The Latest (2021) IECC Energy Codes & High-Performance Homes in MO

Matt Belcher
MO Energy Code Support
Mike Barcik
Southface Energy Institute

- Top Ten List of High Perf Design
- Building Science
- Code Envelope Overview
- MO Energy Code Study
- Mechanicals
- Inspection Checklist

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Energy Code Resources

https://codes.iccsafe.org/content/IECC2021P2

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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

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Learning Objectives

- Grasp design priorities for a High-Performance Home
- Review Building Science basics – Heat, Air, Moisture
- Identify standards for insulation requirements and fenestration performance from 2021 IECC
- Define the building envelope and identify best practices for air sealing (and understand blower door testing requirements)
- Identify opportunities resulting from Missouri Residential Energy Code Field Study
- Identify requirements and best practices for heating and cooling (mechanical and ductwork) and fresh air ventilation systems
- View example compliance checklist & images

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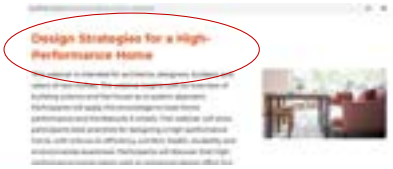
Learn More at www.southface.org

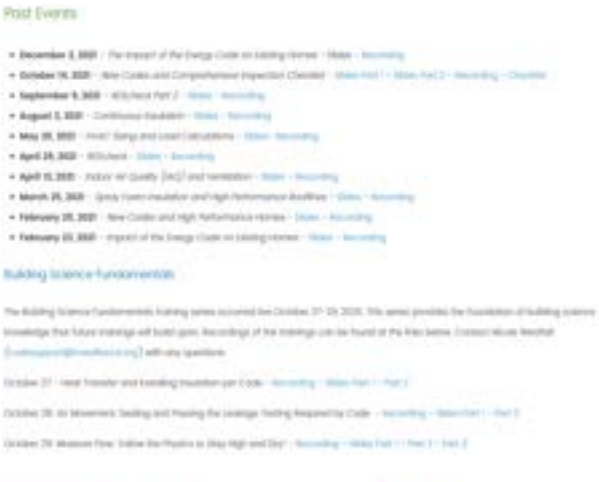
- Energy Code Resources
- 12 BS webinars
  - Heat Transfer
  - Air Movement
  - Moisture Flow
  - Insulation Installation
  - Ventilation – Concepts & Calcs
  - Ventilation – Strategies & Apps
  - Conditioned Crawlspaces
  - Ducted Mechanicals
  - Insulated Rooflines
  - Combustion Safety
  - HVAC Load Calcs
  - Design High Perf Homes

https://www.southface.org/insights/building-science-webinars/



Learn More at MEEA

https://www.mwalliance.org/ameren-missouri-residential-energy-code-support-program



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Part 1

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
- **Distribution - Air (& hot water)**
  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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Part 1

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

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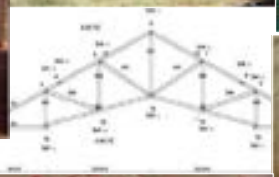
Top Ten List – Ducts

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**
   Prescriptive R-values from 2021 IECC prescriptive chart Walls ~R-20+
   thermal break with continuous insulation (rock wool) & efficient framing
   Insulate foundation walls versus floors – basements, conditioned crawlspaces




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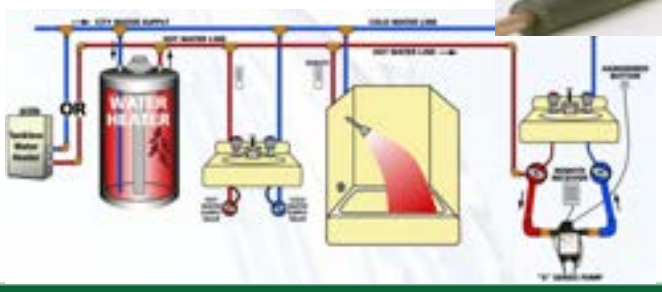
Top Ten List – Mechanical

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



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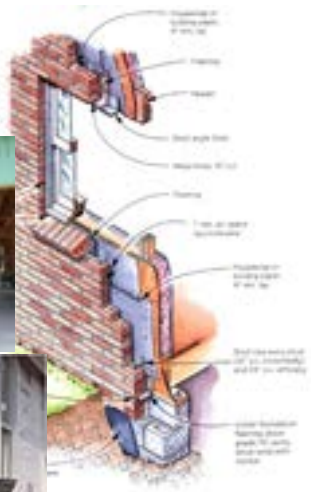
Top Ten List – Water

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



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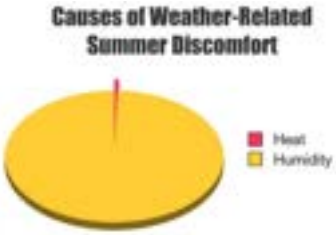
Top Ten - Humidity

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
CFAM	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
			100 CFM	26.3
			110 CFM	27.5
			120 CFM	30.1

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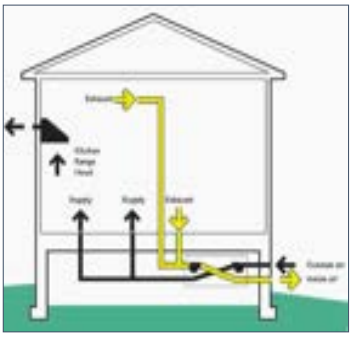
Top Ten List – Fresh Air

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
DC motor ceiling fans

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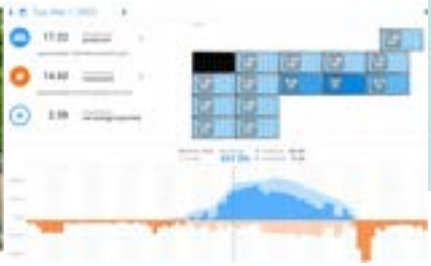
Top Ten List – Renewables

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 – batteries & EV's



Designing for Solar Panels

Early Design Checklist

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

- www.greenbuildingadvisor.com

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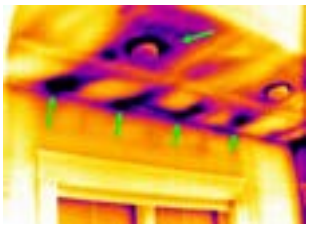
Technology / Programs Can Help

- **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*



Part 2

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.

?

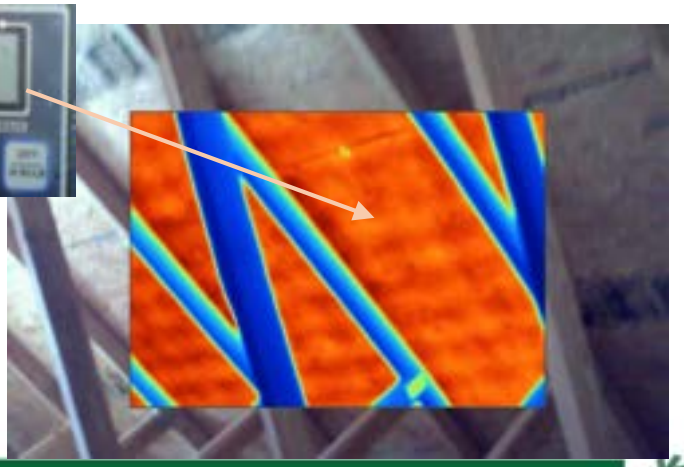
What parts of this house are enclosed by the thermal envelope?

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: Radiation

- Low-emitting surfaces slow radiation



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Knowledge Check

Heat Transfer Problem

Your Choices:

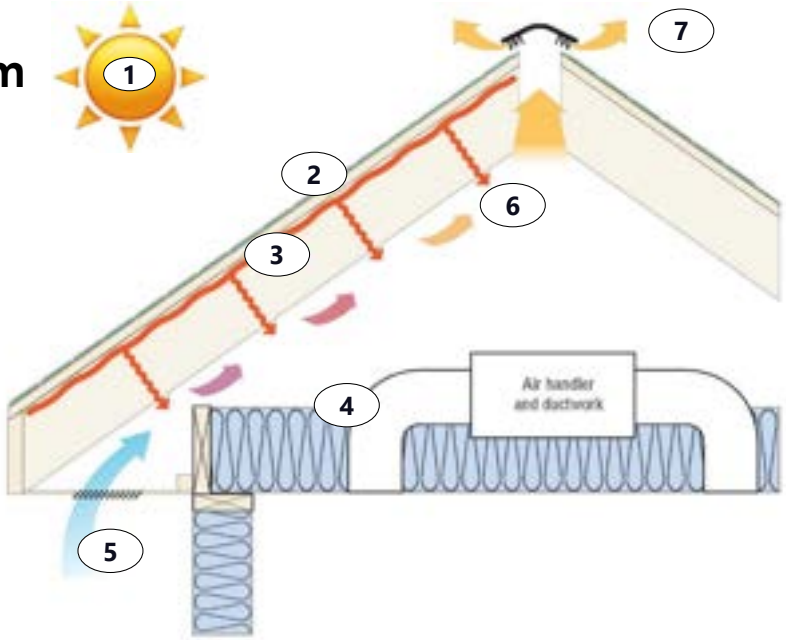
- **Radiation**
- **Conduction**
- **Convection**

1 → 2 = Radiation

2 → 3 = Conduction

3 → 4 = Radiation

5 → 6 → 7 = Convection



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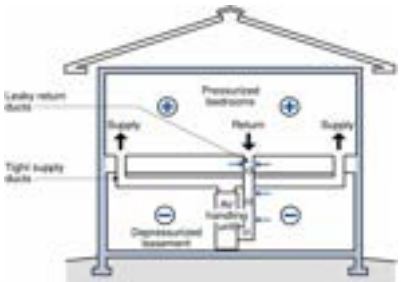
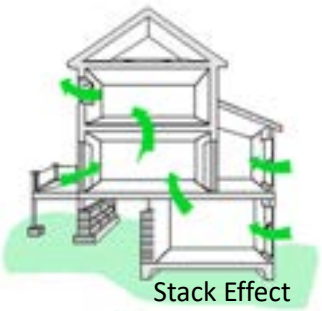
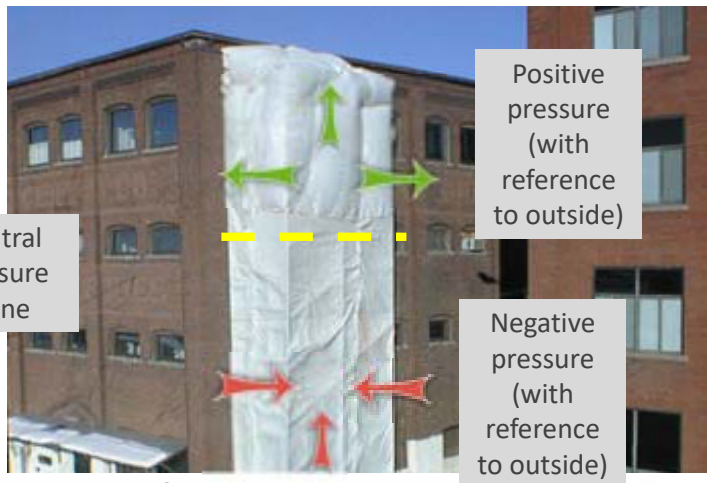
Air Flow

- 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)





Stack Effect



Vermont Energy Investment Corp.

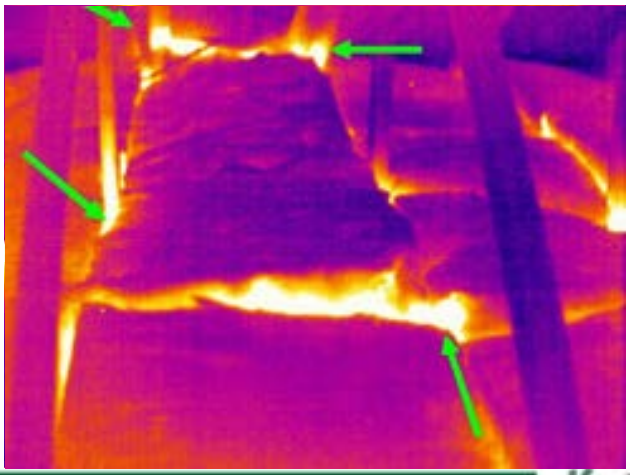
Thermal and Air Barriers

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)

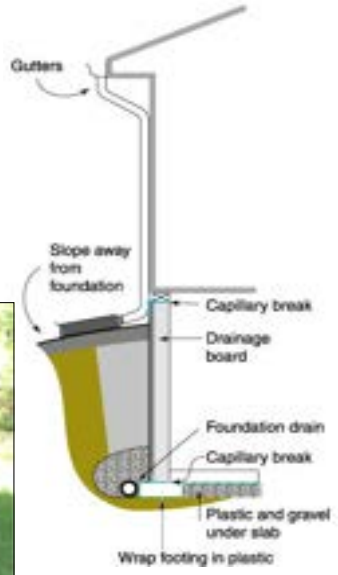
Geography matters! What works in one region may not work in another

Appropriate measures for moisture control are essential!

Building Science: Moisture Transport

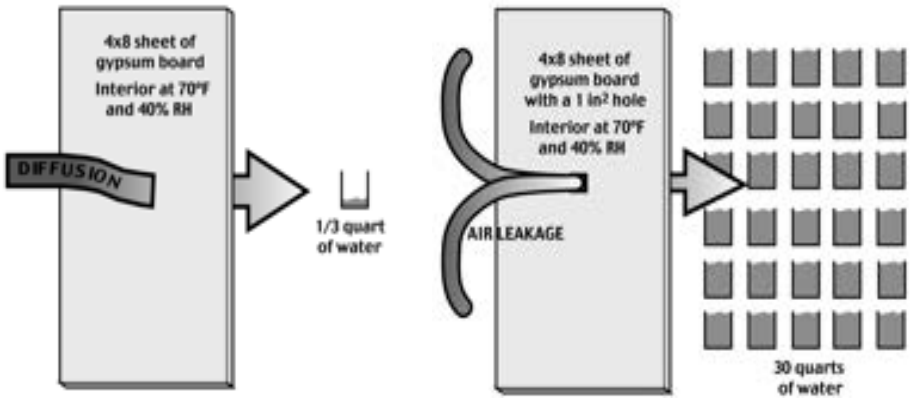
Bulk Moisture Control

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



Building Science: Moisture Transport

Diffusion Vs. Air Leakage



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

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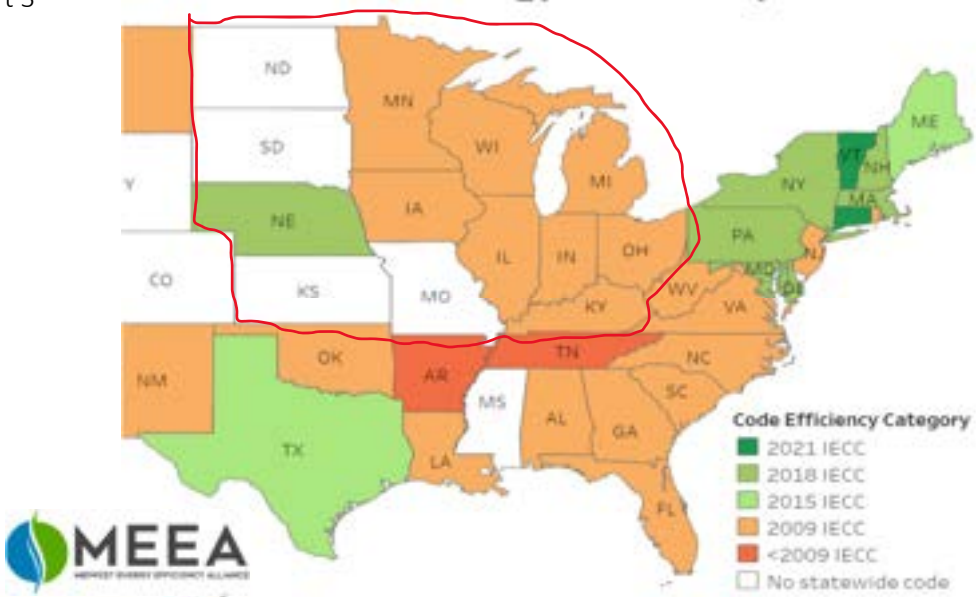
Part 3

