





**New Energy Codes:
Performing Trade-Offs Using *REScheck*, part 2**

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Energy Code Resources



Technical assistance or training requests:

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Energy Code Resources

Missouri Residential Building Energy Code Construction Practices Study:

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

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

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

www.southface.org

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About Southface www.southface.org



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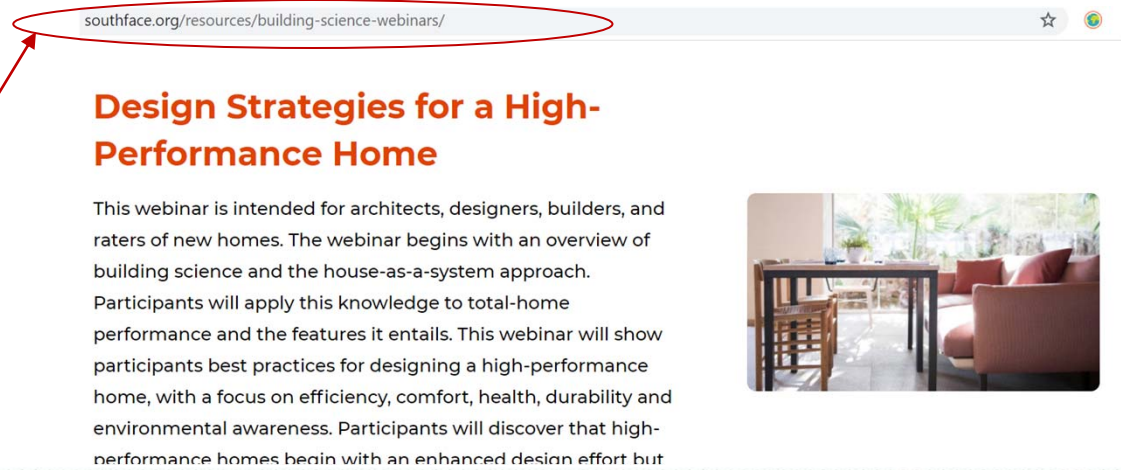


*Building a Regenerative Economy,
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Design Strategies for a High-Performance Home

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

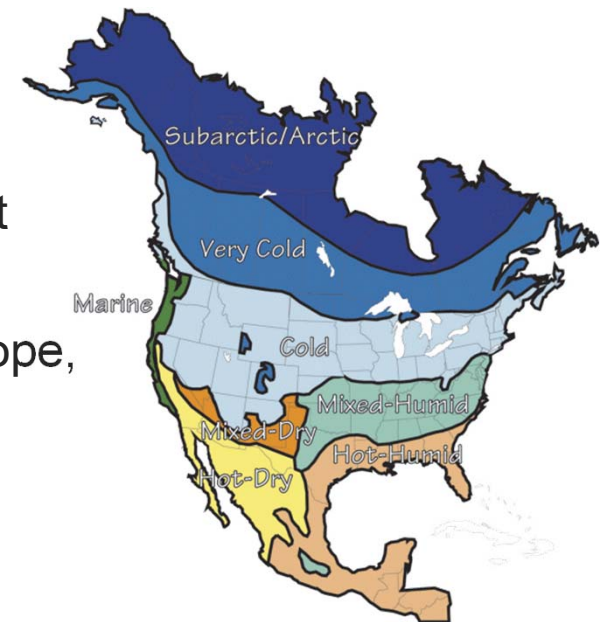


Learning Objectives

- 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
- Use *RESCHECK* for additional designs

