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A photograph of an electrician wearing a bright yellow-green safety helmet with the Ameren logo, safety glasses, and a high-visibility vest. He is looking off to the side with a focused expression. In the background, there are utility poles and power lines, and another worker is visible on a distant structure.

**New Energy Codes & High-Performance Homes:
Performing Trade-Offs Using *REScheck***

**Mike Barcik, Southface Institute
Matt Belcher, MO Energy Code Consultant**

Energy Code Resources



Technical assistance or training requests:

Matt Belcher, Energy Code Consultant

Matt@moenergycodesupport.org

314.749.4189

Energy Code Resources

Missouri Residential Building Energy Code Construction Practices Study:

<https://energy.mo.gov/energy-codes/missouri-residential-building-codes-study>

For additional information on other DOE Field Studies and participating states, please visit <https://www.energycodes.gov/compliance/energy-code-field-studies>.

Additional education resources are available at www.southfaceonlinetraining.org.

www.southface.org

mikeb@southface.org

About Southface

www.southface.org



- Mike Barcik – Technical Principal
- mikeb@southface.org


*Building a Regenerative Economy,
Responsible Resource Use & Social Equity
Through a Healthy Built Environment for All*



Learn More at www.southface.org

- Energy Code Resources
- BS webinars

<https://www.southface.org/resources/building-science-webinars/>



southface.org/resources/building-science-webinars/

Design Strategies for a High-Performance Home

This webinar is intended for architects, designers, builders, and raters of new homes. The webinar begins with an overview of building science and the house-as-a-system approach. Participants will apply this knowledge to total-home performance and the features it entails. This webinar will show participants best practices for designing a high-performance home, with a focus on efficiency, comfort, health, durability and environmental awareness. Participants will discover that high-performance homes begin with an enhanced design effort but



Learning Objectives

- Understand prescriptive energy code requirements from 2018 IECC
- Identify standards for insulation requirements and fenestration performance
- Understand how to use *RESCHECK* for a simple UA Trade-off
- Learn how *RESCHECK* can be used as a Simulated Performance Alternative tool

Design Approach for a High-Performance Home

- **Building Science as guide**

Understand physics of heat air and moisture flow

- **High Performance Enclosure**

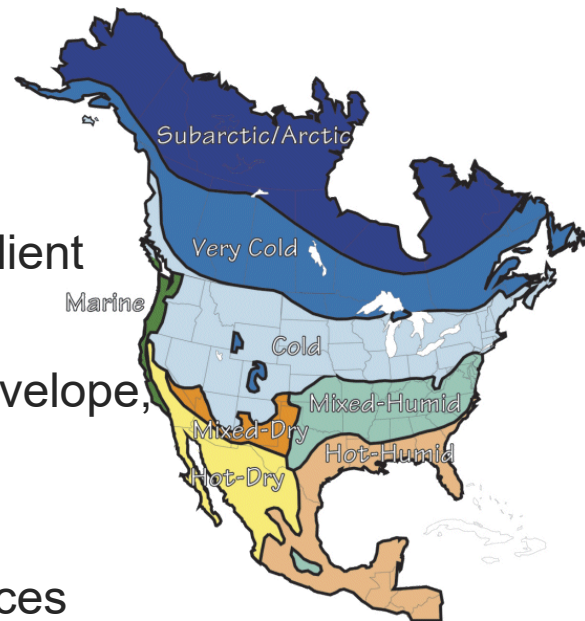
Sound structure, shell is tight, well-insulated and resilient

- **Air Distribution**

Sealed & insulated ducts – located inside building envelope, fresh air delivery

- **Reduced Equipment & Loads**

Efficient Heating, Cooling, Hot Water, Lights, Appliances

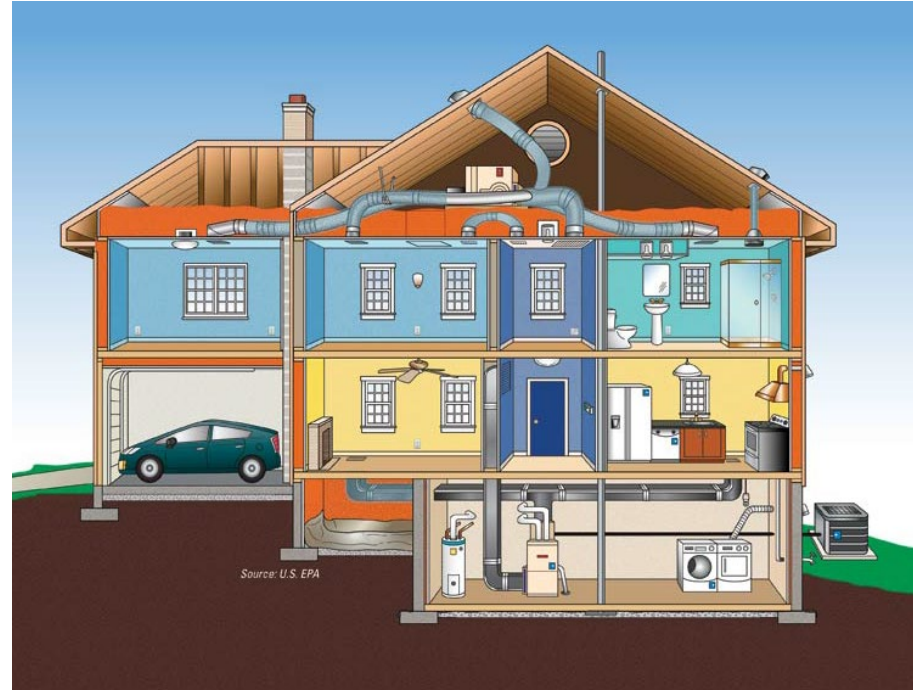


The Key: It's not necessarily the stuff in the building — it's how it's all put together! (The house is a system)