Midwest Residential Energy Code Adoption



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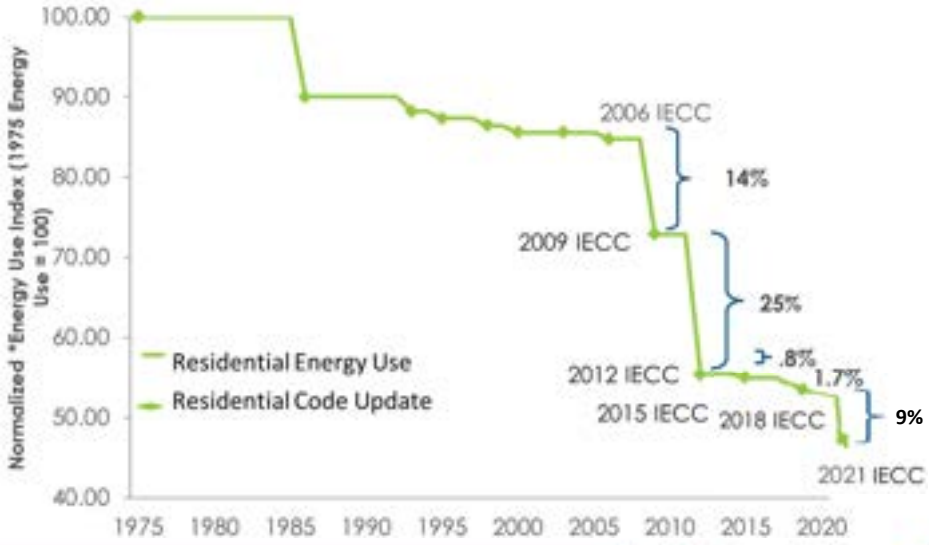
Part 3

Residential Energy Code Background



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Part 3

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
  - Ceilings, walls, windows, floors, foundations
  - Sets insulation levels, window U-factors and SHGC
  - Infiltration control
    - Caulk and seal to prevent air leaks
    - Verify envelope tightness with blower door test (or visual inspection for 2009 code)
- Ducts
  - No building cavities as ducts (post-2009)
  - Seal properly and insulate even if all ductwork is in conditioned space
  - Verify tight with duct pressurization test (2009 on)
- Lighting equipment
  - High-efficacy bulbs required (50%, 75%, 90%, 100%)
- HVAC equipment efficiencies covered by different DOE standard
- No appliance requirements

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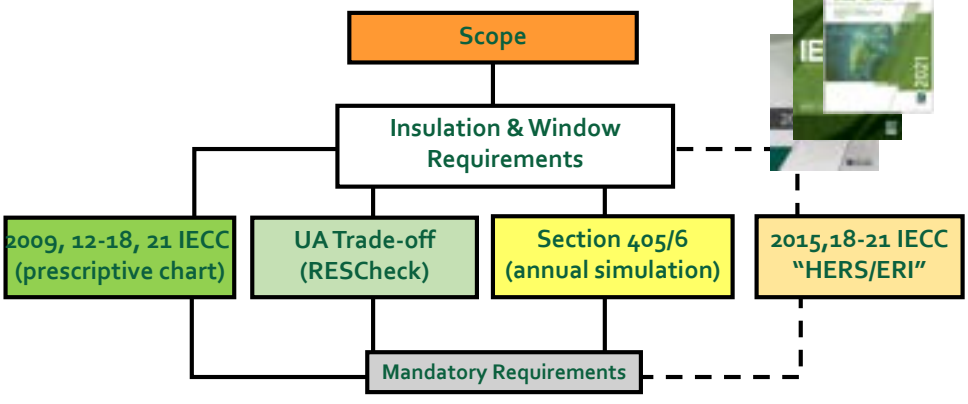
Compliance Paths



- The Energy Rating Index (ERI) path gives the most design flexibility (e.g., credit for mechanical equipment efficiency)

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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	CRAWL SPACE WALL R-VALUE
1	1.2	0.75	0.30	30	13	3/4	13	0	0	0
2	0.65[f]	0.75	0.30	30	13	4/6	13	0	0	0
3	0.50[f]	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

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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 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19

402.1.4 is similar table for U-factors (get U-values from RESCheck)

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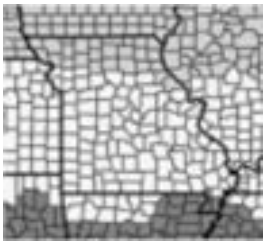
Energy Codes

2021 IECC

- Buchanon, Caldwell, Chariton, Clinton, are now CZ 4A
- Dunklin & Pemiscot, are now CZ 3A



- One prescriptive "answer" for how to build per climate zone (now CZ: 3, 4, 5)

2021

TABLE R402.1.3 INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b, i]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE[f]	MASS WALL R-VALUE[g]	FLOOR R-VALUE	BASEMENT[c, i] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c, i] WALL R-VALUE
1	.30	0.55	0.25	49	20 or 13+5[h] or 15/17	8/13	19	5ci or 13[i]	10ci, 2 ft	5ci or 13[i]
2 except Marine	.30	0.55	0.40	60	20 or 20&5ci[h] or 13&10ci[h] or 15/20[h]	8/13	19	10ci or 13	10ci, 4 ft	10ci or 13
3 and Marine 4	0.32	0.55	0.40	60	20 or 20&5ci[h] or 13&10ci[h] or 15/20[h]	13/17	30	15ci or 13 or 13&5ci	15ci, 4 ft	15ci or 13 or 13&5ci
4	0.30	0.55	NR	60	20 or 20&5ci[h] or 13&10ci[h] or 15/20[h]	15/20	30	15ci or 13 or 13&5ci	10ci, 4 ft	15ci or 13 or 13&5ci

402.1.2 is similar table for U-factors (get U-values from RESCheck)

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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 threshold of ceiling insulation
- 90% Efficient Lighting (LED's)
- ERI relaxed targets (62 for CZ4, 61 for CZ5, backstop penalty for renewables)

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IECC Code Differences – ’18 to ’21

- Redefined CZ’s for 6 counties in MO
- Window Ufactors dropped (more stringent)
- Wall and ceiling R-values increased
- Attic pull-down stairs details – R-13 okay for CZ1-4
- Floor insulation options
- Basement options
- Sunrooms and heated garage separation
- Ducts in conditioned space
  - Must now be tested < 8% Total Leakage
  - Ducts outside, still tested < 4% Total Leakage
- Ventilation fans (kitchen, bath, whole house) have airflow verified to meet minimum required by IMC
- 100% efficient lighting and controls (dimmer, occupant sensors, with exceptions; exterior)
- Additional Efficiency Package - required

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IECC Code’21

- Section 408 Additional Efficiency Package – 1 required

SECTION R408
ADDITIONAL EFFICIENCY PACKAGE OPTIONS

R408.1 Scope.
This section establishes additional efficiency package options to achieve additional energy efficiency in accordance with Section R401.2.5.

R408.2 Additional efficiency package options.
Additional efficiency package options for compliance with Section R401.2.1 are set forth in Sections R408.2.1 through R408.2.5.

R408.2.1 Enhanced envelope performance option.
The total building thermal envelope UA, the sum of U-factor times assembly area, shall be less than or equal to 95 percent of the total UA resulting from multiplying the U-factors in Table R402.1.2 by the same assembly area as in the proposed building. The UA calculation shall be performed in accordance with Section R402.1.5. The area-weighted average SHGC of all glazed fenestration shall be less than or equal to 95 percent of the maximum glazed fenestration SHGC in Table R402.1.2.

R408.2.2 More efficient HVAC equipment performance option.
Heating and cooling equipment shall meet one of the following efficiencies:

1. Greater than or equal to 95 AFUE natural gas furnace and 16 SEER air conditioner.
2. Greater than or equal to 10 HSPF/16 SEER air source heat pump.
3. Greater than or equal to 3.5 COP ground source heat pump.

For multiple cooling systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the cooling design load. For multiple heating systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the heating design load.

- Envelope is 5% better
- HVAC efficiency

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IECC Code'21

- 408 Additional Efficiency Package (cont.) – 1 required

R408.2.3 Reduced energy use in service water-heating option.
The hot water system shall meet one of the following efficiencies:
1. Greater than or equal to 0.82 EF fossil fuel service water-heating system.
2. Greater than or equal to 2.0 EF electric service water-heating system.
3. Greater than or equal to 0.4 solar fraction solar water-heating system.

- Water heater efficiency

R408.2.4 More efficient duct thermal distribution system option.
The thermal distribution system shall meet one of the following efficiencies:
1. 100 percent of ducts and air handlers located entirely within the *building thermal envelope*.
2. 100 percent of ductless thermal distribution system or hydronic thermal distribution system located completely inside the *building thermal envelope*.
3. 100 percent of duct thermal distribution system located in *conditioned space* as defined by Section R403.3.2.

- Ducts inside envelope

R408.2.5 Improved air sealing and efficient ventilation system option.
The measured air leakage rate shall be less than or equal to 3.0 ACH50, with either an Energy Recovery Ventilator (ERV) or Heat Recovery Ventilator (HRV) installed. Minimum HRV and ERV requirements, measured at the lowest tested net supply airflow, shall be greater than or equal to 75 percent Sensible Recovery Efficiency (SRE), less than or equal to 1.1 cubic feet per minute per watt (0.03 m^3/min/watt) and shall not use recirculation as a defrost strategy. In addition, the ERV shall be greater than or equal to 50 percent Latent Recovery/Moisture Transfer (LRMT).

- Tight home with ERV/HRV

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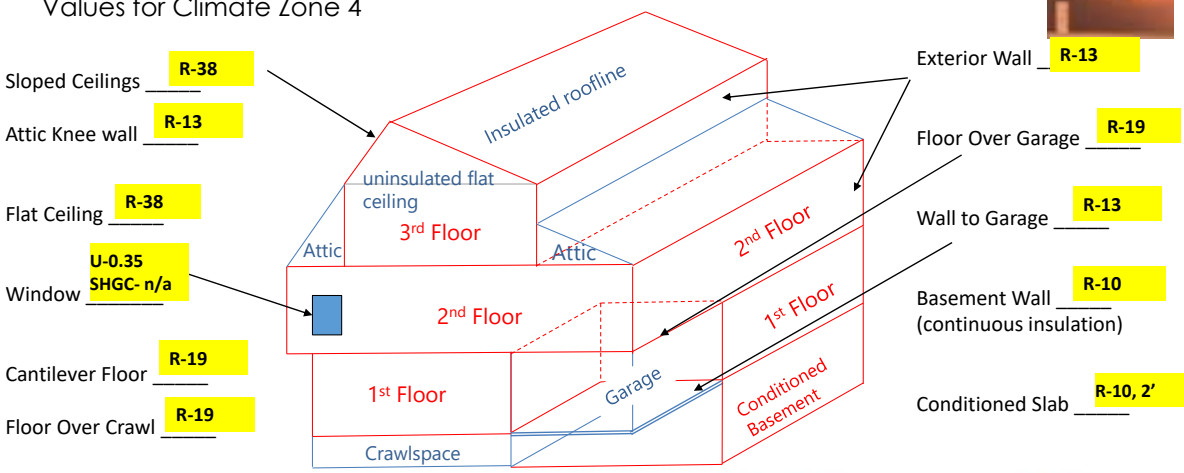
Energy Codes

2009 IECC Prescriptive Code R-Values

Values for Climate Zone 4



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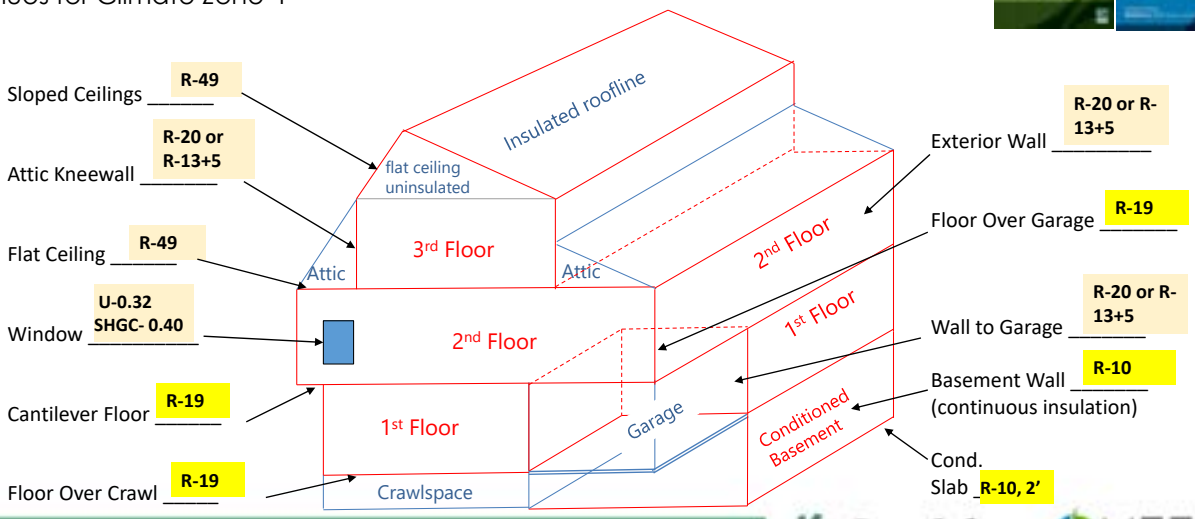
Energy Codes

2018 IECC/IRC Prescriptive Code R-Values

Values for Climate Zone 4



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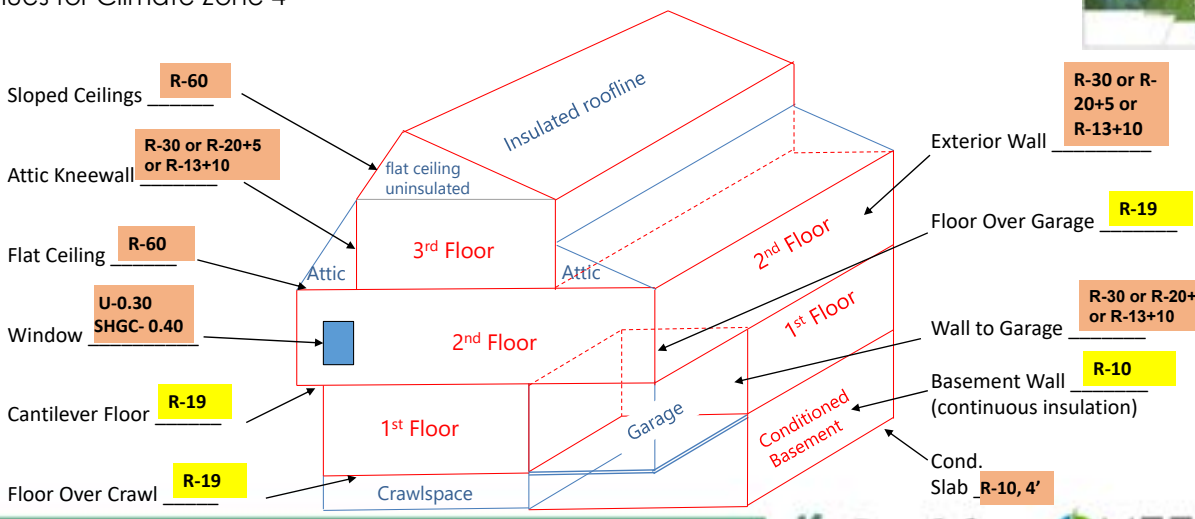
Energy Codes