Design Approach for a High-Performance Home

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



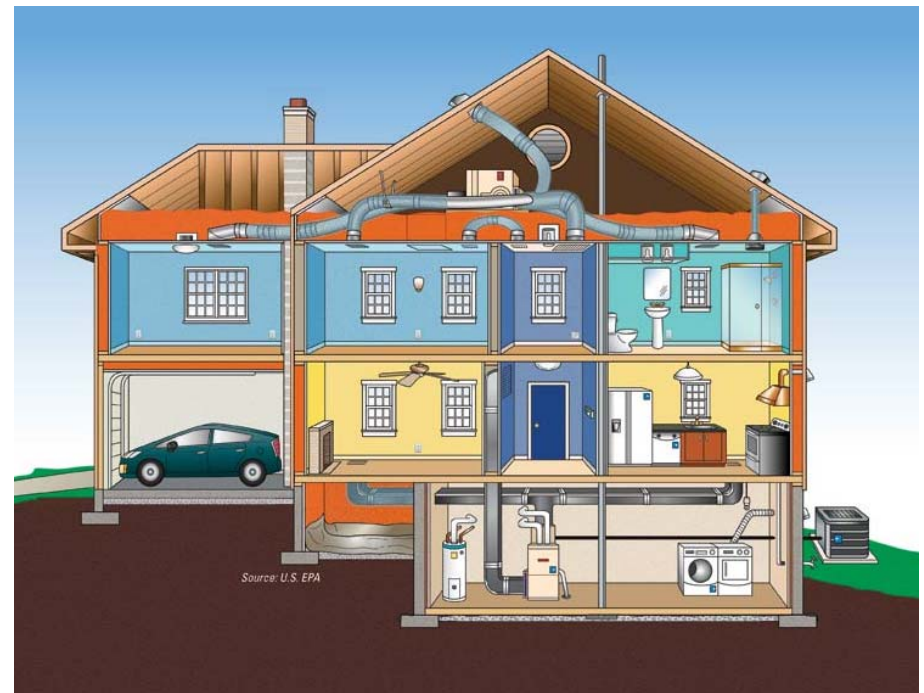
The Key: It's not necessarily the stuff in the building — it's how it's all put together! (The house is a system)

Part I

Building Science

A house is a system made up of interrelated parts:

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



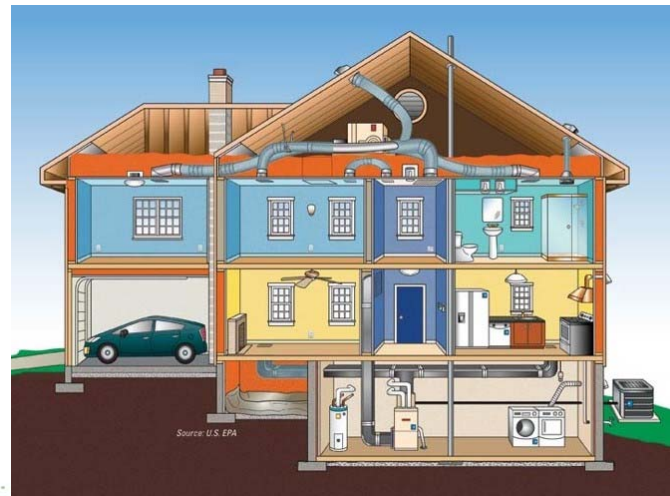
Building Thermal Envelope

IECC Definition

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

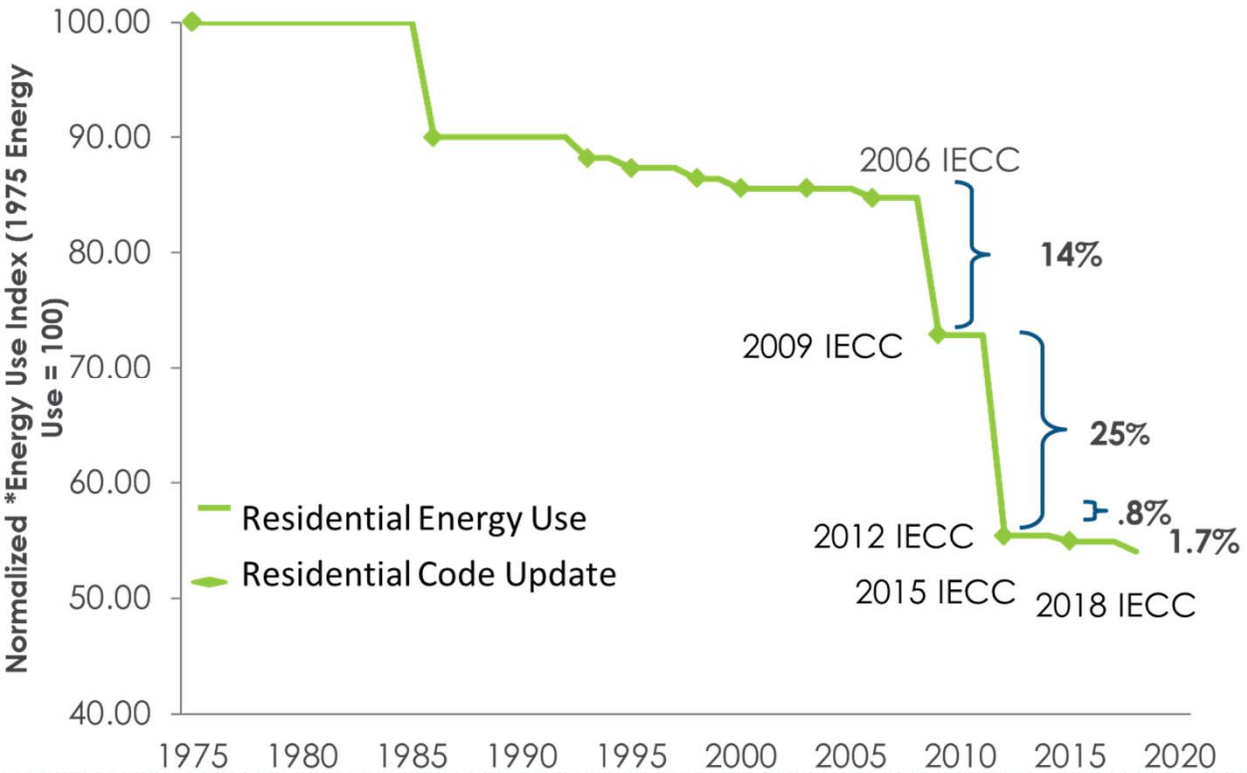


What parts of this house are enclosed by the thermal envelope?

