INTERNATIONAL ENERGY CONSERVATION CODE – BUILDING ENVELOPE

RESIDENTIAL TRAINING

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LEARNING OBJECTIVES

- Understand Georgia Energy Code air barrier & insulation requirements
- Identify house air sealing key points
- Learn thermal boundary requirements of the Georgia energy code
- Recognize common insulation challenges
- Understand HVAC and water heating provisions
- Know how to read and fill in Energy Code Certificate

ENERGY CODE RESOURCES

Online educational resources are available by visiting: www.southfaceonlinetraining.org

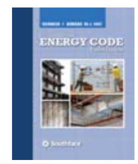
Technical assistance or training requests can be submitted to
Georgia Energy Code Hotline at: energycodes@southface.org or 404-604-3598

Additional Resources
Georgia Energy Code: If you would like additional information on Georgia's current energy code, please visit the Georgia Department of Community Affairs website at:
www.dca.ga.gov/development/ConstructionCodes/programs/EnergyCodeTrainingWorkshops.asp

DOE Field Study: If you would like additional information on other DOE Field Studies and participating states, please visit the Building Energy Codes website here:
https://www.energycodes.gov/compliance/energy-code-field-studies

Georgia Field Study: If you would like further information regarding the Georgia Energy Code Field Study, please visit our project webpage found at: www.seealliance.org

Other Tools Coming!!: Residential and Commercial Field Guides, videos, webinars



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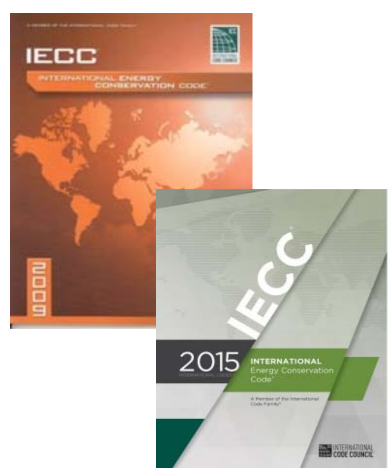
IMPORTANCE OF ENERGY CODES

- **Saves energy** - Buildings consume 40% of energy in U.S.; energy codes reduce dependence on foreign energy sources
- **Saves money-** energy costs continue to escalate and energy codes help keep money within local economy
- **Additional benefits:**
  - Increases comfort, health and durability of homes
  - Increases value of homes in local community
  - Reduces liability for builder and subcontractors



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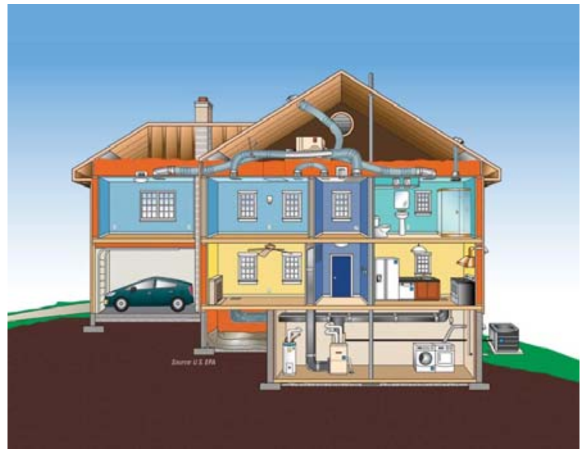
THE HOUSE AS A SYSTEM

A house is a system made up of interrelated parts:

- The building thermal envelope
- Space conditioning
- Ventilation
- Water heating & distribution
- Lighting & appliances



Building Science represents a holistic view of a house and applies and understanding of the flow of: Heat, Air and Moisture

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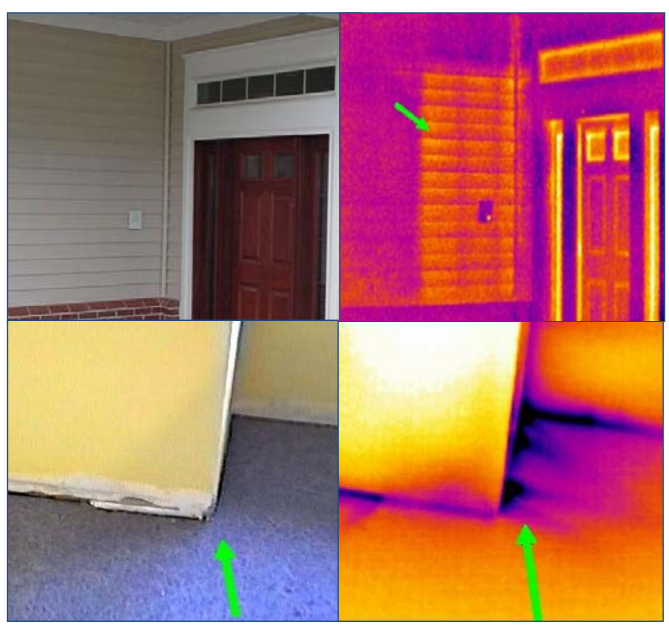
BUILDING SCIENCE: HEAT TRANSFER

- Heat is a form of energy
- Heat moves from hot to cold
- 3 methods 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



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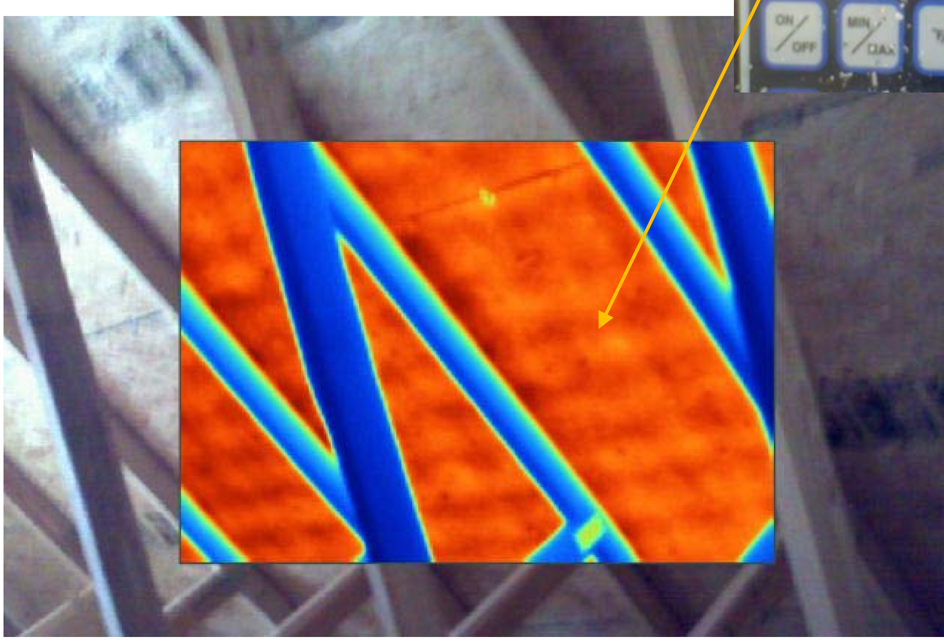
RADIATION

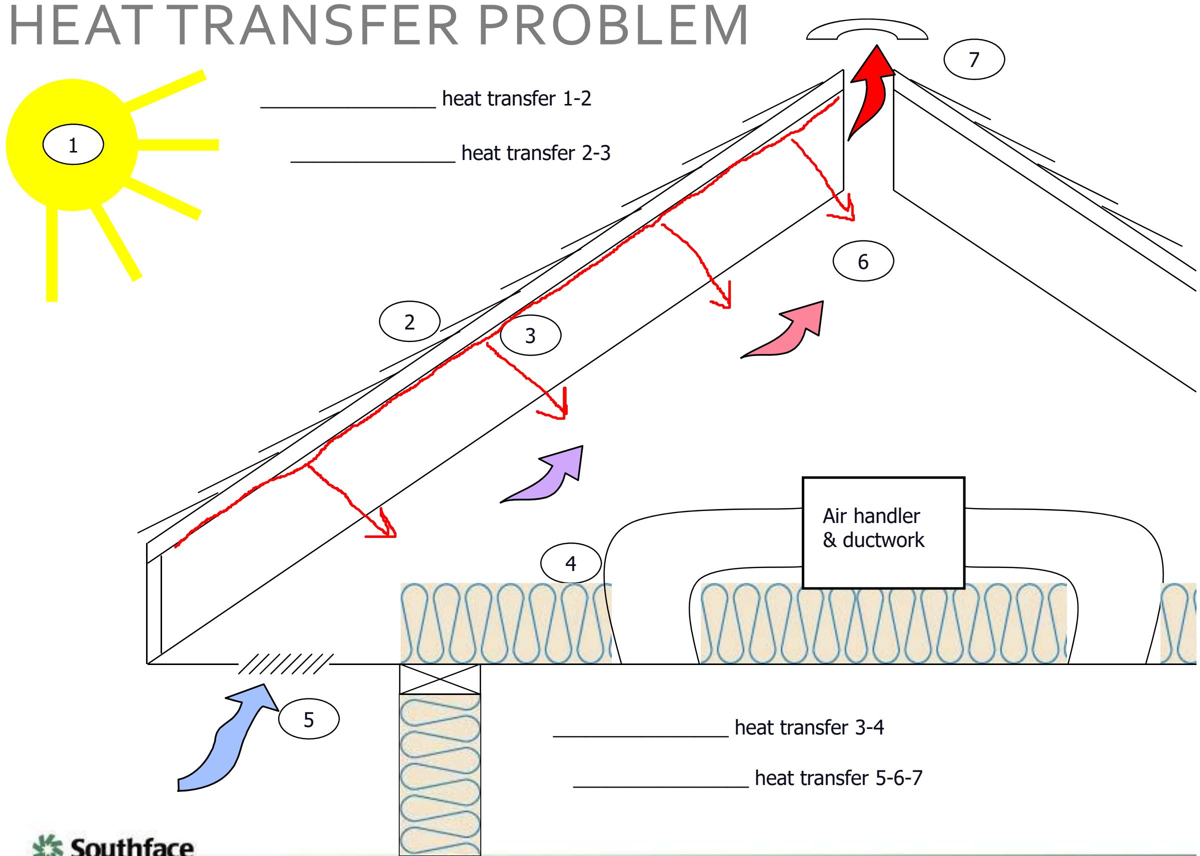
Radiation is the movement of heat from a hot surface to a cold surface with nothing solid or opaque in between (low-emitting surfaces slow radiation)

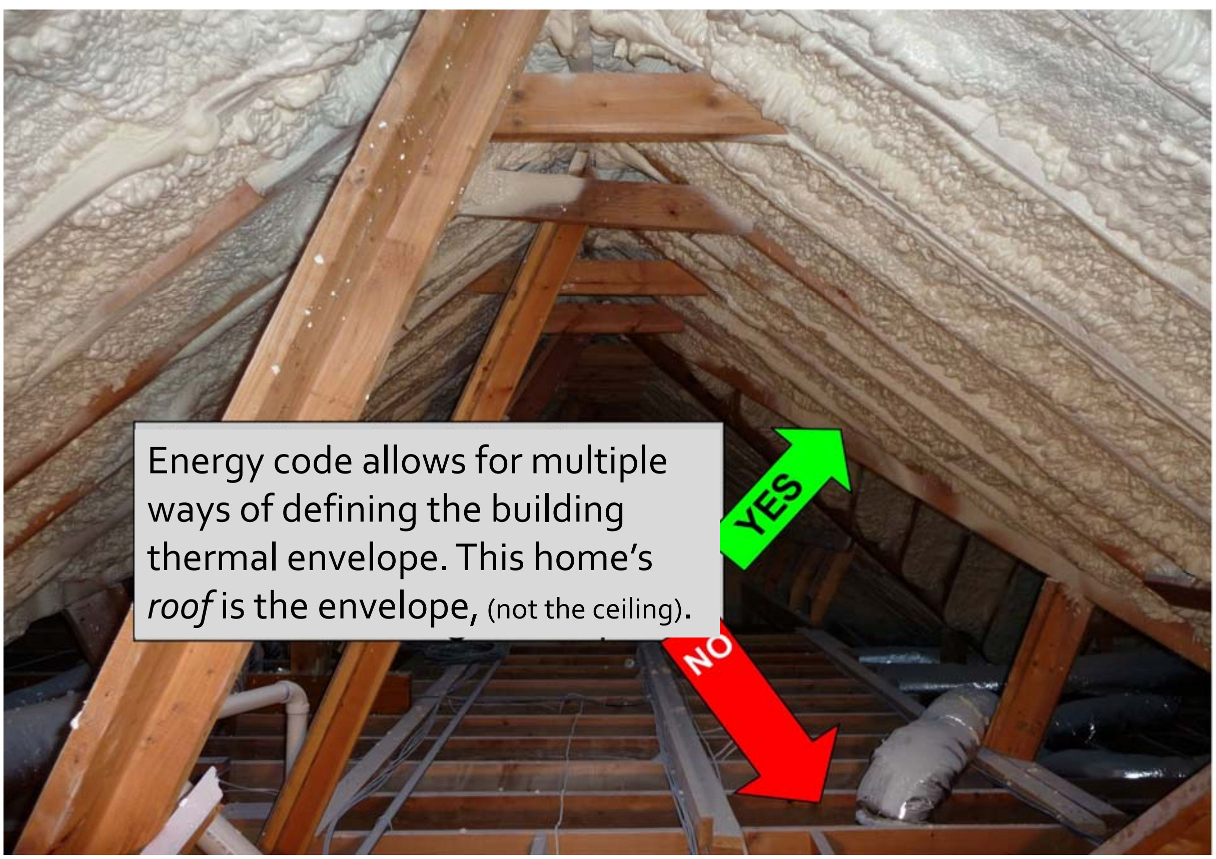
RADIATION

Heat transfer from a hot surface to a cool one



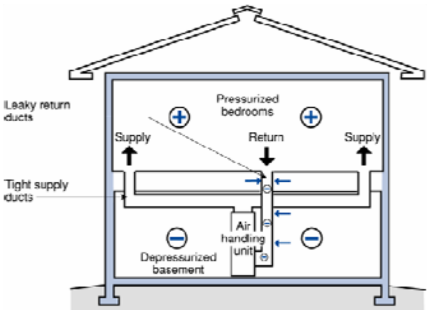
HEAT TRANSFER PROBLEM





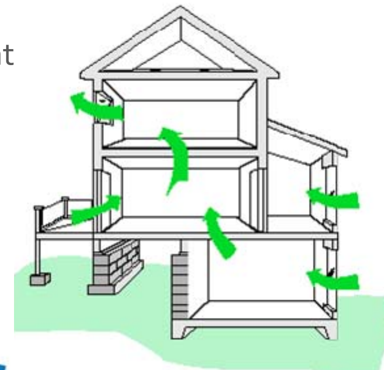
BUILDING SCIENCE: AIR FLOW

- 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 ($CFM_{in} = CFM_{out}$)



Mechanical Systems

Wind



Stack Effect

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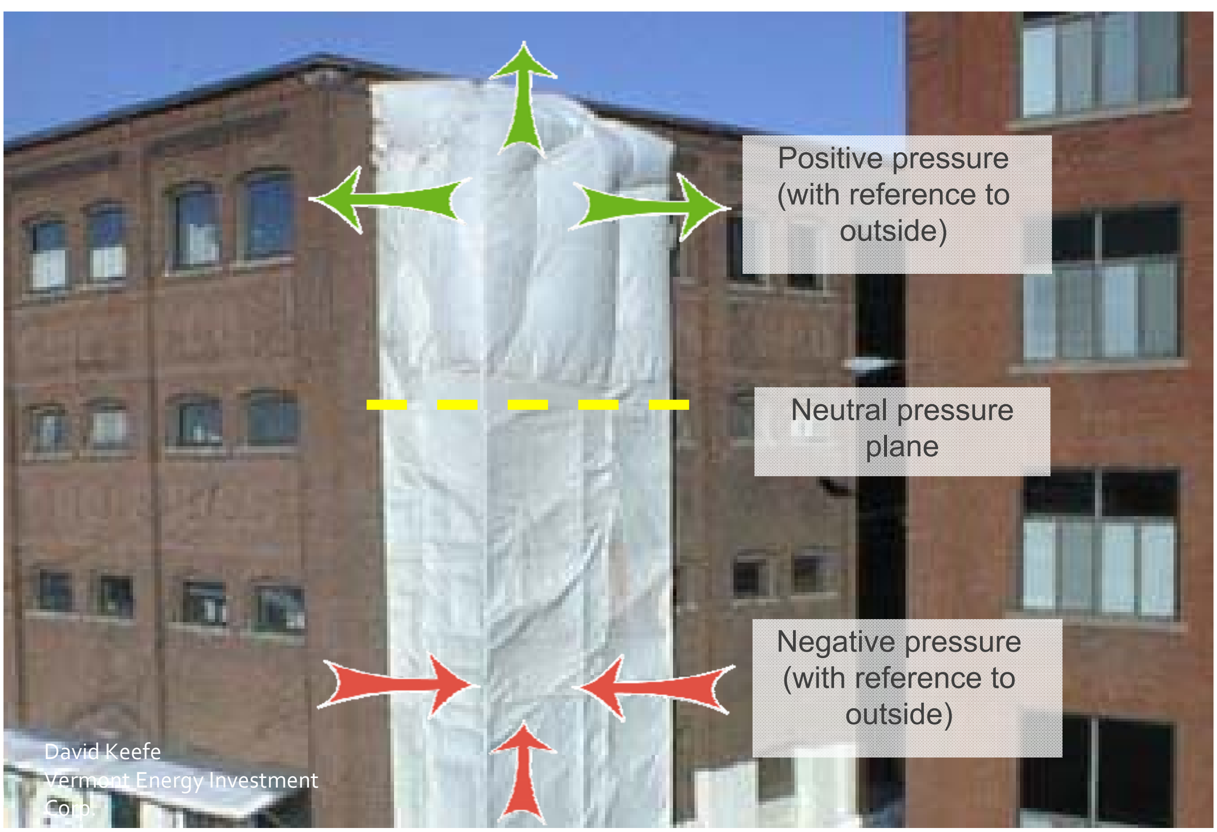
STACK EFFECT



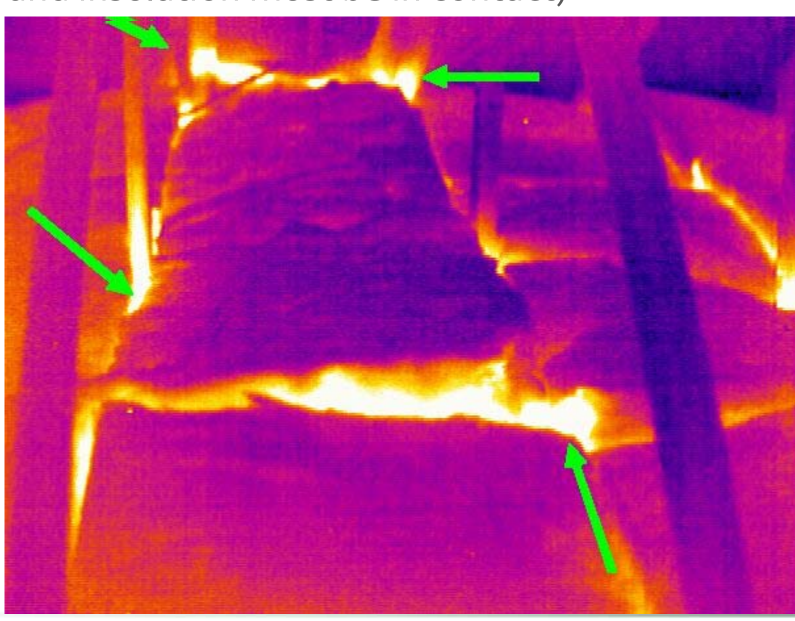
THERMAL AND AIR BARRIERS

- The building envelope is comprised of thermal & pressure boundaries
- The thermal & pressure boundaries must be complete and aligned

- Insulation products such as fiberglass batts need to be completely enclosed on all sides
- Insulation is most effective when it is continuous and located on the exterior

CONTINUOUS INSULATION & AIR BARRIER

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



BUILDING SCIENCE: MOISTURE TRANSPORT

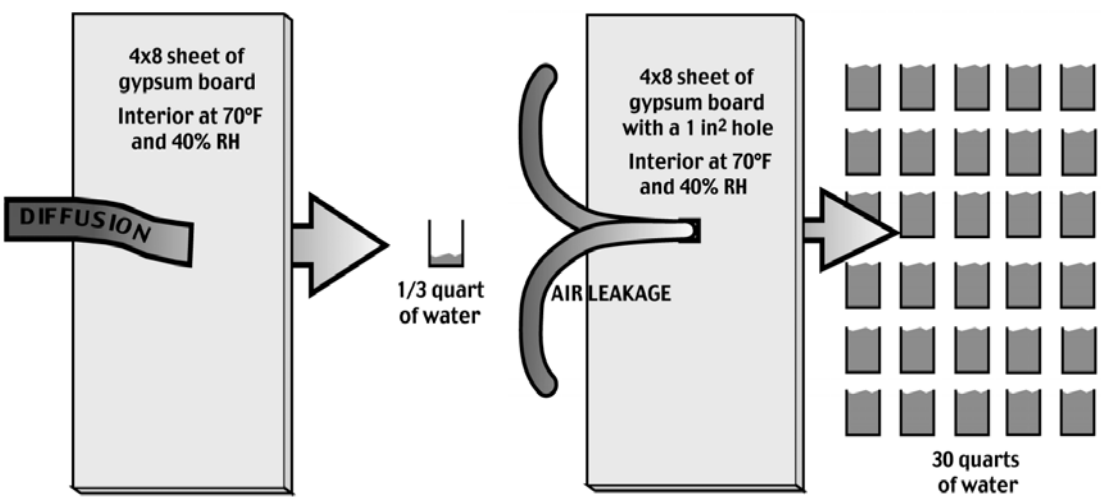
- Moisture moves from wet to dry
- Moisture can move as a liquid or a vapor
  - **Bulk flow**
  - **Capillary action**
  - Diffusion
  - Infiltration

Liquid

Vapor

Appropriate measures for moisture control are essential!

VAPOR DIFFUSION VS. AIR LEAKAGE



SCOPE OF RESIDENTIAL ENERGY CODE

- Heavy focus on building thermal envelope
  - Ceilings, walls, windows, floors, foundations
  - Sets insulation levels, window U-factors and SHGC
  - Infiltration control
    - Caulk and seal to prevent air leaks
    - Verify tight envelope with blower door AND visual inspection
- Ducts
  - No building cavities as ducts
  - Seal properly and insulate
  - Verify tight with duct pressurization test
- Hot water pipe insulation
- Lighting - high-efficacy bulbs required (LED!)
- No appliance requirements

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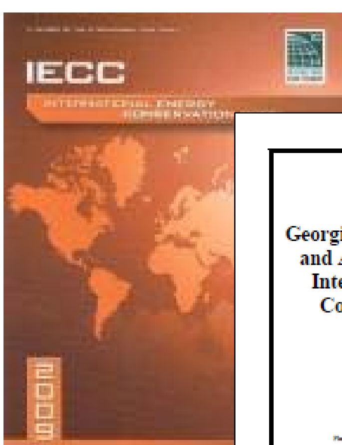
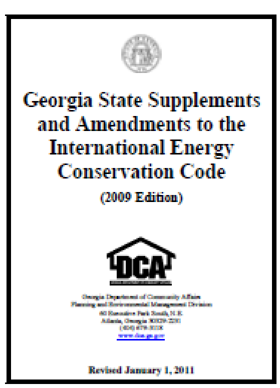
CURRENT 2011 GEORGIA RESIDENTIAL ENERGY CODE




Georgia State Supplements and Amendments to the International Energy Conservation Code

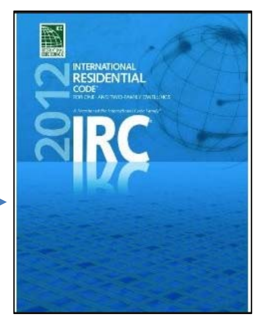
(2009 Edition)

DCA

Revised January 1, 2011

2011

Energy Requirements



Ventilation Requirements

If Blower Door test < 5 ACH_{50}, must install a whole-house mechanical ventilation system

Single Family: Must Blower Door test < 7 ACH_{50}

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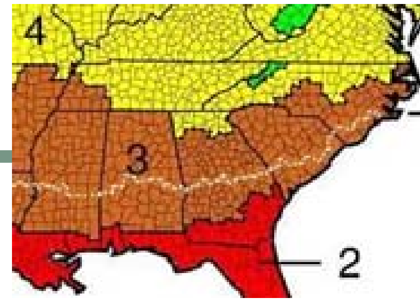
2011 PRESCRIPTIVE GEORGIA RESIDENTIAL ENERGY CODE



- One prescriptive "answer" for how to build per climate zone (CZ: 2, 3 and 4)
- Includes lots of footnotes

TABLE 402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT *U*-FACTOR[b]	GLAZED FENESTRATION SHGC[b]	CEILING[c]	WOOD FRAME WALL[d]	ATTIC KNEEWALL[e]
2	0.50[l]	0.75	0.30	*R*-30 or *U*-0.030	*R*-13 or *U*-0.082	*R*-18 or *U*-0.065
3	0.50[l]	0.65	0.30	*R*-30 or *U*-0.030	*R*-13 or *U*-0.082	*R*-18 or *U*-0.065
4	0.35	0.60	0.30*	*R*-38 or *U*-0.025	*R*-13 or *U*-0.082	*R*-18 or *U*-0.065

CLIMATE ZONE	MASS WALL[f]	FLOOR[g]	BASEMENT WALL[h,k]	SLAB[i]	CRAWL SPACE WALL[j,k]
2	R-4/6 or *U*-0.165	*R*-13 or *U*-0.064	*R*-0 *U*-0.36	R-0	*R*-0 *U*-0.477
3	R-5/8 or *U*-0.141	*R*-19 or *U*-0.047	R-5/13 *U*-0.136	R-0	R-5/13 *U*-0.136
4	R-5/10 or *U*-0.141	*R*-19 or *U*-0.047	R-10/13 *U*-0.059	R-0	R-10/13 *U*-0.059

*** This requirement will take effect on July 1, 2011.***

2011 PRESCRIPTIVE FOOTNOTES

a. *R*-values are minimums. *U*-factors and SHGC are maximums. *R*-19 shall be permitted to be compressed into a 2 × 6 cavity. Non-fenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration, including doors 50 percent or more glazed. One door or window (or up to 15 square feet [1.4 m^2] of glazed fenestration) may be exempt from meeting the *U*-factor and SHGC (Does not apply to attic access doors) See Section 402.2.3 'Fenestration access hatches and doors' of these Georgia State Supplements and Amendments.

c. Ends and sides of ceiling joist cavity shall be blocked with an approved air barrier. Flat ceiling insulation shall be in substantial contact with the ceiling. Ceiling areas without attic space in Climate Zone 4 may be *R*-30 (maximum of 20 percent of ceiling area or 500 square feet, whichever is less). For HVAC platform and floored access path areas, refer to Section 402.2.1 'Ceilings with attic spaces' of these Georgia State Supplements and Amendments.

d. All vertical air-permeable insulation shall be in substantial contact with an air barrier on all six (6) sides.
Exception: Unfinished basements and fireplaces (insulation shall be restrained to stay in place).

e. *R*-13 + *R*-5 insulated sheathing, *R*-15 + *R*-3 insulated sheathing, or *R*-19 compressed into a 2 × 6 cavity is deemed to meet *R*-18 minimum requirement. Attic side shall have a sealed air barrier.