2021 IECC/IRC Prescriptive Code R-Values

Values for Climate Zone 4



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Section 402.2: Insulation Requirements

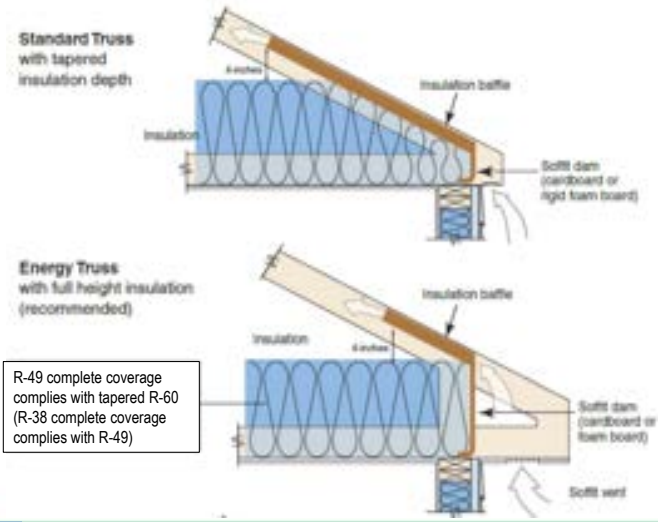
- Details for insulating various aspects of the building envelope:
  - **Ceilings with Attic – 402.2.1**
  - **Ceilings w/out Attic – 402.2.2**
  - **Eave baffles – 402.2.3**
  - **Access hatches and doors– 402.2.4**
  - Mass Walls – 402.2.5
  - Steel Framing – 402.2.6
  - **Floors – 402.2.7**
  - **Basement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

402.2.1 - Ceilings with Attics

- R-49 (CZ3) and R-60 (CZ4-5) is prescriptive requirement
- Rulers required every 300 s.f.

Insulation Requirements

402.2.1 Ceilings with Attics



R-49 complete coverage complies with tapered R-60 (R-38 complete coverage complies with R-49)

R402.2.1 Ceilings with attics.

Where Section R402.1.3 requires R-49 insulation in the ceiling or attic, installing R-38 over 100 percent of the ceiling or attic area requiring insulation shall 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. Where Section R402.1.3 requires R-60 insulation in the ceiling or attic, installing R-49 over 100 percent of the ceiling or attic area requiring insulation shall satisfy the requirement for R-60 insulation wherever the full height of uncompressed R-49 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the insulation and fenestration criteria in Section R402.1.2 and the Total UA alternative in Section R402.1.5.

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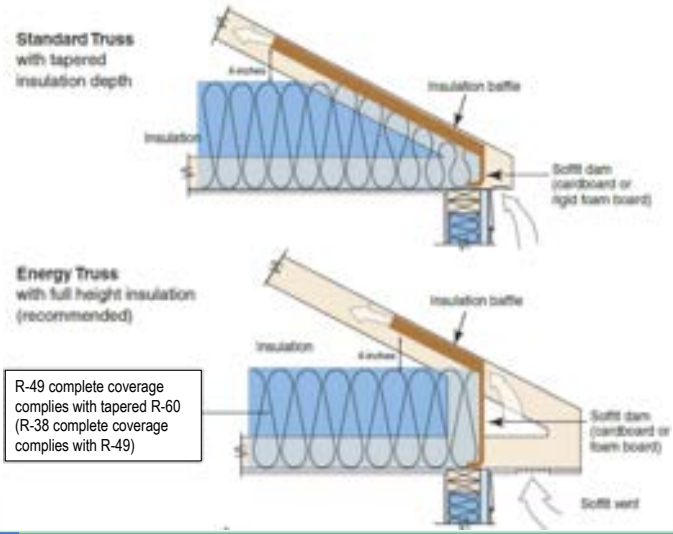
Insulation Requirements

402.2.3 Eave Baffles



R-49 complete coverage complies with tapered R-60 (R-38 complete coverage complies with R-49)

R402.2.3 Eave baffle.

For air-permeable insulation in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain a net free area opening equal to 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. The baffle shall be installed to the outer edge of the exterior wall top plate so as to provide maximum space for attic insulation coverage over the top plate. Where soffit venting is not continuous, baffles shall be installed continuously to prevent ventilation air in the eave soffit from bypassing the baffle.

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402.2.2 - Ceilings without Attics

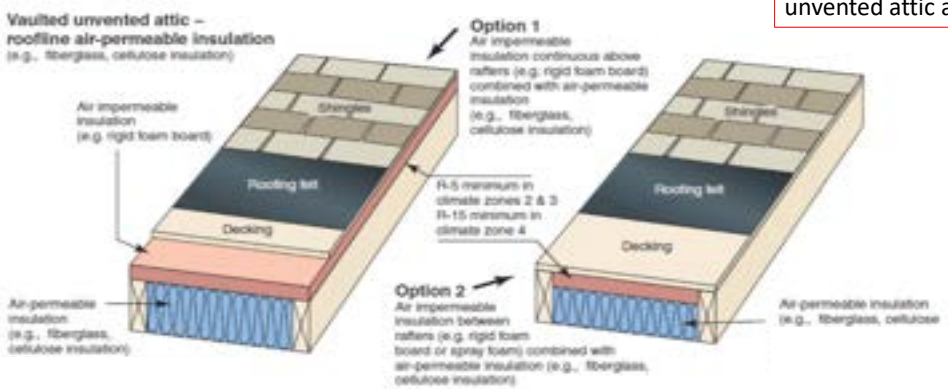
- R-30 for 20% (up to 500 s.f.) acceptable for CZ4&5
- Vaulted ceilings and foam sprayed rooflines will need to perform an R-value trade-off

Insulation Requirements

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

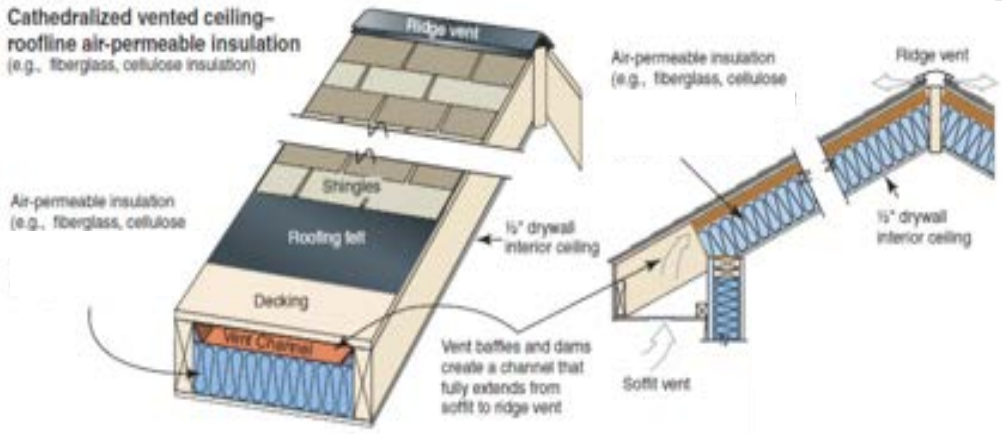
Reference IRC Section 806.5 unvented attic assemblies



Insulation Requirements

402.2.2 - Ceilings without Attics

- Old school approach



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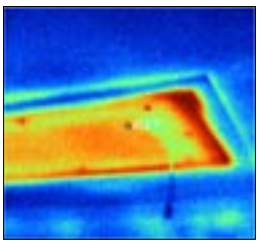
Insulation Requirements

402.2.4 Access Hatches & Doors

- Attic access at same R-value as wall/ceiling
- Exception for pull-down stairs CZ 0-4

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



R402.2.4 Access hatches and doors.

Access hatches and doors from conditioned to unconditioned spaces such as attics and crawl spaces shall be insulated to the same *R*-value required by Table R402.1.3 for the wall or ceiling in which they are installed.

Exceptions:

1. Vertical doors providing access from conditioned spaces to unconditioned spaces that comply with the fenestration requirements of Table R402.1.3 based on the applicable climate zone specified in Chapter 3.
2. Horizontal pull-down, stair-type access hatches in ceiling assemblies that provide access from conditioned to unconditioned spaces in Climate Zones 0 through 4 shall not be required to comply with the insulation level of the surrounding surfaces provided the hatch meets all of the following:
   2.1. The average *U*-factor of the hatch shall be less than or equal to *U*-0.10 or have an average insulation *R*-value of R-10 or greater.
   2.2. Not less than 75 percent of the panel area shall have an insulation *R*-value of R-13 or greater.
   2.3. The net area of the framed opening shall be less than or equal to 13.5 square feet (1.25 m²).
   2.4. The perimeter of the hatch edge shall be weatherstripped.

- Nominal R-13

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402.2.8 Floors

- Insulation should maintain ***continuous permanent*** contact against subfloor

R402.2.7 Floors.

Floor cavity insulation shall comply with one of the following:

1. Installation shall be installed to maintain permanent contact with the underside of the subfloor decking in accordance with manufacturer instructions to maintain required *R*-value or readily fill the available cavity space.
2. Floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing separating the cavity and the unconditioned space below. Insulation shall extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed.
3. A combination of cavity and continuous insulation shall be installed so that the cavity insulation is in contact with the top side of the continuous insulation that is installed on the underside of the floor framing separating the cavity and the unconditioned space below. The combined *R*-value of the cavity and continuous insulation shall equal the required *R*-value for floors. Insulation shall extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed.

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Reality of Underfloor Insulation

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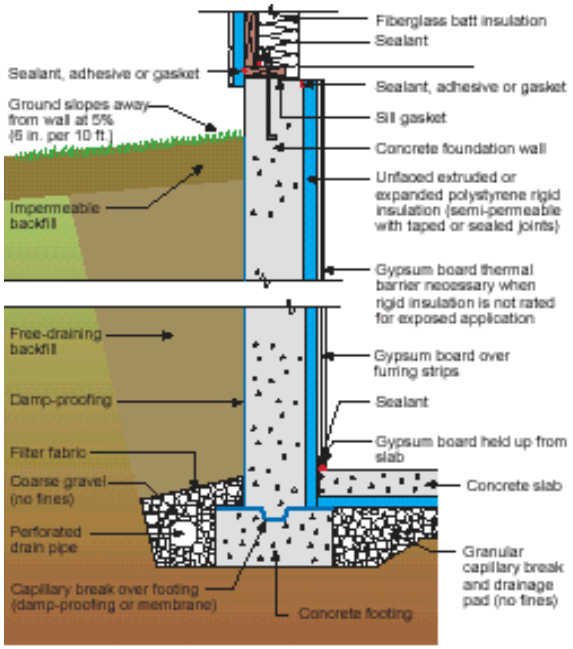
Insulating Basements

www.eeba.org
www.buildingscience.com



Systems Approach to Walkout Basements

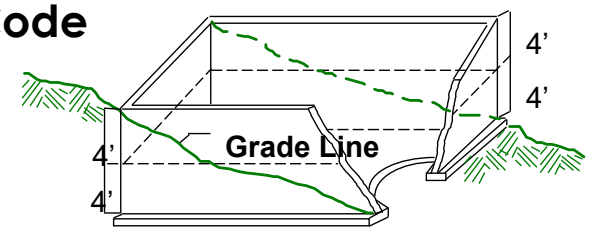
Advantages to insulating *all* basement walls:

- Wall insulation lasts longer and works well (R-10 wall in CZ4 vs. R-19 floor)
- Ducts and AHU are brought inside envelope
- Main floor level is more comfortable
- Basement may be finished or unfinished

Definition and Prescriptive Code

- Basement Wall: Average gross wall must be > 50% below grade and enclose conditioned space
- CZ4-5: R-10 continuous or R-13 cavity
  - 2018 CZ5=R-15/19

Try to avoid cavity insulation; continuous insulation performs better



Interior Insulation Strategies

Cellulose blanket/batt

Rigid foil-faced poly-iso foam board

Fiberglass batt w/ vinyl backing

Insulating Basements

Interior Insulation Strategies

Rigid foam board

Fiberglass batt in AGW, foam board on concrete

Spray Polyurethane Foam

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Insulating Basements

Interior Insulation Strategies

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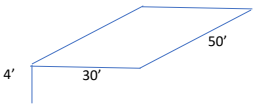
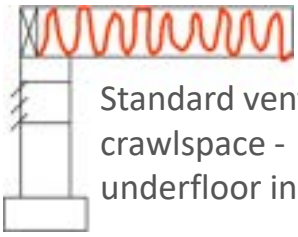
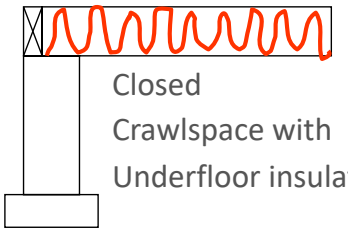
R402.2.11 Crawlspace Walls

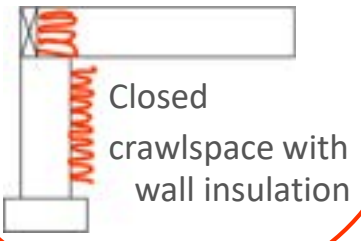




Standard vented crawlspace - underfloor insulation



Closed Crawlspace with Underfloor insulation



Closed crawlspace with wall insulation

- **Note**: all crawspaces must meet vapor retarder requirements, as per IRC
  (exception for open crawlspaces)

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R402.2.11 Crawlspace Walls

- Seal ground with 6-mil plastic (6" up walls, 6" overlaps)
- Insulate interior of walls to satisfy code (R-10 in CZ4, R-15 in CZ5)
- Eliminate all vents and leaks (access doors)
- Satisfy IRC exception to vent requirement (IRC section R408.3)

Venting Exceptions:

- Continuous exhaust (radon)
- Direct condition crawlspace (supply)
- Direct condition (dehumidifier)

Critical Details:

- No drainage problems
- Use a sealed combustion / direct vent furnace or install a Heat Pump
- Pest Control and Code Official awareness

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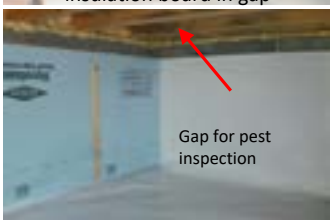
Insulation techniques – Walls



www.crawlspaces.org

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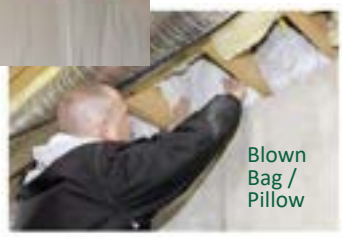
Insulation techniques – Rim/band area

Open/ Closed Cell Foam

Caulk and Fiberglass Batt

- Pest Control industry struggles with band area fully filled with SPF
- SPF that fills band blocks inspection for pest control
- Air seal and then insulate with movable insulation product (batts, pillows, rigid board, etc.)