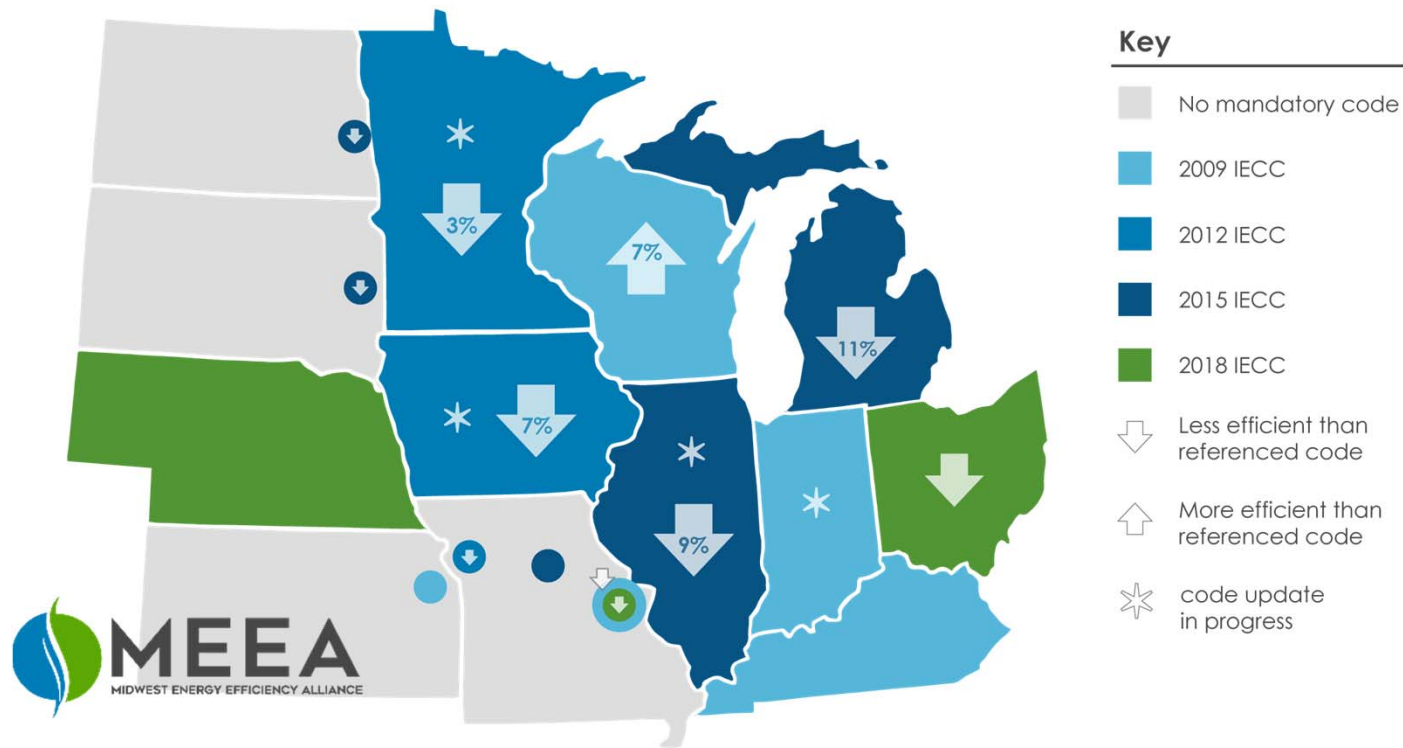


Part 2

Residential Energy Code Background



Midwest Residential Energy Code Adoption



As of May 2019

Percentage change is based on EUI of adopted code

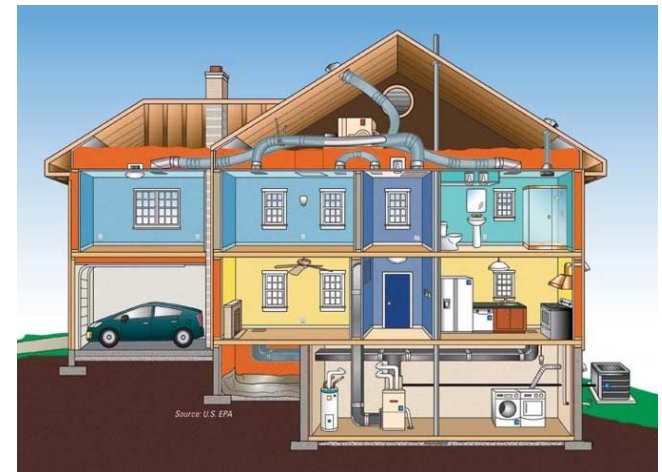
Part 2



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

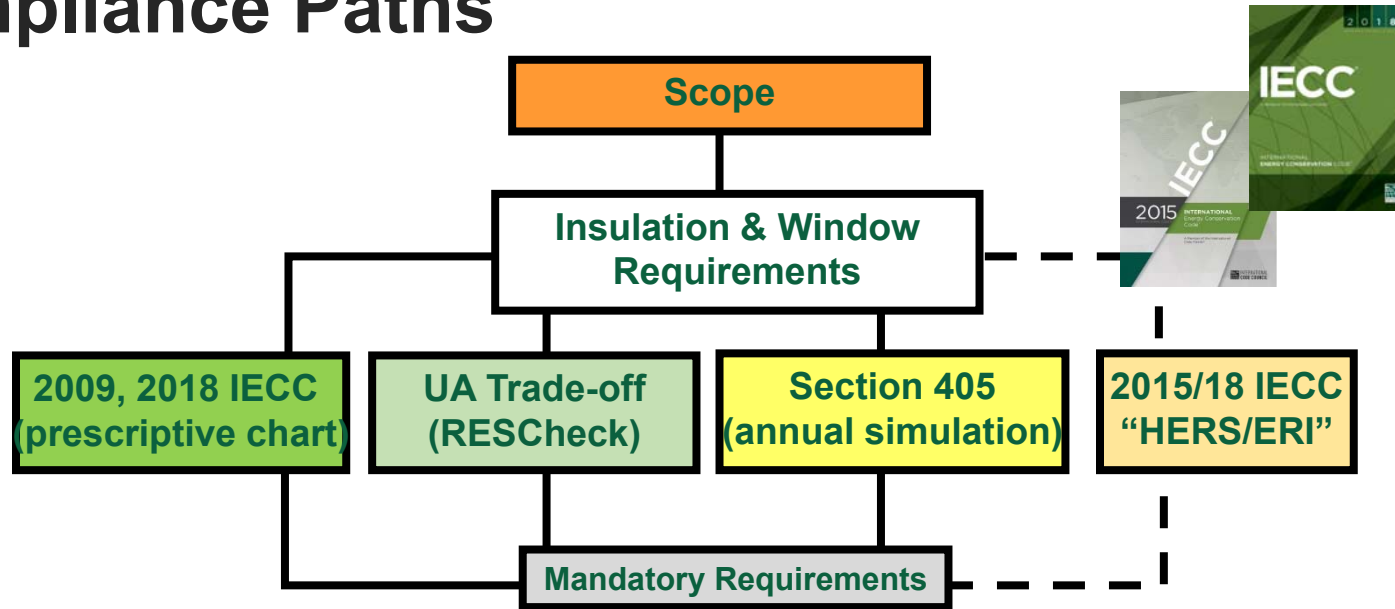
- No conditioning
- Historical

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-efficacy bulbs required (50%, 75%, 90%)
- HVAC equipment efficiencies covered by different DOE standard
- No appliance requirements



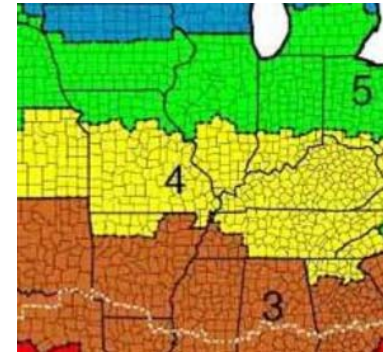
Compliance Paths



- 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

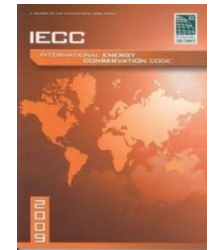
- One prescriptive “answer” for how to build per climate zone (CZ: 4 and 5)
- Includes lots of footnotes