Building Science

A house is a system made up of interrelated parts:

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



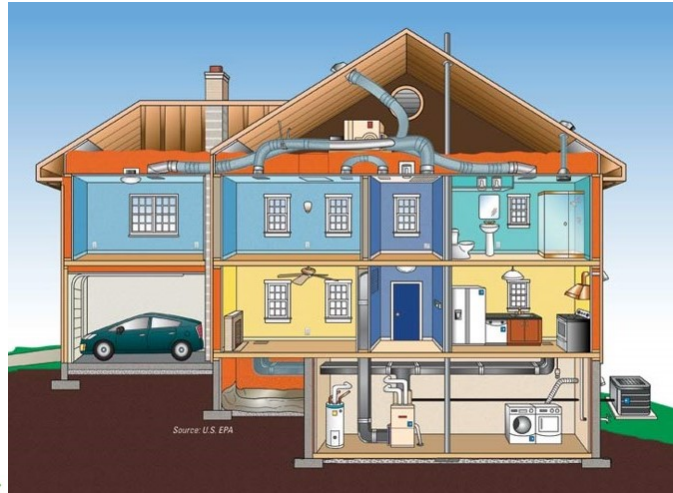
Building Thermal Envelope

IECC Definition

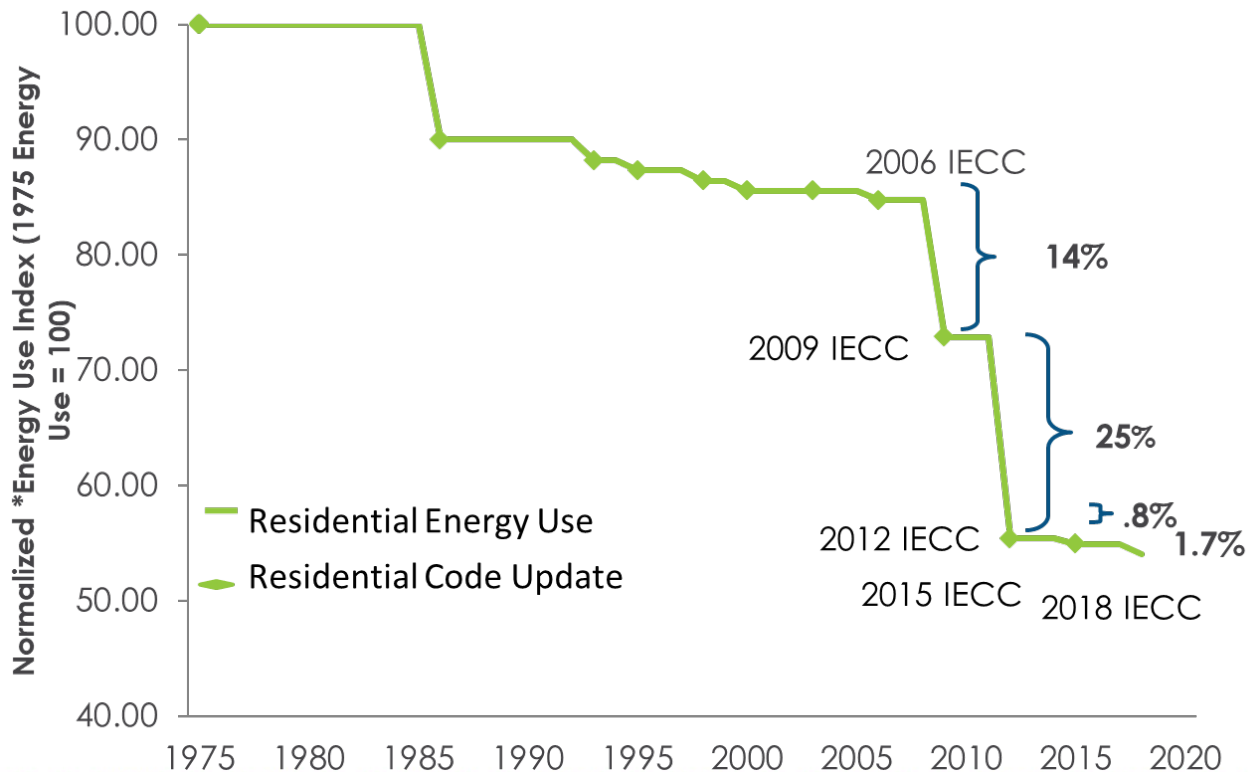
The basement walls, exterior walls, floor, roof and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.