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

g. Floor insulation shall be installed to maintain continuous permanent contact with the underside of the subfloor decking, and insulation ends shall be blocked. Cantilevered floors shall be *R*-30 and band area above exterior wall shall be blocked.

h. *R*-5 and R-10 are continuous and *R*-13 is cavity and band. For basements with no direct conditioning, either the floor or all of the basement walls shall be insulated. For basements with direct conditioning, all of the basement walls shall be insulated.

i. Applies to unheated slabs. Heated slabs shall have exterior edge insulated to *R*-5 to a depth of 2 feet (610 mm). Insulation located below grade shall be in compliance with Section 402.2.7.

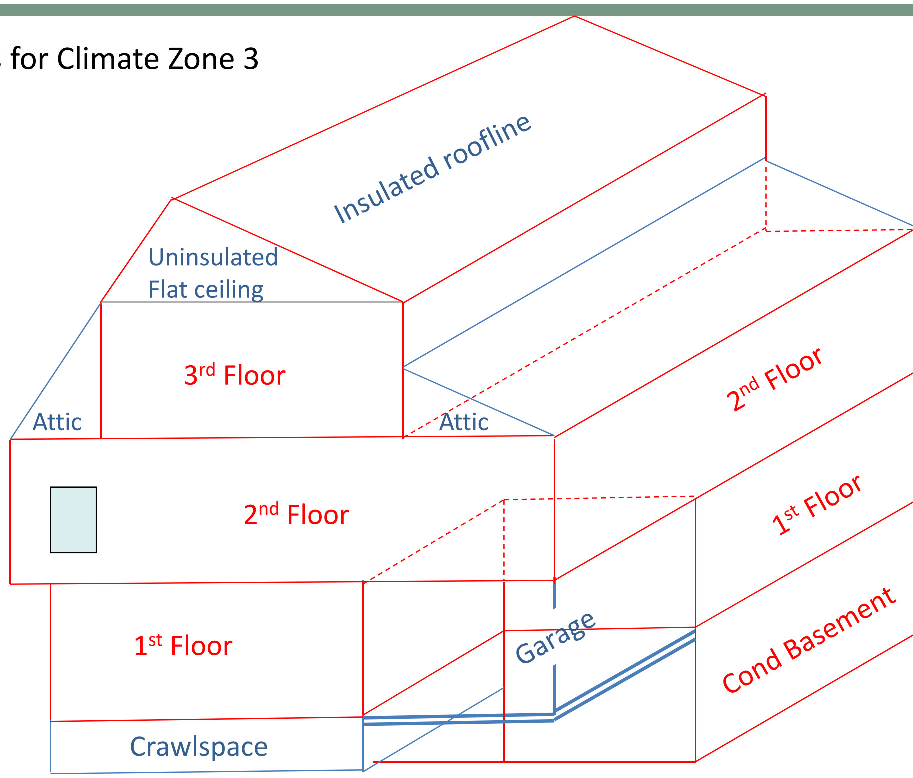
j. *R*-5 and R-10 are continuous and *R*-13 is cavity and band. See Section 402.2.9 'Crawl Space Walls' of these Georgia State Supplements and Amendments.

k. Consideration should be given for mold and moisture, and for termite inspection and treatment.

l. Where impact rated fenestration is required under Section R301.2.1.2 of the *International Residential Code* or Section 1609.1.2 of the *International Building Code*, the maximum *U*-factor shall be 0.75 in Zone 2 and 0.65 in Zone 3.

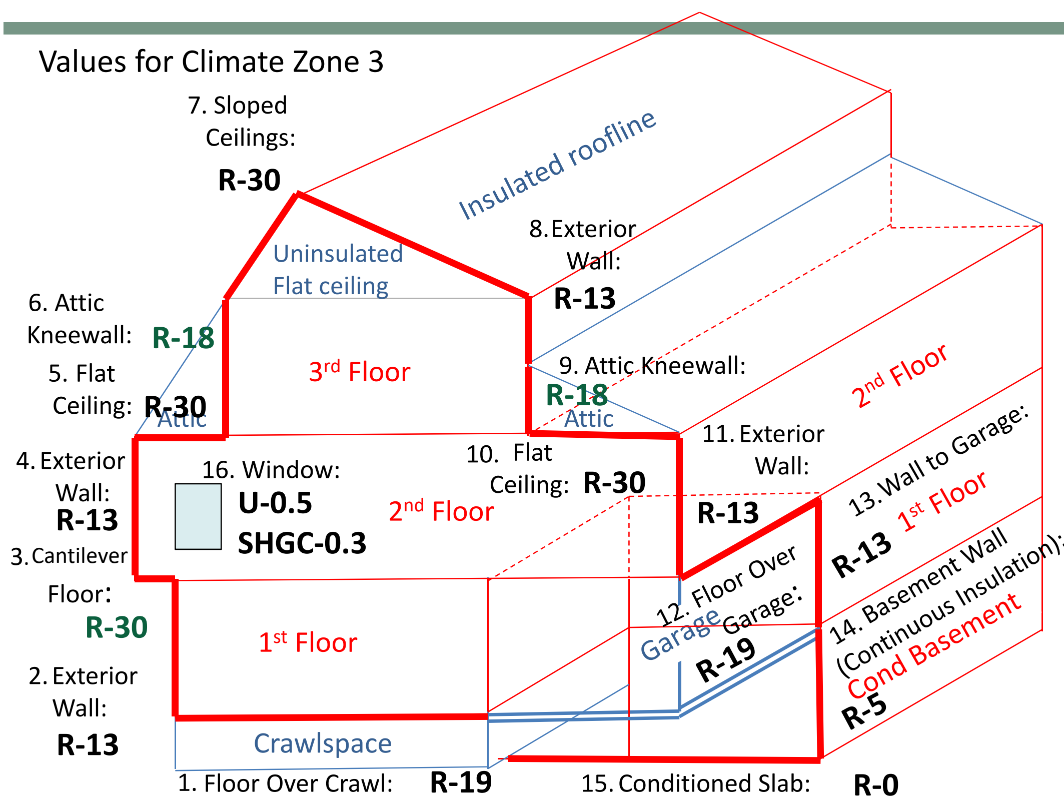
2011 PRESCRIPTIVE GEORGIA RESIDENTIAL ENERGY CODE

Values for Climate Zone 3



2011 PRESCRIPTIVE GEORGIA RESIDENTIAL ENERGY CODE

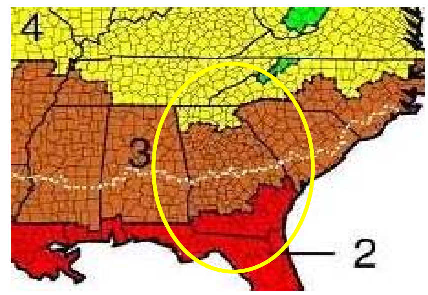
Values for Climate Zone 3



2015 GEORGIA RESIDENTIAL ENERGY CODE FIELD STUDY

8 Key Items :

- High-efficiency lighting
- Envelope tightness (ACH50)
- Duct leakage
- Exterior wall insulation
- Ceiling insulation
- Foundation insulation (floor / basement wall / slab)
- Window U-factor
- Window SHGC



63 observations of each key item minimum

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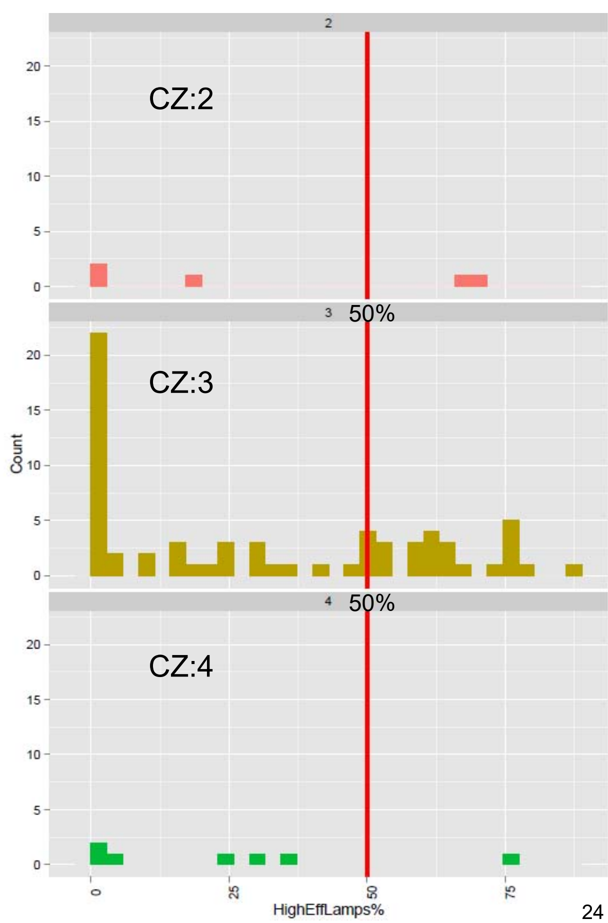
HIGH EFFICACY LAMPS (%)

NO. OF OBSERVATIONS: 79

Vertical **red** line indicates the 2009 IECC prescriptive code requirement of 50% of all lamps

Key Takeaway:

Of 79 homes observed only 27 complied with the minimum Standard (~34% compliance)



Higher is Better!

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ENVELOPE TIGHTNESS (ACH50)

NO. OF OBSERVATIONS: 73

Vertical **red** line indicates the 2009 IECC prescriptive code requirement of **7 ACH50** (max.)

Key Takeaway:
Only 3 results worse than code of 73 tests conducted

The average ACH50 for all homes tested was **4.9**

Lower is Better!

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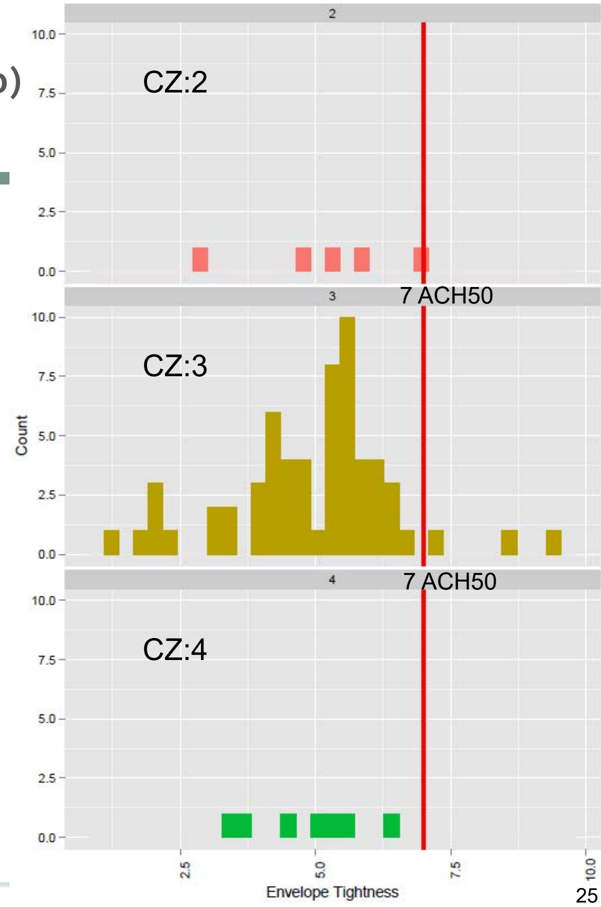

DUCT TIGHTNESS (CFM25/100 FT² CFA)

NO. OF OBSERVATIONS: 70

Vertical **red** line indicates the 2009 IECC prescriptive code requirement of maximum **12%** Total Leakage

Key Takeaways:
While many duct systems complied with the 2009 IECC, most would not comply with 2012/15 codes

Many duct systems located completely inside the thermal envelope tested much worse than 12% duct leakage

Lower is Better!

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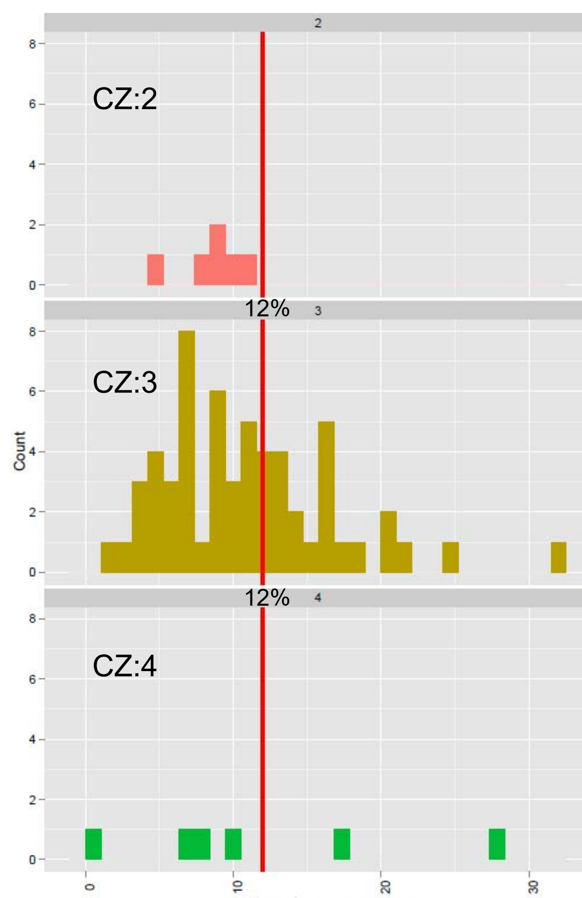

CEILING R-VALUE

NO. OF OBSERVATIONS: 99

Vertical **red** line indicates the 2009 IECC prescriptive code requirement of R-30 in CZ's 2 & 3 and R-38 in CZ 4

GA Code allows ceiling insulation to be traded down to as low as R-19

Key Takeaway:

Quality of installation (Grade) was generally average to poor

Higher is Better!

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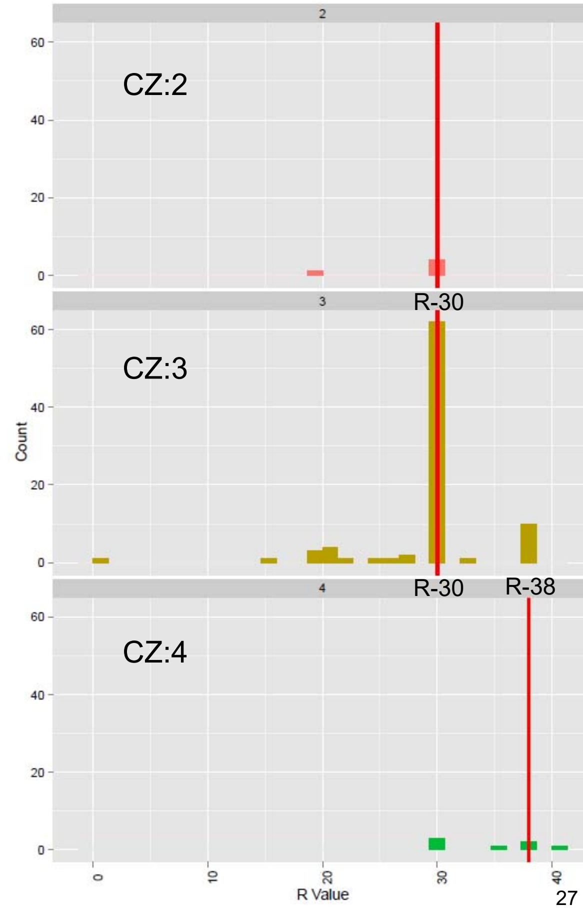

FRAME WALL R-VALUE (CAVITY)

NO. OF OBSERVATIONS: 76

Vertical **red** line indicates the 2009 IECC prescriptive code requirement of R-13 for all CZ's

Key Takeaway:

Quality of installation (Grade) was generally poor

Higher is Better!

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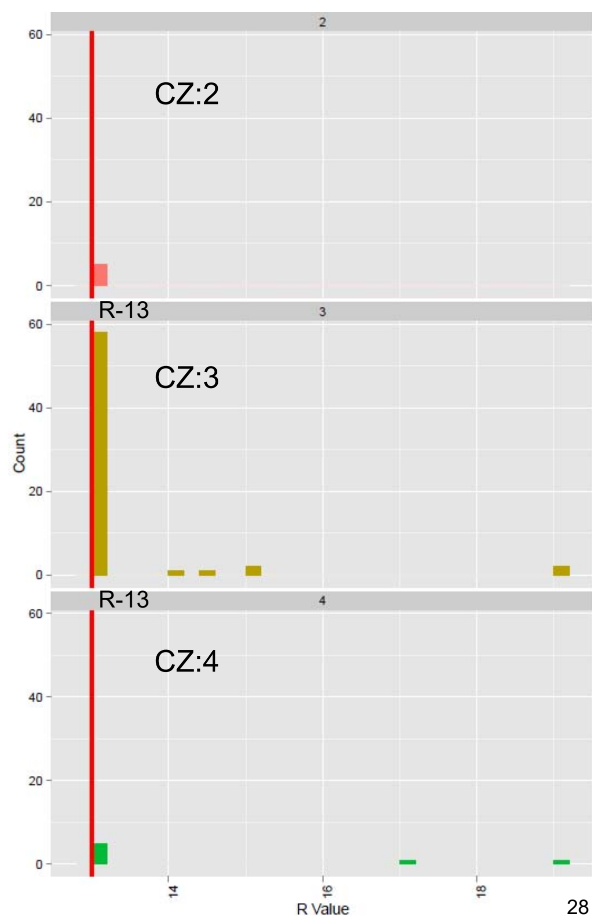

WINDOW U-FACTOR

NO. OF OBSERVATIONS: 122

Vertical **red** line indicates the 2009 IECC prescriptive code requirement – maximum Ufactor for each CZ:

CZ:2 – 0.65 – GA amended to 0.50
CZ:3 – 0.50
CZ:4 – 0.35

Key Takeaway:

Window compliance is very high

Lower is Better!

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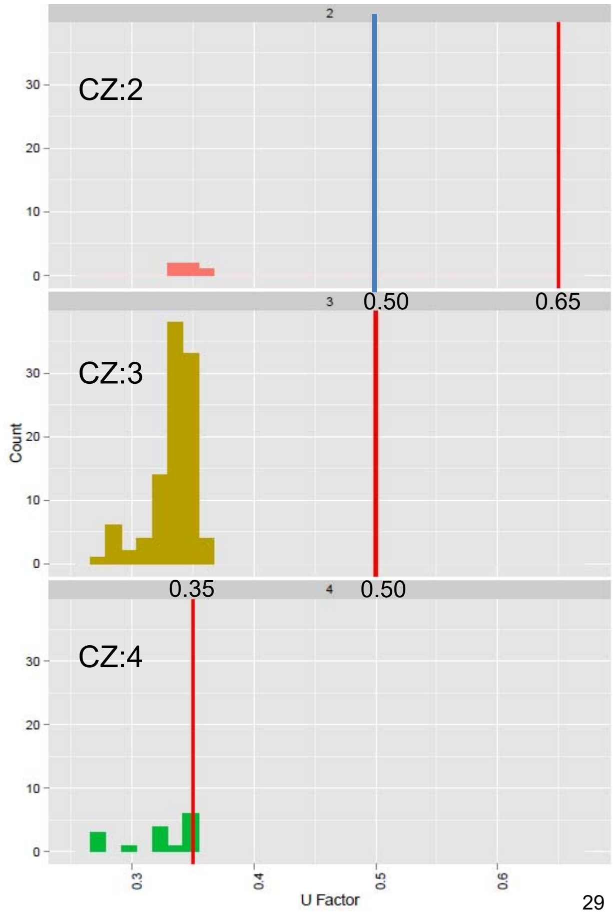

WINDOW SHGC

NO. OF OBSERVATIONS: 122

Vertical **red** line indicates the 2009 IECC prescriptive code requirement – maximum SHGC for each CZ:

CZ:2 – 0.30
CZ:3 – 0.30
CZ:4 – NR – GA amended to 0.30

Key Takeaway:

Window compliance is very high

Lower is Better!

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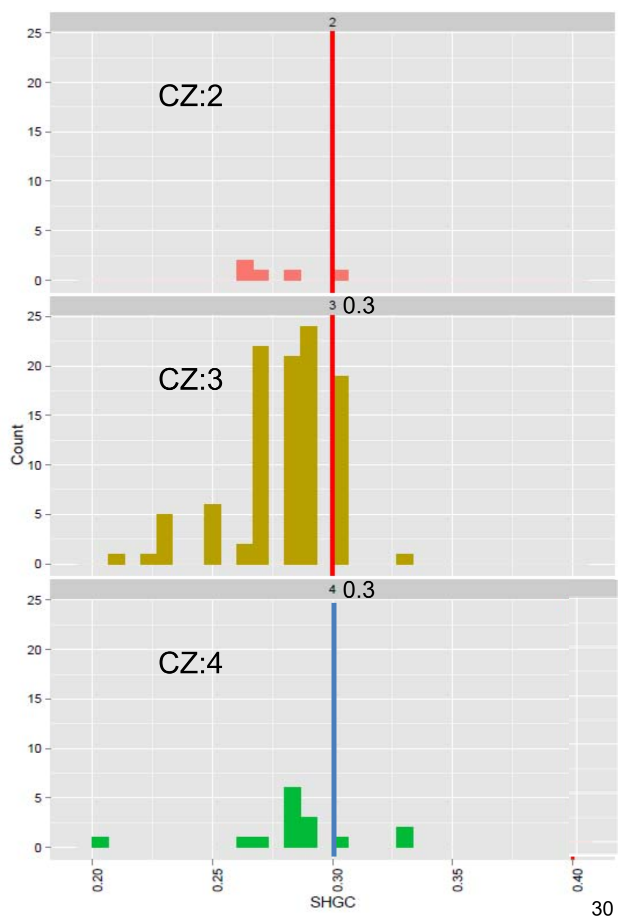

GEORGIA SAVINGS POTENTIAL

First-year savings if 100% compliance achieved

Electricity savings

- 11,148 MWh
- $2.41 million

Gas savings

- 547,700 therms
- $0.78 million

Total first-year savings:
$3.1 million

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RESIDENTIAL BUILDINGS

- New construction
- 1 and 2 family (R3)
- Multi-family, 3 stories and less (R2 and R4) – IECC 2015
- 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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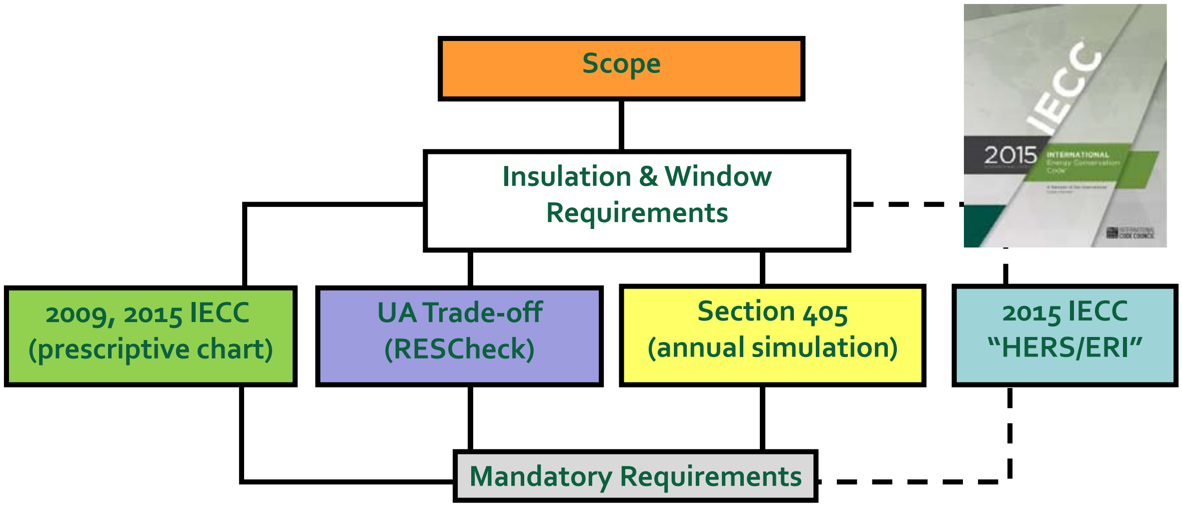
COMPLIANCE PATHS FOR INSULATION & WINDOWS



- 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)

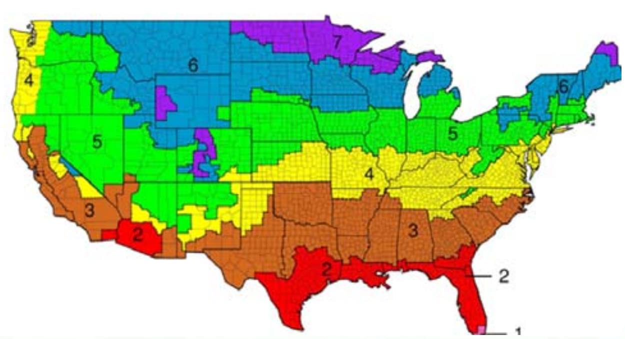
SUMMARY OF PRESCRIPTIVE 2015 IECC VS. ACTUAL 2020 GA ENERGY CODE

2015 Prescriptive R-values

Climate Zone	Fenestration Ufactor	Skylight Ufactor	Glazing SHGC	Ceiling	Wood Walls	Attic Kneewall	Mass Wall	Floor	Basement Wall	Slab	Crawl Wall	ACH_{50}
2	0.40	0.65	0.25	38	13	13	4/6	13	0	0	0	< 5
3	0.35	0.55	0.25	38	20 or 13+5	20 or 13+5	8/13	19	5/13	0	5/13	< 3
4	0.35	0.55	0.40	49	20 or 13+5	20 or 13+5	8/13	19	10/13	10, 2ft	10/13	< 3

Proposed Compromise Prescriptive R-values (Red indicates changes from current GA code)

Climate Zone	Fenestration	Skylight	Glazing	Ceiling	Wood	Attic	Mass Wall	Floor	Basement	Slab	Crawl	ACH_{50}
2	0.35	0.65	0.27	38	13	18	4/6	13	0	0	0	< 5
3	0.35	0.55	0.27	38	13	18	8/13	19	5/13	0	5/13	< 5
4	0.35	0.55	0.27	38	13	18	8/13	19	10/13	0	10/13	< 5



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2020 GA PRESCRIPTIVE CODE

SECTION R402
BUILDING THERMAL ENVELOPE

*Revise Table R402.1.2 'Insulation and Fenestration Requirements by Component[a]' as follows:

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	Attic Kneewall *R*-Value[i]	Mass Wall *R*-Value	Floor *R*-Value	Basement[c] Wall *R*-Value	Slab[d] *R*-Value & Depth	Crawl Space[c] Wall *R*-Value
2	0. 35	0.65	0.27	38	13	18	4/6	13	0	0	0
3	0.35	0.55	0.27	38	13	18	8/13	19	5/13[f]	0	5/13
4 except marine	0.35	0.55	0.27	38	13	18	8/13	19	10/13	0	10/13

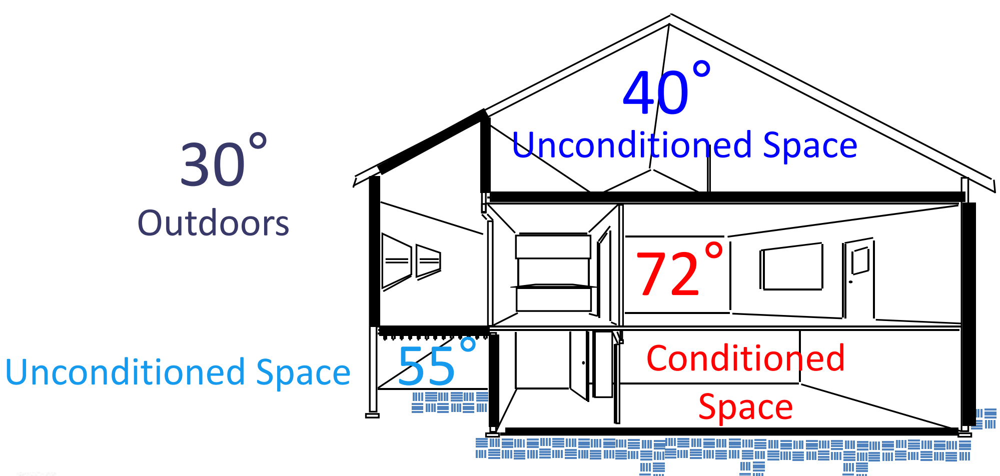
TABLE R402.1.4
EQUIVALENT *U*-FACTORS[a]

Climate Zone	Fenestration *U*-Factor	Skylight *U*-Factor	Ceiling *U*-Factor	Frame Wall *U*-Factor	Mass Wall *U*-Factor[b]	Floor *U*-Factor	Basement Wall *U*-Factor	Crawl Space Wall *U*-Factor
2	0.35	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.084	0.098	0.047	0.091[c]	0.136
4 except marine	0.35	0.55	0.030	0.084	0.098	0.047	0.059	0.065

402—BUILDING THERMAL ENVELOPE

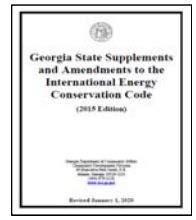
Building Thermal Envelope — The basement walls, exterior walls, floor, roof, and any other building element that enclose conditioned space. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space.