- Must air seal and insulate rim/band area in basements & crawlspaces



Blown Bag / Pillow

The band-joist area can be a challenge to insulat correctly, with some contractors opting for fiberglass batt rather than the complications of spray foam. For installers working with blown fiberglass or cellulose, National Fiber offers another option. Its Insul-Cube is a fire-rated bag can be filled with blown insulation on-site, then friction-fit between the joists. The amount of insulation used will vary according to the size of the space, and the cubes can be filled-in-place behind pipes or wires. National Fiber |

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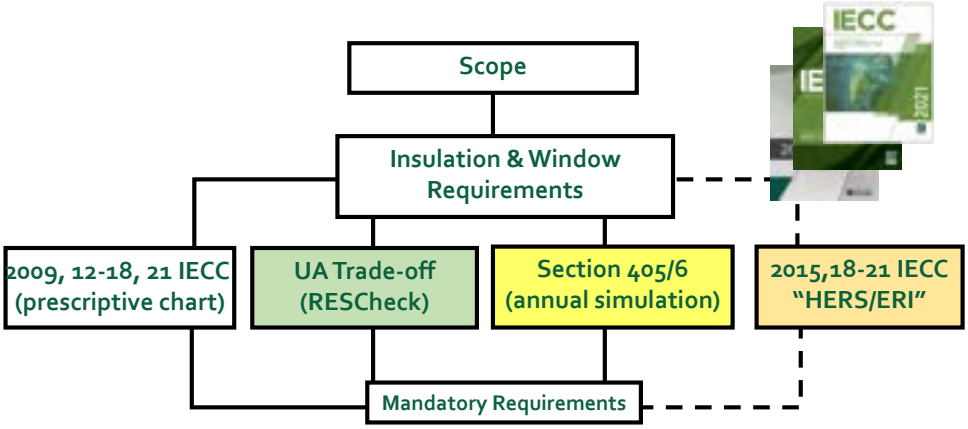
Envelope Tradeoff Options



- The Energy Rating Index (ERI) path gives the most design flexibility (e.g., credit for mechanical equipment efficiency)

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REScheck Tradeoff Option

- www.energycodes.gov
- Software evaluates specific designs quickly
- Demonstrates SHGC compliance
- Allows trade-offs
  - Building envelope components
  - No trade-offs for better heating & cooling equipment efficiencies
- Specify code edition

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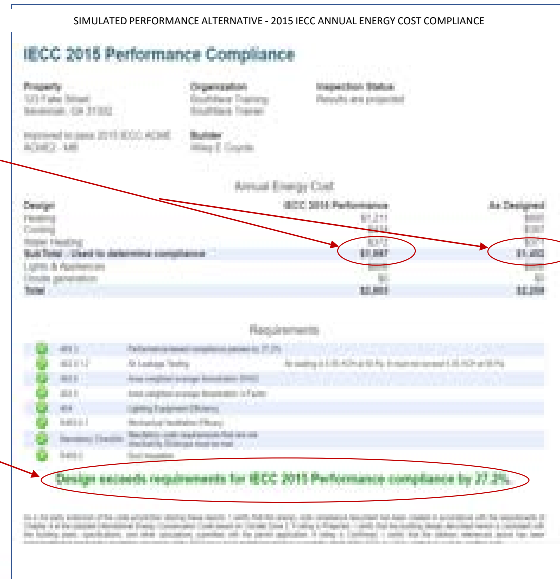
Section 405 Simulated Performance Alternative - Sample Report

- Annual energy usage simulation demonstrates that the proposed building's energy costs are ≤ "standard code" building
- No credit for mechanical efficiencies
- Likely to involve a HERS rater
- Ekotrope, REMrate & Energy Gauge are acceptable

- Compares total annual energy costs
  - Window U-factor and SHGC
  - Envelope and duct testing
  - Lighting, duct insulation
- Compares energy costs of actual home being built against IECC reference home's energy cost



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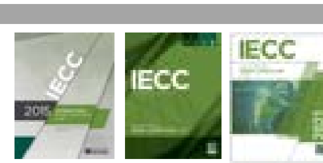
Energy Rating Index (ERI) path



The ERI may allow more options in materials choice, technologies and innovative strategies than the simulated performance path

- The 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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How is the ERI determined?

- The ERI is a numerical integer value
- Lower index numbers indicate lower energy use
- The HERS Index is similar to the ERI
- A HERS Index is generated from a HERS Rating using modeling software (e.g., Energy Gauge, REMRate, Ekotrope)
- HERS stands for *Home Energy Rating System*

RESNET HERS INDEX

HERS was developed by the Residential Energy Services Network (RESNET)

www.resnet.us

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Determining the Energy Rating Index

1. Simulate two homes
   - ***Rated*** Home – what will be built
   - ***Reference*** Home – same home but exactly meets '06 code
2. Compare Annual Energy
   - Space Heating & Cooling, Hot Water, Lighting and some Appliances
   - Multiply by 100 (lower w/ renewables)

$$\textbf{Index} = 100 \times PE_{fraction} \times \frac{[\textit{Rated}\ \text{Home's}\ \underset{40}{\text{Htg}} + \underset{30}{\text{Clg}} + \underset{30}{\text{WtrH}} + \underset{50}{\text{L.A.}}]}{[\textit{Refer}.\ \text{Home's}\ \underset{70}{\text{Htg}} + \underset{20}{\text{Clg}} + \underset{30}{\text{WtrH}} + \underset{80}{\text{L.A.}}]} = 75$$

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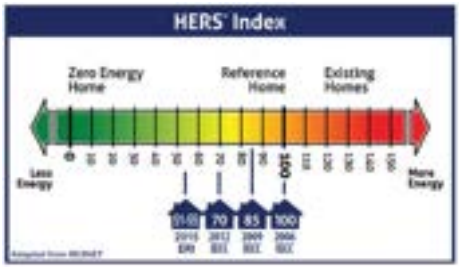
HERS / Energy Rating Index – What does it mean?

- HERS Index (lower is better)
- Rated home with Index of 100 = Reference home exactly meeting 2004/06 IECC
- Net Zero Energy Home = HERS Index of O



$$\textbf{Index} = 100 \times PE_{fraction} \times \frac{[\textbf{\textit{Rated}}\ \text{Home's Htg (40)} + \text{Clg (30)} + \text{WtrH (30)} + \text{L.A. (50)}]}{[\textbf{\textit{Refer}}.\ \text{Home's Htg (70)} + \text{Clg (20)} + \text{WtrH (30)} + \text{L.A. (80)}]} = 75$$

$PE_{fraction}$ is ratio of renewables to purchased energy
(If a home produces 2/3 of its annual energy, the $PE_{fraction}$ is 0.33) In this example, 0.33 x 75 = **25**

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Energy Rating Index: Target Values

- The 2015/18/21 IECC sets a maximum ERI for each climate zone
- The ERI is not a "magic bullet" or "easy"
- However, it opens more options and allows builders more credit for innovative strategies ("*the ERI shall consider all energy used in the residential building*")

TABLE R406.4
MAXIMUM ENERGY RATING INDEX

CLIMATE ZONE	ENERGY RATING INDEX	ENERGY RATING INDEX[a]
1	52	57
2	52	57
3	51	57
4	54	62
5	55	61
6	54	61
7	53	58
8	53	58

The rated design must have an ERI less than or equal to the above table to comply with IECC

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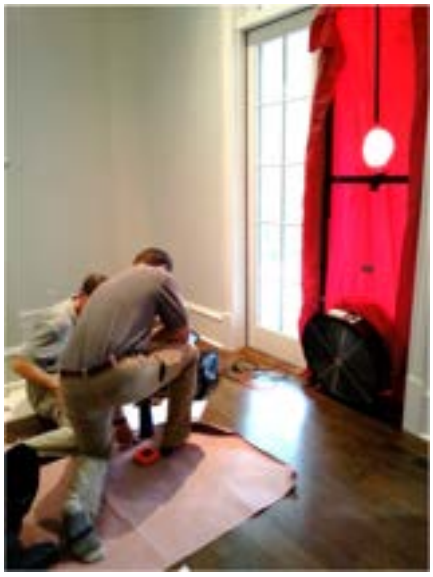
Blower Door Envelope Testing



- **IECC 2009 threshold: < 7 ACH50**
- **IECC 2012–21 threshold: < 3* ACH50** (CZ 3-8)
- Quantifies the Amount of Leakage Across the Home's Thermal Boundary
- Should be administered by a Certified Professional (e.g., DET Verifier, BPI, HERS)
- Reported to Builder and Code Official via Certificate

$$ACH_{50} = \frac{CFM50 \times 60}{Volume}$$

* 2021 IECC allows up to < 5 ACH50 with Simulation based trade-off

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How to Fail a Blower Door Test

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How to Fail a Blower Door Test

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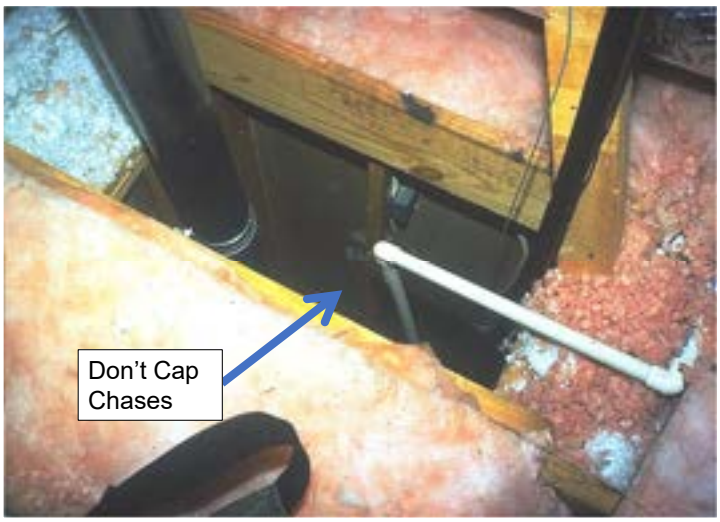
How to Fail a Blower Door Test



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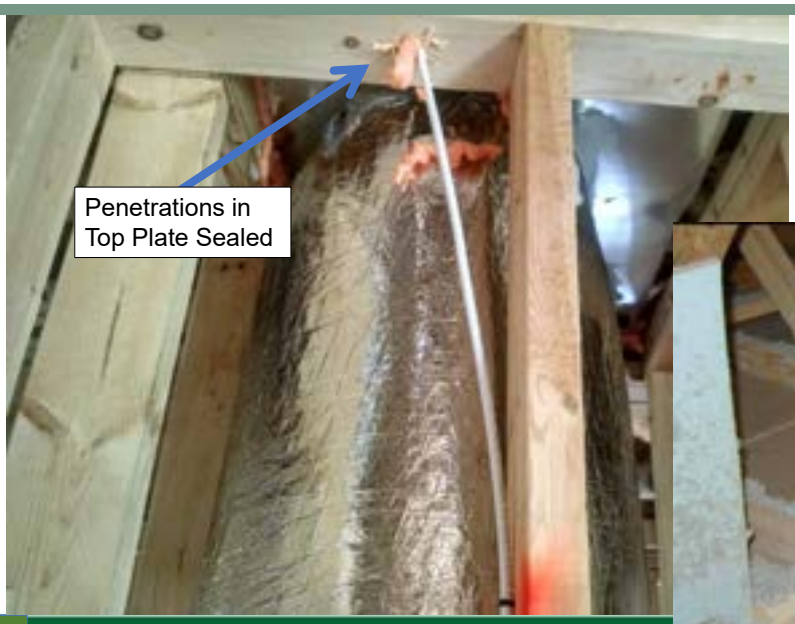
Air Sealing: Critical!



Cap and Seal Chases

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Tubs on Insulated Walls

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Band Area Between Floors

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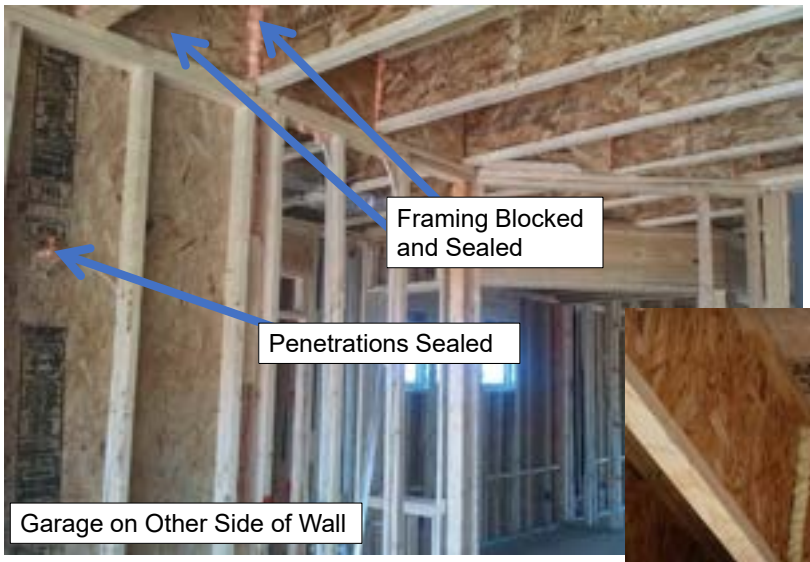
Blocking at Cantilevers



Bottom Plate

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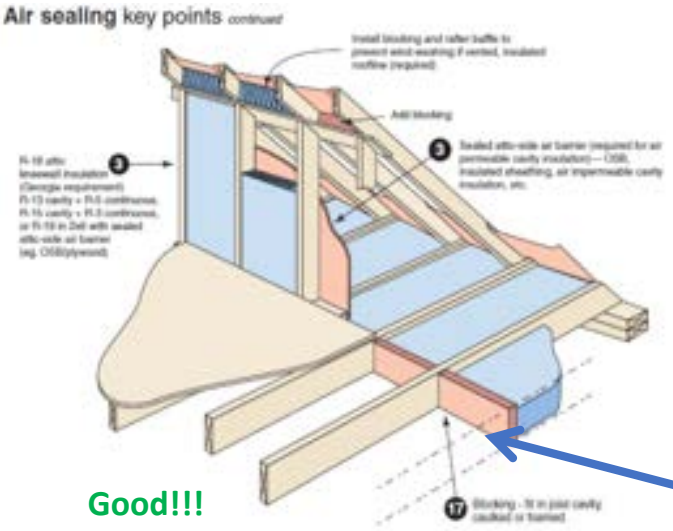
Correct Practices – Block + Sheath Kneewalls



Install Kneewall blocking

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Installing Insulation

- Voids / Gaps
- Compression / Incomplete Fill

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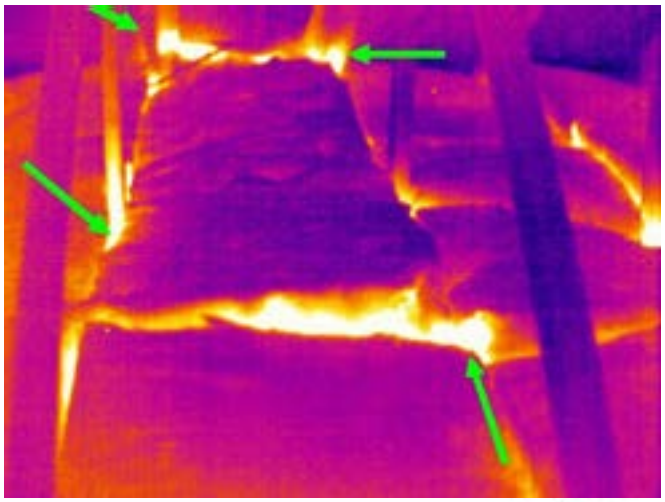
Continuous Insulation & Air Barrier

- Building Thermal Envelope
  (air barrier and insulation must be in contact)



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What's Wrong with This Picture?