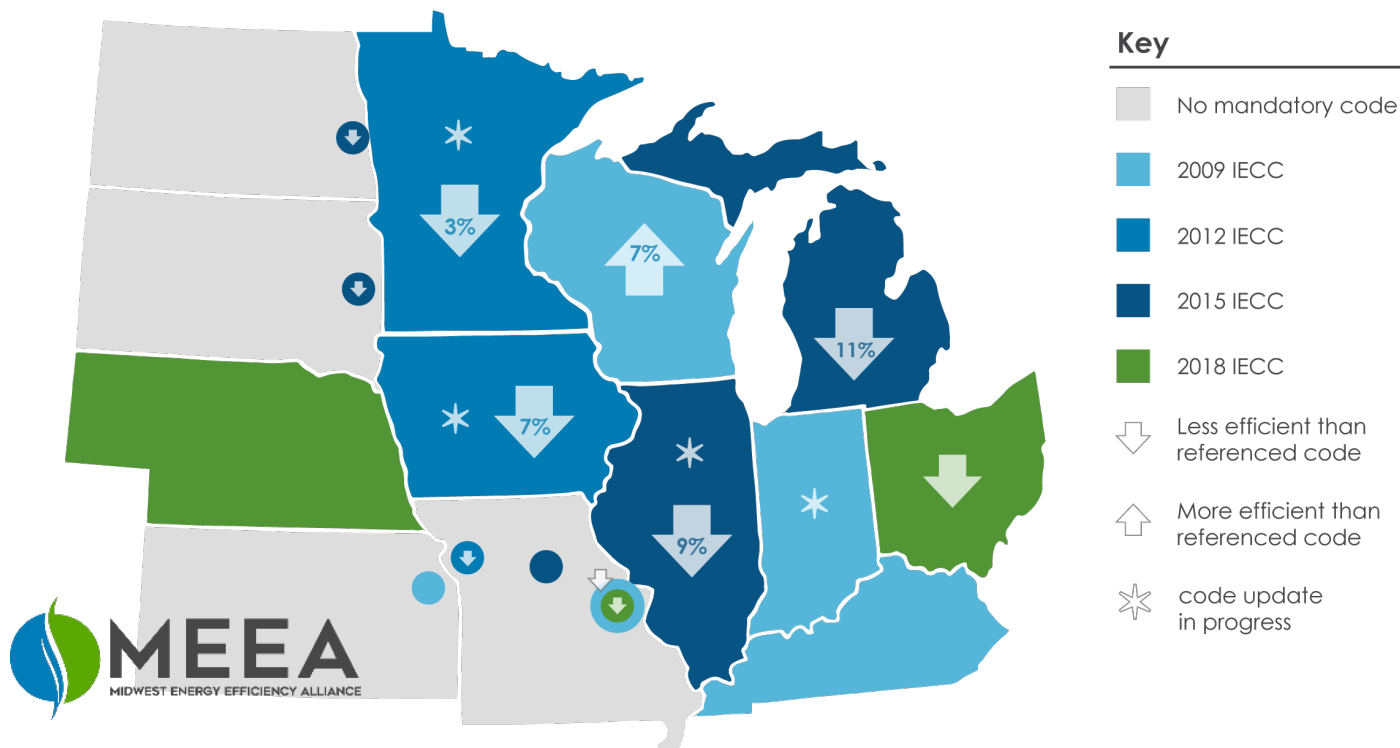
What parts of this house are enclosed by the thermal envelope?



Residential Energy Code Background



Midwest Residential Energy Code Adoption



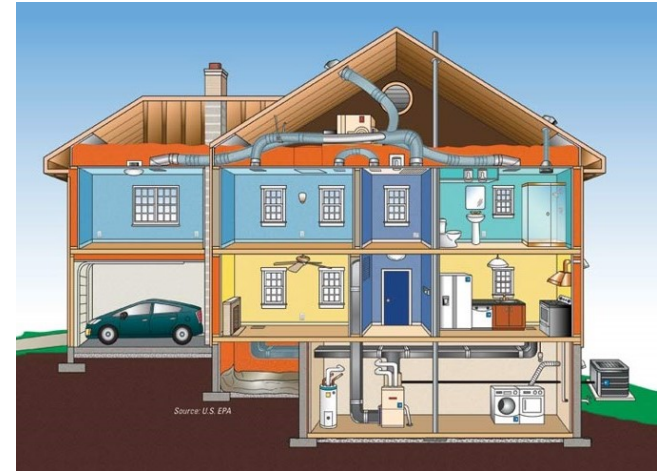
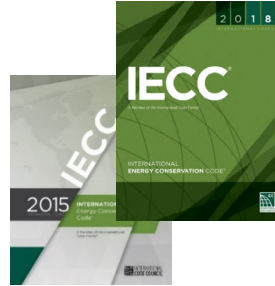
As of May 2019

Percentage change is based on EUI of adopted code

Energy Code: Residential Building

Applies to:

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



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*.