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 ⁱ	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)

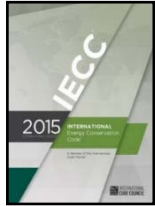


TABLE R402.1.4
EQUIVALENT U-FACTORS^a

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

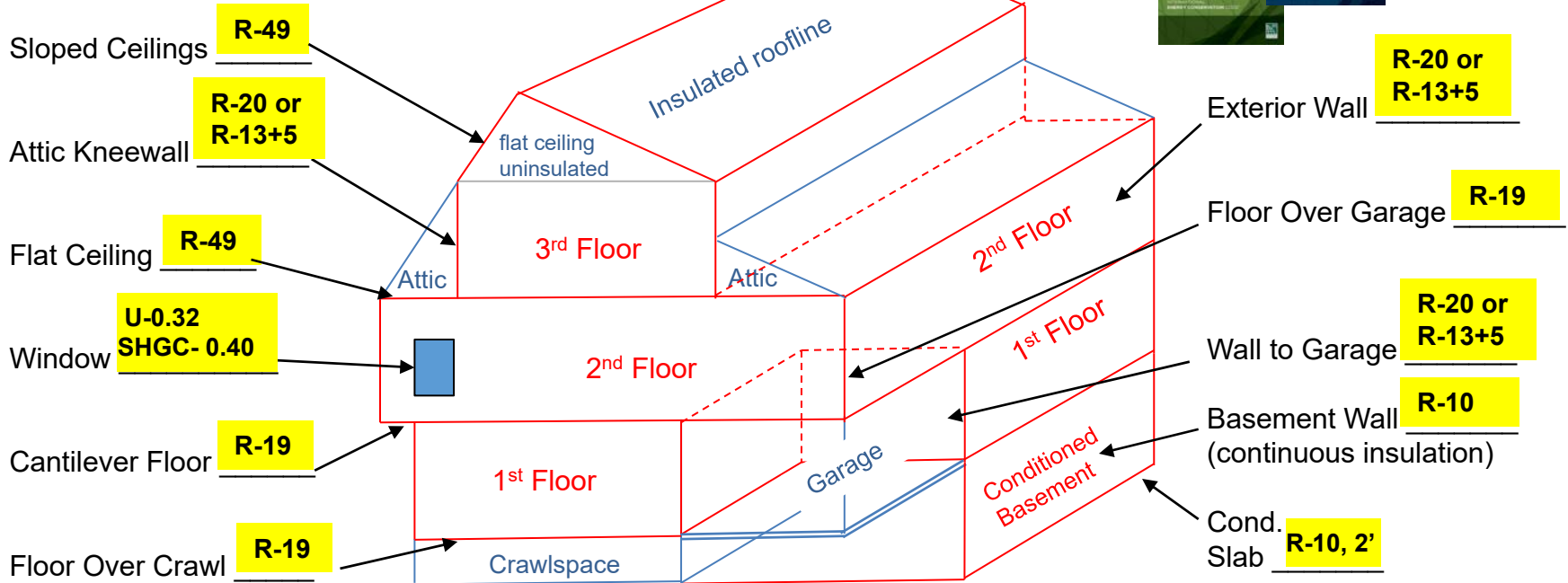
- Window Ufactors dropped slightly from U35 to U32 & U30 (CZ’s 4-5)
- Exception for log homes built according to ICC 400
- ERV/HRV ducts exempt from leakage testing (if independently ducted).
- Ducts allowed to be buried in ceiling insulation
 - Ducts R-8
 - Minimum surrounding insulation R-19 (R-13 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