The *building thermal envelope* is the barrier that separates the conditioned space from the outside or unconditioned spaces. The building envelope consists of two parts - an air barrier and a thermal barrier that must be both continuous and contiguous (touching each other). In a typical residence, the building envelope consists of the roof, walls, windows, doors, and foundation. Examples of unconditioned spaces include attics, vented crawlspaces, garages, and basements with ceiling insulation and no HVAC supply registers.



CONDITIONED SPACE

~~**CONDITIONED SPACE.** An area, room or space that is enclosed within the building thermal envelope and that is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.~~



Georgia clarification:

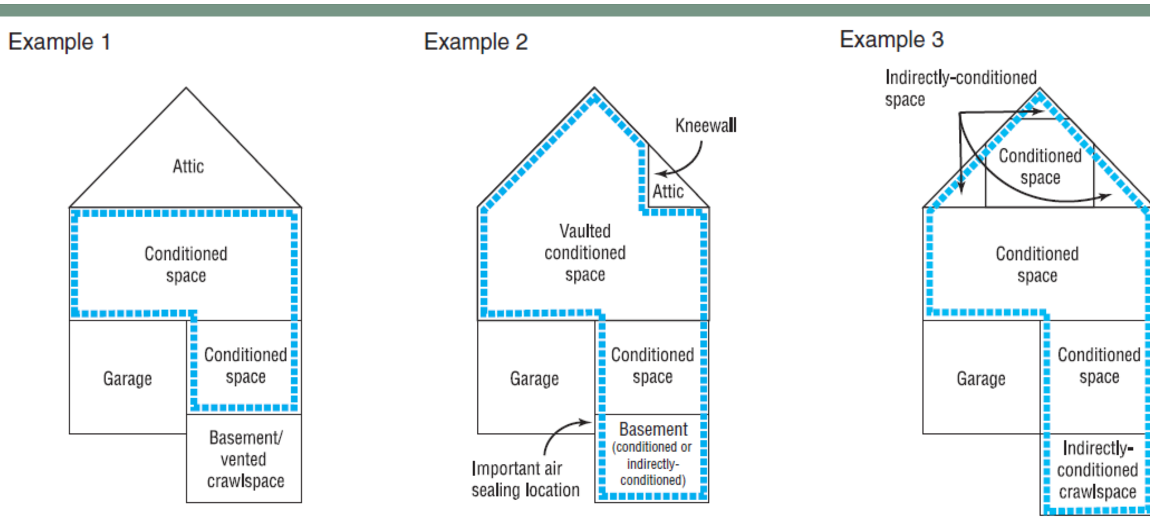
(a) Conditioned space: a cooled space, heated space, or indirectly conditioned space is defined as follows:

(1) Cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^2 of floor area.

(2) Heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h·ft^2.

(3) Indirectly conditioned space: an enclosed space within a building that is not a heated space or a cooled space, containing un-insulated ducts, or containing the heating equipment or which is heated or cooled indirectly by being connected to adjacent space(s), provided that air from heated or cooled spaces is transferred (naturally or mechanically) into the space. Unvented Attic Assemblies meeting the requirements of the IRC are an approved indirectly conditioned space.

APPENDIX RA – BUILDING THERMAL ENVELOPE



- Although these three homes look identical from the outside, each has defined the building thermal envelope differently

R402.2: SPECIFIC INSULATION REQUIREMENTS

Prescriptive details for insulating portions 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

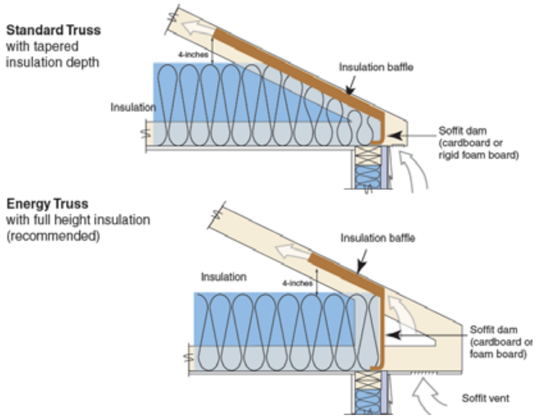
402.2.1 - CEILINGS WITH ATTICS

- R-38 is prescriptive requirement
- Complete coverage of continuous R-30 is deemed to comply
- GA: R-19 is acceptable under HVAC attic platforms
  (32 s.f./platform + 32” walkway)
- Rulers required every 300 s.f. for blown attic insulation (R301.1.1)

402.2.1 - CEILINGS WITH ATTICS

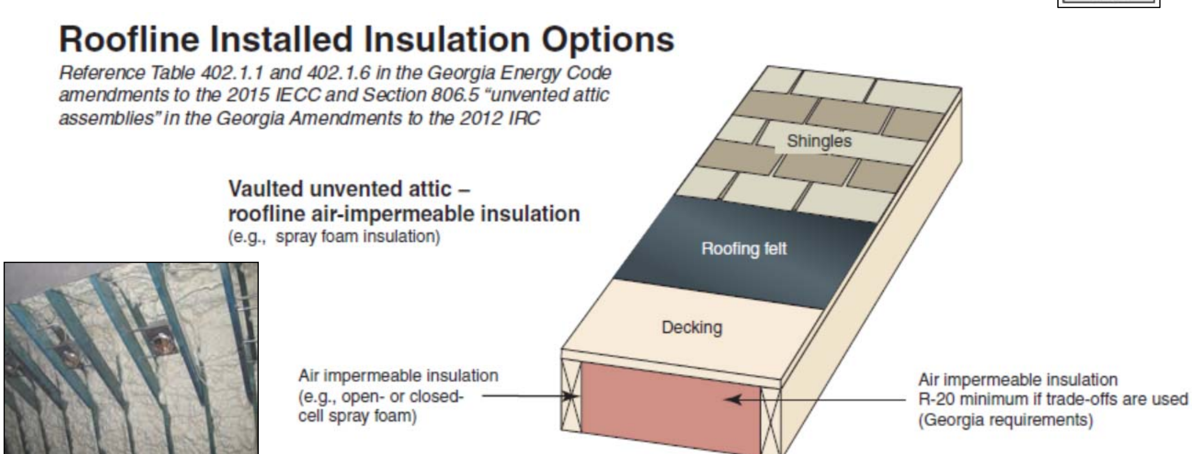
R402.2.1 Ceilings with attic spaces. Where Section R402.1.2 would require R-38 insulation in the ceiling, installing R-30 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-38 wherever the full height of uncompressed R-30 insulation extends completely 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.

For HVAC attic platforms used for locating and servicing equipment, R-19 (maximum *U*-Factor 0.047) shall be deemed to meet the requirements of R-38 (maximum *U*-Factor 0.027) in the ceiling. R-19 is deemed acceptable for up to 32 square feet of attic decking per HVAC system. R-19 shall be deemed acceptable for a maximum 32 inch wide passage to the HVAC system as referenced under M1305.1.2 of the International Residential Code.
(Effective January 1, 2020)



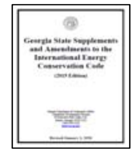
402.2.2 - CEILINGS WITHOUT ATTICS

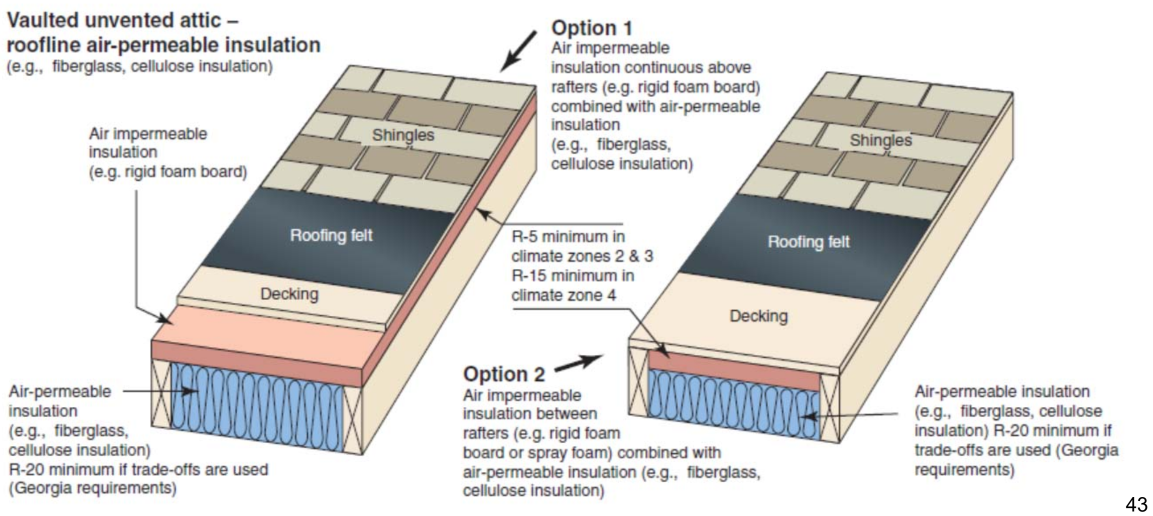
- R-30 for 20% (up to 500 s.f.) acceptable for CZ2-4
- Vaulted ceilings and foam sprayed rooflines will need to perform an R-value trade-off
- GA specific: Can trade down to unvented R-20 if spray foam insulation is used (air impermeable insulation)



402.2.2 - CEILINGS WITHOUT ATTICS

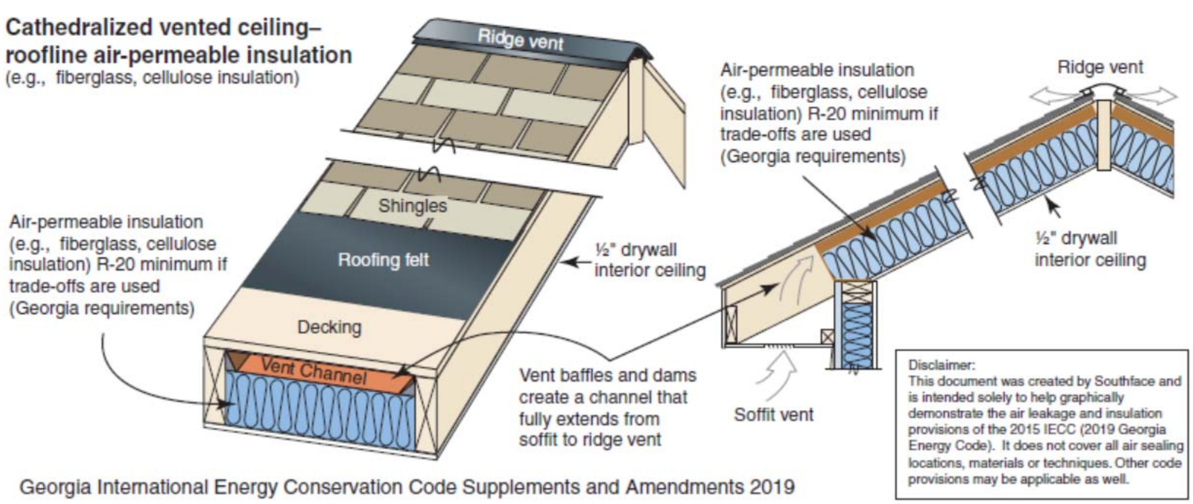
- Can trade down to R-20 fiberglass or cellulose (air-permeable insulation) with added:
  - R-5 (CZ 2 & 3) or R-15 (CZ 4) rigid foam board (air impermeable insulation) for unvented attics



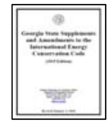


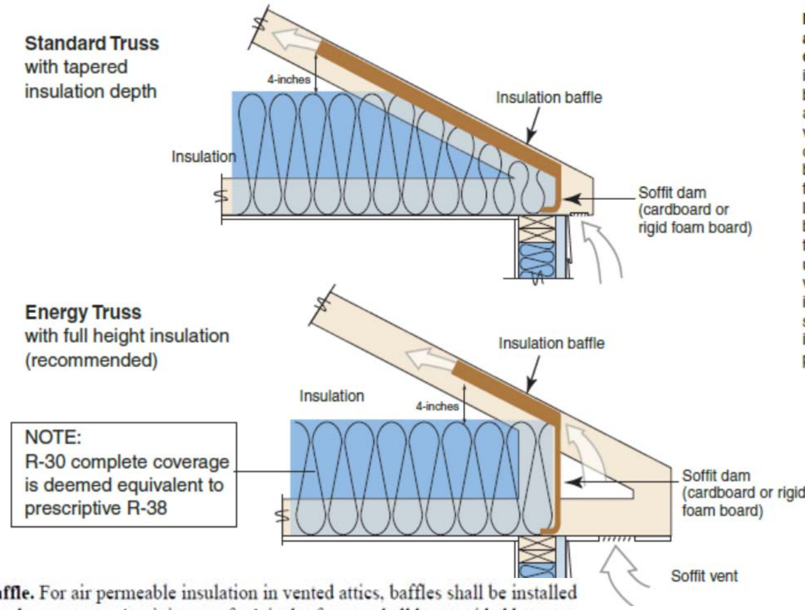
402.2.2 - CEILINGS WITHOUT ATTICS

- May trade down to R-20 fiberglass or cellulose (air-permeable insulation) with complete vented channel that extends to ridge



R402.2.3 EAVE BAFFLES

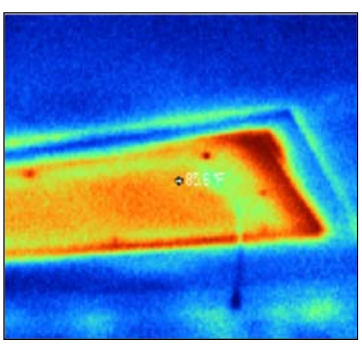




Note: Wind wash baffle and air-permeable insulation dam. For air permeable insulation in vented attics, baffles shall be installed adjacent to soffit and eave vents. A minimum of a 1-inch of space shall be provided between the insulation and the roof sheathing and at the location of the vent. The baffle shall extend over the top of the insulation inward until it is at least 4 inches vertically above the top of the insulation. Any solid material such as cardboard or thin insulating sheathing shall be permissible as the baffle.

R402.2.3 Eave baffle. For air permeable insulation in vented attics, baffles shall be installed adjacent to soffit and eave vents. A minimum of a 1-inch of space shall be provided between the insulation and the roof sheathing and at the location of the vent. The baffle shall extend over the top of the insulation inward until it is at least 4 inches vertically above the top of the insulation. Any solid material such as cardboard or thin insulating sheathing shall be permissible as the baffle. (See Appendix RA for further clarification.)
(Effective January 1, 2020)

R402.2.4 ACCESS HATCHES & DOORS



- 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 doors from conditioned spaces to unconditioned spaces (e.g. attics, unconditioned basements and crawl spaces) shall be weather-stripped and insulated in accordance with the following insulation values:

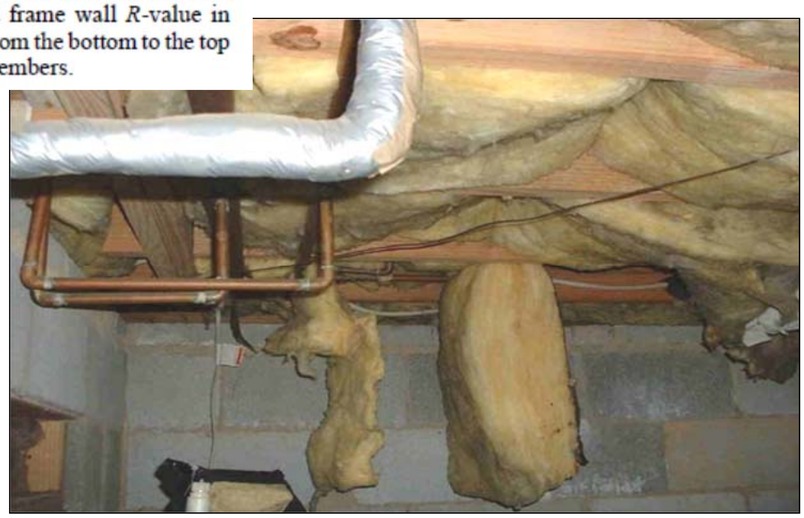
1. Hinged vertical doors shall have a maximum *U*-Factor of U-0.20 (R-5 minimum);
2. Hatches/scuttle hole covers shall have a maximum *U*-Factor of U-0.05 (R-19 minimum); and
3. Pull down stairs shall have a maximum *U*-Factor of U-0.20 with a minimum of 75 percent of the panel area having (R-5 minimum) insulation.

Access shall be provided to all equipment which prevents damaging or compressing the insulation. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed *R*-value of the loose fill insulation.
(Effective January 1, 2020)

R402.2.8 FLOORS

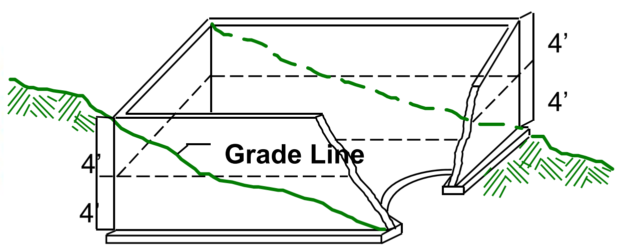
R402.2.8 Floors. Floor framing-cavity insulation shall be installed to maintain permanent contact with the underside of the subfloor decking.

> **Exception:** The floor framing-cavity insulation shall be permitted to 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 402.1.2 and that extends from the bottom to the top of all perimeter floor framing members.



R402.2.9 BASEMENT WALLS

R402.2.9 Basement walls. Walls associated with conditioned basements shall be insulated from the top of the *basement wall* down to 10 feet (3048 mm) below grade or to the basement floor, whichever is less. Walls associated with unconditioned basements shall meet this requirement unless the floor overhead is insulated in accordance with Sections R402.1.2 and R402.2.8.



Basement Wall – Average gross wall must be > 50% below grade and enclose conditioned space

CZ4: R-10 continuous or R-13 cavity

CZ3: R-5 continuous or R-13 cavity

CZ2: No insulation required

R402.2.9 BASEMENT WALLS

Insulation strategies:

Cellulose batt

Fiberglass batt w/ vinyl backing

Rigid foam board

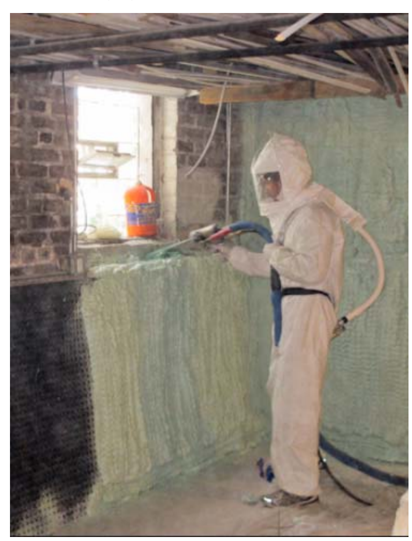
402.2.9 BASEMENT WALLS

Insulation strategies:

Rigid foam board

Fiberglass batt in AGW, foam board on concrete

Spray Polyurethane Foam



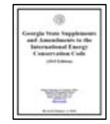
Southface

BASEMENT WALL INSULATION

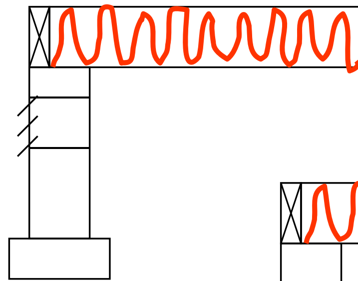

BASEMENT WALL INSULATION

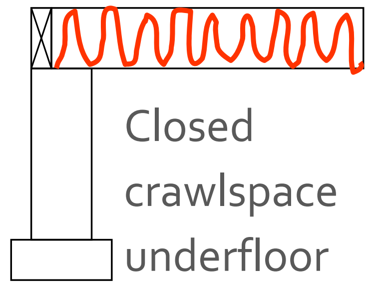
Blanket basement
insulation options


R402.2.11 CRAWLSPACE WALLS

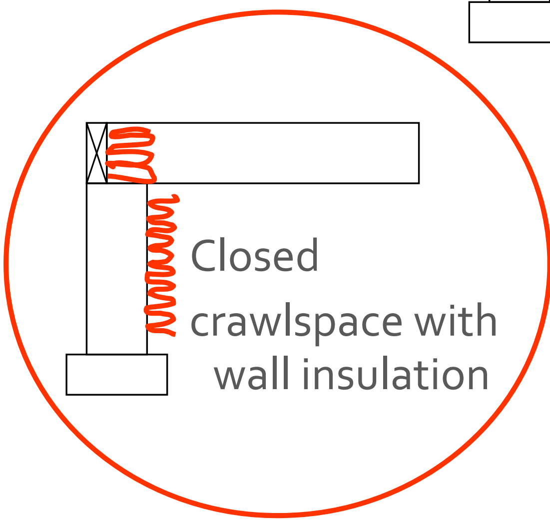


Standard vented crawlspace - underfloor insulation





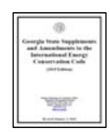
Closed crawlspace underfloor insulation



Closed crawlspace with wall insulation

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

R402.2.11 CRAWLSPACE WALLS



Seal ground with plastic (6" up walls, 6" overlaps)

Insulate interior of walls to satisfy code (R-10 in CZ4, R-5 in CZ3, R-0 in CZ2)

Eliminate all vents and leaks (access doors)

Satisfy IRC exception to vent requirement (IRC section R408.3)

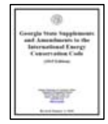
Venting Exceptions:

- 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

R402.2.11 CRAWLSPACE WALLS



R402.2.11 Crawl space walls. As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to within 9 inches (229 mm) of the finished interior grade adjacent to the foundation wall. A 3-inch (76 mm) inspection/view strip immediately below the floor joists shall be provided to permit inspections for termites. Exposed earth in unvented crawl space foundations shall be covered with a continuous Class 1 vapor retarder in accordance with the *International Building Code*. All joints of the vapor retarder shall overlap by 6 inches (152 mm) and be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (152 mm) up the stem wall and shall be attached and sealed to the stem wall.
(Effective January 1, 2020)

www.crawlspaces.org

Air seal & insulate band area

3-inch view strip (removable is option)

Crawl space wall insulation to extend to within 0-9" of finished interior grade

Complete plastic sealed to walls at least 6 inches up the stem wall

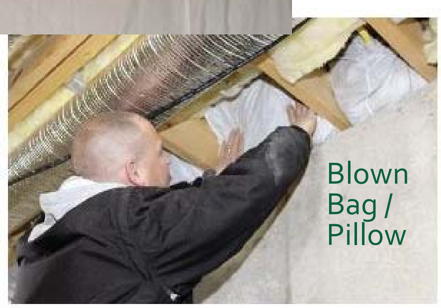
INSULATION TECHNIQUES – BAND AREA

Open/ Closed Cell Foam

- 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.)