Exempt Buildings

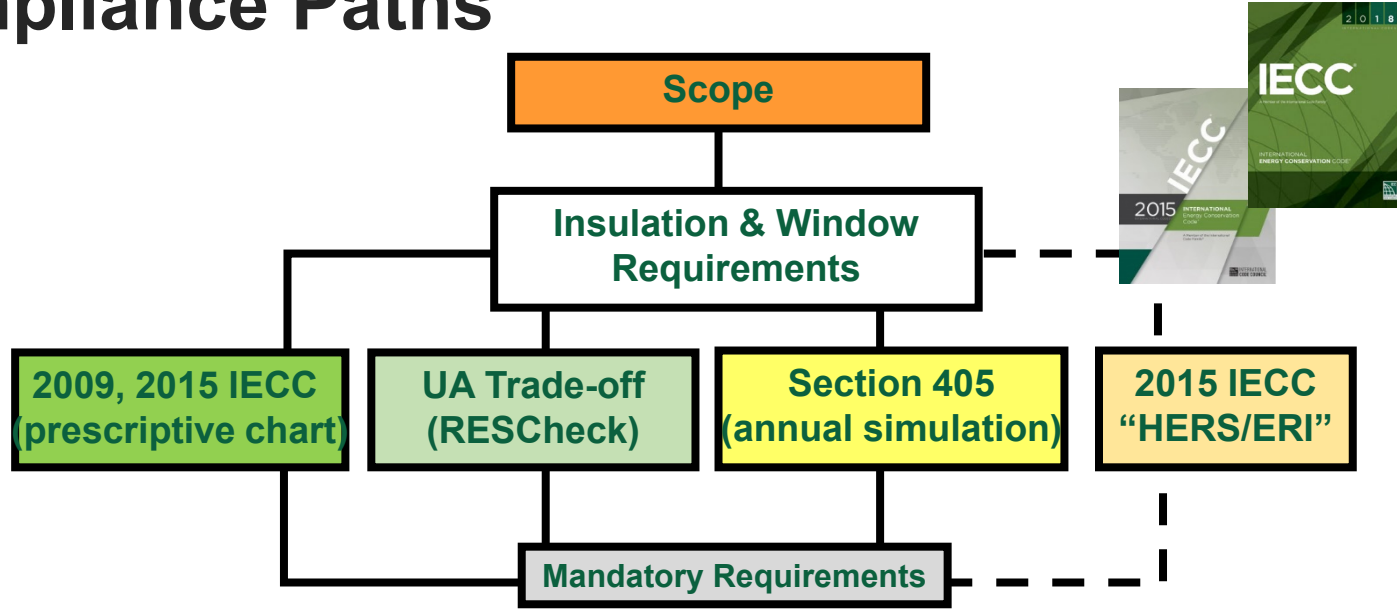
- No conditioning
- Historical

Scope of Residential Energy Code

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



Compliance Paths



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

2009 IECC- Section 402.1

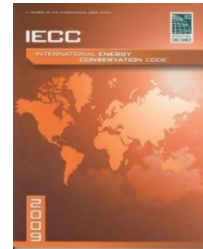
- One prescriptive “answer” for how to build per climate zone (CZ: 4 and 5)
- Includes lots of footnotes



2009

TABLE 402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT^a

CLIMATE ZONE	FENESTRATION U-FACTOR ^b	SKYLIGHT ^b U-FACTOR	GLAZED FENESTRATION SHGC ^{b, e}	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE ⁱ	FLOOR R-VALUE	BASEMENT ^c WALL R-VALUE	SLAB ^d R-VALUE & DEPTH	CRAWL SPACE ^c WALL R-VALUE
1	1.2	0.75	0.30	30	13	3/4	13	0	0	0
2	0.65 ^j	0.75	0.30	30	13	4/6	13	0	0	0
3	0.50 ^j	0.65	0.30	30	13	5/8	19	5/13 ^f	0	5/13
4 except Marine	0.35	0.60	NR	38	13	5/10	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.35	0.60	NR	38	20 or 13+5 ^h	13/17	30 ^g	10/13	10, 2 ft	10/13
6	0.35	0.60	NR	49	20 or 13+5 ^h	15/19	30 ^g	15/19	10, 4 ft	10/13
7 and 8	0.35	0.60	NR	49	21	19/21	38 ^g	15/19	10, 4 ft	10/13



Prescriptive R-values 2015 IECC vs. 2018 IECC

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

402.1.4 is similar table for U-factors

TABLE R402.1.2
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT^a

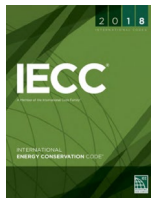
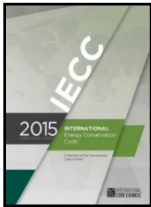
CLIMATE ZONE	FENESTRATION U-FACTOR ^b	SKYLIGHT ^b U-FACTOR	GLAZED FENESTRATION SHGC ^{b, e}	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE ^l	FLOOR R-VALUE	BASEMENT ^c WALL R-VALUE	SLAB ^d R-VALUE & DEPTH	CRAWL SPACE ^c WALL R-VALUE
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2015

3	0.35	0.55	0.25	38	20 or 13+5 ^h	8/13	19	5/13 ^f	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5 ^h	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5 ^h	13/17	30 ^g	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10 ^h	15/20	30 ^g	15/19	10, 4 ft	15/19

2018

3	0.32	0.55	0.25	38	20 or 13+5 ^h	8/13	19	5/13 ^f	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13+5 ^h	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13+5 ^h	13/17	30 ^g	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5 ^h or 13+10 ^h	15/20	30 ^g	15/19	10, 4 ft	15/19



Prescriptive **U-factors** 2015 IECC vs. 2018 IECC

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

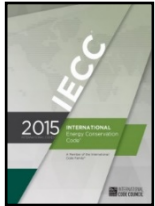


TABLE R402.1.4
EQUIVALENT U-FACTORS^a

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
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2015

4 except Marine	0.35	0.55	0.026	0.060	0.098	0.047	0.059	0.065
5 and Marine 4	0.32	0.55	0.026	0.060	0.082	0.033	0.050	0.055

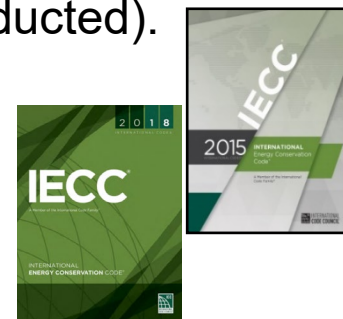
2018

4 except Marine	0.32	0.55	0.026	0.060	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.026	0.060	0.082	0.033	0.050	0.055