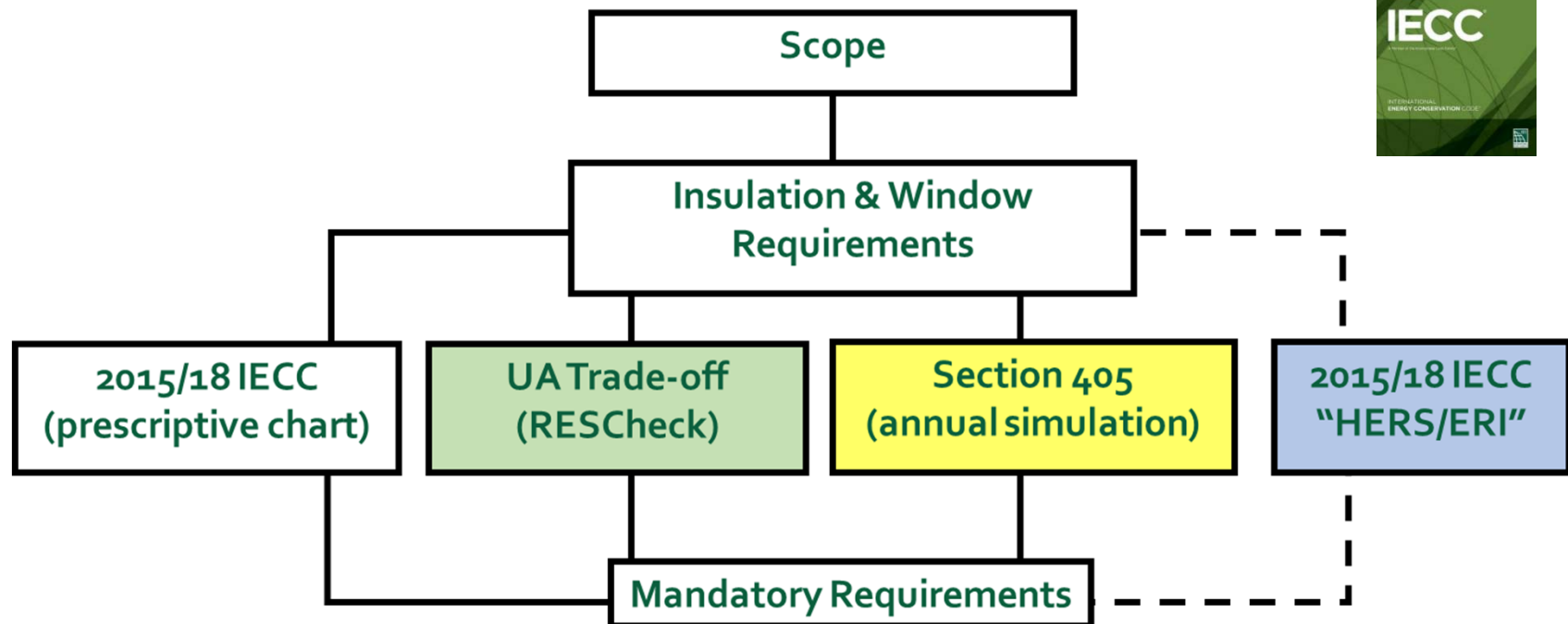


Section 402.2: Insulation Requirements

- 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**

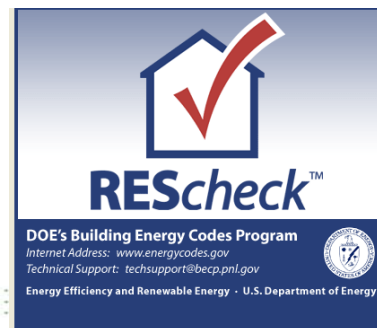
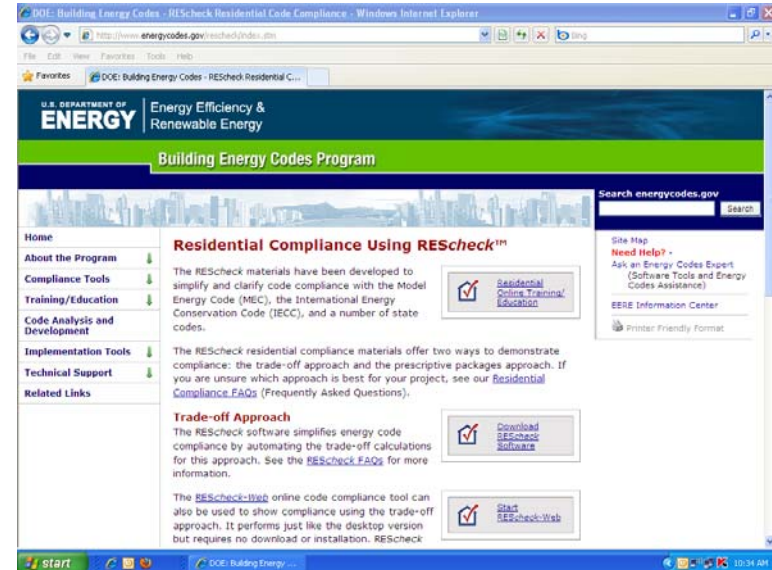