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Insulation Installation: Grade I, II, or III

- Unless verified, assume Grade III (worst) – see RESNET Appendix A-11-16

installation shall be at least this good to be labeled as "Grade III".

No more than 2% of surface area of insulation missing is acceptable for "Grade II"

"Grade I"

Occasional very small gaps are acceptable for "Grade I".

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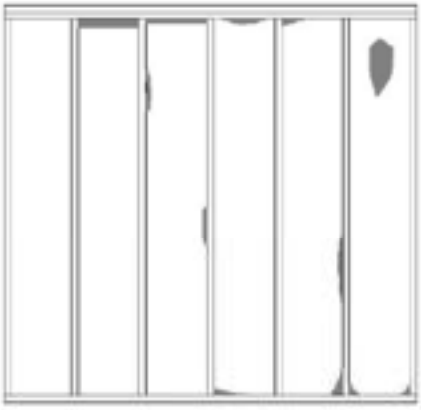
Grade I

RESNET Appendix A-11 - A-13

- occasional very small **gaps/voids**
- less than 2% **compression/incomplete fill** (which may not be more than 30% compressed)

Gaps



Compression

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Grade II

RESNET Appendix A-13 - A-15

- <2% **gaps/voids**
- <10% **compression/incomplete fill**
  (which may not be more than 30% compressed)

Gaps Compression

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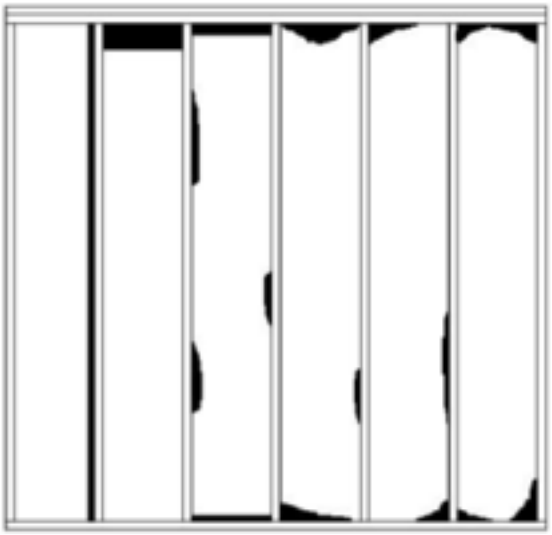
Grade III

RESNET Appendix A-15 - A-16



Gaps

- > 2% and ≤ 5% **gaps/voids**
- (greater than 5% = downgraded R-value)
- 10% or worse **compression/incomplete fill**

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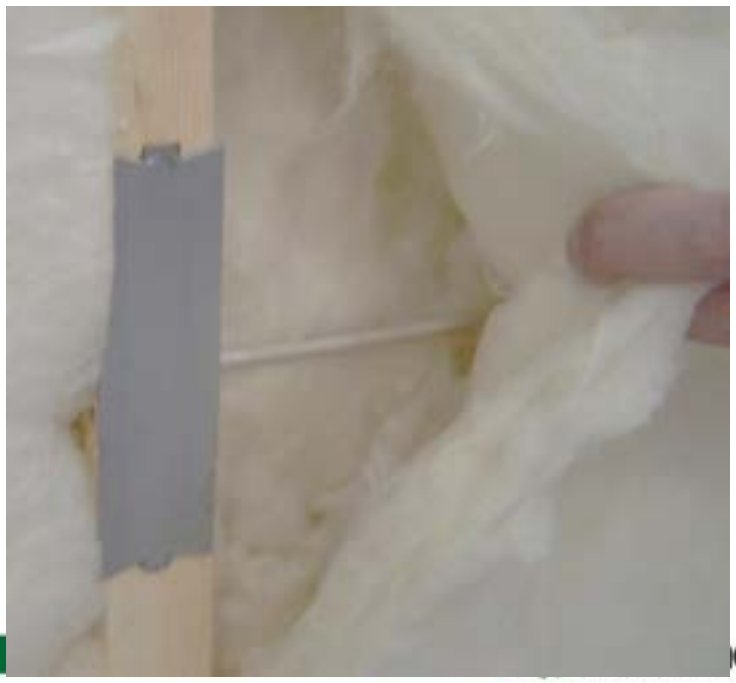
What Grade?



What Grade?

What Grade?

2x4	3 1/2"	15	13	11
2x3	2 1/2"	11	10	8.9
2x2 (metal)	1 5/8"			6.5
2x2	1 1/2"			6.1
Label R-Value		R-15	R-13	R-11
Label Thickness		3 1/2"		

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What Grade?

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What Grade?

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What Grade?

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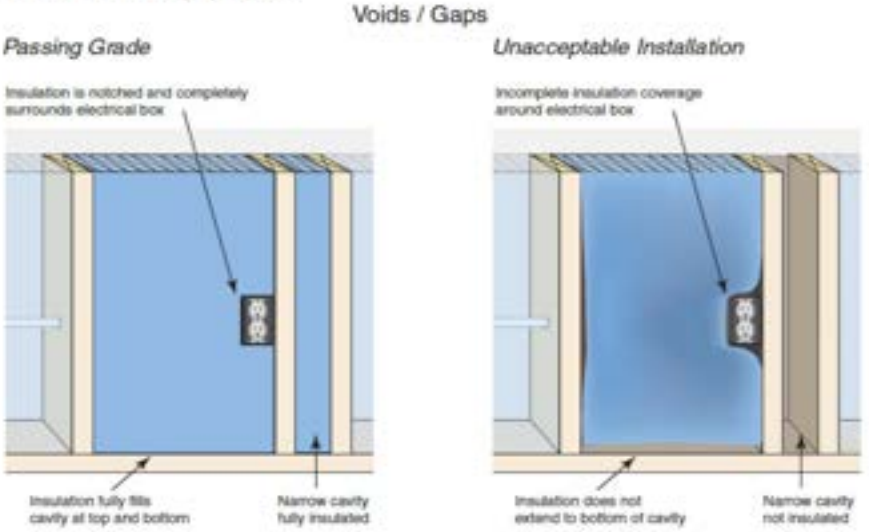
What Grade?

What Grade?

Voids & Gaps

Wall Insulation key points



Good!!!

Bad!!!

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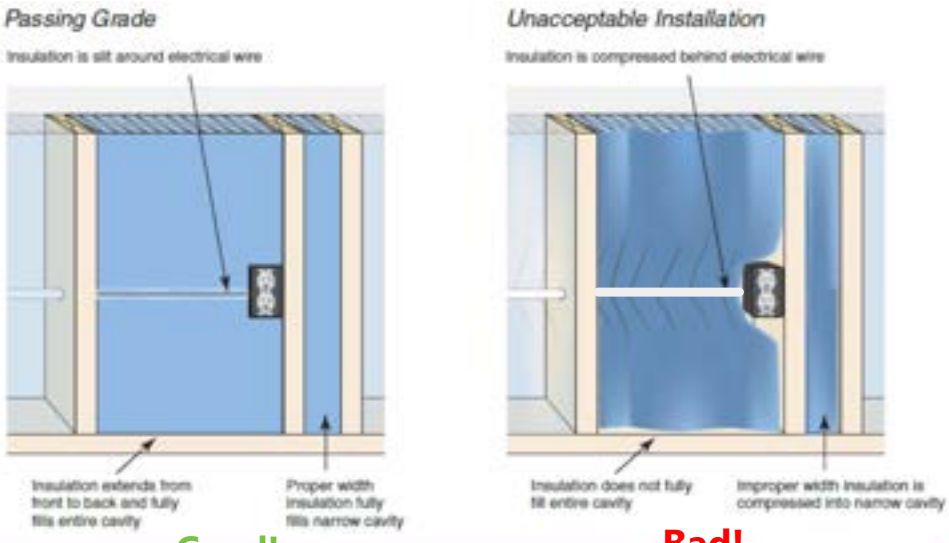
Compression & Incomplete Fill



Good!

Bad!

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Insulation Installation Videos

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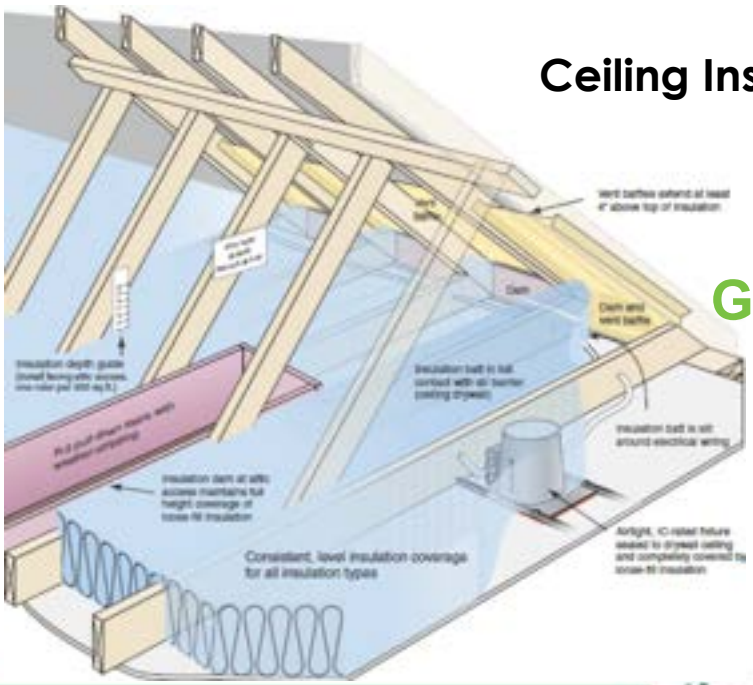
Ceiling Insulation



GOOD!

See IECC R303.1

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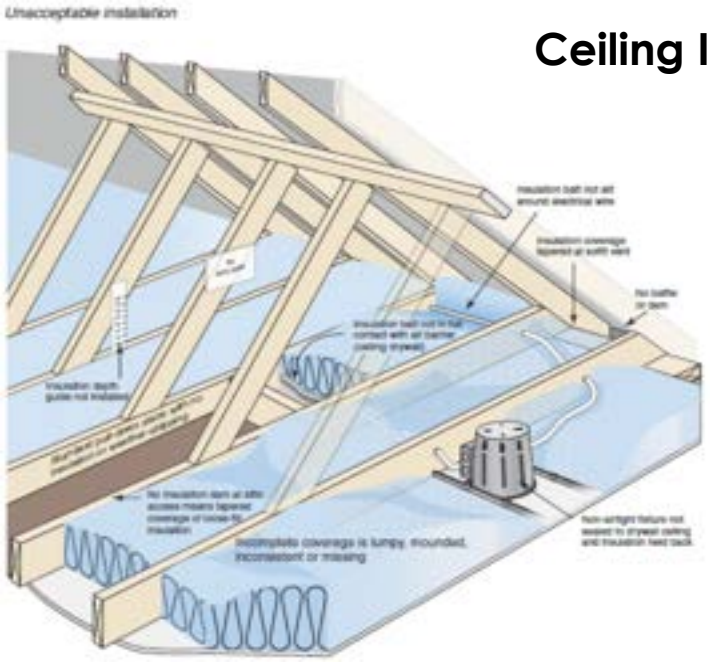
Ceiling Insulation



BAD!

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Ugly Ceiling Insulation

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Part 4

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**

Part 5

Sizing the Mechanical System

"Heating and cooling equipment shall be sized in accordance with Section M1401.3"

"Heating and cooling equipment shall be sized in accordance with **ACCA Manual S** based on building loads calculated in accordance with **ACCA Manual J** or other approved heating and cooling calculation methodologies."
- IECC R403.7

- **Building orientation**
- **Glazing, walls, foundation & roof**
- **Design conditions**
- **Infiltration**
- **Internal loads**
- **Ventilation load**

Loads: Conduction Heat Flow

Heat transfer through a solid object: the formula for calculating conduction heat transfer is q = U x A x ΔT

q = heat flow (Btu/hr)

U = inverse of R-Value [U=1/R, R=1/U] (Btu/hr ft^2 °F)

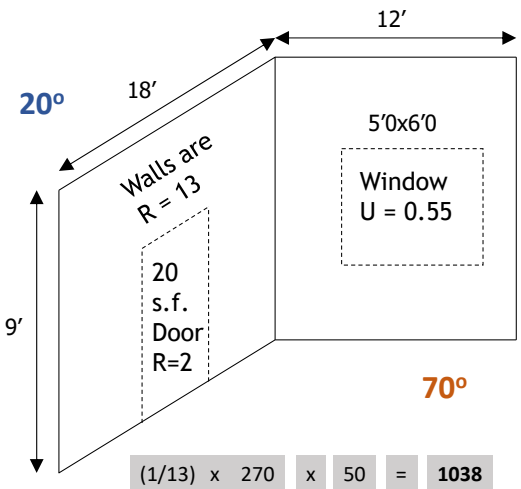
A = area (square feet)

ΔT = temperature difference across component (°F)

q = U x A x ΔT

Manual J: q = A x HTM

where HTM = UxΔT



(1/13) x 270 x 50 = **1038**

R	U	Area	Delta T	q
13	1/13	220	50	846
2	½	20	50	500
-	0.55	30	50	825
				2171

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Climate and Energy Efficiency

Design Temps	W / S
Atlanta	24/92
St. Louis	14/91
Fairbanks	-40/78
Miami	51/90

- **Design Temperatures**
  - Heating, for 99% of the season the outdoor temperature is above this value
  - Only 1% of the Cooling season is hotter than this temperature value
- *Design Temp Example*
  - St. Louis Winter 70 – 14 = 56 F ΔT
  - St. Louis Summer 91 – 75 = 16 F ΔT
- **Load Calcs & Energy Code**
  - IECC Section 302.1: Interior design temperatures (72°F heating, 75°F cooling)
  - **MUST BE ACCURATE**

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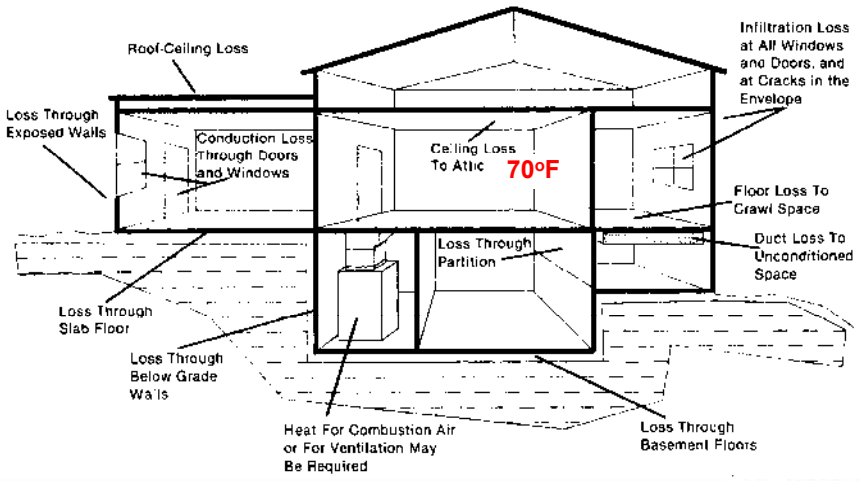
Manual J - Winter Loads