IECC Code Differences – ‘15 to ‘18

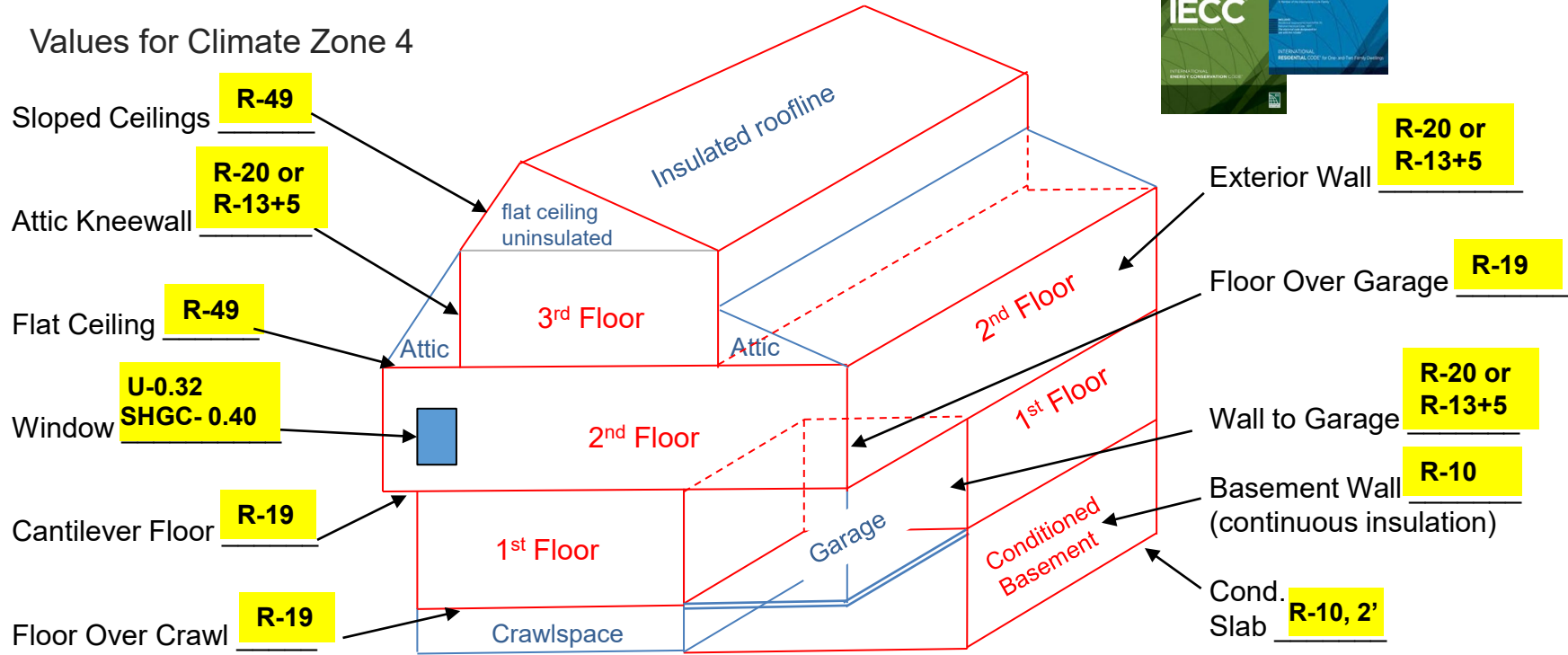
- Window Ufactors dropped slightly from U35 to U32 & U30 (CZ’s 4-5)
- Exception for log homes built according to ICC 400
- ERV/HRV ducts exempt from leakage testing (if independently ducted).
- Ducts allowed to be buried in ceiling insulation
 - Ducts R-8
 - Minimum surrounding insulation R-19 (R-13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



