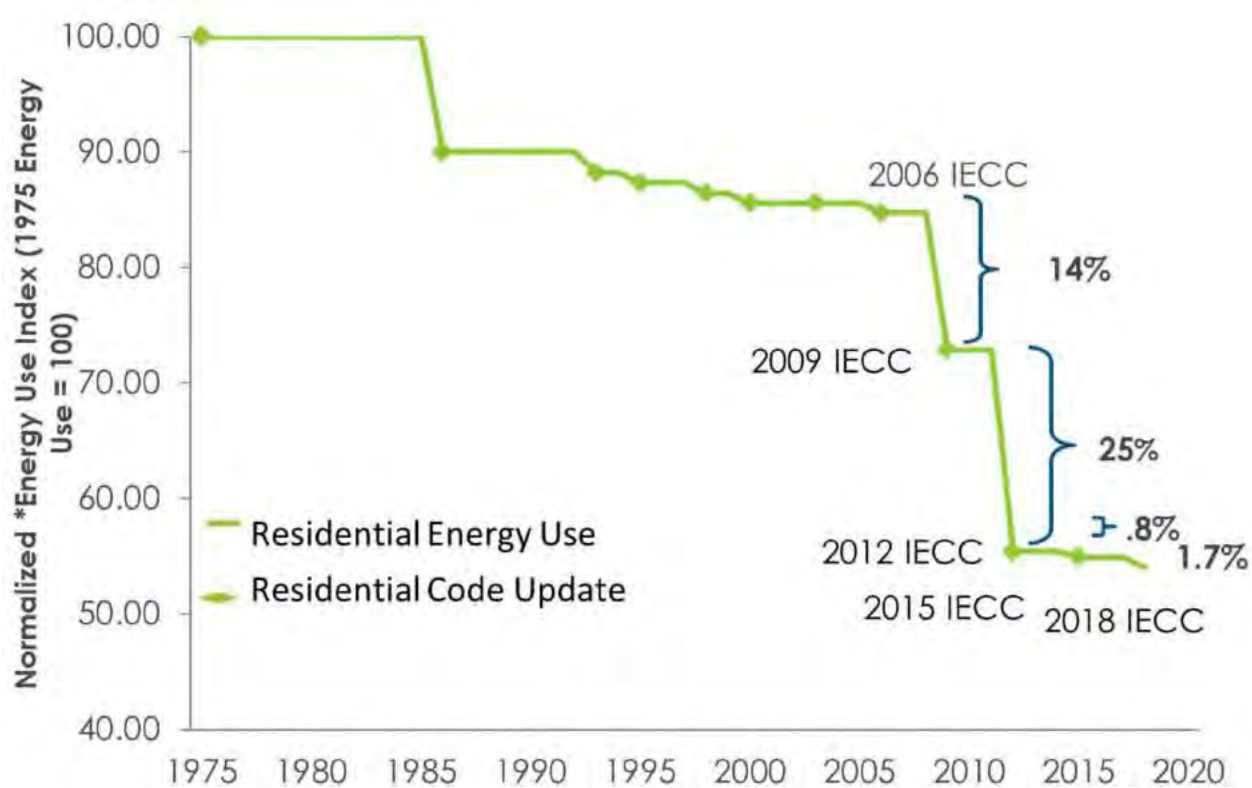
Diffusion Vs. Air Leakage



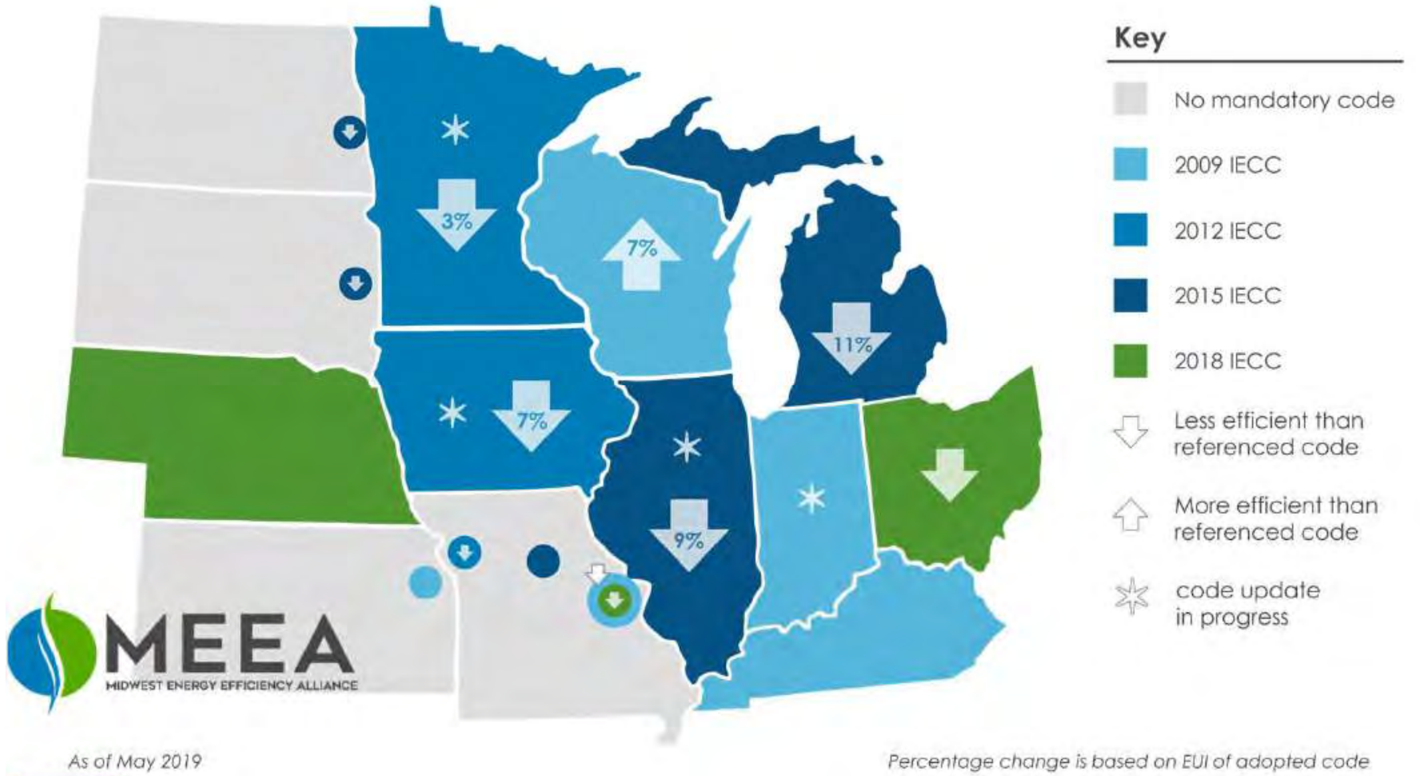
Particularly for a Mixed climate, air leakage is typically far more important a moisture transport mechanism than diffusion

Part 2

Residential Energy Code Background



Midwest Residential Energy Code Adoption



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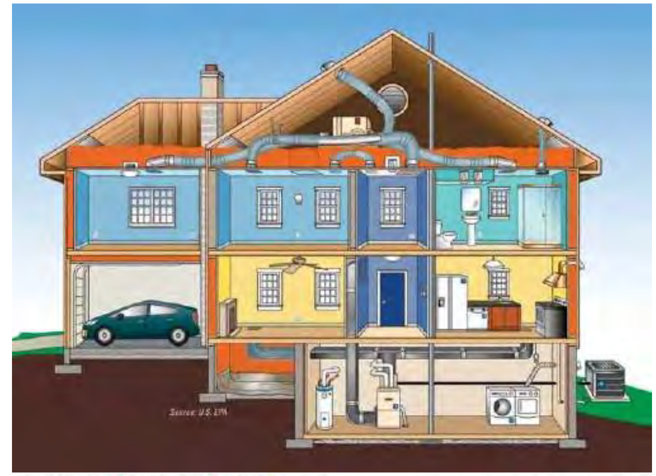
Energy Code: Residential Building

Applies to:

- New construction
- 1 and 2 family (R3)
- Multi-family, 3 stories and less (R2 and R4) – IECC 2009
- Additions, Alterations, Repairs

Exempt Buildings

- No conditioning
- Historical



CONDITIONED SPACE. For energy purposes, space within a building that is provided with heating and/or cooling *equipment* or systems capable of maintaining, through design or heat loss/gain, 50°F (10°C) during the heating season and 85°F (29°C) during the cooling season, or communicates directly with a *conditioned space*. For mechanical purposes, an area, room or space being heated or cooled by any *equipment* or *appliance*.