Caulk and Fiberglass Batt

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



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 |

PROBLEMS WITH UNDERFLOOR INSULATION

R402.3 FENESTRATION

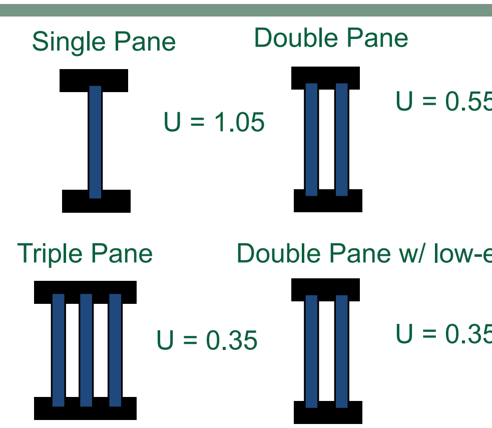
U-factor

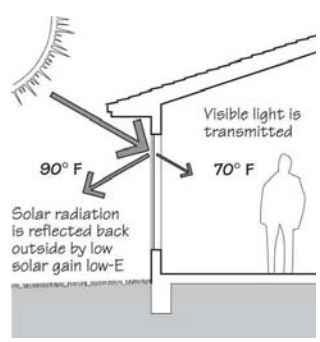
Lower U-factor means better insulated (U = 1/R)

U-factor applies to
- windows,
- skylights,
- doors

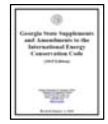
Solar Heat Gain Coefficient

The SHGC is the fraction of the solar heat from the sun that enters through a window
- SP clear glass
  SHGC: ~ 0.8
- DP clear glass
  SHGC: ~ 0.6-0.7
- DP low-e
  (low solar gain)
  SHGC: ~ 0.3





R402.3 FENESTRATION




Low-e effectively required!

Maximum fenestration

U-factor = 0.35 in CZ 2-4

- Area weighted average **Ufactor** acceptable

SHGC = 0.27 for all *glazing*

- Area weighted average **SHGC** acceptable

Southface

Weighted Average Calculator: U Factor and Solar Heat Gain Coefficient (SHGC)
Directions: For each window type, enter the **U-Factor**, the **SHGC**, the **area of a *single* window**, and the **total number** of windows in the bulding (fill in blue shaded cells only)

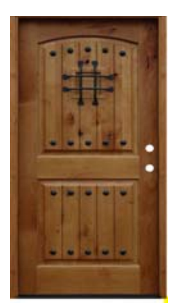
Window Type	U Factor	SHGC	Single window area (sq. ft.)	Number of windows of this type
A	0.33	0.26	20	10
B	0.37	0.28	24	2
C				0
D				0

U-Factor Weighted Average	0.34
SHGC Weighted Average	0.26
Total Window Area (square feet)	248

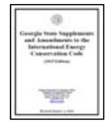
R402.3 FENESTRATION EXEMPTIONS


R402.3.3 Glazed fenestration exemption. Up to 15 square feet (1.4 m^2) of glazed fenestration per dwelling unit shall be permitted to be exempt from *U*-factor and SHGC requirements in Section R402.1.2. This exemption shall not apply to the *U*-factor alternative approach in Section R402.1.4 and the Total UA alternative in Section R402.1.5.

R402.3.4 Opaque door exemption. One side-hinged opaque door assembly up to 24 square feet (2.22 m^2) in area is exempted from the *U*-factor requirement in Section R402.1.4. This exemption shall not apply to Attic Access Doors or the *U*-factor alternative approach in Section R402.1.4 and the total UA alternative in Section R402.1.5.
(Effective January 1, 2020)



AIR SEALING & INSULATION



R402.4.1.1 Installation. The components of the building thermal envelope shall be installed in accordance with the manufacturer's instructions and the criteria listed on page 1 of Appendix RA of the 2020 Georgia State Supplements and Amendments, as applicable to the method of construction. Where required by the *code official,* an *approved* third party shall inspect all components and verify compliance. See Appendix RA 'AIR BARRIER AND INSULATION INSTALLATION COMPONENT GUIDE' of these Georgia State Supplements and Amendments for a graphical representation of the items listed above.

Appendix RA
Air Sealing and Insulation Key Points
Air Barrier and Insulation Installation Component Guide

	COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
1	General requirements	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.
2	Ceiling/attic	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.
3	Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.
4	Windows, skylights and doors	The space between window/door jambs and framing, and skylights and framing shall be sealed.	
5	Rim joists	Rim joists shall include the air barrier.	Rim joists shall be insulated.
6	Floors (including above garage and cantilevered floors)	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extends from the bottom to the top of all perimeter floor framing members.
7	Crawl space walls	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.	Where provided instead of floor insulation (unvented crawl spaces), insulation shall be permanently attached to the crawlspace walls.
8	Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.	Capped chases shall be insulated to surrounding ceiling *R*-values (maintain clearance from combustion flues).
9	Narrow cavities		Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
10	Garage separation	Air sealing shall be provided between the garage and conditioned spaces.	Band area shall be blocked, sealed and insulated.
11	Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be sealed to the drywall.	Recessed light fixtures installed in the building thermal envelope shall be air tight and IC rated.
12	Plumbing and wiring	Wiring and plumbing penetrations shall be sealed.	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
13	Shower/tub on exterior wall	The air barrier installed at exterior walls adjacent to showers and tubs shall separate them from the showers and tubs.	Exterior walls adjacent to showers and tubs shall be insulated.
14	Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air-sealed boxes shall be installed.	
15	HVAC register boots	HVAC register boots shall be sealed to the subfloor or drywall.	Boots in unconditioned spaces shall be insulated. Recommend insulating boots in conditioned spaces for condensation control.
16	Concealed sprinklers	When required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.	
17	Blocking between framing (e.g. beneath knee walls, cantilevered floors, garage separation walls)	Blocking shall be sealed to framing.	Insulation shall be in contact with blocking.
18	Common walls	Air barrier is installed in common wall between dwelling units.	
19	Fireplaces	New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air.	Fireplace chase insulation shall be restrained to stay in place.

AIR SEALING & INSULATION

Appendix RA
Air Sealing and Insulation Key Points
Air Barrier and Insulation Installation Component Guide

	COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
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3	Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.
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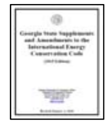
6	Floors (including above garage and cantilevered floors)	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extends from the bottom to the top of all perimeter floor framing members.
7	Crawl space walls	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.	Where provided instead of floor insulation (unvented crawl spaces), insulation shall be permanently attached to the crawlspace walls.

AIR SEALING & INSULATION



8	Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.	Capped chases shall be insulated to surrounding ceiling *R*-values (maintain clearance from combustion flues).
9	Narrow cavities		Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
10	Garage separation	Air sealing shall be provided between the garage and conditioned spaces.	Band area shall be blocked, sealed and insulated.
11	Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be sealed to the drywall.	Recessed light fixtures installed in the building thermal envelope shall be air tight and IC rated.
12	Plumbing and wiring	Wiring and plumbing penetrations shall be sealed.	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
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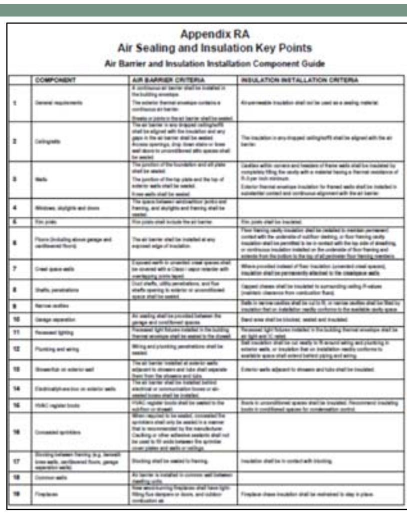
15	HVAC register boots	HVAC register boots shall be sealed to the subfloor or drywall.	Boots in unconditioned spaces shall be insulated. Recommend insulating boots in conditioned spaces for condensation control.
16	Concealed sprinklers	When required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.	
17	Blocking between framing (e.g. beneath knee walls, cantilevered floors, garage separation walls)	Blocking shall be sealed to framing.	Insulation shall be in contact with blocking.
18	Common walls	Air barrier is installed in common wall between dwelling units.	
19	Fireplaces	New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air.	Fireplace chase insulation shall be restrained to stay in place.

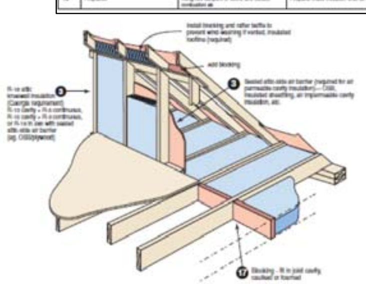
Disclaimer: This document was created by Southface and is intended solely to help graphically demonstrate the air leakage and insulation provisions of the 2015 IECC (2020 Georgia Energy Code). It does not cover all air sealing locations, materials or techniques. Other code provisions may be applicable as well.

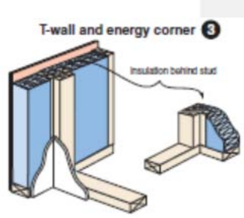
APPENDIX RA - GRAPHICS ILLUSTRATE AIR SEALING & INSULATION

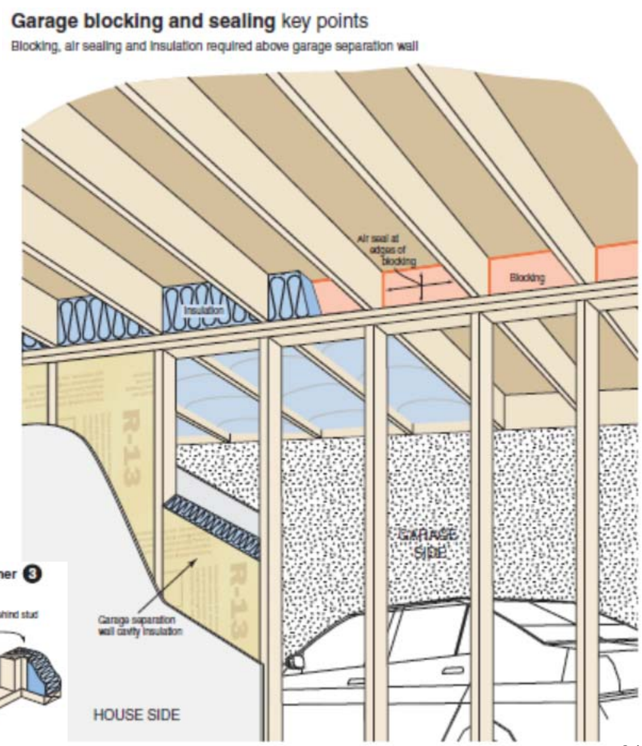


Appendix RA
Air Sealing and Insulation Key Points
Air Barrier and Insulation Installation Component Guide

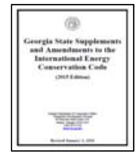
	COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA







BLOWER DOOR ENVELOPE TESTING



- Required by GA Energy Code
- Single Family < 5 ACH_{50}

$$ACH_{50} = \frac{CFM_{50} \times 60}{\text{Volume}}$$

- Quantifies the Amount of Leakage Across the Home's Thermal Boundary
- Test Performed by a Certified Professional (DET Verifier)
- Reported to Builder and Code Official via Certificate

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MULTIFAMILY BLOWER DOOR TESTING

R402.4.1.3 Low-rise R-2 multifamily testing. Low-rise R-2 multifamily dwellings shall be tested to less than 7 air changes per hour at 50 Pascals (ACH50).

As an alternative to ACH50, compliance for Low-rise R-2 dwellings may be attained by achieving an Envelope Leakage Ratio at 50 Pascals (ELR50) of less than 0.35 (ELR50 < 0.35, where ELR50 = CFM50 / Envelope Shell Area, in square feet). (Effective January 1, 2020)

*Add a new Section R402.4.1.3.1 'Low-rise multifamily testing protocol (Optional)' to read as follows:

R402.4.1.3.1 Low-rise multifamily testing protocol (Optional). Where a residential building is classified as R-2, envelope testing may (optionally) employ either one or both of the following testing protocols:

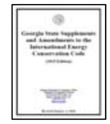
1. Utilize multiple fans in adjacent units (commonly referred to as Guarded Blower Door testing) to minimize effect of leakage to adjacent units (not required).
2. Envelope testing of less than 100 percent shall be acceptable assuming a maximum sampling protocol of 1 in 4 units per floor (if sampled unit passes, the remaining up to three units are deemed to comply; if sampled unit fails, it must be sealed and retested and the remaining up to three units shall also be tested).

- Low-rise Multifamily < 7 ACH_{50}
- Option for < 0.35 ELR_{50}

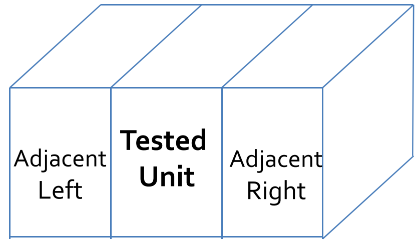
$$ELR_{50} = \frac{CFM_{50}}{\text{Shell Area}}$$

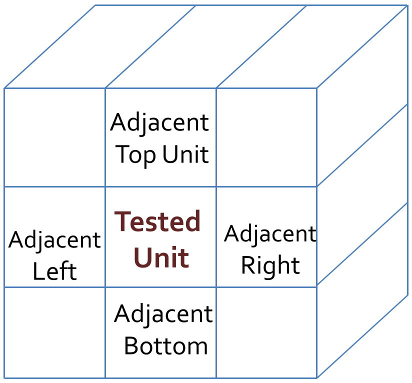
- Option for Guarded MF Testing
- Option for 1 in 4 per floor Sampling

MULTIFAMILY BLOWER DOOR TESTING



- MF testing options
  - Unguarded
  - Guarded





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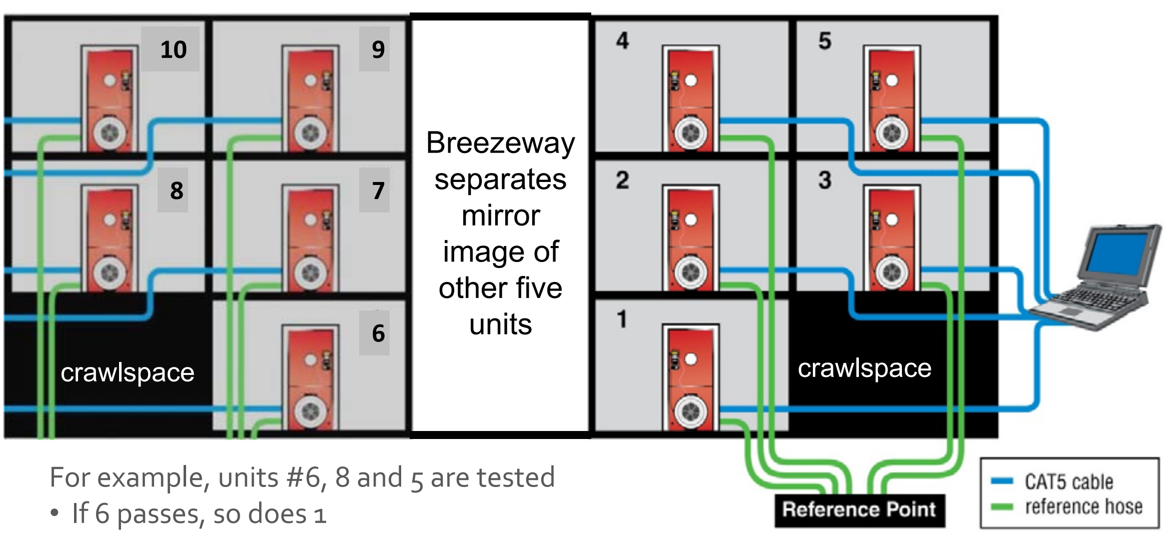
MULTIFAMILY BLOWER DOOR SAMPLING OPTION

- 1 unit in (up to) 4 per floor is tested – if it **passes**, remaining (up to 3) units pass
- If sampled unit **fails**, it must be sealed and retested and remaining (up to 3) units must be tested and pass



For example, units #6, 8 and 5 are tested

- If 6 passes, so does 1
- If 8 passes, so do 7, 2 and 3
- If 5 passes, so do 4, 9 and 10

ENVELOPE TESTING SUMMARY

REQUIRED Blower Door test by certified **Duct and Envelope Tightness (DET) verifier**

- Single Family less than **5 ACH_{50}**

Exceptions

- Low-rise multifamily (R2 only) – 2 options
  1. Test each unit at less than 7 ACH_{50}
  2. Sample Test 1 in 4 units (<7 ACH_{50})
- Renovations that do not touch entire building envelope

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

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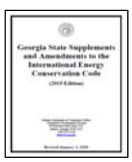
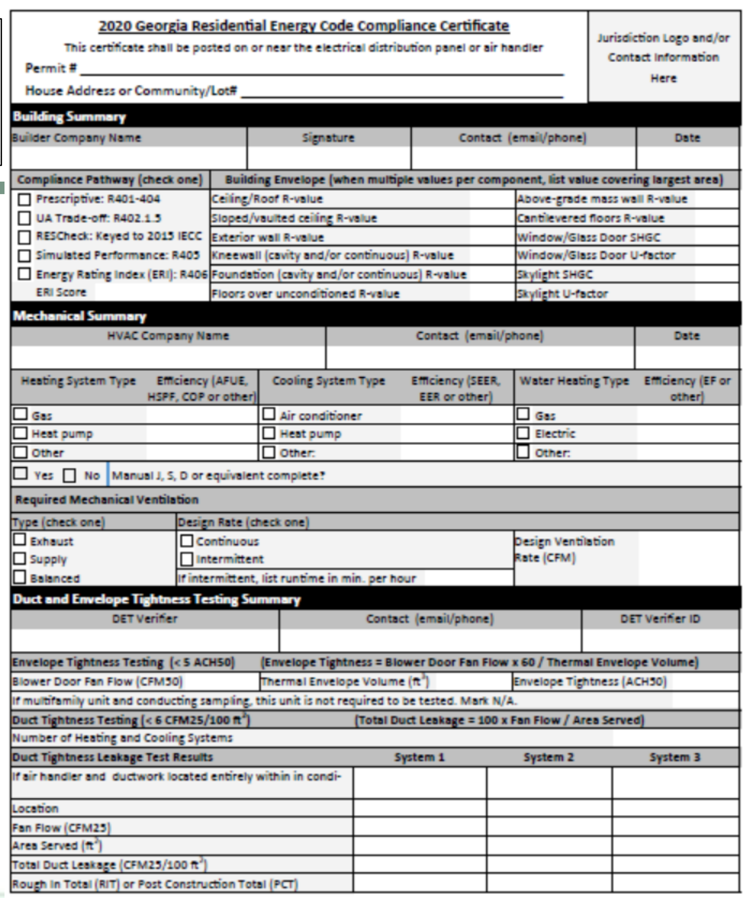
THE GA 2020 COMPLIANCE CERTIFICATE



Blower Door test results go here:

Duct Tightness results go here:



2020 Georgia Residential Energy Code Compliance Certificate

This certificate shall be posted on or near the electrical distribution panel or air handler

Permit # ____

House Address or Community/Lot# ____

Jurisdiction Logo and/or Contact Information Here

Building Summary

Builder Company Name	Signature	Contact (email/phone)	Date

Compliance Pathway (check one)	Building Envelope (when multiple values per component, list value covering largest area)			
☐ Prescriptive: R401-404	Ceiling/Roof R-value		Above-grade mass wall R-value	
☐ UA Trade-off: R402.1.5	Sloped/vaulted ceiling R-value		Cantilevered floors R-value	
☐ RESCheck: Keyed to 2015 IECC	Exterior wall R-value		Window/Glass Door SHGC	
☐ Simulated Performance: R405	Kneewall (cavity and/or continuous) R-value		Window/Glass Door U-factor	
☐ Energy Rating Index (ERI): R406	Foundation (cavity and/or continuous) R-value		Skylight SHGC	
ERI Score	Floors over unconditioned R-value		Skylight U-factor	

Mechanical Summary

HVAC Company Name	Contact (email/phone)	Date

Heating System Type	Efficiency (AFUE, HSPF, COP or other)	Cooling System Type	Efficiency (SEER, EER or other)	Water Heating Type	Efficiency (EF or other)
☐ Gas		☐ Air conditioner		☐ Gas	
☐ Heat pump		☐ Heat pump		☐ Electric	
☐ Other		☐ Other:		☐ Other:	

☐ Yes ☐ No Manual J, S, D or equivalent complete?

Required Mechanical Ventilation

Type (check one)	Design Rate (check one)		
☐ Exhaust ☐ Supply ☐ Balanced	☐ Continuous ☐ Intermittent If intermittent, list runtime in min. per hour	Design Ventilation Rate (CFM)	

Duct and Envelope Tightness Testing Summary

DET Verifier	Contact (email/phone)	DET Verifier ID

Envelope Tightness Testing (< 5 ACH50) (Envelope Tightness = Blower Door Fan Flow x 60 / Thermal Envelope Volume)

Blower Door Fan Flow (CFM50)		Thermal Envelope Volume (ft^3)		Envelope Tightness (ACH50)	

If multifamily unit and conducting sampling, this unit is not required to be tested. Mark N/A.

Duct Tightness Testing (< 6 CFM25/100 ft^2) (Total Duct Leakage = 100 x Fan Flow / Area Served)

Number of Heating and Cooling Systems

Duct Tightness Leakage Test Results	System 1	System 2	System 3
If air handler and ductwork located entirely within in condi-			
Location			
Fan Flow (CFM25)			
Area Served (ft^2)			
Total Duct Leakage (CFM25/100 ft^2)			
Rough In Total (RIT) or Post Construction Total (PCT)			

Version 1.0

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HOW TO FAIL A BLOWER DOOR TEST

Bad!!!

CORRECT PRACTICE –
INSULATE + SEAL BEFORE TUB IS SET

Good!!!

HOW TO FAIL A BLOWER DOOR TEST

Bad!!!

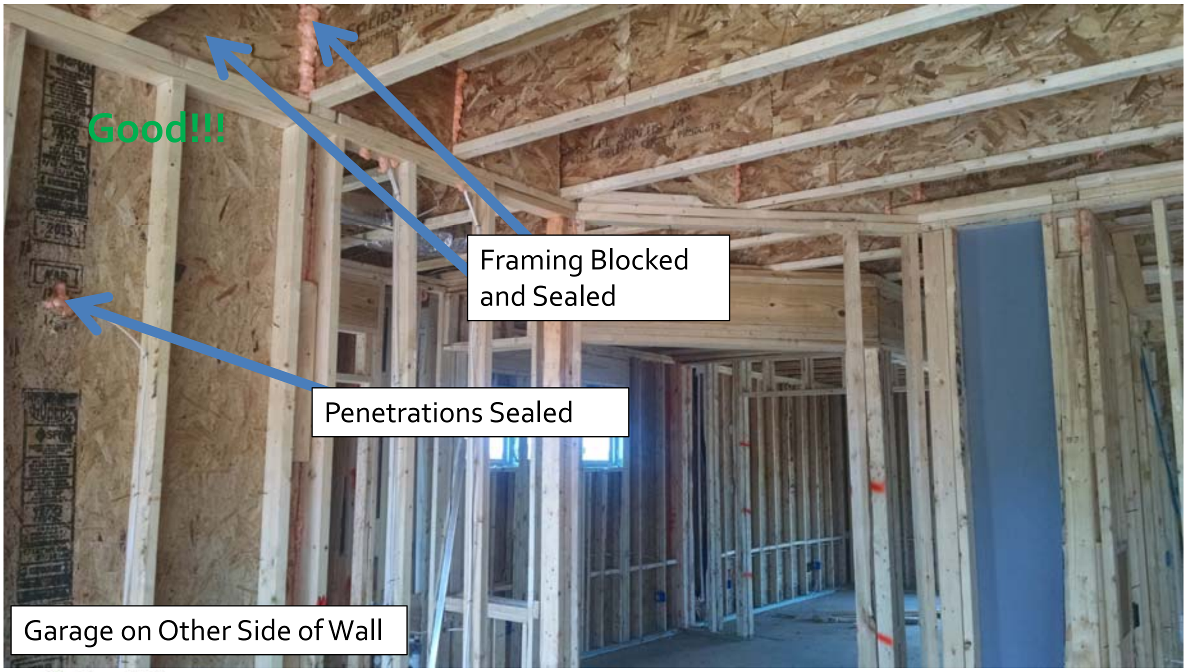
Don't Install Blocking
(Just Cover Over With Insulation)

HOW TO FAIL A BLOWER DOOR TEST

Bad!!!

Don't Air Seal Blocking
(Just Cover Over With Insulation)

CORRECT PRACTICE – BLOCK AND SEAL BAND AREAS



HOW TO FAIL A BLOWER DOOR TEST

Bad!!!

CORRECT PRACTICE – CAP CHASES

Good!!!

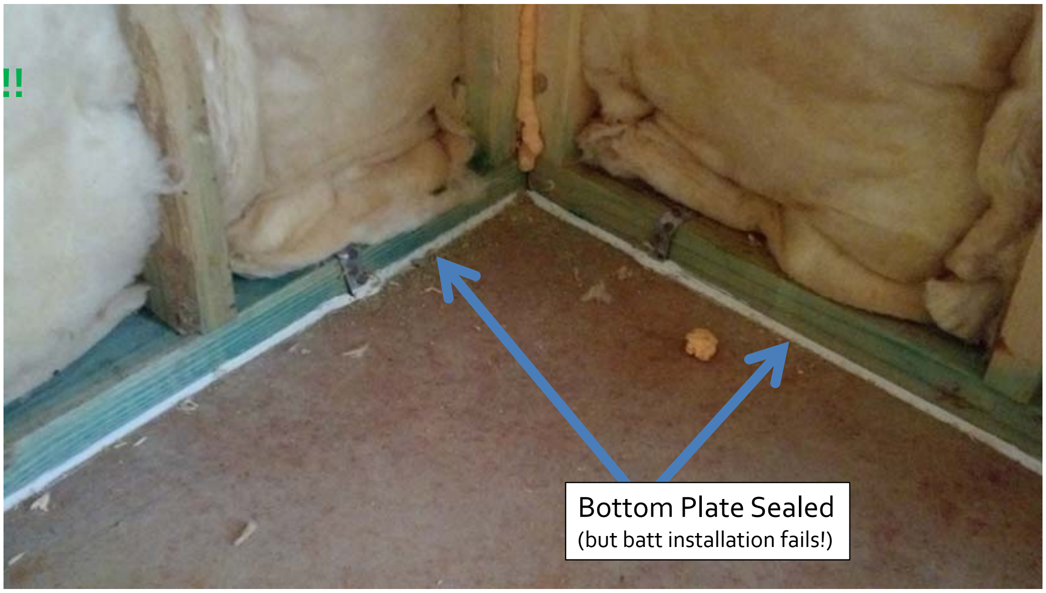
Chase capped and sealed around duct

CORRECT PRACTICE – SEAL PLATE PENETRATIONS

Good!!!