Winter Outdoor Design Temp

14°F

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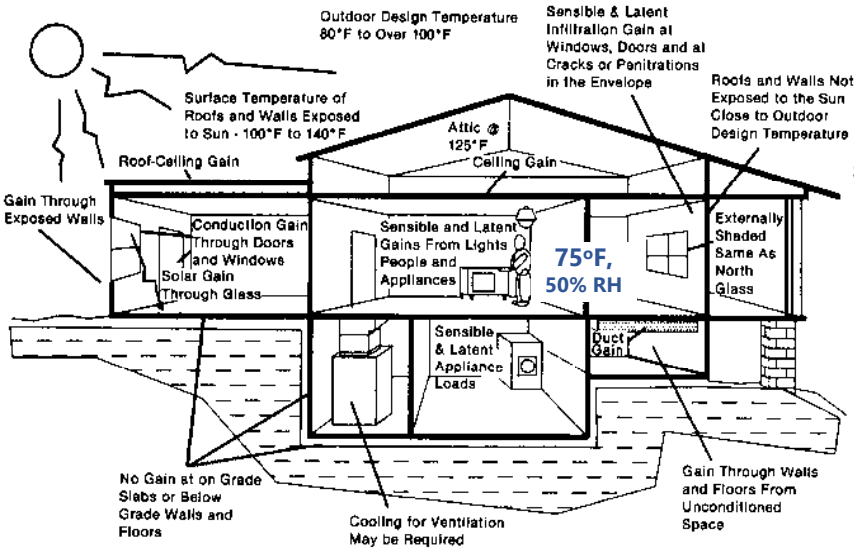
Manual J- Summer Loads



Summer Outdoor Design Temp

91°F

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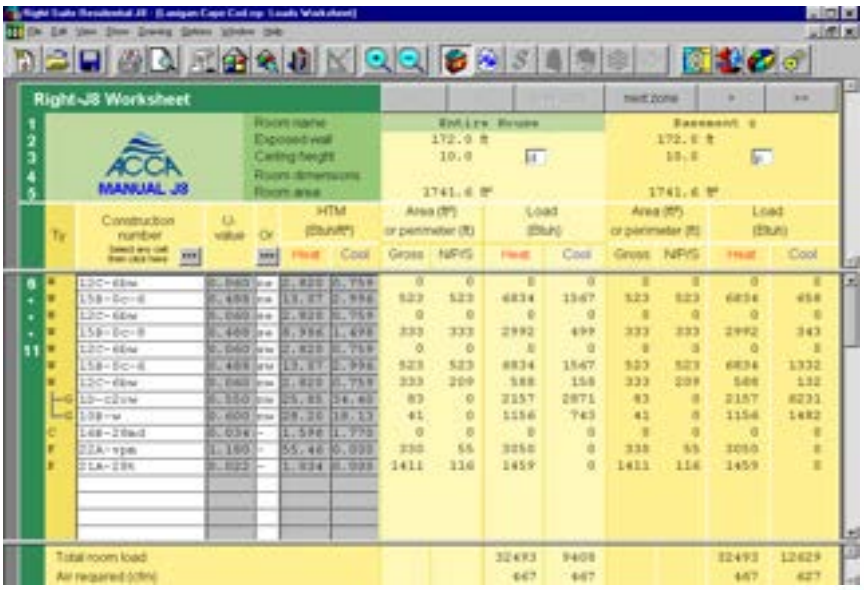
Manual J Software



Why is proper equipment sizing important?

- Equipment first-cost
- Longer/more efficient run times
- Limits equipment cycling
- Better dehumidification

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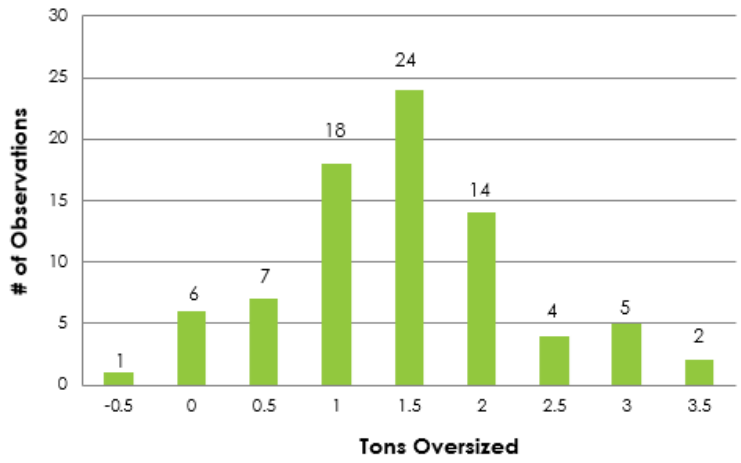
MO Equipment Sizing Study

Installed AC Units

Tons Oversized



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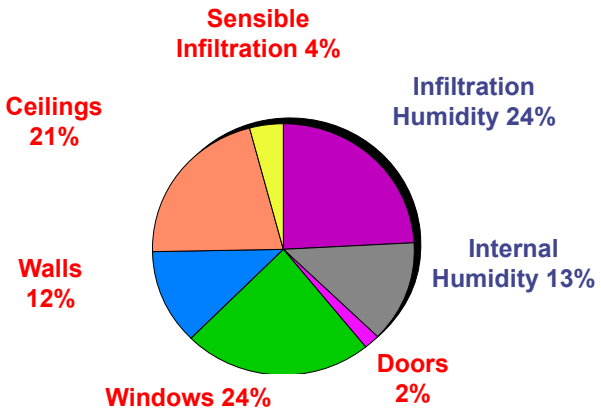
Cooling Load Breakdown



- Sensible = Δ Temperature
- Latent = Δ Moisture
- Total = Sensible + Latent
- **SHF = S / Total**

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Variable Speed / Capacity Equipment

- Allow slower fan speeds in A/C mode to improve dehumidification
- Utilize ECM motors or inverter-driven technology
  - Reduce fan wattage up to 1/10 at low speeds
  - Must operate most of the time at low for energy savings
  - Will consume more energy to satisfy flow if duct restrictions are high
- Permit modest upsizing
- Staged or variable speed compressors offer the greatest efficiency potential

  - *Moisture removal is a function of the condensing unit, indoor coil, & fan speed (airflow)*
  - *Proper refrigerant charge is also critical*

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Equipment Location

- Locate the air handler within conditioned space to reduce energy penalty from leakage.
- Don't have leaky air handler next to an atmospheric combustion appliance!!!

- Design Goal:
  Get all the ducts and the air handler within conditioned space so no energy penalty from leakage

How does duct leakage affect combustion safety?

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Ductwork

- Types
- Design
- Sealing
- Insulation

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Types of Ductwork

- **Round Metal**: Minimal air pressure loss retards growth of fungus and mildew; joints leak unless well sealed; must be insulated (in unconditioned space only); installation is more expensive
- **Flex Duct**: Few joints to leak; inexpensive to install; poor design & installation can crimp duct and reduce air flow; easier to damage



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Proper Flex Duct Installation

- Short straight runs from rigid trunk preferred
- Upsize diameter from rigid by 1″
- Support with 1″ or wider straps spaced no more than 5′
- Sag no more than ½″ per foot
- Cut duct to proper length
- Do not pinch duct to change direction or at connections

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Types of Ductwork

- **Fiberglass Ductboard**: Must be sealed carefully to be airtight; good noise control; exposed fiberglass; less durable; can be field fabricated
- **Building Cavities**: panned ducts; shelf systems that support for air handler; often violated (not permitted in IECC2015+)

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Site-Built Cavity Ducts

- Do not use as supply or return duct (example, toe-kick under cabinets should be fully ducted)

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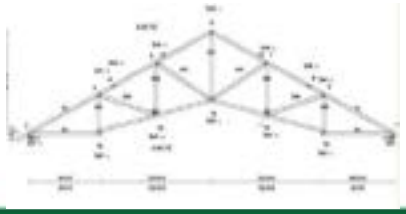
Violated ductwork

IAQ Issues?

Duct Design

- Try to locate the ductwork inside conditioned space



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Duct Design

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Proper Duct Design Details

- Dampers allow easy alteration of flow to each room
- Hard metal elbows should be used for tight turns
- Flex ducts turns must be gradual (radius of turn must be > than the duct diameter)

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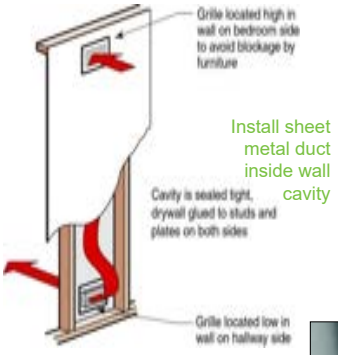
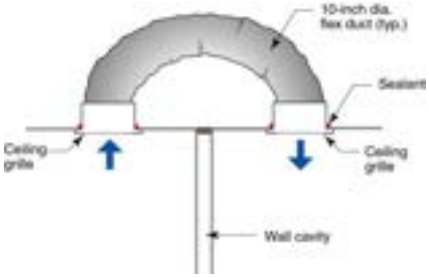
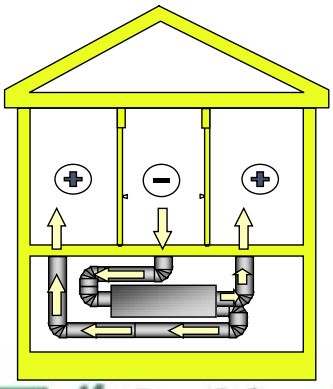
Duct Design- Proper Return Path







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Ducts in Buildings

- Don't use building components (stud cavities or joist cavities) as ducts
- If air must run through these spaces, use ducts designed to fit inside those spaces

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Duct Sizing

- Manual D
- Duct Calculator

Supply Branches for Entire House

Heating friction rate 0.070 in/100ft
Cooling friction rate 0.070 in/100ft
Duct Tree

Duct name	ST	RB	Heat (Btuh)	Cool (Btuh)		Ds. flow (cfm)	STEL (ft)	Pr. drop (in H2O)	Veloc (fpm)		Diam (in)	Rect. duct (in)		Matl
Bedroom 3	st1	rb1	2047	1244	h	68	246	0.17	346	p	6	0	0	VlFx
Bedroom 2	st1	rb1	1757	1248	c	68	246	0.17	344	p	6	0	0	VlFx
Laundry	st1	rb1	796	415	h	26	246	0.17	303	p	4	0	0	VlFx
Kitchen	st2	rb1	389	1644	c	89	246	0.17	333	p	7	0	0	VlFx
Dining	st2	rb1	1088	1135	h	63	246	0.17	319	p	6	0	0	VlFx
Foyer	st2	rb1	1263	718	h	42	246	0.17	308	p	5	0	0	VlFx
Master Bathroom	st3	rb1	1993	1058	h	66	246	0.17	337	p	6	0	0	VlFx
Master Bedroom	st3	rb1	3565	2272	c	123	246	0.17	353	p	8	0	0	VlFx
Living	st2	rb1	2915	1779	h	97	246	0.17	362	p	7	0	0	VlFx
Breakfast	st2	rb1	1220	668	h	41	246	0.17	297	p	5	0	0	VlFx

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Poor Duct Design…

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Sealing Ductwork

- Mastic must be installed on seams & joints of ductwork, not the insulation!

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Sealing Ductwork is Code

- Rigid fiberglass ducts must be sealed with UL181A-P tape, UL181A-M tape, UL181A-H tape, or water based mastic
- Flex duct must be sealed with UL181B-FX tape, UL181B-M tape or water based mastic

International Residential Code, M1601.3.1

"Tapes and mastics used with rigid fibrous glass ducts shall be listed and labeled in accordance with UL 181-A. Tapes and mastics used with flexible air ducts shall be listed and labeled in accordance with UL 181-B. "Duct tape" is not permitted as a sealant on any ducts."

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Sealing Ductwork

Sealing end of rigid supply run with water based mastic

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Sealing Ductwork

1. Put mastic on collar to plenum connection
2. Put mastic on sheet metal connection
3. Slide liner over connection and install compression strap (zip tie)
4. Mastic over liner & zip tie (about 1" on either side of liner edge
5. Pull insulation over connection and zip tie

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Sealing Ductwork

All duct connections must be sealed with mastic, including connections to:
- Plenums
- Y-joints
- Boots

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Sealing at the Unit Is Critical!

A 13 SEER A/C in a (30%) leaky duct system acts as an 8.5 SEER! Neither the builder or homeowner get what they pay for!

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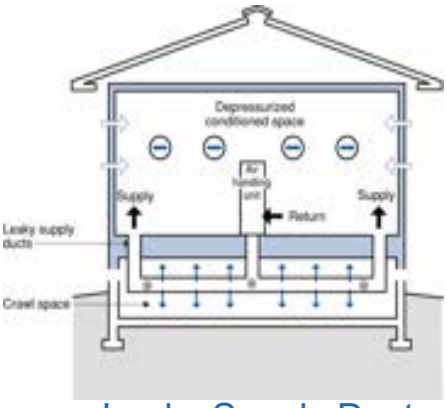
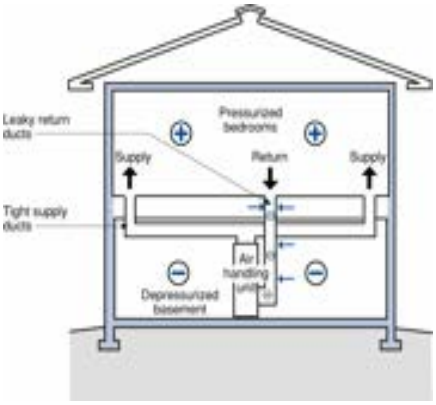
Duct Leakage Affects House Pressure



Leaky Supply Duct
(makes house pressure go negative)



Leaky Return Duct
(makes house pressure go positive)

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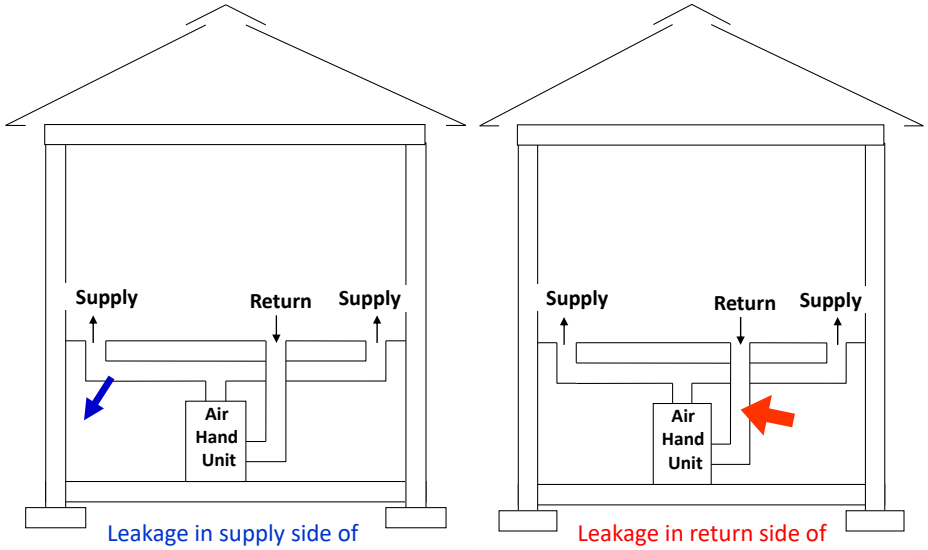
Duct Leakage—Driving force for Infiltration



Leakage in supply side of duct system

Leakage in return side of duct system

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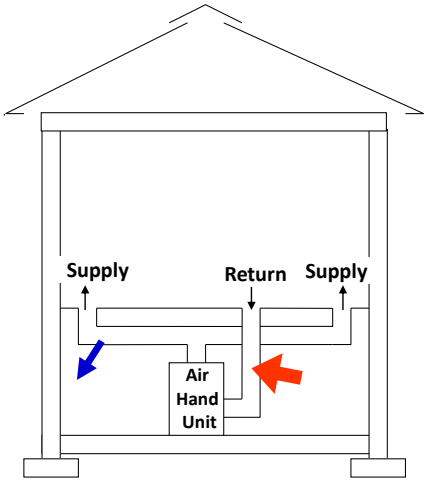
Dominant Duct Leakage – Affects House Pressure

Impact on House pressure due to small supply and larger return duct leakage

What is the net effect on house pressure due to 100 cfm of supply and 300 cfm of return duct leakage?