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Scope of Residential Energy Code

- Focus is on building envelope
  - o Ceilings, walls, windows, floors, foundations
  - o Sets insulation levels, window U-factors and SHGC
  - o Infiltration control
    - Caulk and seal to prevent air leaks
    - Verify envelope tightness with blower door test (or visual inspection for 2009 code)
- Ducts
  - o No building cavities as ducts (post-2009)
  - o Seal properly and insulate even if all ductwork is in conditioned space
  - o Verify tight with duct pressurization test
- Lighting equipment
  - o High-efficacy bulbs required (50%, 75%, 90%)
- HVAC equipment efficiencies covered by different DOE standard
- No appliance requirements

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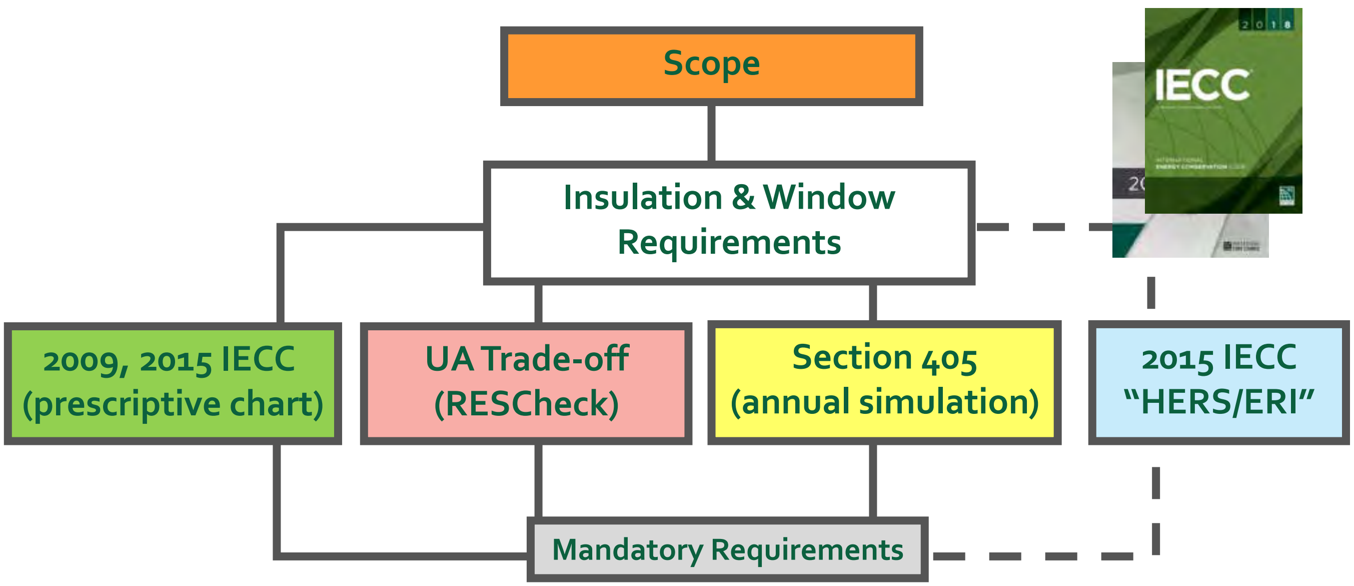
Compliance Paths



- The new Energy Rating Index (ERI) path gives the most design flexibility (e.g., credit for mechanical equipment efficiency).
- It also credits items not covered by the code (e.g., appliance efficiencies).