CORRECT PRACTICE – BOTTOM PLATE SEALED

Good!!!



HOW TO FAIL A BLOWER DOOR TEST

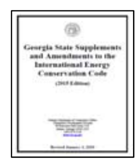
Bad!!!

HOW TO FAIL A BLOWER DOOR TEST

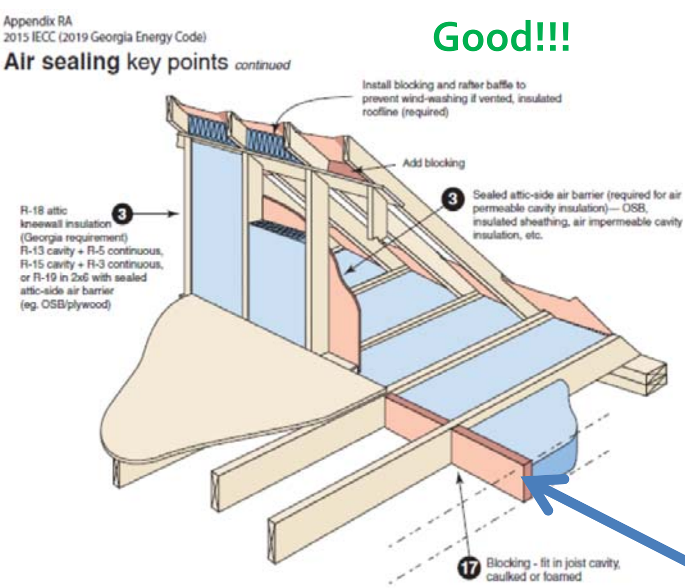
Bad!!!

Don't sheath and block kneewalls
(Just Cover With Insulation)

CORRECT PRACTICES – BLOCK + SHEATH KNEEWALLS



Good!!!



Install Kneewall blocking

INSTALLING INSULATION

- Voids/gaps
- Compression/ incomplete fill

These do NOT pass code!!

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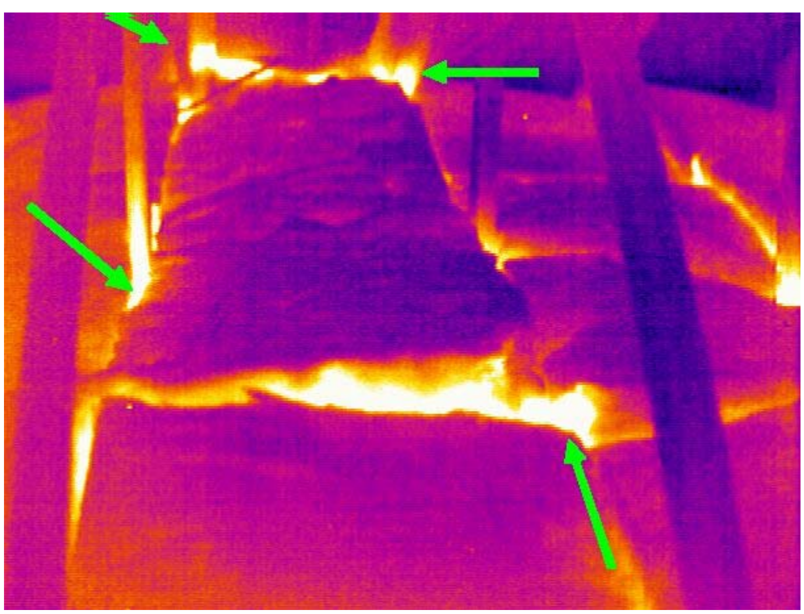
CONTINUOUS INSULATION & AIR BARRIER

Building Thermal Envelope

(air barrier and insulation must be in complete contact)



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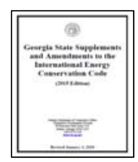
CEILING INSULATION FAIL

INSTALLING INSULATION

- Voids / Gaps
- Compression / Incomplete Fill



Georgia Insulation Installation – *Passing Grade Details*

Wall and ceiling insulation that makes up portions of the building thermal envelope in Georgia residences shall be installed to Passing Grade quality.

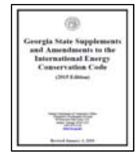
Two criteria affect installed insulation grading: **voids/ gaps** (in which no insulation is present in a portion of the overall insulated surface) and **compression/incomplete fill** (in which the insulation does not fully fill out or extend to the desired depth).

Voids/Gaps
- Voids or gaps in the insulation are < 1% of overall component surface area (only occasional and very small gaps allowed for Passing Grade)

Compression/Incomplete Fill
- Compression/Incomplete Fill for both *air permeable insulation* (e.g., fiberglass, cellulose) and *air impermeable insulation* (e.g., spray polyurethane foam) must be less than 1 inch in depth or less than 30% of the intended depth, whichever is more stringent. The allowable area of compression/incomplete fill must be less than 2% of the overall insulated surface to achieve a Passing Grade.
- Any compression/incomplete fill with a **depth** greater than the above specifications (up to 1" or 30% of the intended depth, whichever is more stringent) shall not achieve a Passing Grade.

Additional Wall Insulation Requirements
- All vertical air permeable insulation shall be installed in substantial contact with an air barrier on all six (6) sides. *Exception*: Unfinished basements, rim/band joist cavity insulation and fireplaces (insulation shall be restrained to stay in place).
  For unfinished basements, air permeable insulation and associated framing in a framed cavity wall shall be installed less than ¼" from the basement wall surface.
- Attic kneewall details – Attic kneewalls shall be insulated to a total R-value of at least R-18 through any combination of cavity and continuous insulation. Air permeable insulation shall be installed with a fully sealed attic-side air barrier (e.g., OSB with seams caulked, rigid insulation with joints taped, etc.). Attic kneewalls with air impermeable insulation shall not require an additional attic-side air barrier.

WALL INSULATION – VOIDS / GAPS

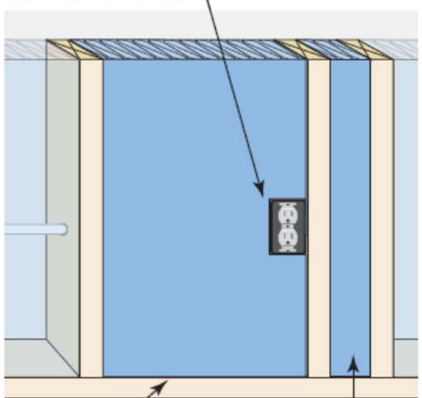


Wall Insulation key points

Voids / Gaps

Passing Grade

Insulation is notched and completely surrounds electrical box



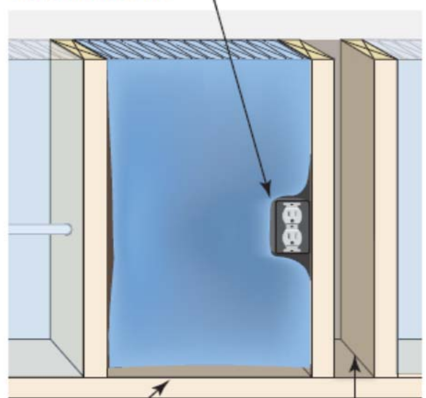
Insulation fully fills cavity at top and bottom

Narrow cavity fully insulated

Good!!!

Unacceptable Installation

Incomplete insulation coverage around electrical box



Insulation does not extend to bottom of cavity

Narrow cavity not insulated

Bad!!!

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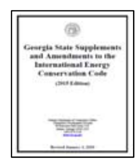
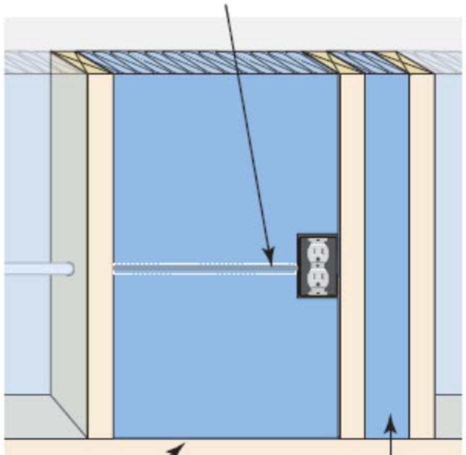
WALL INSULATION – COMPRESSION / INCOMPLETE FILL



Passing Grade

Insulation is slit around electrical wire



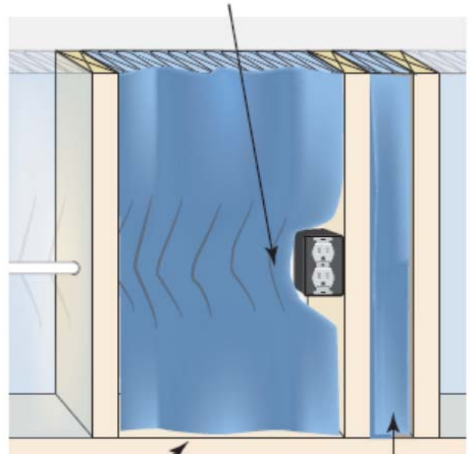
Insulation extends from front to back and fully fills entire cavity

Proper width insulation fully fills narrow cavity

Good!!!

Unacceptable Installation

Insulation is compressed behind electrical wire



Insulation does not fully fill entire cavity

Improper width insulation is compressed into narrow cavity

Bad!!!

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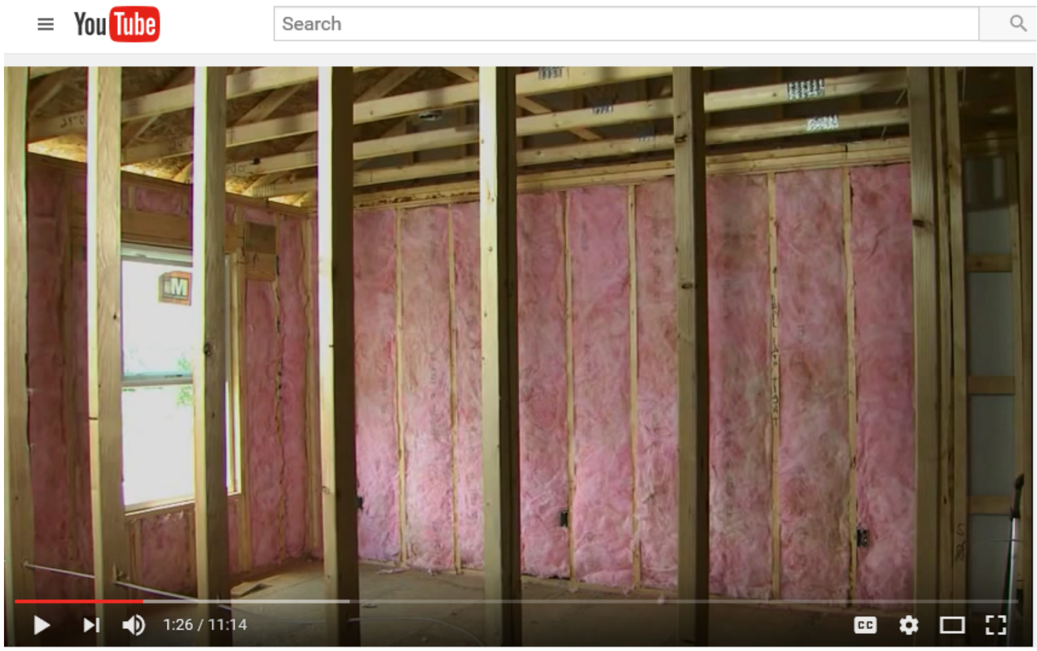
INSULATION:
INSTALLATION VS. VAPOR RETARDER

R402.1.1 Vapor retarder. Wall assemblies in the *building thermal envelope* shall comply with the vapor retarder requirements of Section R702.7 of the *International Residential Code* or Section 1405.3 of the *International Building Code*, as applicable.

- Vapor retarders such as plastic or kraft paper on batts is not required in CZ 1-4 (all of GA)

VIDEOS OF INSULATION INSTALLATION

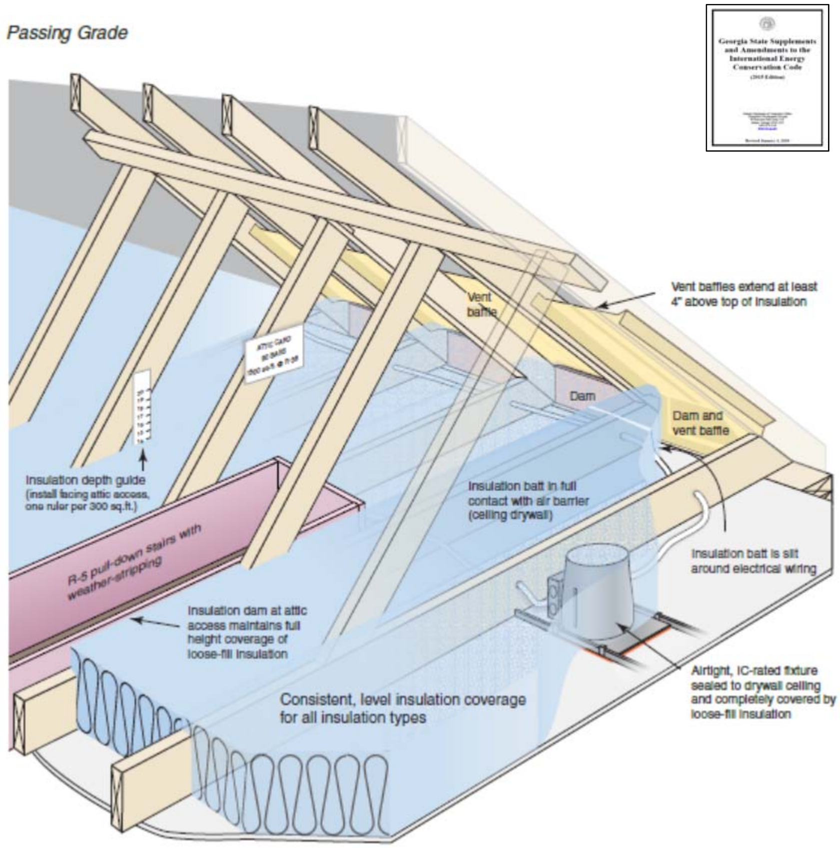
VIDEOS OF INSULATION INSTALLATION



VIDEOS OF INSULATION INSTALLATION

CEILING INSULATION

Good!!!



Georgia State Supplements and Amendments to the International Energy Conservation Code (2015 Edition)

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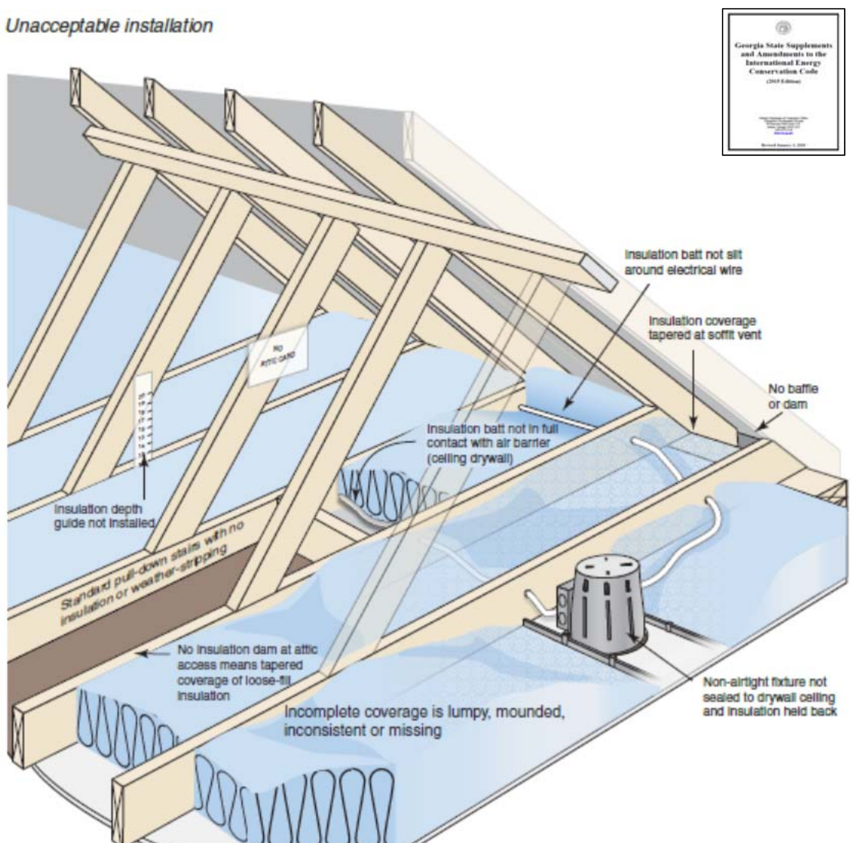
CEILING INSULATION

Bad!!!



Georgia State Supplements and Amendments to the International Energy Conservation Code (2015 Edition)

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Ugly Ceiling Insulation

FLOOR INSULATION

Underfloor insulation that makes up portions of the building thermal envelope in Georgia residences shall be installed to Passing Grade quality.

Two criteria affect installed insulation grading: **voids/ gaps** (in which no insulation is present in a portion of the overall insulated surface) and **compression/incomplete fill** (in which the insulation does not fully fill out or extend to the desired depth).

Voids/Gaps

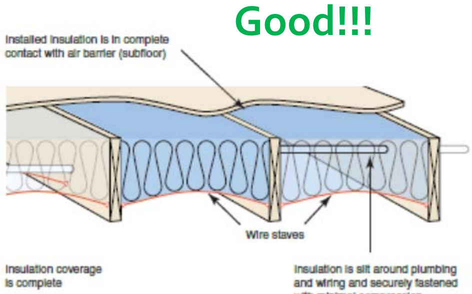
- Voids or gaps in the insulation are minimal for Passing Grade (< 2% of overall component surface area)

Compression/Incomplete Fill

- Compression/Incomplete Fill for both *air permeable insulation* (e.g., fiberglass, cellulose) and *air impermeable insulation* (e.g., spray polyurethane foam) must be less than 1 inch in depth or less than 30% of the intended depth, whichever is more stringent. The allowable area of compression/incomplete fill must be less than 10% of the overall insulated surface to achieve a Passing Grade.
- Any compression/incomplete fill with a **depth** greater than the above specifications (up to 1" or 30% of the intended depth, whichever is more stringent) shall not achieve a Passing Grade.
- Air-permeable underfloor insulation shall be permanently installed against the subfloor decking. Adequate insulation supports (e.g., wire staves) for air permeable insulation shall be installed at least every 18-24".
  Exception: The floor framing-cavity insulation shall be permitted to 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 and that extends from the bottom to the top of all perimeter floor framing members

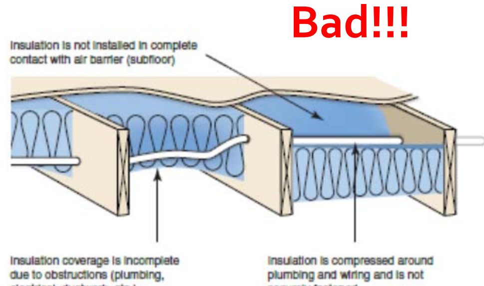
Passing Grade

Good!!!



Unacceptable Installation

Bad!!!



402.4.2 Wood burning fireplaces

R402.4.2 Fireplaces. New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air. Where using tight-fitting doors on factory-built fireplaces listed and labeled in accordance with UL 127, the doors shall be tested and listed for the fireplace.

Where using tight-fitting doors on masonry fireplaces, the doors shall be listed and labeled in accordance with UL 907.

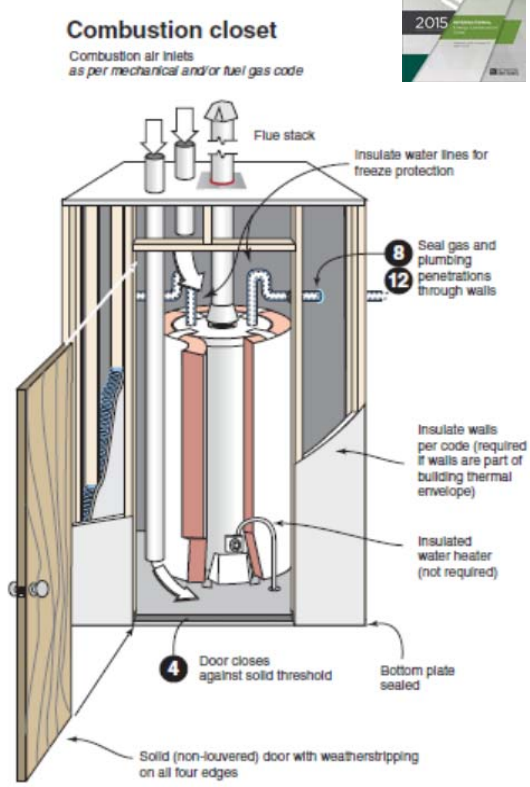
2015 IECC SECTION 402.4.4

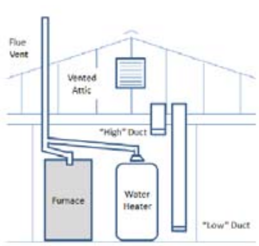
REQUIRES COMBUSTION AIR SEPARATE FROM OCCUPANT AIR!

R402.4.4 Rooms containing fuel-burning appliances. In Climate Zones 3 through 8, where open combustion air ducts provide combustion air to open combustion fuel burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room, isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.2, where the walls, floors and ceilings shall meet not less than the basement wall *R*-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section R403. The combustion air duct shall be insulated where it passes through conditioned space to a minimum of R-8.

Exceptions:

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
2. Fireplaces and stoves complying with Section R402.4.2 and Section R1006 of the *International Residential Code*.





COMBUSTION AIR & THE CODE

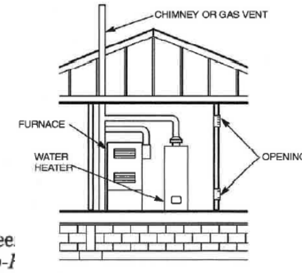


FIGURE G2407.5.3 (304.5.3)
ALL AIR FROM INSIDE THE BUILDING
(see Section G2407.5.3)

Ugh! Code allows Combustion Air to come from Occupant Air!

CHAPTER 24

FUEL GAS

The text of this chapter is extracted from the 2012 edition of the *International Fuel Gas Code* and has bee essary to conform to the scope of application of the *International Residential Code for One- and Two-F* section numbers appearing in parentheses after each section number are the section numbers of the cor *International Fuel Gas Code*.

SECTION G2407 (304)
COMBUSTION, VENTILATION AND DILUTION AIR

G2407.5 (304.5) Indoor combustion air. The required volume of indoor air shall be determined in accordance with Section G2407.5.1 or G2407.5.2, except that where the air infiltration rate is known to be less than 0.40 air changes per hour (ACH), Section G2407.5.2 shall be used. The total required volume shall be the sum of the required volume calculated for all *appliances* located within the space. Rooms communicating directly with the space in which the *appliances* are installed through openings not furnished with doors, and through *combustion air* openings sized and located in accordance with Section G2407.5.3, are considered to be part of the required volume.

G2407.5.1 (304.5.1) Standard method. The minimum required volume shall be 50 cubic feet per 1,000 *Btu*/h (4.8 m^3/kW).

G2407.5.2 (304.5.2) Known air-infiltration-rate method. Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows:

For *appliances* other than fan assisted, calculate volume using Equation 24-1.

$$\text{Required Volume}_{\text{other}} \geq \frac{21\,\text{ft}^3}{ACH}\left(\frac{I_{other}}{1{,}000\ \text{BTU/hr}}\right)$$

(Equation 24-1)

For fan-assisted *appliances*, calculate volume using Equation 24-2.

$$\text{Required Volume}_{\text{fan}} \geq \frac{15\,\text{ft}^3}{ACH}\left(\frac{I_{fan}}{1{,}000\ \text{BTU/hr}}\right)$$

(Equation 24-2)

where:

I_{other} = All *appliances* other than fan assisted (input in *Btu*/h).

I_{fan} = Fan-assisted *appliance* (input in *Btu*/h).

ACH = Air change per hour (percent of volume of space exchanged per hour, expressed as a decimal).

For purposes of this calculation, an infiltration rate greater than 0.60 ACH shall not be used in Equations 24-1 and 24-2.

SOUTHFACE ***STRONGLY*** RECOMMENDS:
SEPARATE COMBUSTION AIR FROM OCCUPANT AIR!

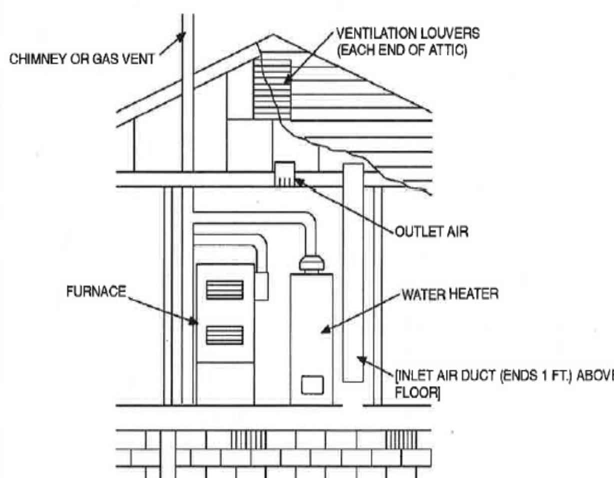
G2407.6 (304.6) Outdoor combustion air. Outdoor *combustion air* shall be provided through opening(s) to the outdoors in accordance with Section G2407.6.1 or G2407.6.2. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

G2407.6.1 (304.6.1) Two-permanent-openings method. Two permanent openings, one commencing within 12 inches (305 mm) of the top and one commencing within 12 inches (305 mm) of the bottom of the enclosure, shall be provided. The openings shall communicate directly, or by ducts, with the outdoors or spaces that freely communicate with the outdoors.

Where directly communicating with the outdoors, or where communicating with the outdoors through vertical ducts, each opening shall have a minimum free area of 1 square inch per 4,000 *Btu*/h (550 mm^2/kW) of total input rating of all *appliances* in the enclosure [see Figures G2407.6.1(1) and G2407.6.1(2)].

Where communicating with the outdoors through horizontal ducts, each opening shall have a minimum free area of not less than 1 square inch per 2,000 *Btu*/h (1,100 mm^2/kW) of total input rating of all *appliances* in the enclosure [see Figure G2407.6.1(3)].

Good! Code allows Combustion Air to come



04.8 mm.