2018 IECC/IRC Prescriptive Code R-Values



Values for Climate Zone 4

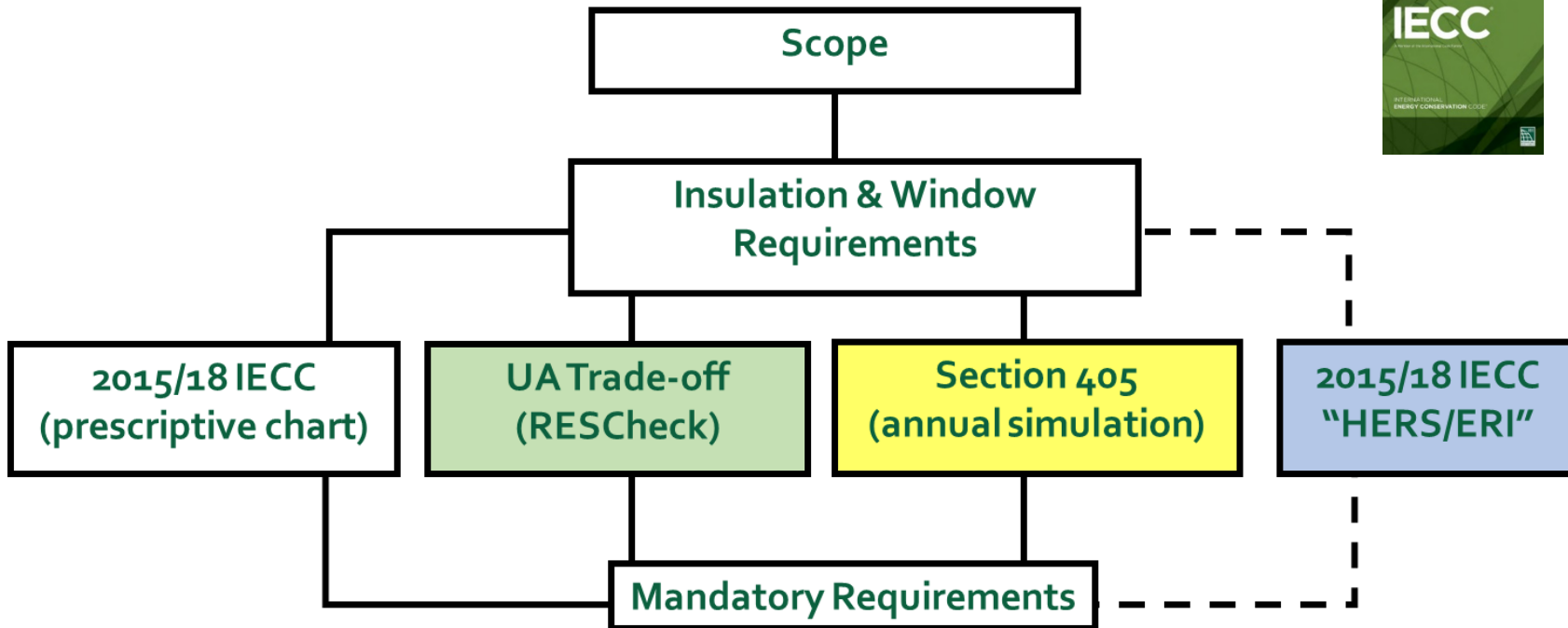


Section 402.2: Insulation Requirements

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

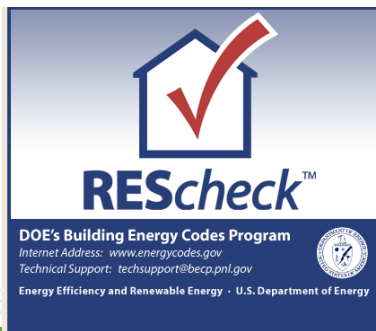
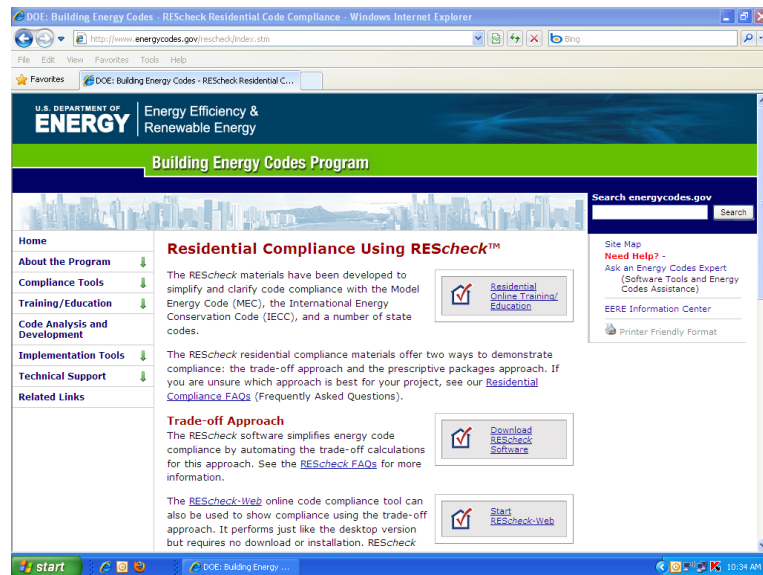


Envelope Tradeoff Options



REScheck Tradeoff Option

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



Section 405 Simulated Performance Alternative, Sample Report

- Annual energy usage simulation demonstrates that the proposed building's energy costs are \leq "standard code" building
 - No credit for mechanical efficiencies
 - Likely to involve a HERS rater
 - Ekotrope, REMrate & Energy Gauge are acceptable
- Compares total annual energy costs
 - ❑ Window U-factor and SHGC
 - ❑ Envelope and duct testing
 - ❑ Lighting, duct insulation
 - Compares energy costs of actual home being built against 2015/18 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 ACMEZ - MB	Builder Wiley E Coyote	

	Annual Energy Cost	
	IECC 2015 Performance	As Designed
Design Heating	\$4,211	\$695
Cooling	\$414	\$387
Water Heating	\$372	\$371
Sub Total - Used to determine compliance	\$1,997	\$1,462
Lights & Appliances	\$800	\$800
Onsite generation	\$0	\$0
Total	\$2,803	\$2,259

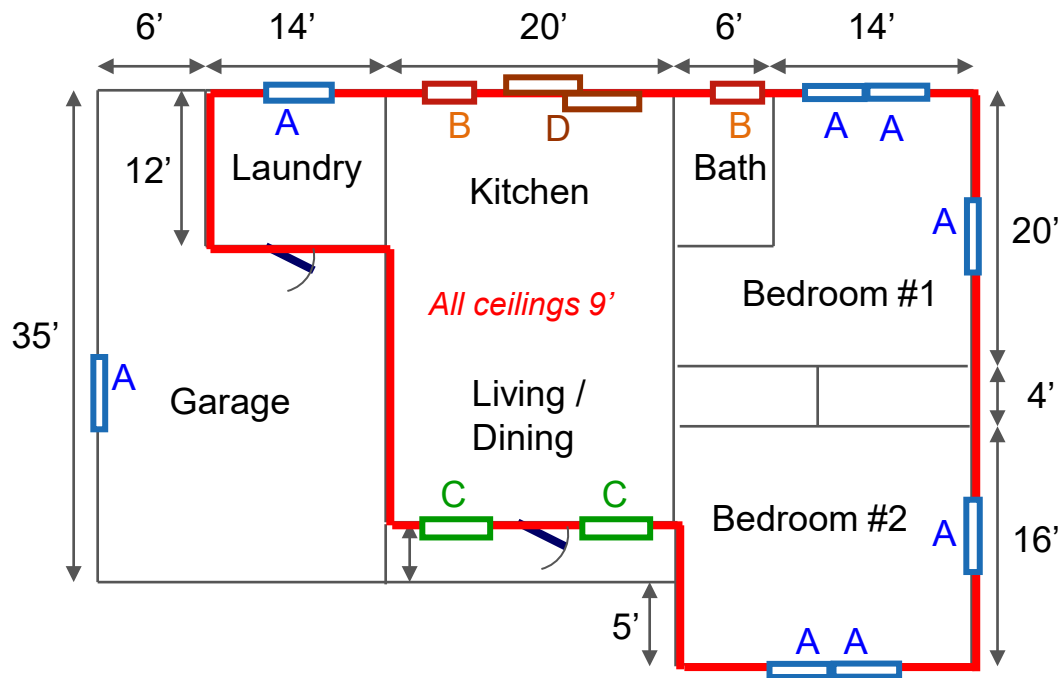
Requirements

✔ 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 inspected and that the mandatory provisions of the IECC have been installed to meet or exceed the intent of the IECC as will be verified as such by the code official.