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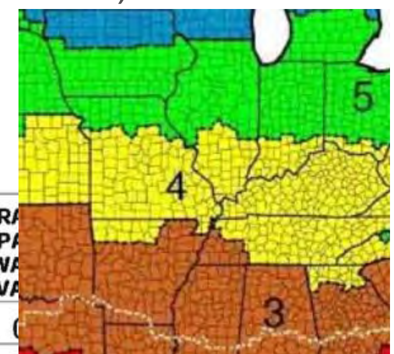
2009 IECC- Section 402.1

- One prescriptive "answer" for how to build per climate zone (CZ: 4 and 5)
- Includes lots of footnotes



2009

TABLE 402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	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	CRA SPA WA R-VA
1	1.2	0.75	0.30	30	13	3/4	13	0	0	[illegible]
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, 2 ft	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

Energy Codes

2015 IECC vs. 2018 IECC

- One prescriptive "answer" for how to build per climate zone (CZ: 4 and 5)

TABLE R402.1.2
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	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
2015										
3	0.35	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
2018										
3	0.32	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13+5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5[h] or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19

IECC Code Differences – ‘15 to ’18

- Window Ufactors dropped slightly from U35 to U32 & U30 (CZ’s 4-5)
- Exception for log homes built according to ICC 400
- ERV/HRV ducts exempt from leakage testing (if independently ducted).
- Ducts allowed to be buried in ceiling insulation
  - Ducts R-8
  - Minimum surrounding insulation R-19 (R-13 for CZ1-3A, ducts >3’)
  - Effective R-25 when modeling
- Ducts in conditioned space
  - Completely inside thermal envelope
  - Buried ducts with AHU inside envelope plus < 1.5% Total Leakage plus min. ceiling insulation
- 90% Efficient Lighting (LED’s)
- ERI relaxed targets
  (62 for CZ4, 61 for CZ5, backstop penalty for renewables)

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2009 IECC Prescriptive Code R-Values

Values for Climate Zone 4

Sloped Ceilings _____

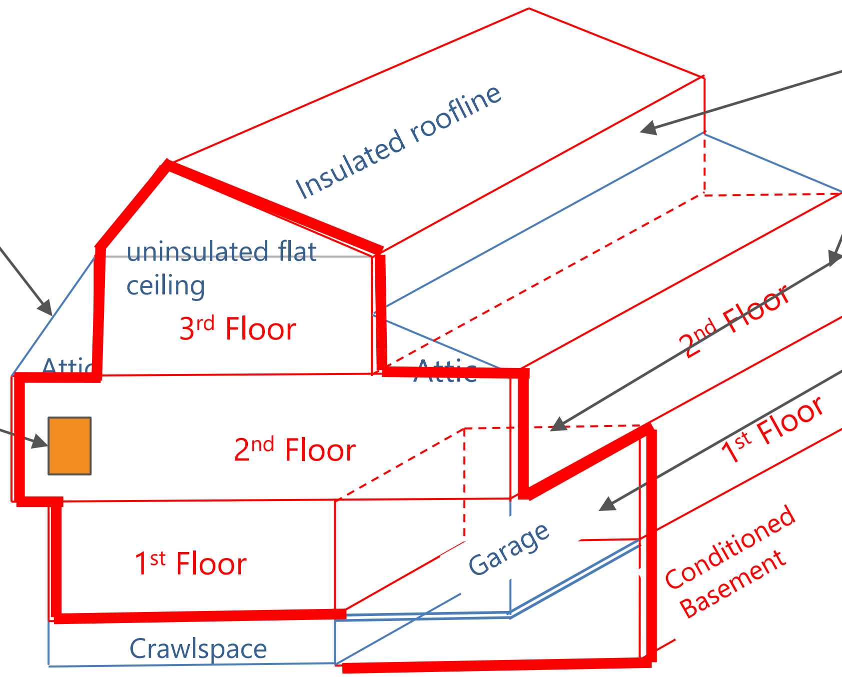
Attic Knee wall _____

Flat Ceiling _____

Window _______

Cantilever Floor _____

Floor Over Crawl _____



Exterior Wall _____

Floor Over Garage _____

Wall to Garage _____

Basement Wall _____
(continuous insulation)