FIGURE G2407.6.1(2) [304.6.1(2)]
ALL AIR FROM OUTDOORS THROUGH VENTILATED ATTIC (see Section G2407.6.1)

SOUTHFACE ACBI – *SMALL COMMERCIAL BUILDING ASSESSMENT COMBUSTION TOOLKIT*

		(4) If CAZ alone is confined and combustion air is provided via connection with the indoor space,	
y	y / n	- are **Both** connections to indoor space made within 1' of ceiling **and** 1' of floor?	
		typically, this is rectangular with a grill	
18.00	in	- width of opening of each connecting duct	
8.00	in	- length of opening of each connecting duct	**Net Free Area Required by Code:**
0.75		- Net free area multiplier for *rectangular* duct (between 0 and 1)	- interior ducts: 1 in^2 for 1 kBtu/hr
108.00	in^2	TOTAL cross sectional area of each duct connection	(but not less than 100 in^2)
100.00	in^2	CALCULATED cross sectional net free area required for each duct	minimum opening dimension is 3"
Adequate		Adequate or Undersized? Is the duct cross sectional area greater or less than the net free area required by code?	

- 3" round – 7 square inches
- 4" round – 12.5 square inches
- 5" round – 19.6 square inches
- 6" round – 28.3 square inches
- 7" round – 38.5 square inches
- 8" round – 50.3 square inches
- 10" round – 78.5 square inches
- 12" round – 113 square inches

- Guidelines with lots of pictures and case studies
- Spreadsheet / Workbook that checks combustion air compliance

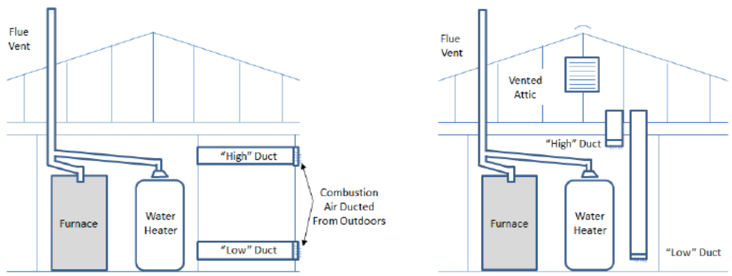


Figure 18: Safe! – Source combustion air via "High-Low" vents directly from the exterior (left) or from spaces connected to outdoors (e.g., a ventilated attic, right). (Barcik)

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SUPPLYING COMBUSTION AIR: DETERMINING VOLUME REQUIRED IN CAZ

- Ensure that sufficient air is available for complete combustion when all appliances are in operation simultaneously
- Determine if CAZ is a **confined** or **unconfined** space per NFPA.
- Follow established standards for bringing in combustion air (e.g. high/low venting)
  - **Confined** Space
    Not enough volume in the combustion appliance zone to provide for complete combustion when all appliances are operating and the building is set in worst case criteria
  - **Unconfined** Space
    Enough volume is present to provide for complete combustion when all combustion appliances are operating and the house is set for worst case criteria

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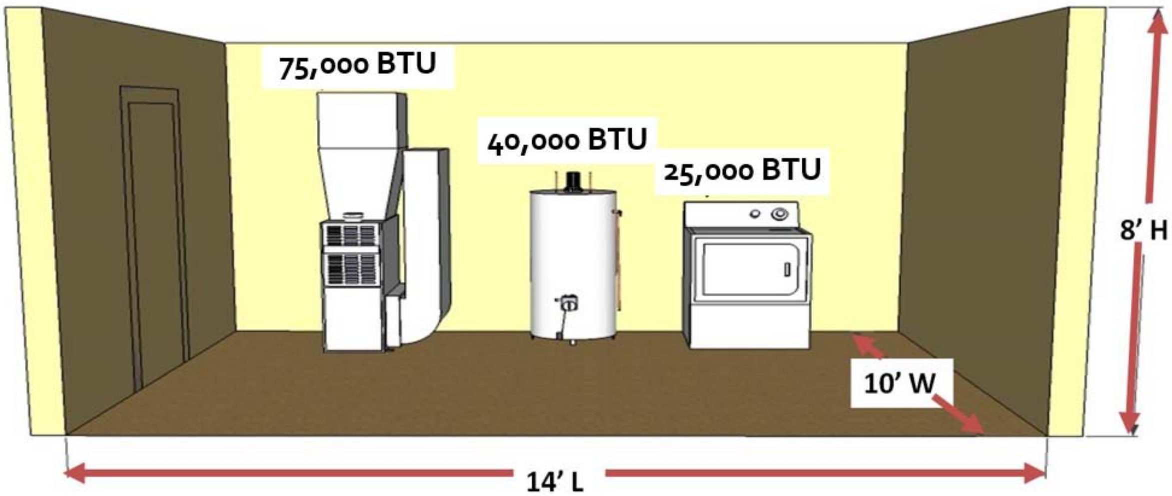
EXAMPLE PROBLEM:
CONFINED OR UNCONFINED?

- Minimum required volume will be
  50 ft³ per 1,000 BTU/hr input in accordance with 2012 IRC G2407.5.1



STANDARD 1/20 RULE

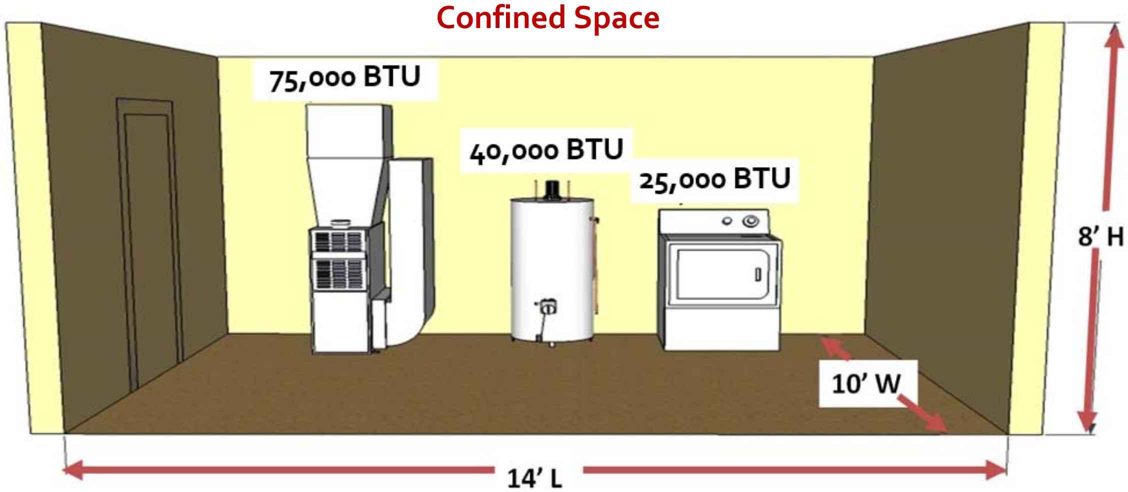
- Measure the *CAZ Volume*
- Add all input Btu/h ratings of all appliances in the CAZ
- Divide this total Btu/h by 20 (this is *Required Volume*)
- The resulting number is the cubic feet separating confined from unconfined space
  - Required Volume **below** CAZ Volume = confined space
  - Required Volume **above** CAZ Volume = unconfined space

EXAMPLE PROBLEM: CONFINED OR UNCONFINED?

CAZ Volume	*Required Volume*	
Volume: 14′ x 10′ x 8′ = **1120 ft³**	Btu's: 75K + 40K + 25K = **140,000 Btu**	$\frac{140{,}000 \text{ Btu's}}{20}$ = **7,000 ft³**

1120 < 7000

Confined Space

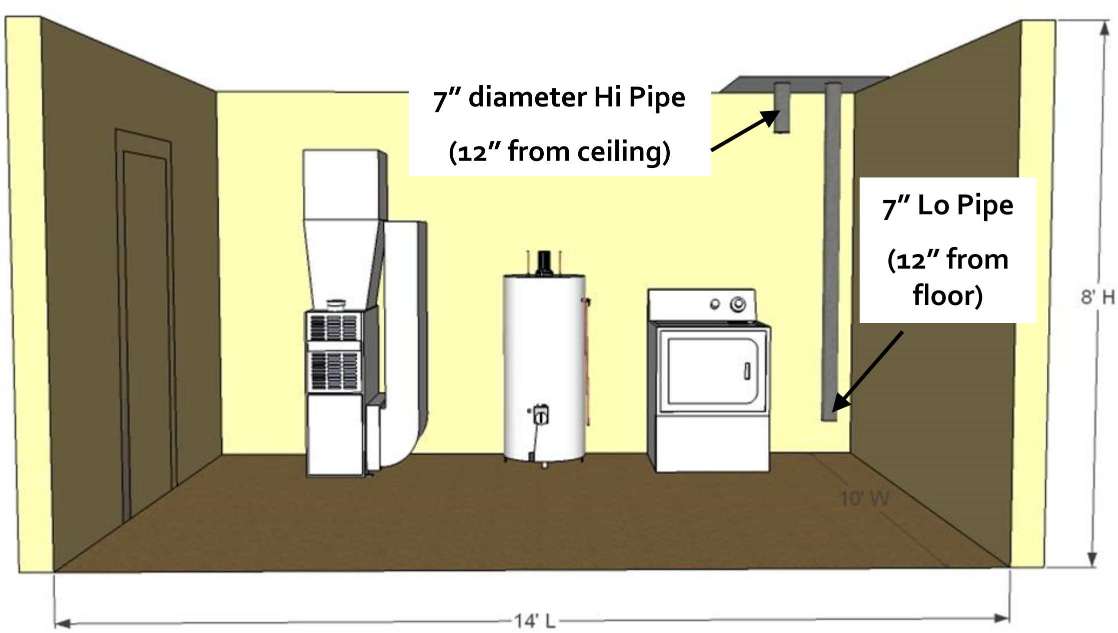


INSTALL HI-LO PIPE

Rule for Vertical: 1 sq. in. for every 4,000 Btuh

140k / 4k = 35 sq. inches of cross section required

(7″ diameter pipe = 38.5 sq. in.)



CH. 4 – SUPPLYING COMBUSTION AIR: SIZING HI/LOW VENTS

Free spreadsheet tool and Guidelines at southface.org

Determine Total k-Btu/hr Rating of Appliances in the CAZ
(Used to Calculate Required Air Volume of CAZ)

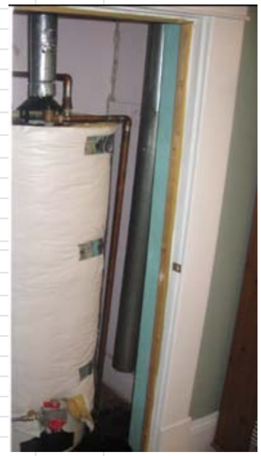
			model #s
40	kBtu/hr	Water Heater 1	MD10-22-10
	kBtu/hr	Water Heater 2	
75	kBtu/hr	Furnace 1	RNZ60VD51
	kBtu/hr	Furnace 2	
	kBtu/hr	Furnace 3	
25	kBtu/hr	other gas applianc	
140		Total kBtu/hr	
7000	ft^3	Required Volume of CAZ	
		Volume = total kBtu/hr x 50	

Assessment of Combustion (dilution) Air:

y	y / n	(1) Is combustion air only provided via a direct ducted connection between the appliance and outdoors? (Strongly Recommended)
		NOTE: if combustion air is provided to the CAZ via connection to interior spaces, skip down to **Assessment of CAZ Volume**
		(2) Combustion air is provided to the CAZ from outdoors or a well ventilated space (e.g., attic) via:
y	y / n	- **Two Vertical Hi-Low Ducts (no horizontal runs)**
	y / n	- **Two Horizontal Hi-Low Ducts**
	y / n	- **Single Opening**
		(3) Calculate Net Free Area of Air Ducts (Round/Rectangular)
7.00	in	- Diameter of each round duct
1.00		- Net free area multiplier for round duct (between 0 and 1)
38.48	in^2	- Calculated cross sectional area of each round duct
	in	- Length of opening of Rectangular duct
	in	- Width of opening of Rectangular duct
		- Net free area multiplier for rectangular duct (between 0 and 1)
	in^2	- Calculated net free area for rectangular duct
38.48	in^2	TOTAL (round + rectangular) net free cross sectional area of each installed connecting duct (Hi or Low)
35.00	in^2	CALCULATED cross sectional net free area required by code for each duct
		(4) Check ducts and answer as appropriate:
y	y / n	- do the **Two Hi-Low** ducts terminate within 1' of ceiling **and** 1' of floor?
	y / n	- is the **Single** duct opening a minimum of 3" in both horizontal and vertical dimension?
Adequate		Undersized or Adequate? Is the duct area greater or less than the net free area needed?

Net Free Area Codes:	
· vertical ducts:	1 in^2 for 4 kBtu/hr
· horizontal ducts:	1 in^2 for 2 kBtu/hr
· single duct:	1 in^2 for 3 kBtu/hr

BEST PRACTICE DICTATES:
- **ALL** combustion air should come from the outdoor space
- **Do NOT** use combustion air from the inside space
- **Do NOT** accept a hybrid approach (mix of inside and outdoor air)



EXAMPLE PROBLEM: CONFINED OR UNCONFINED?

Room Dimensions:
10' x 9.5' with 9' ceiling

Appliance:
40k Btu/h Water Heater

CAZ Volume
Volume = **855 ft³**

855 < 2,000
Confined Space

Required Volume
Btu's: **40k Btu/h**

$$\frac{40{,}000 \text{ Btu/h}}{20} = \mathbf{2{,}000\ ft^3}$$

Rule for Vertical (vented attic above):
1 sq. in. for every 4k Btuh
40k / 4k = 10 sq. inches of Hi / Lo cross section area required
(4" diameter pipe = 12.5 sq. in.)

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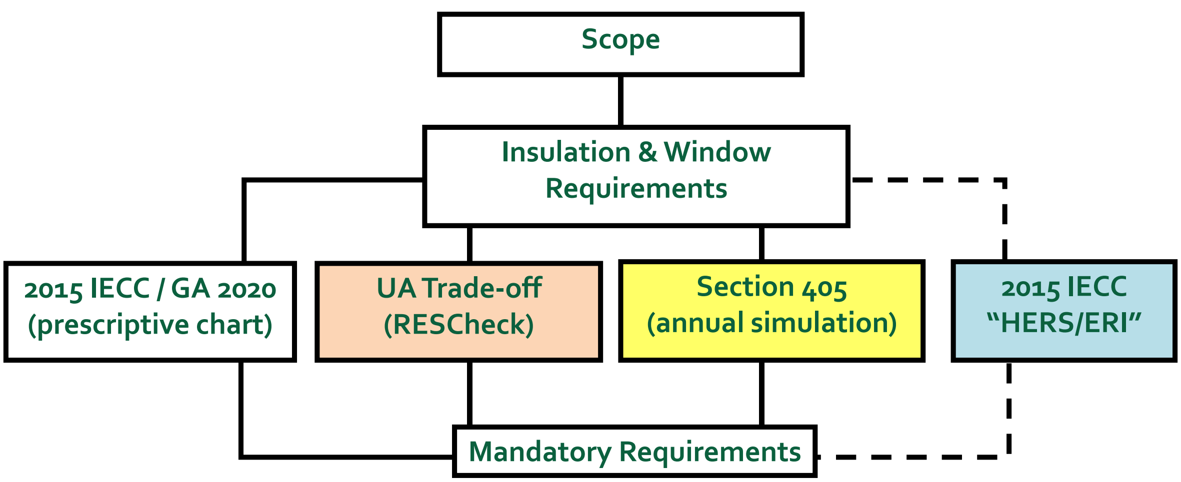
402.4.5 Recessed Lights

Standard Can Light

Air-tight and IC Rated

R402.4.5 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and *labeled* as having an air leakage rate not more than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E 283 at a 1.57 psf (75 Pa) pressure differential. All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering.

ENVELOPE TRADEOFF OPTIONS



UA & RESCHECK TRADEOFFS

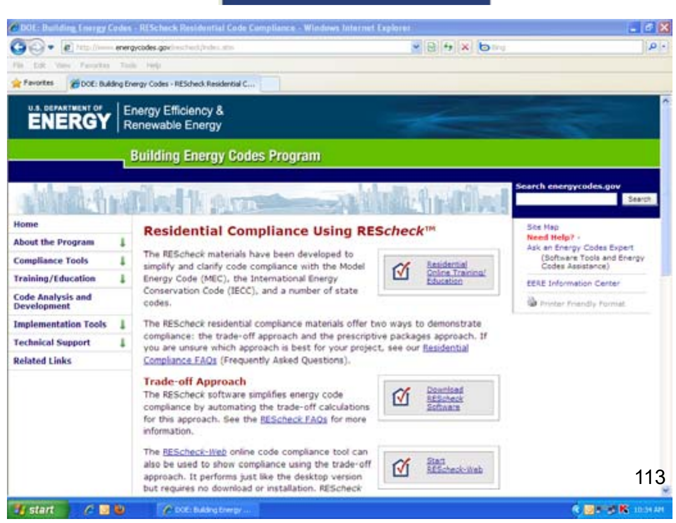
- Equivalency using UA approach
- Allows for simple envelope trade-offs against prescriptive code – may be performed manually (spreadsheet)
- However, using REScheck for GA would require selecting generic **2015 IECC** as reference code
- Thus, much more stringent to comply with than prescriptive GA 2020 code

2015 Prescriptive R-values												
Climate Zone	Fenestration Ufactor	Skylight Ufactor	Glazing SHGC	Ceiling	Wood Walls	Attic Kneewall	Mass Wall	Floor	Basement Wall	Slab	Crawl Wall	ACH_{50}
2	0.40	0.65	0.25	38	13	13	4/6	13	0	0	0	< 5
3	0.35	0.55	0.25	38	20 or 13+5	20 or 13+5	8/13	19	5/13	0	5/13	< 3
4	0.35	0.55	0.40	49	20 or 13+5	20 or 13+5	8/13	19	10/13	10, 2ft	10/13	< 3

Proposed Compromise Prescriptive R-values				(Red indicates changes from current GA code)								
Climate Zone	Fenestration	Skylight	Glazing	Ceiling	Wood	Attic	Mass Wall	Floor	Basement	Slab	Crawl	ACH_{50}
2	0.35	0.65	0.27	38	13	18	4/6	13	0	0	0	< 5
3	0.35	0.55	0.27	38	13	18	8/13	19	5/13	0	5/13	< 5
4	0.35	0.55	0.27	38	13	18	8/13	19	10/13	0	10/13	< 5

RESCHECK & TRADEOFFS

- 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
- **No GA specific version** (must choose '15 IECC)



2015 IECC – SECTION 405

SIMULATED PERFORMANCE ALTERNATIVE

- 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

www.resnet.us

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SECTION 405 SIMULATED PERFORMANCE ALTERNATIVE- SAMPLE REPORT

- 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 2015 IECC reference home's energy cost

SIMULATED PERFORMANCE ALTERNATIVE - 2015 IECC ANNUAL ENERGY COST COMPLIANCE

IECC 2015 Performance Compliance

Property
123 Fake Street
Savannah, GA 31302

Organization
Southface Training
Southface Trainer

Inspection Status
Results are projected

Improved to pass 2015 IECC ACME
ACME2 - MB

Builder
Wiley E Coyote

Annual Energy Cost

Design	IECC 2015 Performance	As Designed
Heating	$1,211	$695
Cooling	$414	$387
Water Heating	$372	$371
SubTotal - Used to determine compliance	**$1,997**	**$1,452**
Lights & Appliances	$806	$806
Onsite generation	$0	$0
Total	**$2,803**	**$2,259**

Requirements

405.3	Performance-based compliance passes by 27.2%	
402.4.1.2	Air Leakage Testing	Air sealing is 5.00 ACH at 50 Pa. It must not exceed 5.00 ACH at 50 Pa.
402.5	Area-weighted average fenestration SHGC	
402.5	Area-weighted average fenestration U-Factor	
404	Lighting Equipment Efficiency	
R403.6.1	Mechanical Ventilation Efficacy	
Mandatory Checklist	Mandatory code requirements that are not checked by Ekotrope must be met.	
R405.2	Duct Insulation	

Design exceeds requirements for IECC 2015 Performance compliance by 27.2%.

As a 3rd party extension of the code jurisdiction utilizing these reports, I certify that this energy code compliance document has been created in accordance with the requirements of Chapter 4 of the adopted International Energy Conservation Code based on Climate Zone 2. If rating is Projected, I certify that the building design described herein is consistent with the building plans, specifications, and other calculations submitted with the permit application. If rating is Confirmed, I certify that the address referenced above has been

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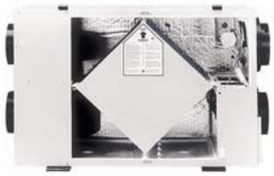
THE ENERGY RATING INDEX (ERI) PATH

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



- 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)

HOW IS THE ERI DETERMINED?

- The ERI is a numerical integer value
- Lower index numbers indicate lower energy use
- The HERS Index is currently accepted for use as 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*

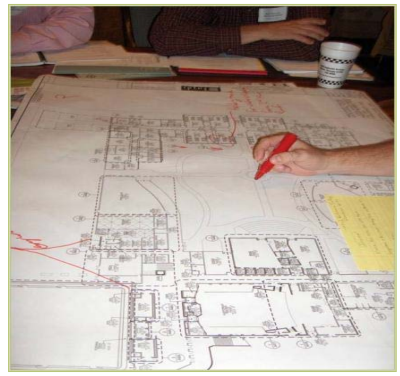
RESNET HERS® INDEX

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

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)

40 30 30 50

Index = 100 x $PE_{fraction}$ x [***Rated*** Home's Htg + Clg + WtrH + L.A.] / [***Refer***. Home's Htg + Clg + WtrH + L.A.] **= 75**

70 20 30 80

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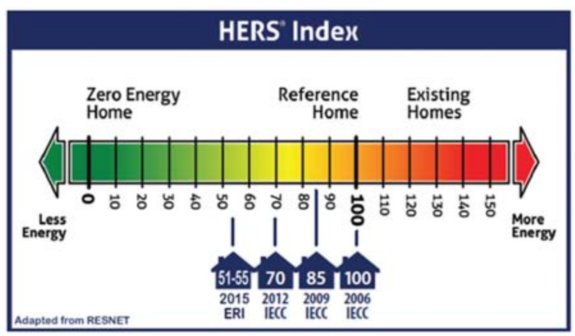
HERS INDEX - WHAT DOES IT MEAN?

- 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



40 30 30 50

Index = $PE_{fraction}$ x 100 x [Rated Home's Htg + Clg + WtrH + L.A.] / [Ref. Home's Htg + Clg + WtrH + L.A.] **= 75**

70 20 30 80

$PE_{fraction}$ is ratio of renewables to purchased energy

(e.g, a home that produces 20% of its annual energy would have a $PE_{fraction}$ of 0.8)

In this example, 0.8 x 75 = **60**

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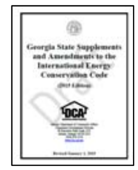
ERI: TARGET VALUES

- The 2015 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
1	~~52~~
2	~~52~~
3	~~51~~
4	~~54~~
5	~~55~~
6	~~54~~
7	~~53~~
8	~~53~~

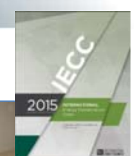
ENERGY RATING INDEX[a]
57
57
57
62
61
61
58
58

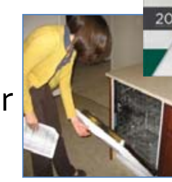


The rated design must have an ERI less than or equal to the above table to comply with 2015 IECC

NOTE: GA amended to match 2018 numbers!

PROS AND CONS?





1. Concerns

- **Conflict of interest** because rater works for the builder
- **Size Bias** against small houses
  - **Code** – because it uses the antiquated ACH50 term for air tightness (which favors larger, high volume homes)
  - **ERI** –small homes have less envelope load and are hindered in a trade-offs
- **Credit for unregulated items** not in the Prescriptive code
  "Should the dishwasher be allowed to trade down insulation R-values?"

2. Benefits

- **Professional** (HERS Rater) who understands energy efficiency is now involved and energy code isn't ignored
- **Marketing** – Builders can market their index and guarantee performance

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A WORD ABOUT RENEWABLES…

R406.3 Energy Rating Index. The Energy Rating Index (ERI) shall be a numerical integer value that is based on a linear scale constructed such that the *ERI reference design* has an Index value of 100 and a *residential building* that uses no net purchased energy has an Index value of 0. Each integer value on the scale shall represent a 1-percent change in the total energy use of the rated design relative to the total energy use of the *ERI reference design*. The ERI shall consider all energy used in the *residential building*.

ON-SITE RENEWABLE ENERGY. Energy systems that are located on the building site, are installed on the building's side of the utility service provider's meter, produce energy primarily intended for use in the building and not solely for export to utilities, and produce energy derived from any of the following sources: solar radiation, wind, waves, tides, biogas, biomass or the internal heat of the earth. Energy systems that derive energy from solar radiation shall be modeled in the orientation of the energy system.

The following description only pertains to energy systems that derive energy from solar radiation and are owned by a third-party. The Georgia Solar Power Free-Market Financing Act of 2015 (commonly referred to as "HB 57") allows a customer to purchase solar electricity generated by a solar system owned by a third-party so long as certain criteria are met. Two key criteria are that the law only authorizes solar systems that generate electricity fueled by sunlight and that the solar system must be installed on property owned or occupied by the entity purchasing the system's electricity. The definition of "property" extends to all adjacent contiguous tracts of land utilized by the entity purchasing the solar system's electricity. "Building Site" in R202 is defined as a contiguous area of land that is under the ownership or control of one entity. While this definition of "building site" is similar to HB 57's definition of "property," the key difference is that HB 57 focuses on the entity purchasing the solar system's electricity. When modeling a solar system that is owned by a third-party, it is best to refer to HB 57 to determine whether all criteria have been met.

- The 2015 IECC does not directly address renewables in the ERI
- GA Amendments clarify that panels must be on the house side of the meter and solar has same backstop ('09 code) as other technologies

SUMMARY OF ERI …

1. 2015 IECC targets

- **Low 50's - GA Amended to match 2018 values**

CLIMATE ZONE	ENERGY RATING INDEX[a]
2	57
3	57
4	62

2. Who Can Do This?

- 3rd party – HERS Rater
- Approved software

3. Benefits

- Greater design flexibility
- High efficiency equipment and appliances credited

4. Backstops

- Envelope cannot be traded to be worse than 2009 IECC
- Mandatory Requirements (air sealing, duct insulation, sealing, testing, etc.)