Some leaks in supply & More leaks in return

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Testing Duct Leaks

Although it is permitted in the code, Southface does not accept / endorse using UL181 tape to seal ducts!

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403.2.2 Duct Tightness Testing*

- Duct systems must be leak tested
  - When tested at rough-in
    - 4% Total leakage no AHU installed
    - 6% Total leakage w/ AHU
  - When tested at final
    - 12% Total Leakage
    - 8% Leakage to Outside

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

Total Duct Leakage ≤ 4%

Total Duct Leakage ≤ 4%

Ducts Inside Total Leakage ≤ 8%

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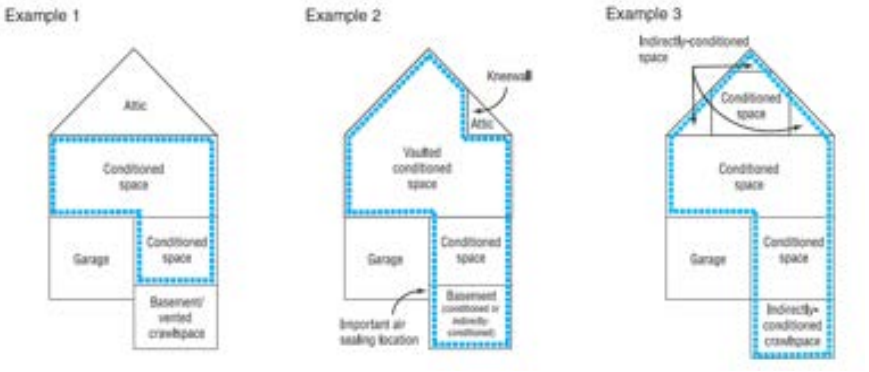
Building Thermal Envelope Impacts Duct Testing



- Although these three homes look identical from the outside, each has defined the building thermal envelope differently
- This affects the requirement for duct testing

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Filters

- Change every leap year?
- El Cheapo vs. HEPA filters
- Want thicker, pleated filters
- Don't accept installations that prohibit easy filter access
- Seal covers with foil tape
- MERV rating

Practical Pleat

www.filtrationmfg.com

www.anykindoffilter.com

"AKF003" is discount code

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IECC Section 403.3—Ducts

Mandatory Requirements:

- **Insulation** required for ducts outside of envelope
  - R-8 Insulation for Supply & Return ducts in attic
  - R-6 Insulation – all other ducts in unconditioned space
  - No Insulation required if ducts inside building thermal envelope (but should insulate to prevent condensation)
- Sealing required with mastic or UL 181 tape
- May not use building cavities as supply ducts

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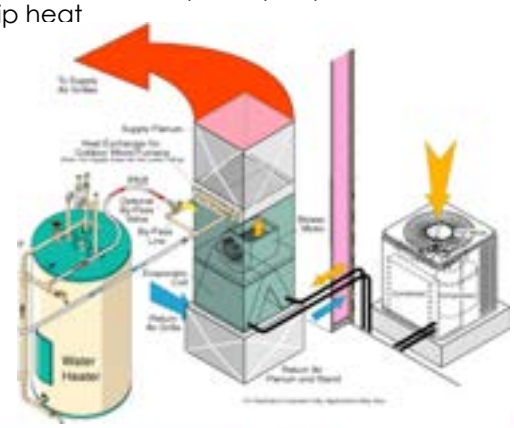
Section 403.1—HVAC Controls

Mandatory Requirement:

- **Programmable** thermostat required
- Heat Pump requires lockout capability to prevent unnecessary strip heat



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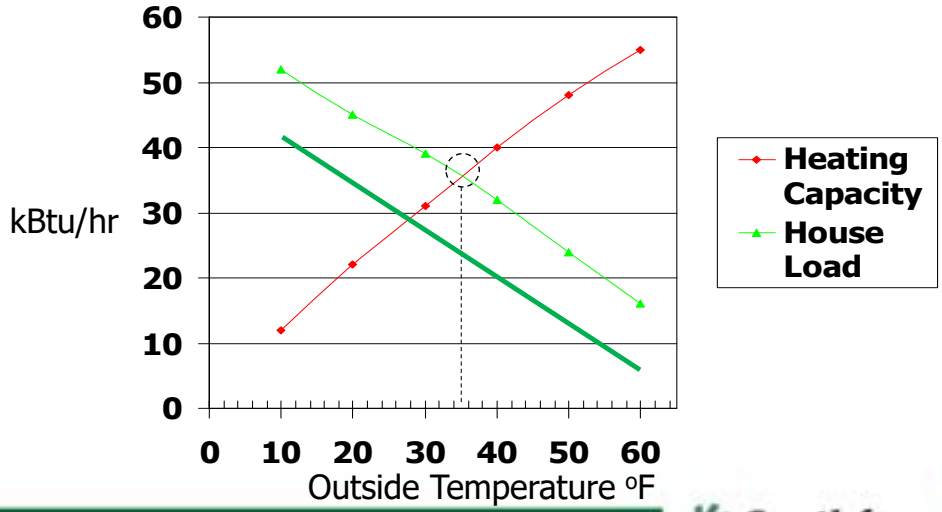
Heat Pump Balance Point

The winter outdoor temperature at which the heat pump can deliver exactly the same amount of Btu's that the house is losing



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Part 6

Energy Codes – The Power of a One-Page Checklist!

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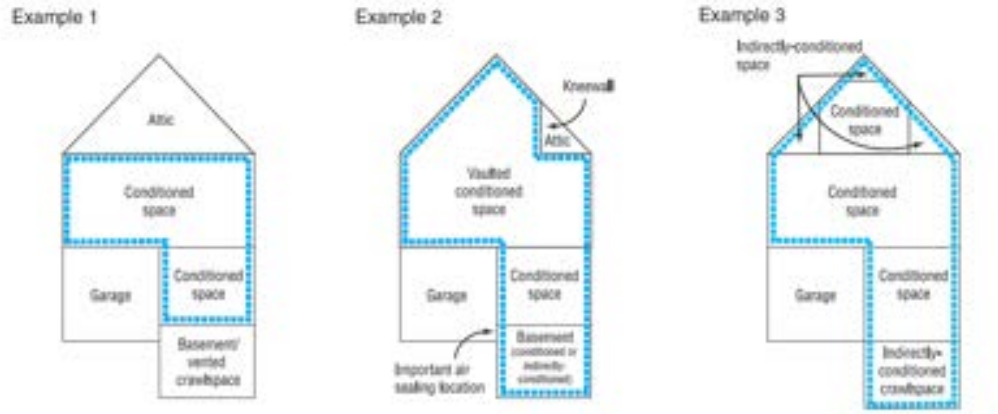
Building Thermal Envelope

- Options for defining the building thermal envelope



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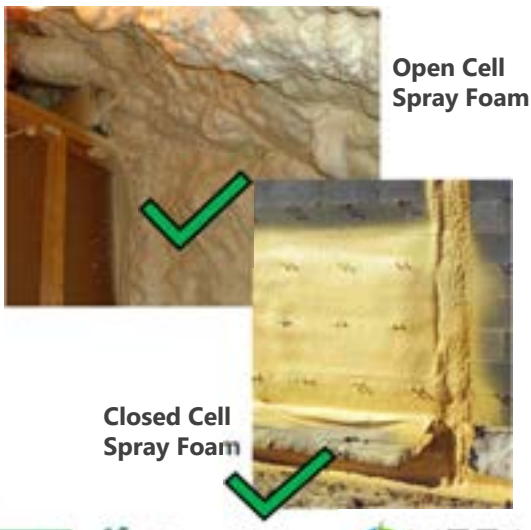
Air permeable vs. air impermeable insulation



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St. Louis 2018 IECC Energy Code - Comprehensive Field Inspection Checklist
(Southface version 10-5-21)

Instructions/Overview
The purpose of this checklist is to assist in field inspection primarily for air sealing and insulation details of the 2018 IECC St. Louis Energy Code. While not every detail is included, the list below contains the majority of critical inspected items. It is likely that certain items are not applicable to all houses.
Note: St Louis amended to R-38 ceilings and R-0 basements.

The checklist has been separated into three sections, corresponding to three different stages of construction. If an item does not comply and must be remedied, or if it cannot be confirmed at this stage of construction, that item should be verified at a later inspection or, at their discretion, by photographic documentation provided to the code official. An item that is not present shall be marked "N/A".

Permit
Air barrier and insulation details are located on plans (as applicable).

Pre-insulation, pre-drywall

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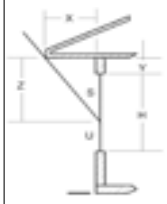
Pre-insulation, pre-Drywall

- May coincide with framing, rough-in inspection

Pre-insulation, pre-drywall list: (Framing rough inspection)

1. Bottom Plate sealed to slab or subfloor – gasket or sealant on inside edge
2. Bottom Plate penetrations sealed – (electrical, plumbing knockout, etc.)
3. Top Plate penetrations sealed – (electrical, plumbing knockout, etc.)
4. Exterior wall sheathing seams are sealed OR completely sealed housewrap installed on exterior (housewrap edges all sealed and housewrap penetrations sealed/repaired)
5. Cavities within headers, corners and intersecting T-walls are fully insulated
6. Attic kneewalls have blocking installed at ceiling joist intersection
7. Rim and band areas have air sealing performed
8. Windows and doors sealed into rough opening (fiberglass chinking not permissible)
9. Window spot check: U-factor and SHGC are reasonable and expected for DP low-e wood/vinyl frame. Weighted average U-factor ≤ 0.32, SHGC ≤ 0.40 (Climate Zone 4)
10. Cantilevered Floor joists have blocking (and air sealing) installed above supporting walls
11. Rafters have sufficient depth provided for insulation in vaulted ceilings.
12. Chases (e.g., to attic) are capped and sealed (chase walls have interior air barrier at insulated wall)
13. Tubs and Showers against exterior walls have insulation and sealed air barrier on interior.
14. Plumbing penetrations sealed: through envelope floors (e.g., tub drains, supply lines, vent stacks), walls (e.g., kneewalls, crawlspaces, wall plates) and ceilings (e.g., chases and soffits)
    -Hot water piping buried in slabs is insulated to R-3
15. Electrical penetrations sealed: Similar to plumbing, includes main service line entry (Best practice: locate panel box in non-insulated wall)
16. HVAC penetrations sealed – Fuel lines and penetrations through chases sealed.
17. Platforms in attics for HVAC & appliances are elevated for sufficient depth of insulation
18. Fireplace inserts –
    -Sheathing in chase is sealed (or exterior housewrap sealed) before insulation installed
    -Insulation coverage is complete (walls, top and bottom) and aligns with air barrier
    -Fire-rated caulk sealed at flue to cap transition (and flue includes damper)
    -Outside/combustion air duct installed and sealed (and includes shut off damper)
    -Fuel gas penetrations are sealed.
    (Best practice: fully air-seal and insulate before setting insert)



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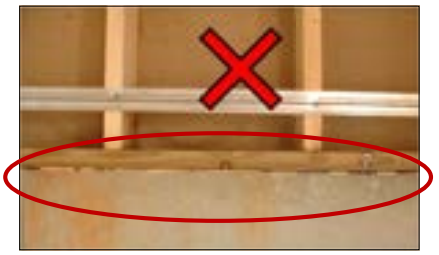
Pre-insulation, pre-Drywall

1. Bottom plate sealed to slab or subfloor



Y N N/A

☐☐☐ 1. Bottom Plate sealed to slab or subfloor – gasket or sealant on inside edge

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Pre-insulation, pre-Drywall

2. Bottom plate penetrations sealed

Y N N/A

☐☐☐ 2. Bottom Plate penetrations sealed – (electrical, plumbing knockout, etc.)

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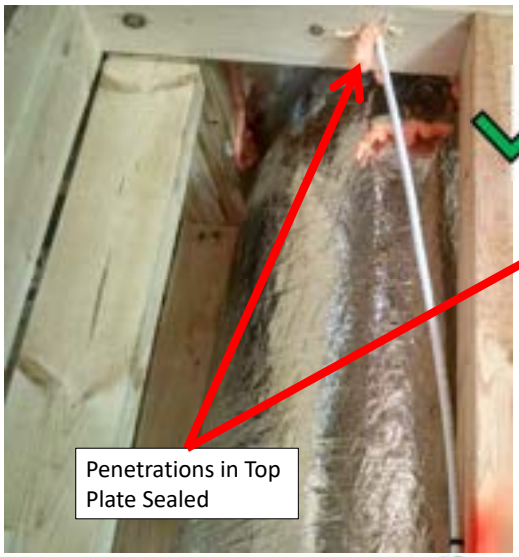
Pre-insulation, pre-Drywall

3. Top plate penetrations sealed

Yes No N/A

☐☐☐ 3. Top Plate penetrations sealed – (electrical, plumbing knockout, etc.)