Conditioned Slab _____

Energy Codes

2015 IECC Prescriptive Code R-Values

Values for Climate Zone 4

Sloped Ceilings **R-49**

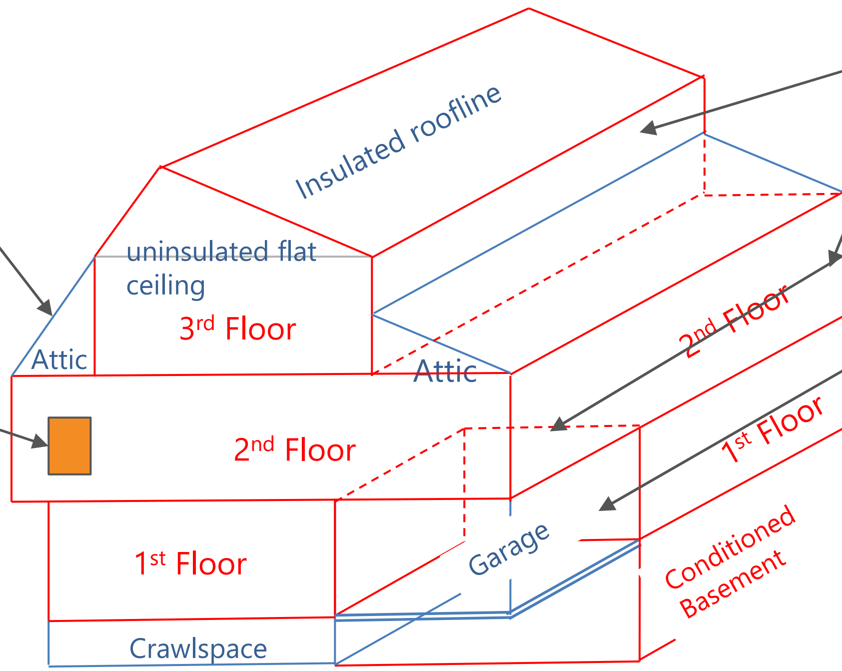
Attic Knee wall **R-20**

Flat Ceiling **R-49**

Window **U-0.35/0.32 SHGC- 0.40**

Cantilever Floor **R-19**

Floor Over Crawl **R-19**



Exterior Wall **R-20**

Floor Over Garage **R-19**

Wall to Garage **R-20**

Basement Wall (continuous insulation) **R-10**

Conditioned Slab **R-10, 2’**

Missouri Residential Energy Code Baseline Study

In 2016, the Midwest Energy Efficiency Alliance (MEEA) was contracted by the Missouri Department of Economic Development Division of Energy (DED/DE) to collect data about current Missouri residential construction practices as they relate to the **2009 International Energy Conservation Code (IECC).**

5

Patterns of Noncompliance

The study found five **"patterns of noncompliance"** in which buildings failed to meet 2009 standards:

1. **Duct Leakage** (unconditioned space)
2. **Duct Sealing** (conditioned space)
3. **Exterior Wall Insulation Installation Quality**
4. **High Efficacy Lights**
5. **Basement Wall Insulation**

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Section 402.2: Insulation Requirements

- Details for insulating various aspects of the building envelope:
  - **Ceilings with Attic – 402.2.1**
  - **Ceilings w/out Attic – 402.2.2**
  - **Eave baffles – 402.2.3**
  - **Access hatches and doors– 402.2.4**
  - Mass Walls – 402.2.5
  - Steel Framing – 402.2.6
  - Partial Structural sheathed walls – 402.2.7
  - **Floors – 402.2.8**
  - **Basement Walls – 402.2.9**
  - Slab-on-grade – 402.2.10
  - **Crawlspace Walls – 402.2.11**
  - Masonry Veneer – 402.2.12
  - Sunrooms – 402.2.13

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402.2.1 - Ceilings with Attics

- R-30 (CZ3) and R-38 (CZ4) is prescriptive requirement.
  - 2018 values are R-38 and R-49, respectively.
- Rulers required every 300 s.f.