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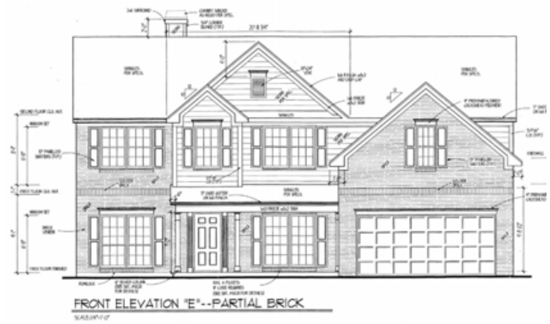
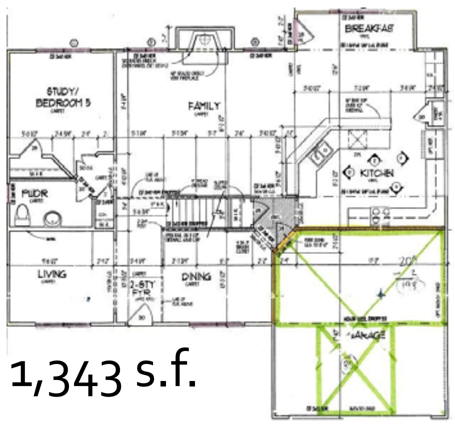
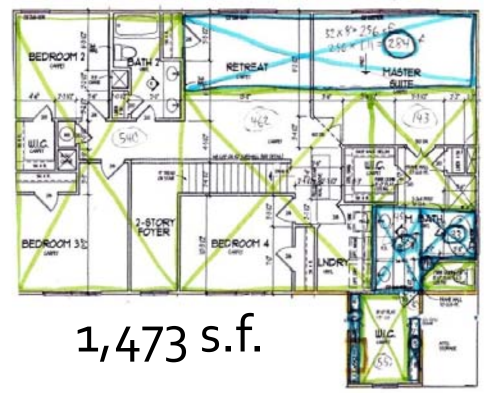
HERS RATING EXAMPLE



"Acme" base case, 2-story 2816 s.f home (Atlanta)



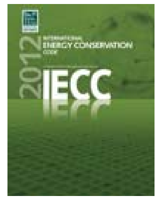


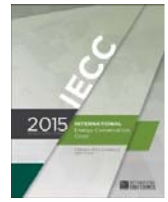
ACME BASE - 2816 S.F. HOME IN EKOTROPE

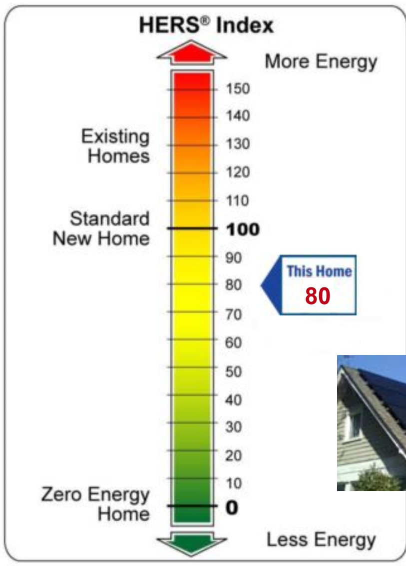
- Two mechanical systems – both in the vented attic
- 75% of 1st floor ducts inside; all others plus 2nd floor ducts in attic
- 80% furnaces, 14 SEER A/C's, no mechanical ventilation, 50 gal gas DHW
- Basic 2009 energy code compliant R-values (assume Grade III)
  - R-30 flat ceiling, R-19 vault
  - R-13 + OSB walls
  - R-19 floor over garage; no slab insulation

- Typical DP low-e windows: U-0.35 SHGC-0.30; poor orientation
- Duct leakage is 12% Total; 8% To Outside
- Envelope Leakage is 7 ACH_{50}, 0.45 ELR_{50}, 3009 cfm_{50}
- Elec rate 12.5¢/kWh + $10 base fee; Gas rate 75¢/therm + $20 base fee

HERS RATING DEMONSTRATION







- Index drops to **71** with 2012/15 IECC prescriptive envelope values
- Index drops to **67** when 2012/15 IECC prescriptive 75% efficient lighting values are entered

- Index drops to **mid-50's** with condensing furnace, 16 SEER AC, and more efficient appliances
- House load drops (4 tons to 3 tons)

80 => 70 with 2 kW
- => 56 with 5 kW
- => 32 with 10 kW

57 => 49 with 2 kW
- => 36 with 5 kW
- => 13 with 10 kW

LIMITS ON TRADEOFFS

- Home must meet mandatory requirements of R401.2 and R403.5.3
- The **building thermal envelope** shall be greater than or equal to levels of efficiency of the **2009 IECC**
- **Applies to all trade-off options**

Table applies to all Trade-off options:
- RESCheck
- UA Trade-off
- Simulated Perf
- Energy Rating Index

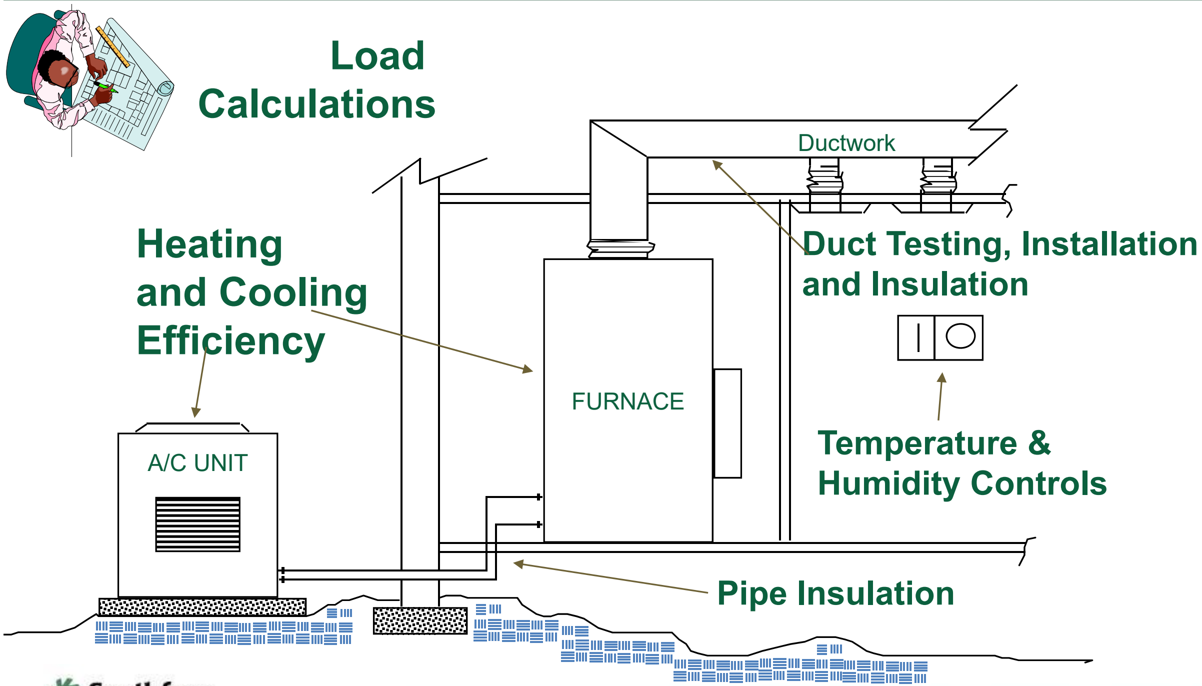
Table R402.1.6
MINIMUM INSULATION *R*-VALUES FOR ENVELOPE COMPONENTS WHEN TRADE-OFFS ARE USED

Climate Zone	Wood Framed Walls [a]	Mass Wall [a, b]	Attic Kneewall [a, c]	Basement Wall [a]	Crawl Wall [a]	Floor Over Unheated Spaces	Ceilings with Attic Space	Vaulted Unvented Attic Roofline Air-impermeable [c, d]	Vaulted Unvented Attic Roofline Air-permeable [c, d]	Cathedralized Vented Ceiling Roofline Air-permeable [c, d]
2	13	4	18	0	0	13	30	20	20+5*	20
3	13	5	18	5	5	13	30	20	20+5*	20
4	13	5	18	5	5	13	30	20	20+15*	20
Window *U*-Factor 0.5 max with SHGC 0.30 max								* Air -impermeable as per IRC 806.5		

a: Weather-stripped hinged vertical doors (minimum R-5 insulation or maximum U-0.20), weather-stripped hatches/scuttle hole covers (minimum R-19 insulation or maximum U-0.05), or weather-stripped and disappearing/ pull-down stairs (minimum R-5 insulation or maximum U-0.20) shall be deemed to meet the minimum insulation *R*-values of the corresponding envelope element.
b: Any mass wall (masonry, CMU, etc.)
c: Attic kneewall for the purpose of this code is defined as any vertical or near vertical wall in the building envelope that has conditioned space on one side and attic space on the other side.
Exception: When the building roofline is insulated, the former kneewall is classified as an interior wall.
d: Examples of air-impermeable insulation include spray foam and rigid foam board. Examples of air-permeable insulation include fiberglass batts and cellulose. See 'Roofline Installed Insulation Options' in Appendix RA, of these Georgia State Supplements and Amendments for details.

SECTION 403 - SYSTEMS

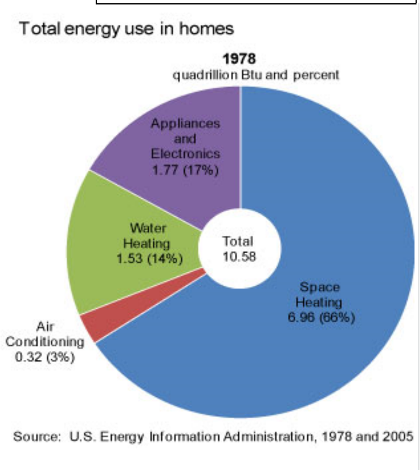
All Mandatory Requirements

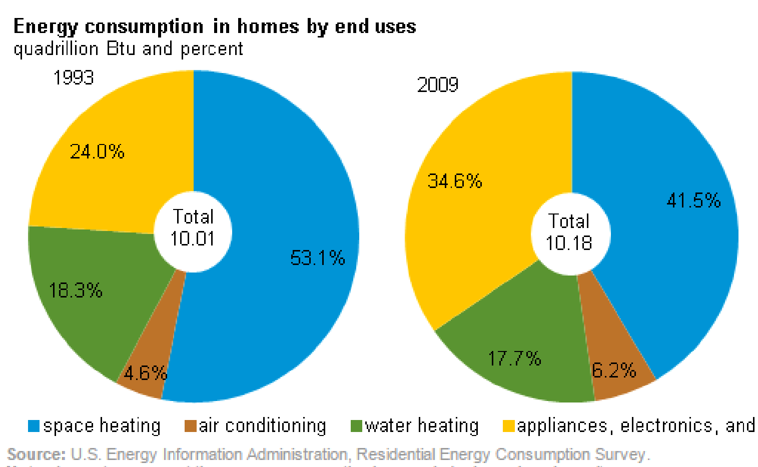


HOME ENERGY USAGE OVER TIME

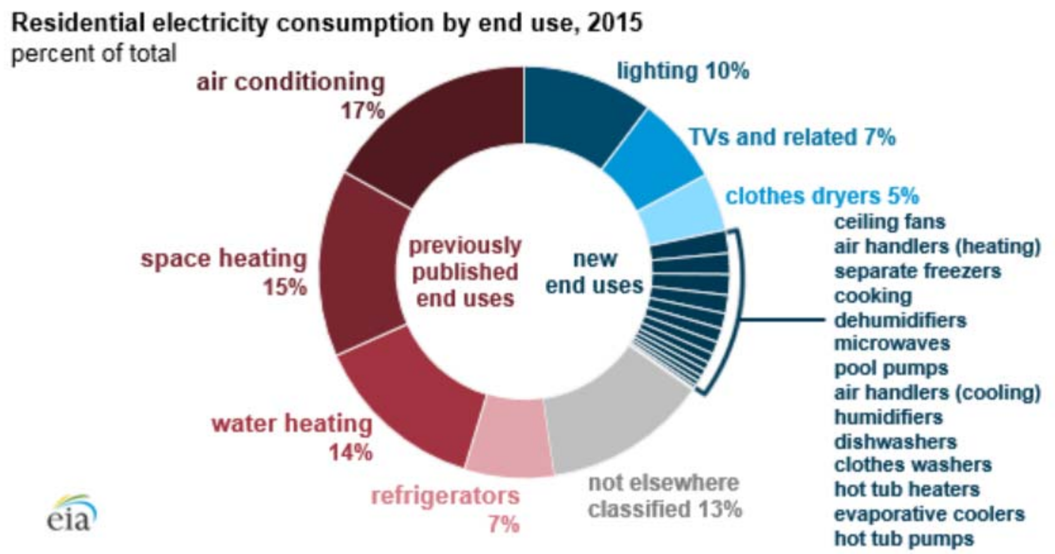
-Shrink the pie!

-Usage shifts



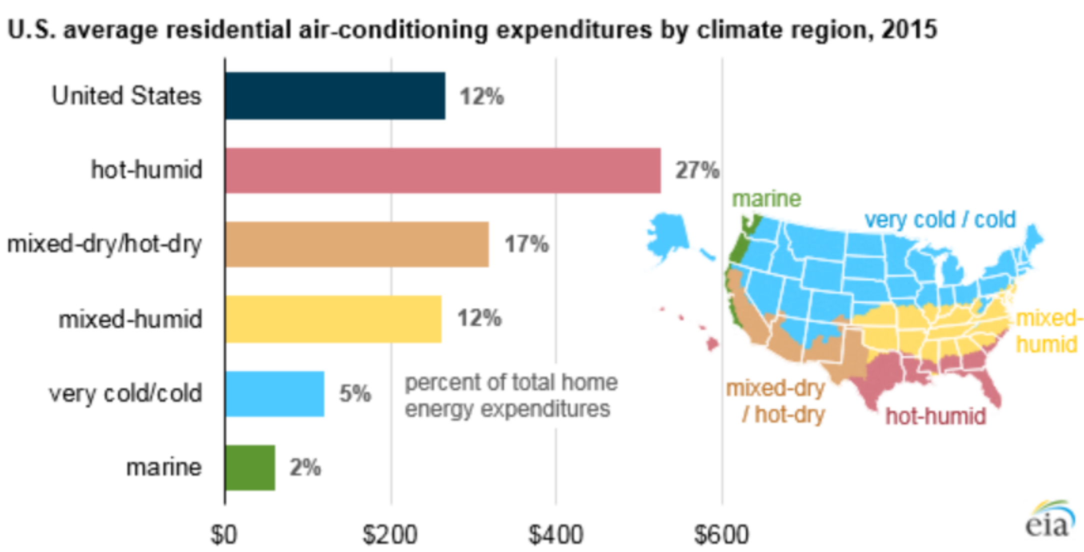


HOME ENERGY USAGE BREAKDOWN



AC USAGE VARIES GREATLY

Air conditioning accounts for about 12% of U.S. home energy expenditures

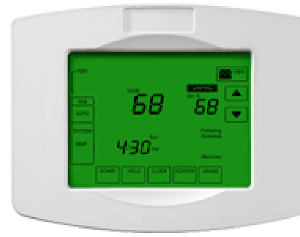


R403.1 HVAC CONTROLS

R403.1 Controls (Mandatory). At least one thermostat shall be provided for each separate heating and cooling system.

R403.1.1 Programmable thermostat. The thermostat controlling the primary heating or cooling system of the dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of the day. This thermostat shall include the capability to set back or temporarily operate the system to maintain *zone* temperatures down to 55°F (13°C) or up to 85°F (29°C). The thermostat shall initially be programmed by the manufacturer with a heating temperature set point no higher than 70°F (21°C) and a cooling temperature set point no lower than 78°F (26°C).

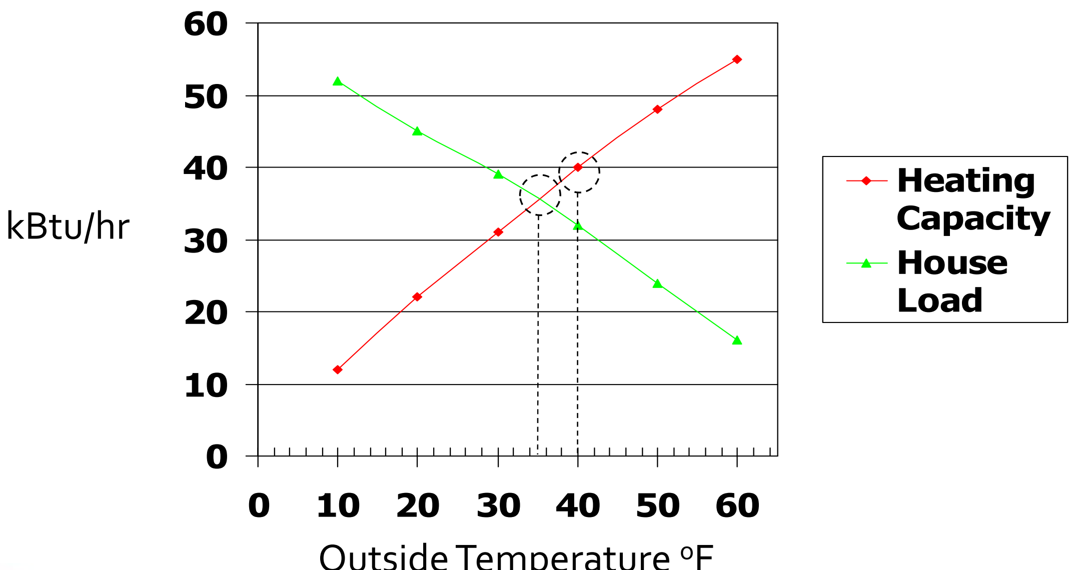
R403.1.2 Heat pump supplementary heat (Mandatory). Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load.



GA Amendment R403.1.2. Except in emergency heating mode, the supplementary electric-resistance heat in heat pump systems installed in new construction may not energize unless the outdoor temperature is below 40 degrees F (4 degrees C).

HEAT PUMP BALANCE POINT

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



403.3.1 – DUCT DETAILS CARRY FORWARD

Mandatory Requirement:

Insulation:

- R-8 Insulation in Attic
- R-6 Insulation other unconditioned space
- No Insulation required when completely inside envelope

Sealing with Mastic required – "thick as a nickel" (2 mm)

403.3.5 - May not use building cavities as supply or return

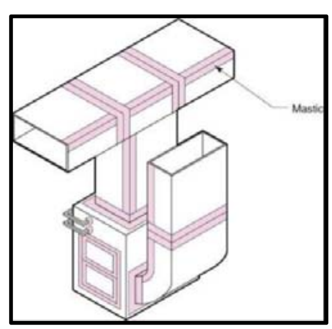
403.3.2– DUCT SEALING

R403.3.2 Sealing (Mandatory). Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section R403.3.6 of these Georgia State Supplements and Amendments.

Exceptions:

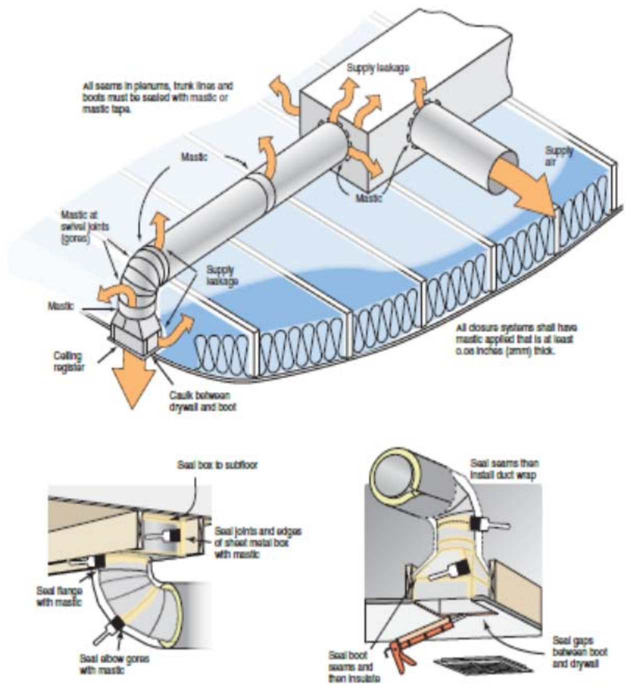
1. Air-impermeable spray foam product shall be permitted to be applied without additional joint seals.
2. For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams, and locking-type joints and seams of other than the snap-lock and button-lock types.
3. Where a duct connection is made that is partially inaccessible, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.
4. Sealing that would void product listings is not required.

R403.3.2.1 Sealed air handler. Air handlers shall have a manufacturer's designation for an air leakage of no more than 2 percent of the design air flow rate when tested in accordance with ASHRAE 193.

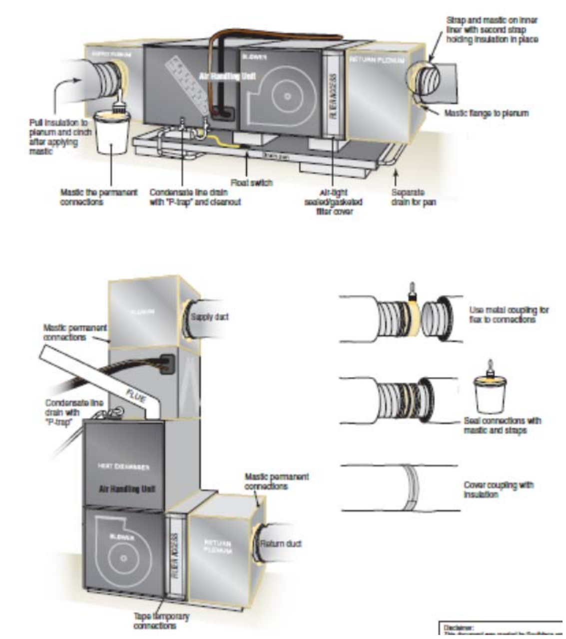


APPENDIX RA – DUCT SEALING

Appendix RA
2015 IECC (2019 Georgia Energy Code)
Duct Sealing key points



Appendix RA
2015 IECC (2019 Georgia Energy Code)
Air Handler Sealing key points



403.3.6- DUCT CONNECTIONS

R403.3.6 Joints, seams and connections. All longitudinal and transverse joints, seams and connections in metallic and nonmetallic ducts shall be constructed as specified in *SMACNA HVAC Duct Construction Standards*- Metal and Flexible and NAIMA *Fibrous Glass Duct Construction Standards*. All joints, longitudinal and transverse seams, and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes. Without exception all closure systems shall have mastic applied that is at least 0.08 inches (2 mm) thick.

Closure systems used to seal flexible air ducts and flexible air connections shall comply with UL 181B and shall be marked "181B-FX" for pressure-sensitive tape or "181B-M" for mastic. Duct connections to flanges of air distribution systems equipment shall be sealed and mechanically fastened. Mechanical fasteners for use with flexible non-metallic air ducts shall comply with UL 181B and shall be marked 181B-C. Crimp joints for round metallic ducts shall have a contact lap of not less than 1 inch (25.4 mm) and shall be mechanically fastened by means of not less than three sheet-metal screws or rivets equally spaced around the joint.

Closure systems used to seal metal ductwork shall be installed in accordance with manufacturer's instructions. Round metallic ducts shall be mechanically fastened by means of at least three sheet metal screws or rivets spaced equally around the joint. Unlisted duct tape shall not be permitted as a sealant on any duct.

403.3.3&4- DUCT TIGHTNESS TESTING

Duct Tightness Testing REQUIRED by **DET Verifier**

- When tested at rough-in (**RIT**)
  - o Maximum **6%** leakage with AHU installed
- When tested at final (**PCT**)
  - o Maximum **6%** – Total Leakage

"6%" means 6 cfm25 per 100 s.f. of conditioned zone floor area

Blower Door and Duct Leakage test results **MUST be recorded on Certificate!**

403.3.3&4- DUCT TIGHTNESS TESTING

R403.3.3 Duct testing (Mandatory). Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure. All registers shall be taped or otherwise sealed during the test.

2. Post-construction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exceptions:

1. A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.
2. Duct tightness testing is not required for existing duct systems unless more than 50% of the duct system is modified.
3. If the air handler, furnace or evaporator coil is replaced on an existing system, all joints, seams and connections from equipment to duct system and duct system connections to plenums within 5 feet from the new work shall meet the sealing requirements of this code and be verified by a visual inspection by the state licensed conditioned air contractor or by a DET Verifier.

A report of the results of the test shall be signed by the party conducting the test and provided to the owner or the owner's agent and, if requested, to the *code official*.
(Effective January 1, 2020)

R403.3.4 Duct leakage (Mandatory). The total leakage of the ducts, where measured by one of the following methods in accordance with Section R403.3.3 shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 6 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m^2) of conditioned floor area where the air handler is installed at the time of the test.
2. Post-construction test: Total leakage shall be less than or equal to 6 cubic feet per minute (113.3 L/min) per 100 sq. feet (9.29 m^2) of conditioned floor area.

DUCT TESTING EXCEPTIONS

1. If all ductwork & air handler is inside the building envelope
2. If less than 50% of duct system is modified
3. If Air handler, furnace or coil is *replaced*
   - Must mastic,seal all joints, seams and connections within 5' of new work (including equipment to plenum and plenum to duct system)
   - Must be verified via visual inspection by a state licensed conditioned air contractor or a Georgia DET verifier

1. A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.
2. Duct tightness testing is not required for existing duct systems unless more than 50% of the duct system is modified.
3. If the air handler, furnace or evaporator coil is replaced on an existing system, all joints, seams and connections from equipment to duct system and duct system connections to plenums within 5 feet from the new work shall meet the sealing requirements of this code and be verified by a visual inspection by the state licensed conditioned air contractor or by a DET Verifier.