Envelope Tradeoff Options



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
- UA or Simulated Performance



Conduction Heat Flow

Heat transfer through a solid object: the formula for calculating conduction heat transfer is $q = U \times A \times \Delta T$

q = heat flow (Btu/hr)

U = inverse of R-Value [$U=1/R$, $R=1/U$] (Btu/hr ft² °F)

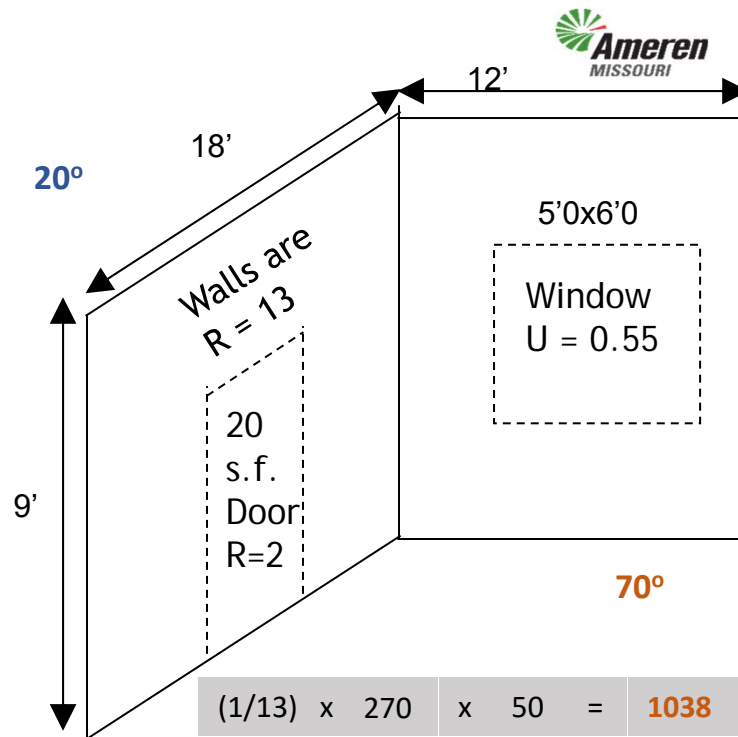
A = area (square feet)

ΔT = temperature difference across component (°F)

$$q = U \times A \times \Delta T$$

Manual J: $q = A \times HTM$

where $HTM = U \times \Delta T$



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

2171

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	

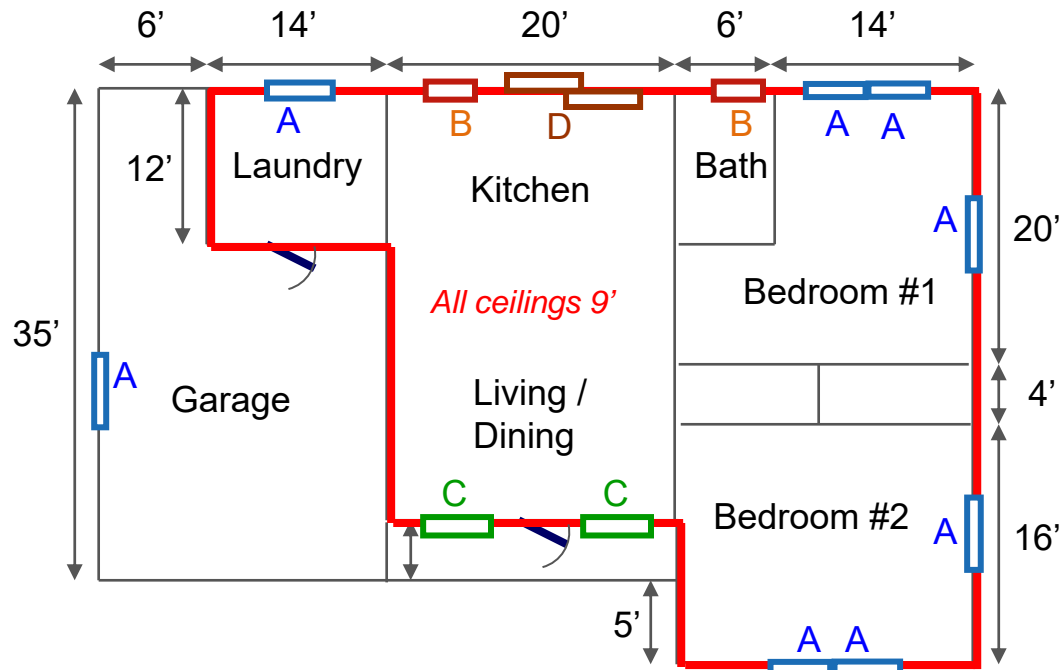
Design	Annual Energy Cost	
	IECC 2015 Performance	As Designed
Heating	\$4,241	\$695
Cooling	\$414	\$387
Water Heating	\$372	\$371
Sub Total - Used to determine compliance	\$1,997	\$1,462
Lights & Appliances	\$800	\$800
Onsite generation	\$0	\$0
Total	\$2,803	\$2,269





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 code requirements of the IECC have been verified to be met.