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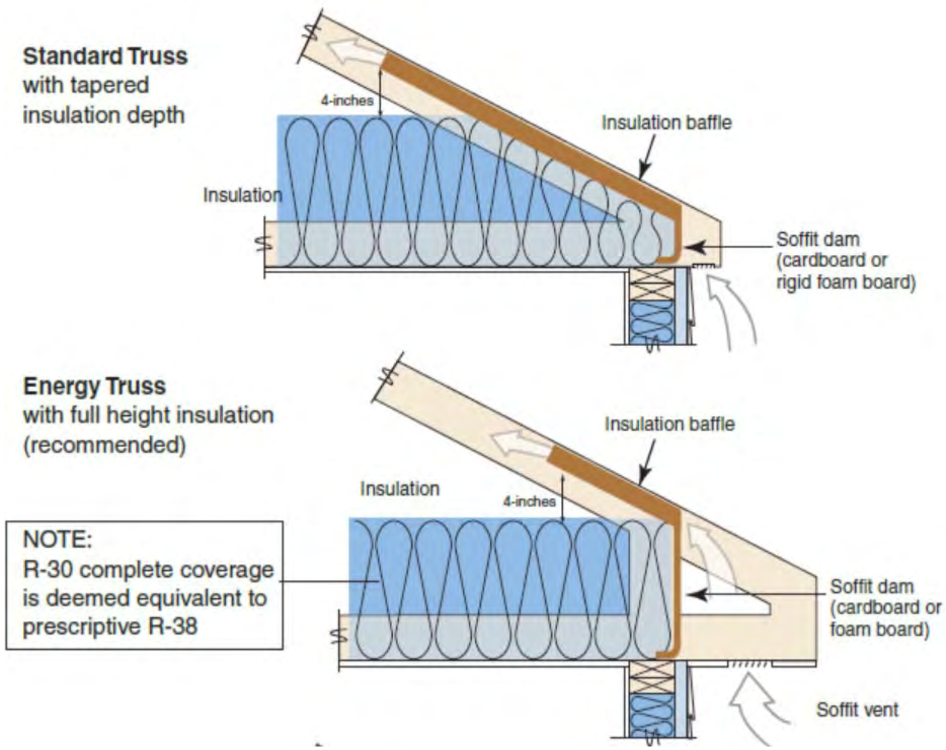
Insulation Requirements

402.2.1 Ceilings with Attics



R402.2.1 Ceilings with attic spaces. Where Section R402.1.2 would require R-38 insulation in the ceiling, installing R-30 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-38 wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Similarly, where Section R402.1.2 would require R-49 insulation in the ceiling, installing R-38 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the total UA alternative in Section R402.1.5.

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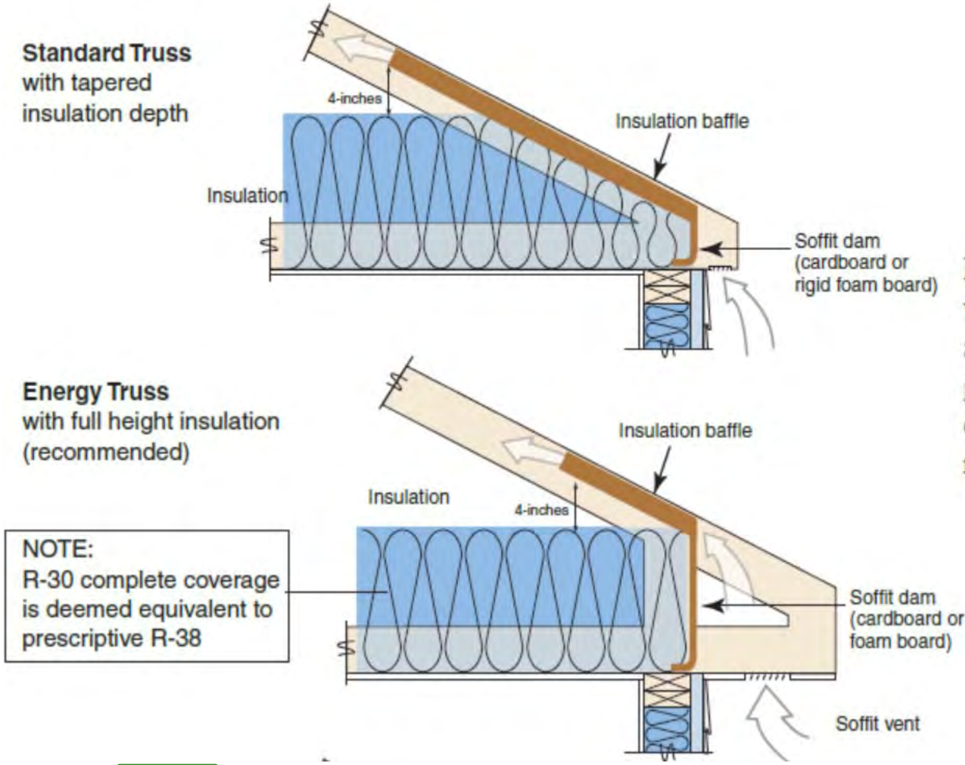
402.2.3 Eave Baffles



R402.2.3 Eave baffle. For air-permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.