DUCT & ENVELOPE TIGHTNESS (DET) VERIFIER

Certified DET Verifier can either:

Be previously certified
- HERS Rater
- BPI Analyst
- Home Performance with ENERGY STAR contractor

Pass a DET Verifier Course
- Discuss testing protocol (setup, safety, and accuracy)
- Explain calculations for ACH50 and % duct leakage
- Field exam on tools (use blower door and duct tester)
- Pass Written Exam – 25 Questions (1 hour)

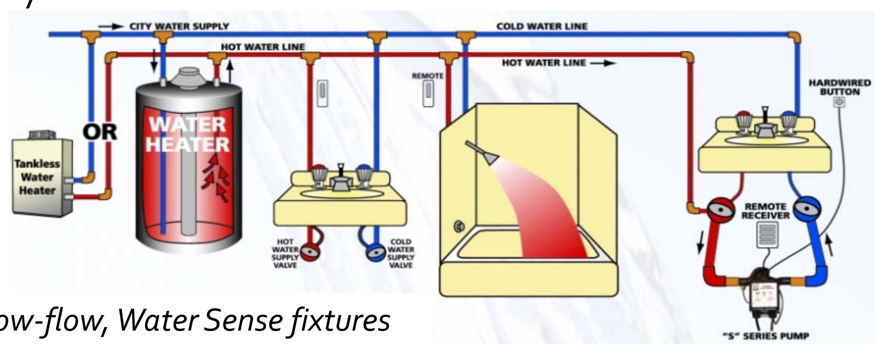
CERTIFIED DUCT AND ENVELOPE TIGHTNESS (DET) VERIFIER. A certified DET verifier shall be a certified Home Energy Rating Systems (HERS) rater, or be a certified Home Performance with ENERGY STAR contractor, or be a Building Performance Institute (BPI) Analyst, or successfully complete a certified DET verifier course that is approved by the Georgia Department of Community Affairs.
(Effective January 1, 2011)

EFFICIENT HOT WATER DISTRIBUTION

Efficient delivery of hot water to the fixture is critical

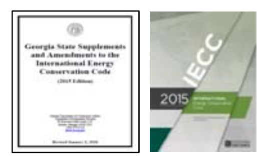
- Insulation on all hot water pipes – smaller diameter best
- Centrally locate hot water source near fixtures
  (or point of use)
- Small diameter tubes to each fixture ("home run")
  (make sure manifold is very close to WH!)

- Recirculating systems – controls are critical
  - Timer
  - Demand (best!)



Specify low-flow, Water Sense fixtures

403.4 & 403.5.3 PIPING



Pipe Insulation

- R-3: mechanical systems – fluids > 105 F or < 55 F
- R-3: for plumbing & circulating systems (non-demand)
- R-4 for suction line as per M1411.5

R403.5.3 Hot water pipe insulation (Prescriptive). Insulation for hot water pipe with a minimum thermal resistance (*R*-value) of R-3 shall be applied to the following:

1. Piping $^3/_4$ inch (19.1 mm) and larger in nominal diameter.
2. Piping serving more than one dwelling unit.
3. Piping located outside the conditioned space.
4. Piping from the water heater to a distribution manifold.
5. Piping located under a floor slab.
6. Buried in piping.
7. Supply and return piping in recirculation systems other than demand recirculation systems.

R403.4 Mechanical system piping insulation (Mandatory). Mechanical system piping capable of carrying fluids above 105°F (41°C) or below 55°F (13°C) shall be insulated to a minimum of R-3.

R403.4.1 Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted.

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403.5.1&2 CIRCULATING SYSTEMS

R403.5 Service hot water systems. Energy conservation measures for service hot water systems shall be in accordance with Sections R403.5.1 and R403.5.4.

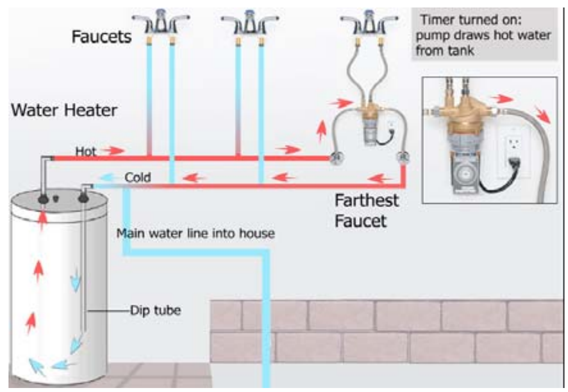
R403.5.1 Heated water circulation and temperature maintenance systems (Mandatory). Heated water circulation systems shall be in accordance with Section R403.5.1.1. Heat trace temperature maintenance systems shall be in accordance with Section R403.5.1.2. Automatic controls, temperature sensors and pumps shall be accessible. Manual controls shall be readily accessible.

R403.5.1.1 Circulation systems. Heated water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermosyphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water.

R403.5.1.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1 or UL 515. Controls for such systems shall automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy.

R403.5.2 Demand recirculation systems. A water distribution system having one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe shall be a *demand recirculation water system*. Pumps shall have controls that comply with both of the following:

1. The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.
2. The control shall limit the temperature of the water entering the cold water piping to 104°F (40°C).

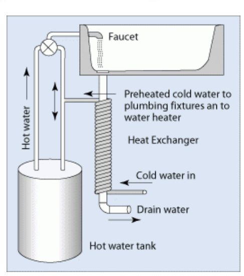


DRAIN WATER HEAT RECOVERY

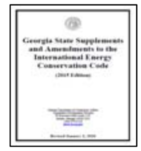
403.5.4 Drain Water Heat Recovery systems

- Vertical and Horizontal

R403.5.4 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2 or IAPMO PS 92. Vertical drain water heat recovery units shall be tested in accordance with CSA B55.1 and have a minimum effectiveness of 42 percent when tested in accordance with CSA B55.1. Sloped drain water heat recovery units shall be tested in accordance with IAPMO IGC 346 and have a minimum rated effectiveness of 42 percent when tested in accordance with IAPMO IGC 346 at the minimum slope specified in the Georgia plumbing code. Potable water-side pressure loss of vertical drain water heat recovery units shall be less than 3 psi (20.7 kPa) for individual units connected to one or two showers. Potable water-side pressure loss of vertical drain water heat recovery units shall be less than 2 psi (13.8 kPa) for individual units connected to three or more showers. Potable water-side pressure loss of sloped drain water heat recovery units shall be less than 4 psi (20.7 kPa).
(Effective January 1, 2020)



403.6 MECHANICAL VENTILATION



Mechanical Vents

- Require dampers (gravity/barometric or motorized)

R403.6 Mechanical ventilation (Mandatory). Where required, the building shall be provided with ventilation that meets the requirements of the *International Residential Code* or *International Mechanical Code*, as applicable, or with ASHRAE 62.2-2016, *Ventilation* and Acceptable Indoor Air Quality in Low-Rise Residential Buildings (in entirety) or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.
(Remainder of section left unchanged)

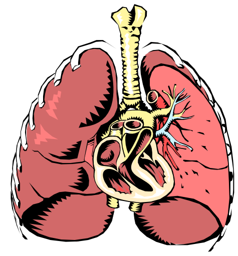
R403.6.1 Whole-house mechanical ventilation system fan efficacy. Mechanical ventilation system fans shall meet the efficacy requirements of Table R403.6.1.

> **Exception:** Where mechanical ventilation fans are integral to tested and listed HVAC equipment, they shall be powered by an electronically commutated motor.

IS IT POSSIBLE TO BUILD A HOUSE "TOO TIGHT"?

WHAT'S THE PURPOSE OF VENTILATION?

Provide fresh air for the occupants

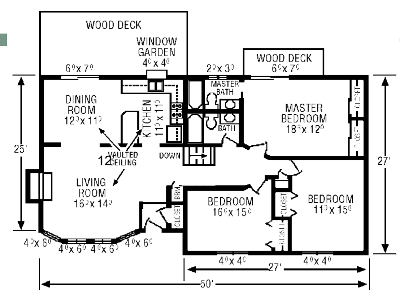


Dilute pollutants

HOW MUCH VENTILATION?

- ASHRAE 62.2 - 2010

7.5 cfm / person + 1 cfm / 100 ft²



(1400 s.f. house)

ASHRAE 62.2 - 2010

3 Bedrooms = 4 people
4 x 7.5 cfm / person = 30 cfm
30 cfm + 14 = 44 cfm

TABLE M1507.3.3(1) CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SY

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor[a]	4	3	2	1.5	1.3	1.0

ASHRAE 62.2-2016
7.5 cfm/person + 3 cfm / 100 s.f.

WHOLE HOUSE VENTILATION STRATEGIES

[Negative] Spot Ventilation

- (exhaust fans)

[Balanced] Air-in / Air-out

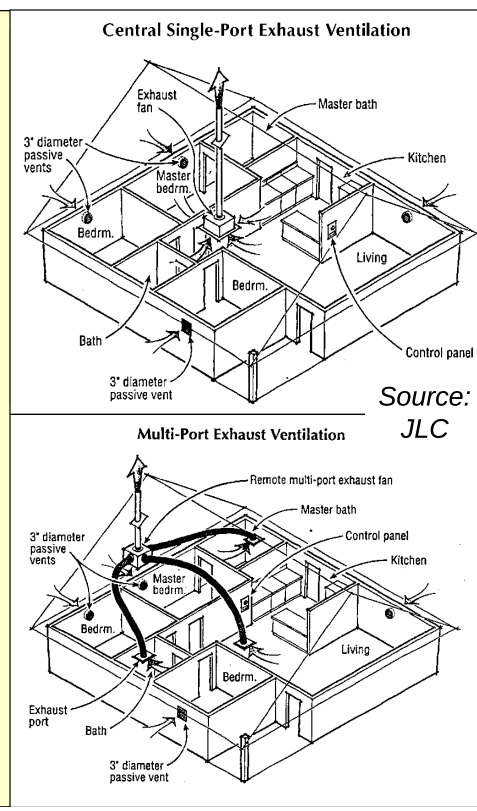
- (HRV, ERV, multiple fans)

[Positive] Pull/pump air into home

- (ducted supply, return intake)

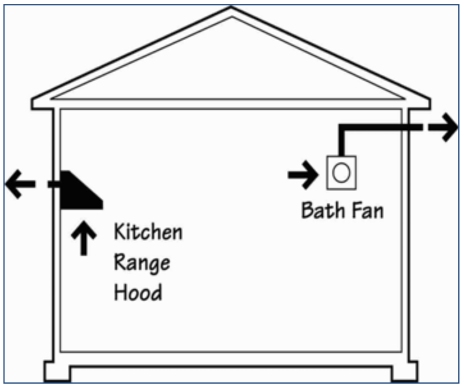
NEGATIVE / EXHAUST STRATEGIES

- Quality fans can run continuously
- Preferred for colder climates
- Doesn't really offer control of where inlet air comes from
- Not recommended for humid climates
- Spot ventilation is an excellent strategy for all climates



Source: JLC

QUALITY EXHAUST FAN VENTILATION



- Bath (50 cfm) and kitchen (100 cfm) fans vent to the outside
- Rigid duct is preferred

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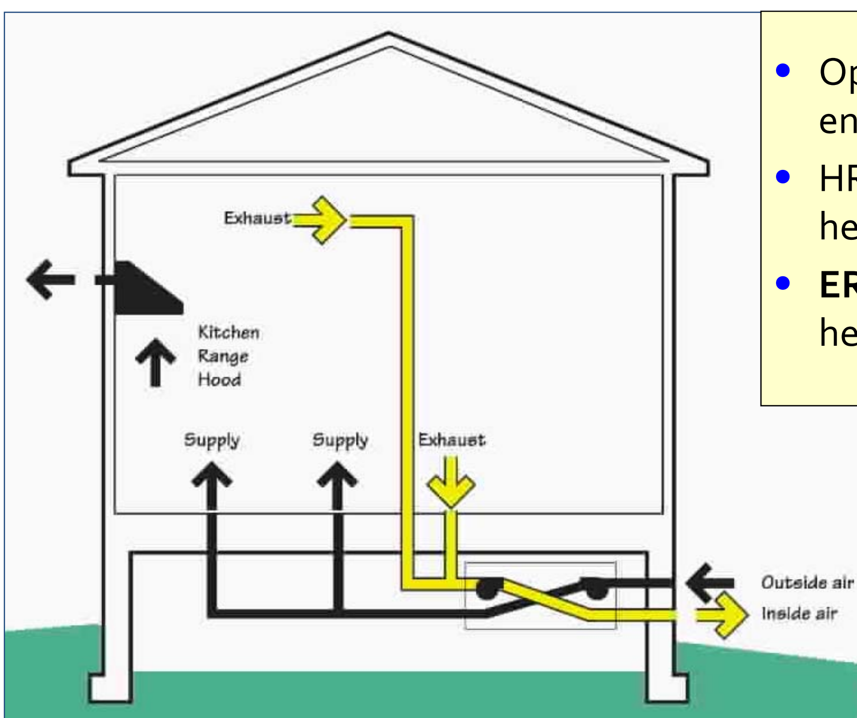
AIR TO AIR HEAT EXCHANGER



- Opportunities for energy recovery
- HRV - recovers heat
- **ERV** - transfers heat & moisture

Balanced Ventilation

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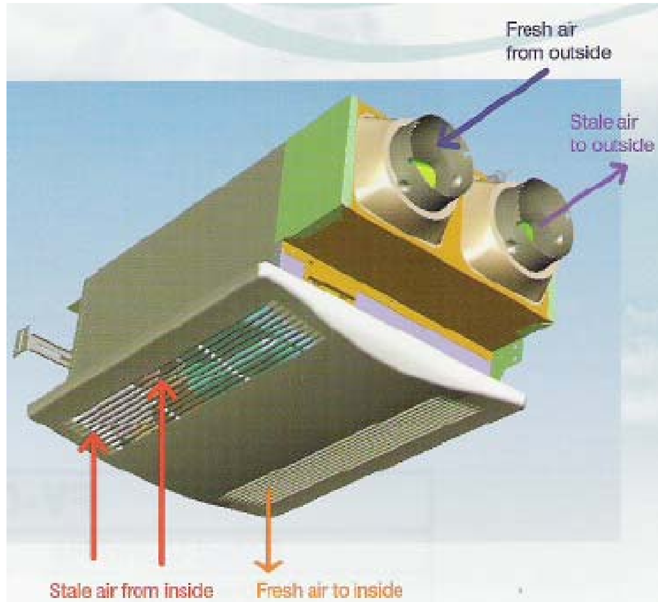
BALANCED VENTILATION

- Controlled inlet and outlet with filtering
- Could be separate fans or single unit
- Opportunities for heat/energy recovery



BALANCED ERV - WHOLE UNIT

Broan ERV70S

- 35-70 cfm
- 35-60 watts
- low sones
- Sensible Recovery Effectiveness 69%
- Total Recovery Efficiency 50%

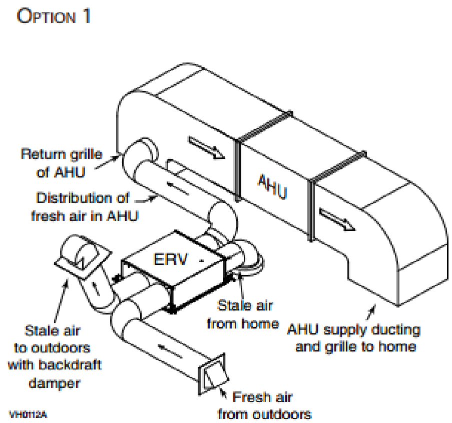
BALANCED ERV- INSTALL OPTIONS

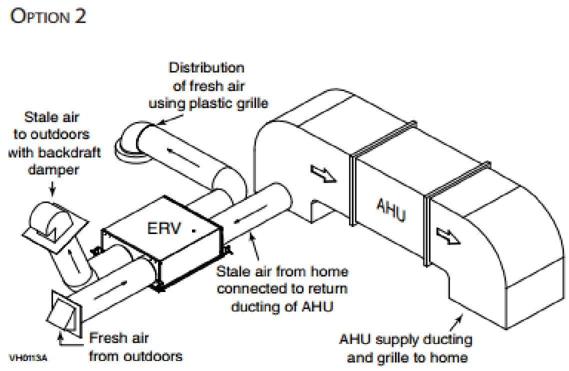
- Independently ducted system is best
- Can tie into return duct of main system (don't connect to both supply and return)

Combining with an AHU

Recommanded configurations

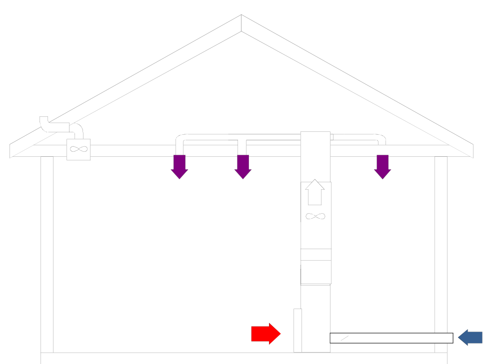
When the distribution of fresh air from the ERV is connected to the return of an AHU (such as in the image below, on the left), the connection should be done **as close as possible from the AHU return grille** to ensure proper functionning of the built-in fresh air damper.



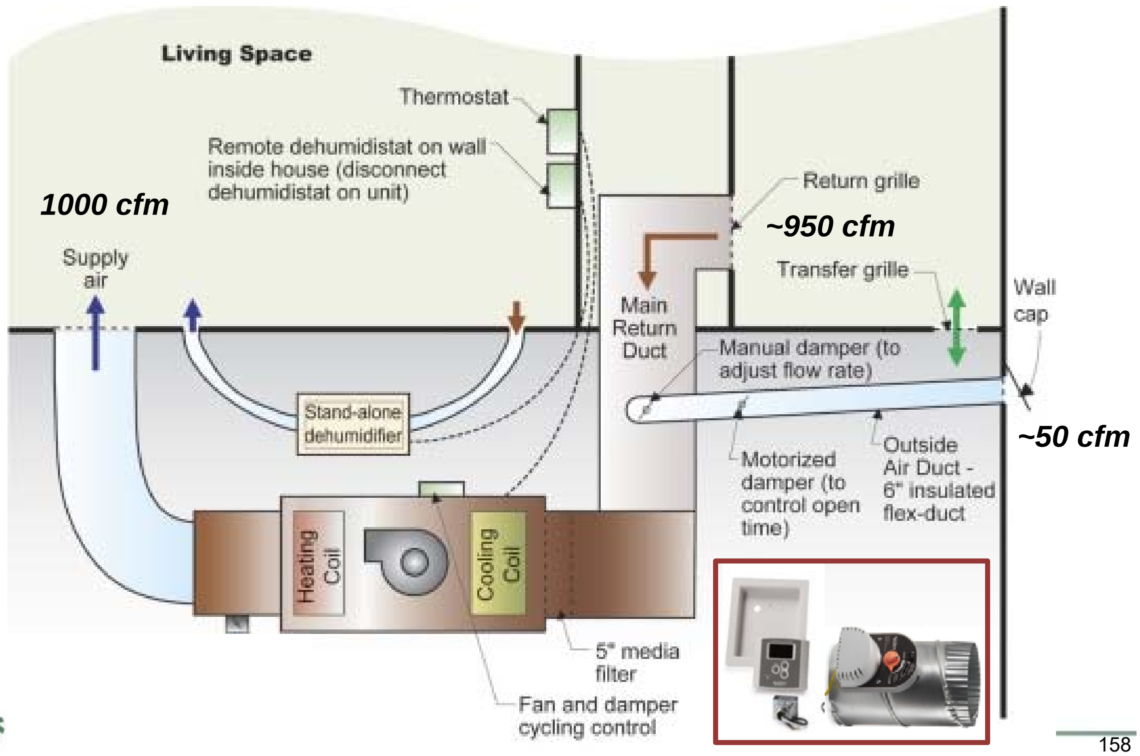


POSITIVE PRESSURE VENTILATION

- Tends to drive pollutants out
- Air enters from known source plus filtering and mixing
- Could be separate fan or duct connected to return
- AirCycler™ type controller can run AHU on regular basis
- Reduces chances of backdrafting



POSITIVE VENTILATION SUPPLIED VIA FRESH O.A. DUCTED TO RETURN



POSITIVE PRESSURE IN-LINE FAN + SENSOR

- Plus- Likely to have correct ventilation cfm that is filtered & from known source
- Plus- Low initial and operating cost
- Plus- Can be set to not ventilate during "bad" times (too hot, too cold, too humid, too dry)
- No dehumidification!
- No energy recovery!

QUFRESH BY Air King

Patents Pending

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
			100 CFM	26.3
			110 CFM	27.5
			120 CFM	30.1

Southface

HVAC AND MOISTURE

It's Not the Heat, It's The Humidity..

Atlanta, GA									
Bin Temperature	70-75	75-80	80-85	85-90	90-95	95-100	100-105	105-110	Total
# of Hours of Occurrence	1188	880	620	361	172	23	2	0	3246
	37%	27%	19%	11%	5%	1%	0%	0%	
	83%			17%					
Manual J Design, Load based on Temperature					92°	99	gr/lb		
ASHRAE Humidity Design, Load based on Moisture					82°	133	gr/lb		
Approximate Extra Moisture Added per 100 CFM Of O.S.A.					3.9	pts/hr	or	93.9	pts/day

WHAT'S THE BEST VENTILATION SYSTEM?

Smart, sensor based controller- Likely temperature + moisture plus other pollutants, adjusts based on conditions and activity; alerts when needed

Energy recovery- preconditions entering fresh air

Supplemental dehumidification- Can assist with house drying as well as fresh air

Quality filter- Accessible for easy maintenance

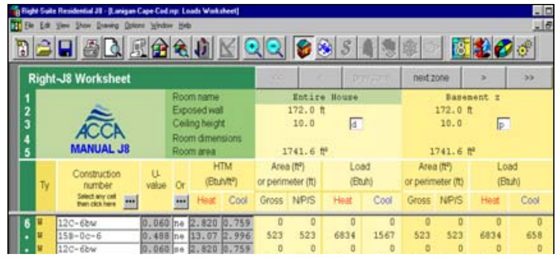
Low 1st cost and low operating cost

Easy to install and tested to verify airflow

403.7 EQUIPMENT SIZING

Load Calcs & Sizing

- ACCA Manual J or approved equivalent, i.e., ASHRAE Fundamentals
- 302.1: Interior design temp (72°F heating, 75°F cooling)
- **MUST BE ACCURATE**



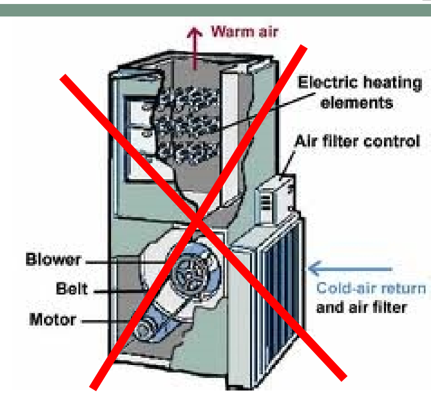
R403.7 Equipment sizing and efficiency rating (Mandatory). Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies. "For automatically modulating capacity heating and cooling equipment, the system shall be deemed to comply with appropriate portions of Manual S provided the lowest output capacity of the equipment is less than the peak design load as determined by Manual J." New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law for the geographic location where the equipment is installed.

GA Amendment for Variable Capacity

403 HEAT SOURCE, POWER ATTIC VENTS

GA Amendment – 403.1.2.3

New or replacement central HVAC systems shall not use electric-resistance heat as primary heat source for home



GA Amendment – 403.13

No grid-tied power attic ventilators allowed (exception for solar powered)

R403.13 Electric powered attic ventilators. In new construction, electric powered attic ventilators shall not be connected to the Service supply premise wiring system. Solar photovoltaic (PV) powered attic ventilators shall be permitted. (Effective January 1, 2020)

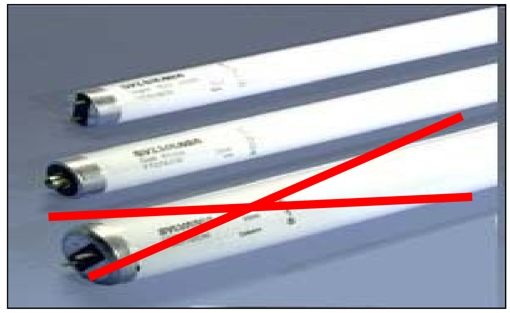
404 - LIGHTING

A minimum of **75 percent** of bulbs in permanent fixtures must be high-efficacy

High efficacy =

+ CFL,
+ T8 or T5 fluorescent bulb or,
+ Meet certain lumen/W requirements (good LEDs)

- NOT incandescent/ halogen bulbs
- NOT T12 fluorescent bulbs
- EXCEPTION
  – low voltage lighting



ECONOMICS OF INCANDESCENT LIGHTING

9 bulbs x 60 watts each = 540 w

540 w x 4 hours a day = 2160 wh

2160 wh x 365 days = 788,400 wh a year

788,400 / 1000 = 788.4 kwh

788.4 kwh x $.125 = $98.55 per year

ECONOMICS OF LED LIGHTING

Cree 60W Equivalent Soft White A19 Dimmable LED Light Bulb with 4-Flow Filament Design

9 bulbs x 10 watts each = 90 w

90 w x 4 hours a day = 360 wh

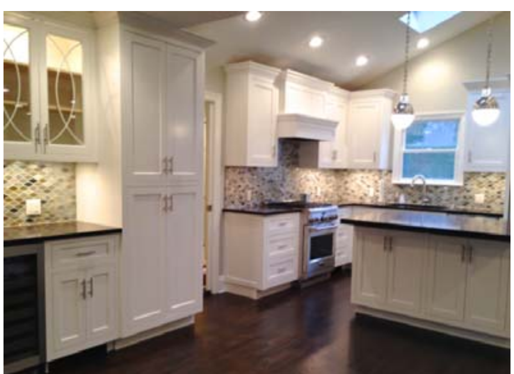
360 wh x 365 days = 131,400 wh a year

131,400 / 1000 = 131.4 kwh

131.4 kwh x $.125 = $16.43 per year

Save ~$82 annually on just the chandelier

THE ECONOMICS OF LIGHTING FOR BUILDERS



Bulb Cost Assumption:		Electricity Rate:	0.12 $/kwh		
Incandescent = $0.25					
LED = $2 each					
				Bulb Wattage	
	# Incand	# LED's	Price Premium	Incand	LED
All Incand House	60	0	$ -	60	10
50% LED House	30	30	$ 52.50	60	10
100% LED House	0	60	$ 105.00	60	10

It takes 24 days to payback LED's if half the lights are left on during construction!

(12 days if all on!!!)

	$ Cost for 1 month - ON half the time			Simple Payback		
	Incand	LED	Total	$ Savings	(months)	(days)
100% Incand House	$ 158.11	$ -	$ 158.11	0		
50% Incand / 50% LED	$ 79.06	$ 13.18	$ 92.23	$ 65.88	0.80	24.3
100% LED House	$ -	$ 26.35	$ 26.35	$ 131.76	0.80	24.3

GEORGIA RESIDENTIAL ENERGY CODE FIELD STUDY

Key Items :

- Envelope tightness (ACH50) – *Verified on Energy Certificate*
- Window SHGC – *Verified at inspection and on Certificate*
- Window U-factor – *Verified inspection and on Certificate*
- Exterior wall insulation – *Verified at insulation inspection ***
- Ceiling insulation – *Verified at final*
- High-efficiency lighting – *Verified at final*
- Foundation (floor / basement wall / slab) – *Verified at final*
- Duct leakage – *Verified on Energy Certificate*

WRAP UP AND Q&A

Thank you!

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