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Pre-insulation, pre-Drywall

4. Exterior Wall Sheathing seams are sealed OR completely sealed housewrap installed on exterior

Yes No N/A

☐☐☐ 4. Exterior wall sheathing seams are sealed OR completely sealed housewrap installed on exterior (housewrap edges all sealed and housewrap penetrations sealed/repaired)

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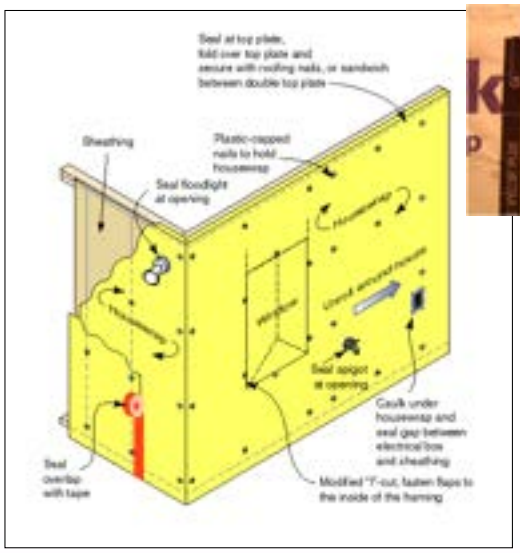
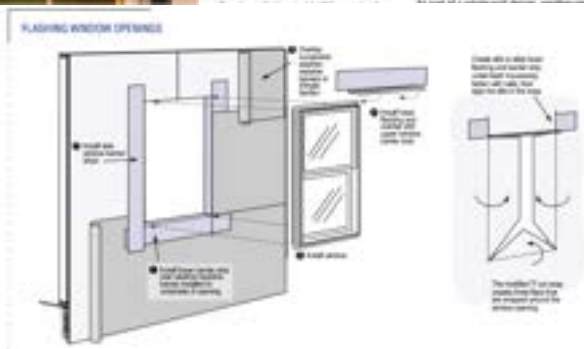
Pre-insulation, pre-Drywall

Yes No N/A

☐☐☐ 4. Exterior wall sheathing seams are sealed OR completely sealed housewrap installed on exterior (housewrap edges all sealed and housewrap penetrations sealed/repaired)





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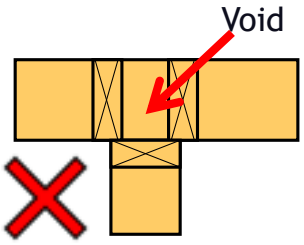
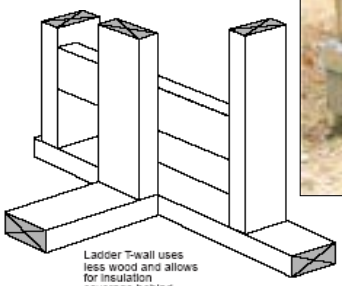
Pre-insulation, pre-Drywall

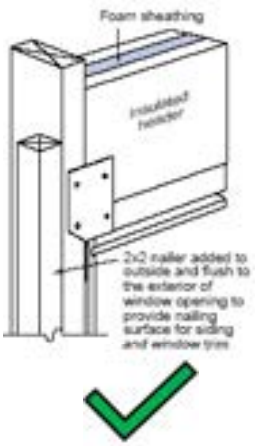
Yes No N/A

☐☐☐ 5. Cavities within headers, corners and intersecting T-walls are fully insulated

5. Cavities within headers, corners & intersecting T-walls are fully insulated



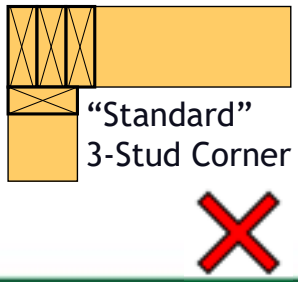




Southface MEEA

Pre-insulation, pre-Drywall

5. Cavities within headers, corners & intersecting T-walls are fully insulated

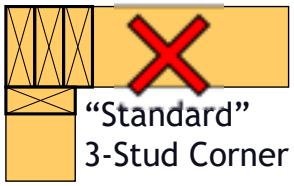


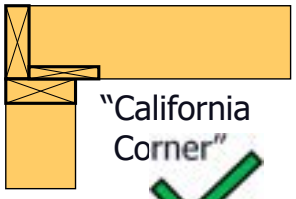
Southface MEEA

Pre-insulation, pre-Drywall

5. Cavities within headers, corners & intersecting T-walls are fully insulated

Energy Corner

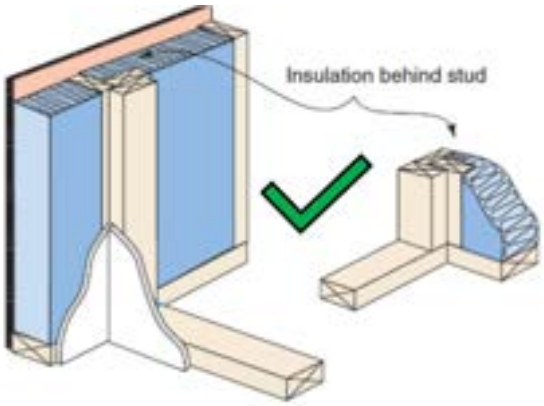




Southface MEEA

Pre-insulation, pre-Drywall

5. Cavities within headers, corners & intersecting T-walls are fully insulated



Yes No N/A

☐☐☐ 5. Cavities within headers, corners and intersecting T-walls are fully insulated

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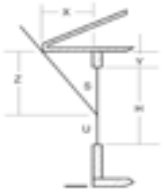
Pre-drywall, post-insulation

- Insulation installed properly



St. Louis 2018 IECC Energy Code - Comprehensive Field Inspection Checklist

Yes No N/A

Pre-Drywall, post-insulation (Insulation installed properly)

☐☐☐ 1. Wall insulation installed in substantial contact and continuous alignment with the air barrier(s)
☐☐☐ 2. Wall insulation neatly fills cavity (no voids, no insulation compression due to wiring & plumbing)
☐☐☐ 3. Attic insulation prep properly performed
- Dams and vent baffles extend over top plate of exterior walls
- Dams installed at attic access and to adjacent uninsulated areas (porches & garages, etc.)
- Insulation installed under elevated HVAC/appliance platforms in attics

☐☐☐ 4. Attic pull-down stairs sealed into rough opening
☐☐☐ 5. Cantilevered floors insulated properly (R-19)
☐☐☐ 6. Rim/band areas insulated properly (R-20)
☐☐☐ 7. Ducts insulated to R-8 in attics, R-6 in other unconditioned space.
Visually check for sealant at seams and fittings
☐☐☐ 8. Floor insulation supported and in full contact with subfloor sheathing
☐☐☐ 9. Floor assembly end-dam barriers installed under attic knee walls
(such as for bonus room floors above garages)
☐☐☐ 10. Mechanical spaces receiving outdoor combustion air have continuous, air sealed and insulated thermal envelope (walls, floors, ceiling as applicable) to isolate from main house
☐☐☐ 11. R-3 Hot water piping insulation installed (and recirculation system pipe insulation & controls)
- Piping ¾ inch and larger in nominal diameter
- Piping serving more than one dwelling unit
- Piping located outside the conditioned space
- Piping from the water heater to a distribution manifold
- Piping located under a floor slab & buried in piping
- Supply and return piping in recirculation systems other than demand recirculation systems

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Pre-drywall, post-insulation

- Insulation **NOT** aligned with ceiling air barrier

WHAT'S WRONG WITH THESE PICTURES?

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Installing Insulation

- Voids / Gaps
- Compression / Incomplete Fill
- Alignment with air barrier

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Pre-drywall, post-insulation

1. Wall insulation in substantial contact and continuous alignment with air barrier (typically sheathing and drywall)

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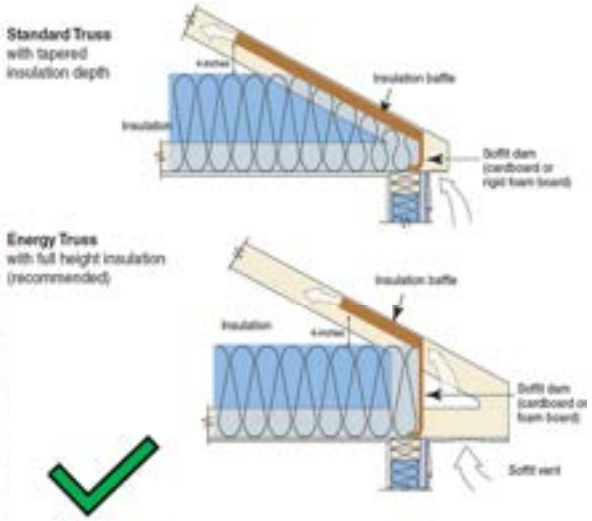
Pre-drywall, post-insulation

3. Attic insulation preparation (dams, baffles, elevated platforms)



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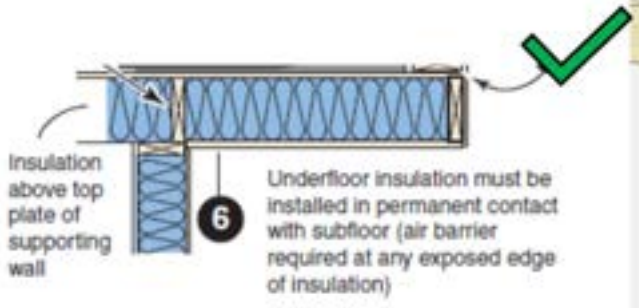
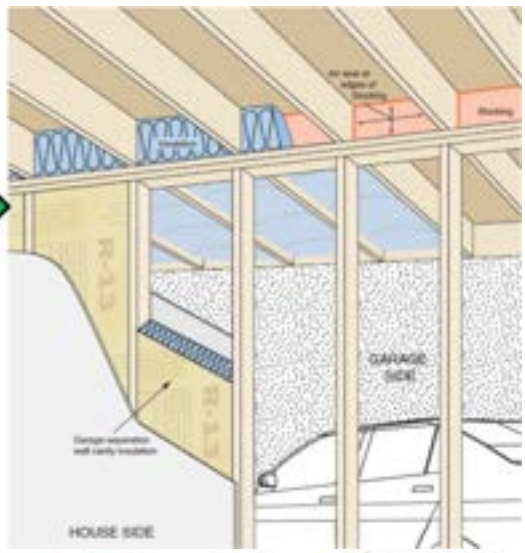
Pre-drywall, post-insulation

5. Cantilevered floors insulated properly



Yes No N/A

☐☐☐ 5. Cantilevered floors insulated properly (R-19)



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Pre-drywall, post-insulation

6. Rim/band areas insulated properly (R-20 or R-13+5)

Bagged Insulation

☐☐☐ 6. Rim/band areas insulated properly (R-20)

Rigid Foam Board

Batt Insulation

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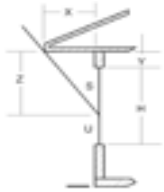
Final Inspection

- Confirm all items prior to Certificate of Occupancy



Final inspection (confirm prior to Certificate of Occupancy)

1. Blower door and duct leakage passing results correctly displayed on energy code certificate
2. Mechanical ventilation system installed for homes < 5 ACH50
3. Duct boots insulated and sealed to drywall and/or subfloor
4. Underfloor insulation installed in complete contact with air barrier and permanently secured in place (e.g., wire staves)
5. Crawlspace has complete (min. 6-mil poly) vapor barrier (overlapped and sealed to foundation)
6. Conditioned Crawlspace Wall has insulation installed as per code (402.2.11)
7. Basement wall insulated as per code (~~R-13 cavity or R-10 continuous for CZ 4~~; amended to R-0)
8. Attic access (pull-down stairs or hatch) meets R-38 insulation and air sealing requirements (pull-down stairs door is sealed into rough opening)
9. Utility (e.g., gas piping) penetrations sealed at exterior
10. Plumbing penetrations in drywall are sealed
11. Attic Ceiling insulation is properly installed: coverage is consistent, proper depth throughout
    - Attic contains Loose-fill Insulation Card and Rulers (1 per 300 sf)
    - Dams and vent baffles extend over top plate of exterior walls at eave/soffit vents
    - Dams installed at attic access and to adjacent uninsulated portions (porches & garages, etc.)
    - Insulation shield around appliance vent pipes and chimneys
12. Refrigerant line-set insulation is protected from elements and air sealed at envelope junction
13. Efficient lighting for 90% of bulbs– CFL's, linear fluorescent & LED (not incandescent or halogen)

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Final inspection

1. Blower door (< 3 ACH_{50}) and duct leakage (≤ 4%) passing results correctly obtained and displayed on energy code certificate

Yes No N/A

☐☐☐ 1. Blower door and duct leakage passing results correctly displayed on energy code certificate

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Final inspection

1. Blower door and duct leakage passing results correctly obtained and displayed on **energy code certificate**

Yes No N/A

☐☐☐ 1. Blower door and duct leakage passing results correctly displayed on energy code certificate

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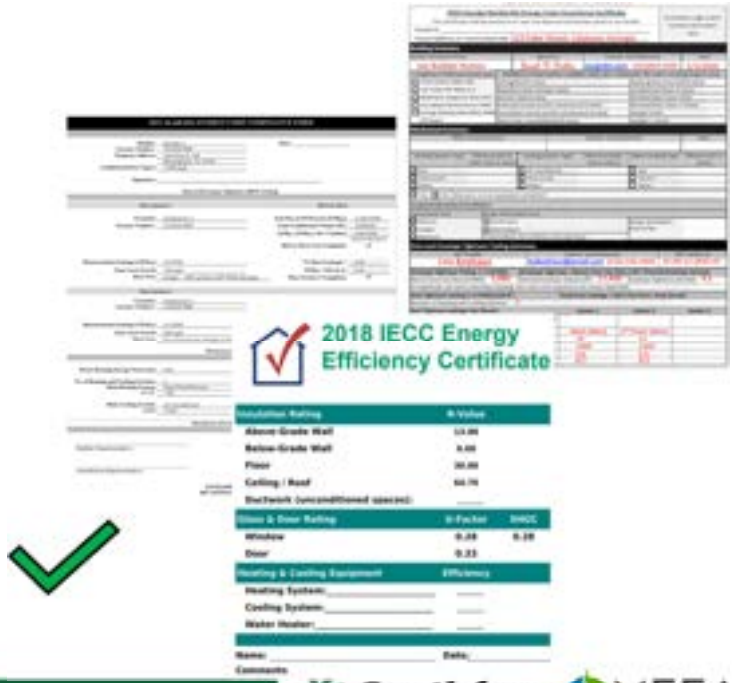
Final inspection

Yes No N/A

☐☐☐ 1. Blower door and duct leakage passing results correctly displayed on energy code certificate

1. Blower door and duct leakage passing results correctly obtained and displayed on **energy code certificate**



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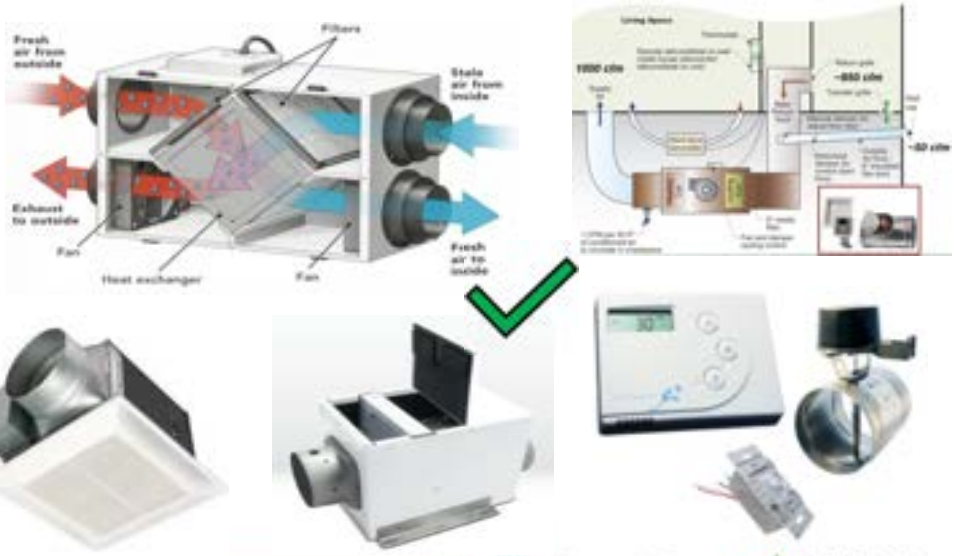
Final inspection

Yes No N/A

☐☐☐ 2. Mechanical ventilation system installed for homes < 5 ACH50

2. Mechanical ventilation system installed for homes < 5 ACH50 (as per IRC)



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Final inspection

3. Duct boots insulated and sealed to drywall/ subfloor

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Biggest Changes in IECC 2021

- Redrawn Climate Zones (6 CZ's in MO)
- Improved Window Ufactors & Wall and Ceiling R-values
- Attic pull-down stairs – R-13 okay for CZ1-4
- Floor insulation – 3 options
- Basement option details
- Sunrooms and heated garage separation
- Ducts Testing on all systems
  - Ducts inside, < 8% Total Leakage
  - Ducts outside, < 4% Total Leakage
- Verified fan (kitchen, bath, whole house) airflow
- All efficient lighting and controls
- Must choose your Additional Efficiency Package

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Wrap up and Q&A

Thank you!

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