RESCHECK - Simple House



- A: 3'0 x 4'0 DP low-e (U.31, SHGC.24)
- B: 3'0 x 3'0 DP low-e (U.33, SHGC.26)
- C: 4'0 x 5'0 DP low-e (U.32, SHGC.25)
- D: 6'0 x 6'8 DP Sliding Glass Door with tint (U.47, SHGC.48)

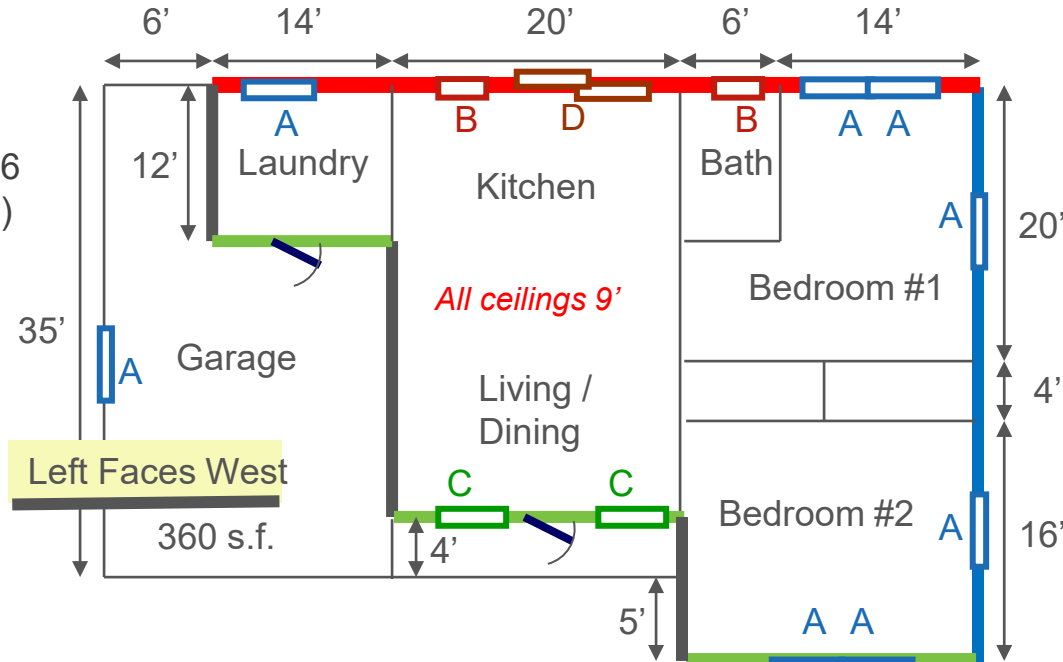
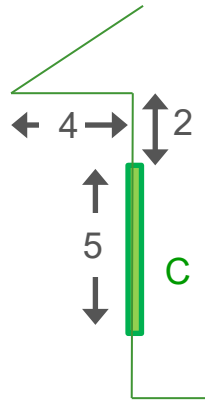
- Perimeter: $54 \times 2 + 40 \times 2 = \underline{188}$ ft.
- Gross Wall: $188 \times 9 = \underline{1,692}$ sq. ft.
- Floor Area:
 - $12 \times 14 +$
 - $20 \times 31 +$
 - $20 \times 40 =$
 - $\underline{1,588}$ sq. ft.
- Ceiling Area: $\underline{1,588}$ sq. ft.
- Windows
 - A: $12 \times 7 = 84$ sq. ft.
 - B: $9 \times 2 = 18$ sq. ft.
 - C: $20 \times 2 = \underline{40}$ sq. ft.
 Windows: $\underline{142}$ sq. ft.
- Glass Doors: $20 \times 2 = \underline{40}$ sq. ft.
- Solid Doors: $\underline{42}$ sq. ft. (R-3)
- Volume: $1588 \times 9 = 14,292$ c.f.

Simple House (1588 s.f.)



Assume:





- Front faces south
- 1' overhang except 4' porch
- 2x4 frame walls, R-13+R-6
- R-49 flat ceiling (1588 s.f.)
- R-5 slab edge insulation



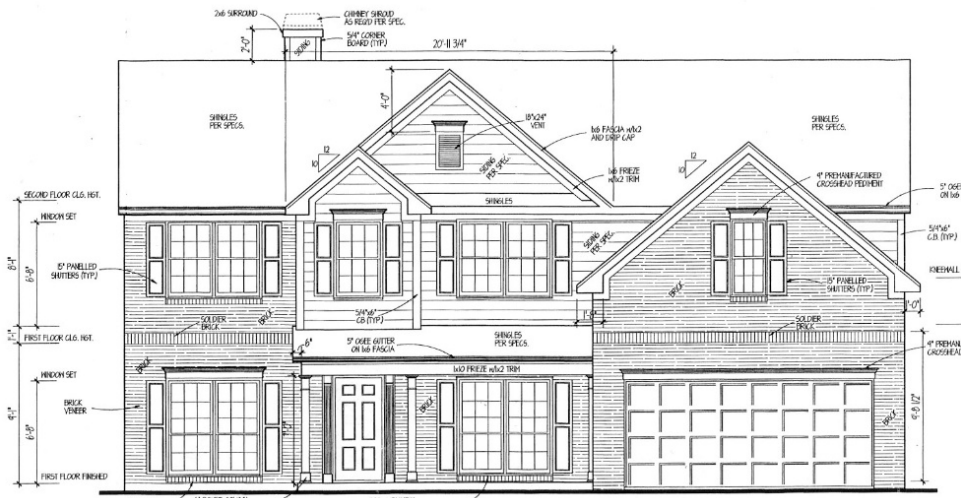
Back Faces North 486 s.f.