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402.2.2 - Ceilings without Attics

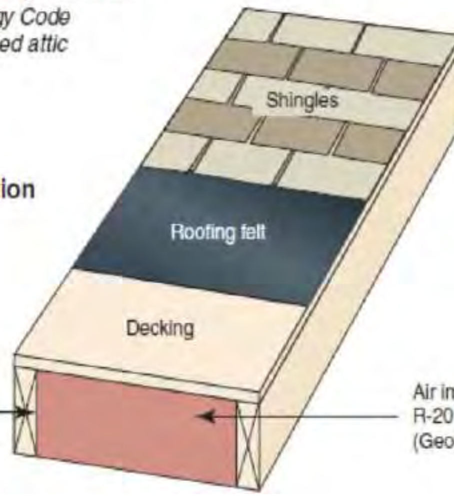
- R-30 for 20% (up to 500 s.f.) acceptable for CZ4&5
- Vaulted ceilings and foam sprayed rooflines will need to perform an R-value trade-off

Roofline Installed Insulation Options

Reference Table 402.1.1 and 402.1.6 in the Georgia Energy Code amendments to the 2015 IECC and Section 806.5 "unvented attic assemblies" in the IRC

R402.2.2 Ceilings without attic spaces. Where Section R402.1.2 requires insulation *R*-values greater than R-30 in the ceiling and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation *R*-value for such roof/ceiling assemblies shall be R-30. Insulation shall extend over the top of the wall plate to the outer edge of such plate and shall not be compressed. This reduction of insulation from the requirements of Section R402.1.2 shall be limited to 500 square feet (46 m²) or 20 percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.

Vaulted unvented attic – roofline air-impermeable insulation
(e.g., spray foam insulation)



Air impermeable insulation (e.g., open- or closed-cell spray foam)

Air impermeable insulation R-20 minimum if trade-offs are used (Georgia requirements)

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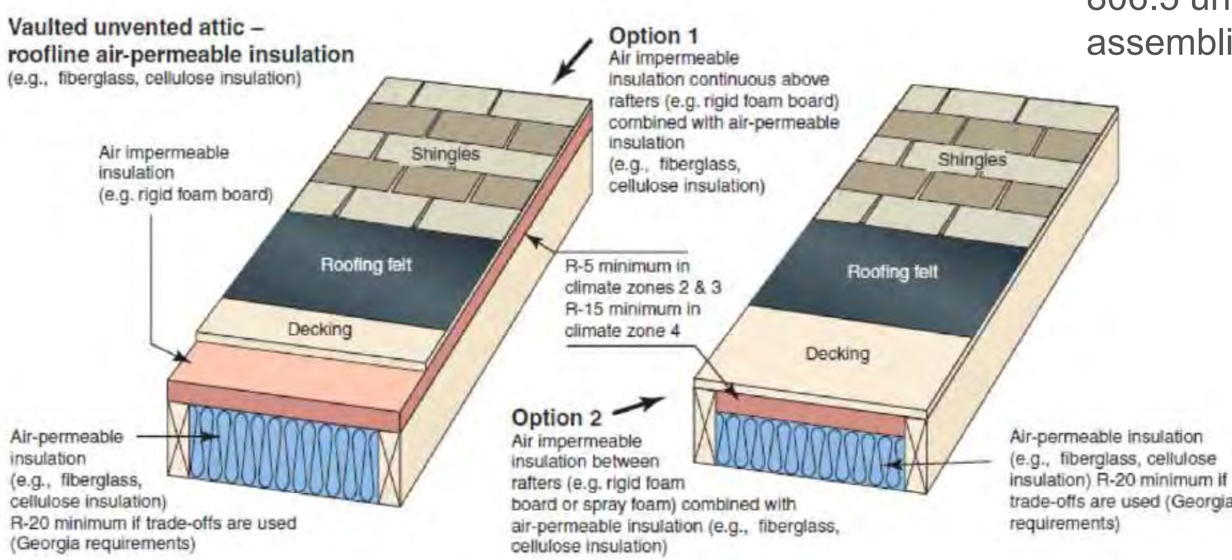
402.2.2 - Ceilings without Attics

- Can use fiberglass or cellulose in vault for unvented roofs (air-permeable insulation) with added:
  - R-15 (CZ 4) rigid foam board

Reference IRC Section 806.5 unvented attic assemblies



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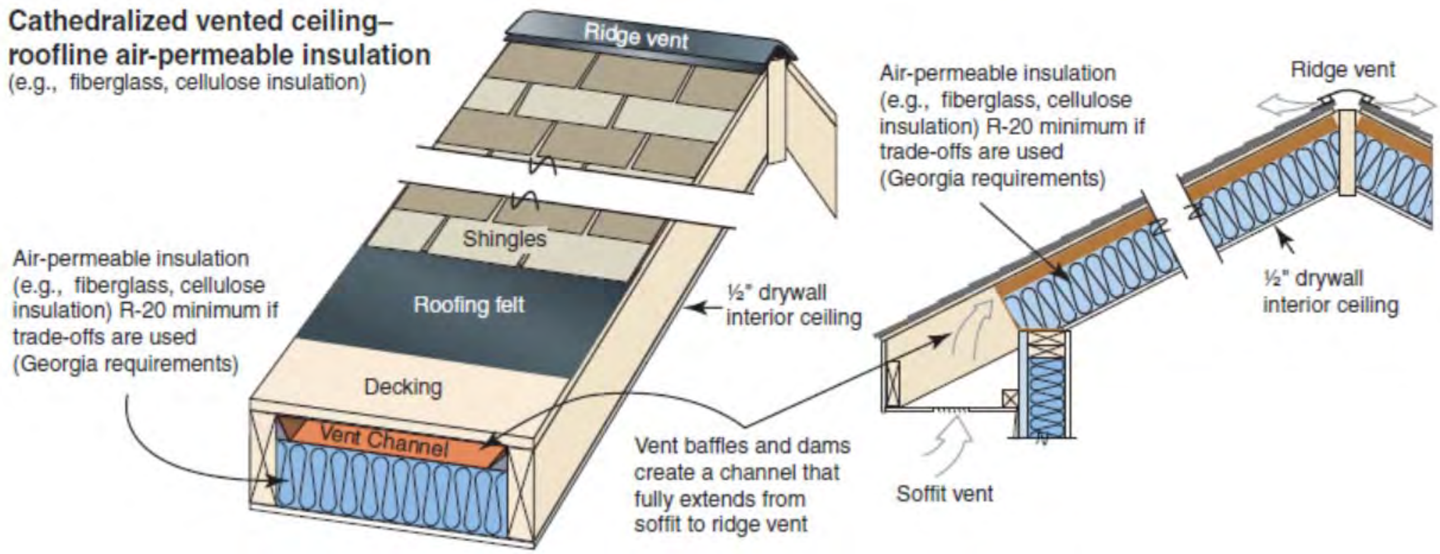
402.2.2 - Ceilings without Attics

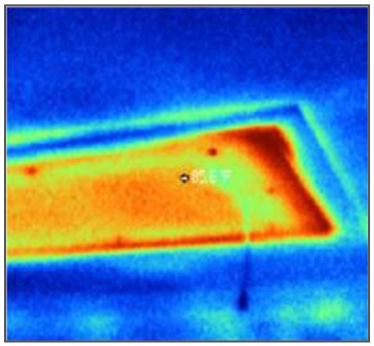
- Old school approach



402.2.4 Access Hatches and Doors

- Attic access cover at same R-value as ceiling

- For an attic with 990 s.f. = R-38, and 10 s.f. = R-1, Effective R-value = R-29!



402.2.8 Floors

- Insulation must maintain ***continuous permanent*** contact against subfloor.

R402.2.8 Floors. Floor framing-*cavity insulation* shall be installed to maintain permanent contact with the underside of the subfloor decking.

Exception: As an alternative, the floor framing-*cavity insulation* shall be in contact with the topside of sheathing or continuous insulation installed on the bottom side of floor framing where combined with insulation that meets or exceeds the minimum wood frame wall *R*-value in Table R402.1.2 and that extends from the bottom to the top of all perimeter floor framing members.

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