Right Faces East 360 s.f.

Front Faces South 486 s.f.

-  A: 3'0 x 4'0 DP low-e (U.31, SHGC.24)
-  B: 3'0 x 3'0 DP low-e (U.33, SHGC.26)
-  C: 4'0 x 5'0 DP low-e (U.32, SHGC.25)
-  D: 6'0 x 6'8 DP Sliding Glass Door with sun tint (U.47, SHGC.48)

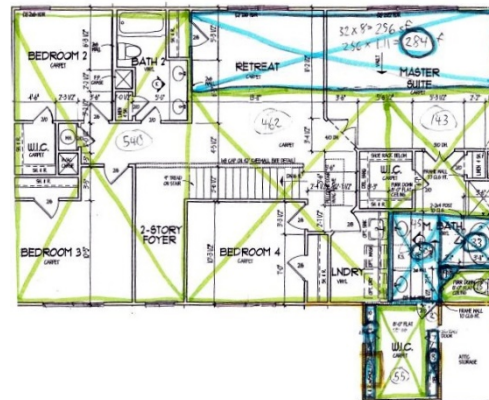
RESCHECK – ACME House



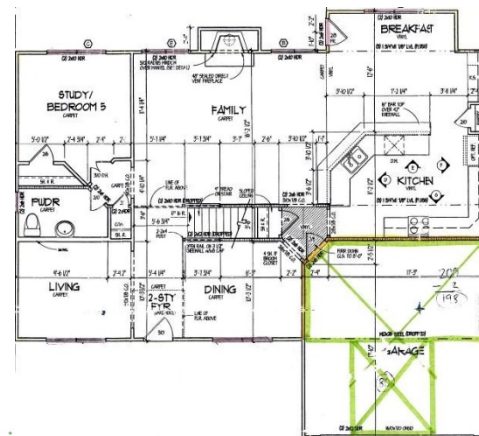
FRONT ELEVATION "E" -- PARTIAL BRICK

SCALE: 1/4" = 1'-0"

“Acme” base case, 2-story
2816 s.f home (St. Louis)



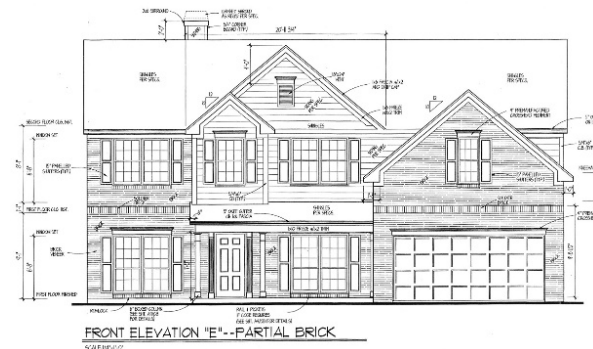
Second:
1,473 s.f.



First:
1,343 s.f.

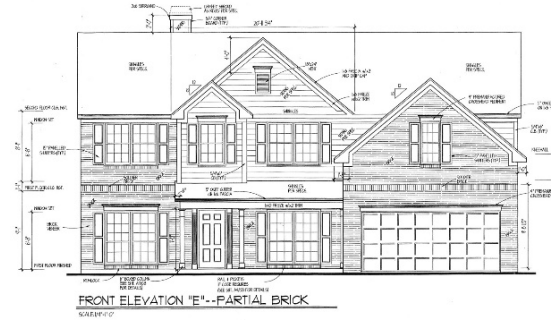
RESCHECK – ACME House Base Case Takeoffs

- Total cond. Floor area: 2816 s.f., Volume: 25,791 c.f.
- First floor area: 1343 s.f., slab on grade: **167' perimeter**, R-10. 2'
- Second level, floor over garage: **280 s.f.**, R-19
- Gross Exterior walls: **2578 s.f.**
 - Net Exterior walls: 2170 s.f., R-20
- Gross Wall Adjacent to Garage: **257 s.f.**
 - Net Wall Adjacent to Garage: 237 s.f., R-13
- Attic Kneewall: **420 s.f.**, R-13+R-5 continuous
- Windows (F,L,B,R): 157+22+177+12 = **368 s.f.**, U-0.30, SHGC-0.26
- Glass Door: **20 s.f.**, U-0.33, SHGC-0.30
- Front Door wood: **20 s.f.**, U-0.5
- Garage Door metal, foam core: **20 s.f.**, U-0.33
- Flat ceiling: **1220 s.f.**, R-49 Vaulted ceiling: **390 s.f.**, R-25



RESCHECK – ACME House Roofline Takeoffs

- Total cond. Floor area: 2816 s.f., **Volume: 29,811 c.f.**
- First floor area: 1343 s.f., slab on grade: **167' perimeter**, R-10, 2'
- Second level, floor over garage: **280 s.f.**, R-19
- Gross Exterior walls: 2578 s.f.
 - Net Exterior walls: **2170 s.f.**, R-20
- Gross Wall Adjacent to Garage: 257 s.f.
 - Net Wall Adjacent to Garage: **237 s.f.**, R-13
- **Foamed Gable End walls: 744 s.f.**, R-20
- Windows (F,L,B,R): 157+22+177+12 = **368 s.f.**, U-0.30, SHGC-0.26
- Glass Door: **20 s.f.**, U-0.42, SHGC-0.30
- Front Door wood: **20 s.f.**, U-0.5
- Garage Door metal, foam core: **20 s.f.**, U-0.33
- **Foamed Roofline (vaulted ceiling): 1986 s.f.**, R-20





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