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: $\underline{40}$ sq. ft. (R-3)
- Volume: $1588 \times 9 = 14,292$ c.f.

Simple House (1588 s.f.)

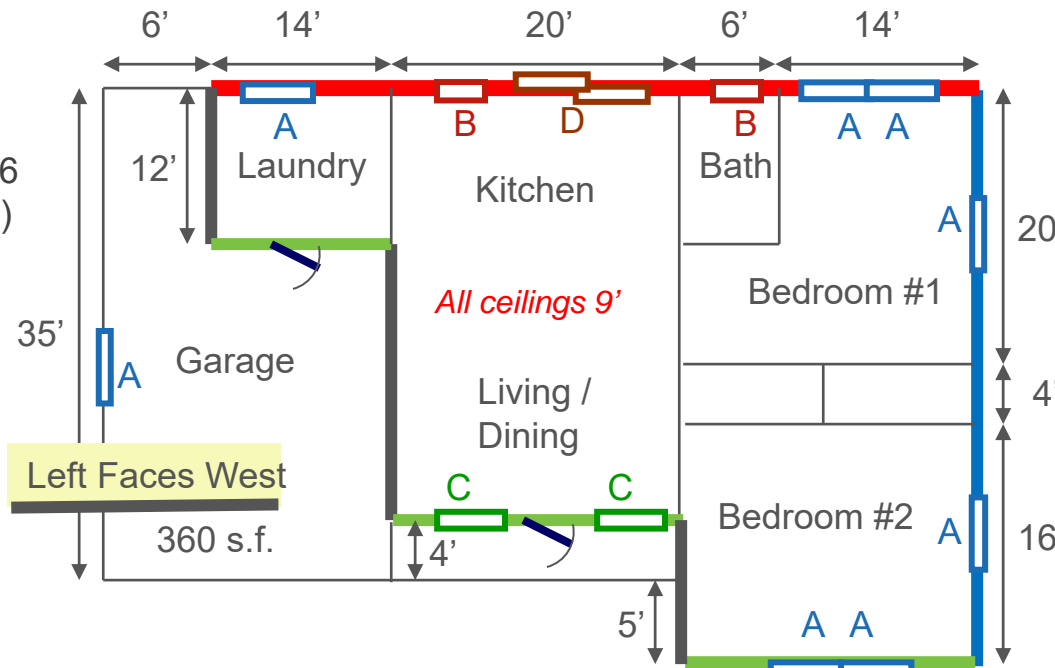


Assume:

- 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

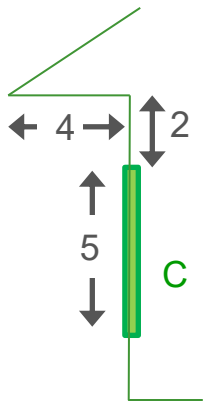
360 s.f.

Left Faces West

360 s.f.

Front Faces South

486 s.f.

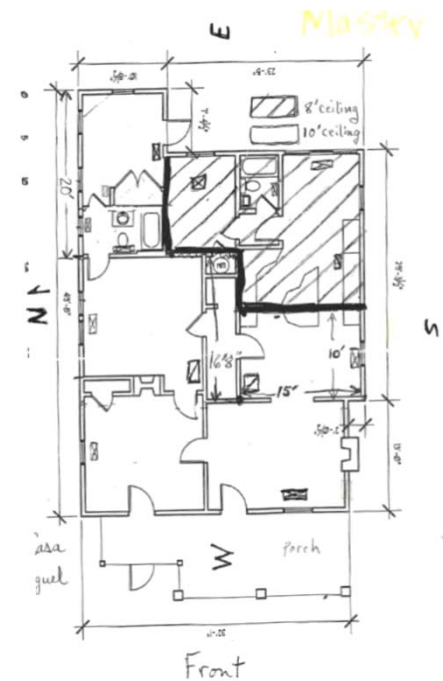


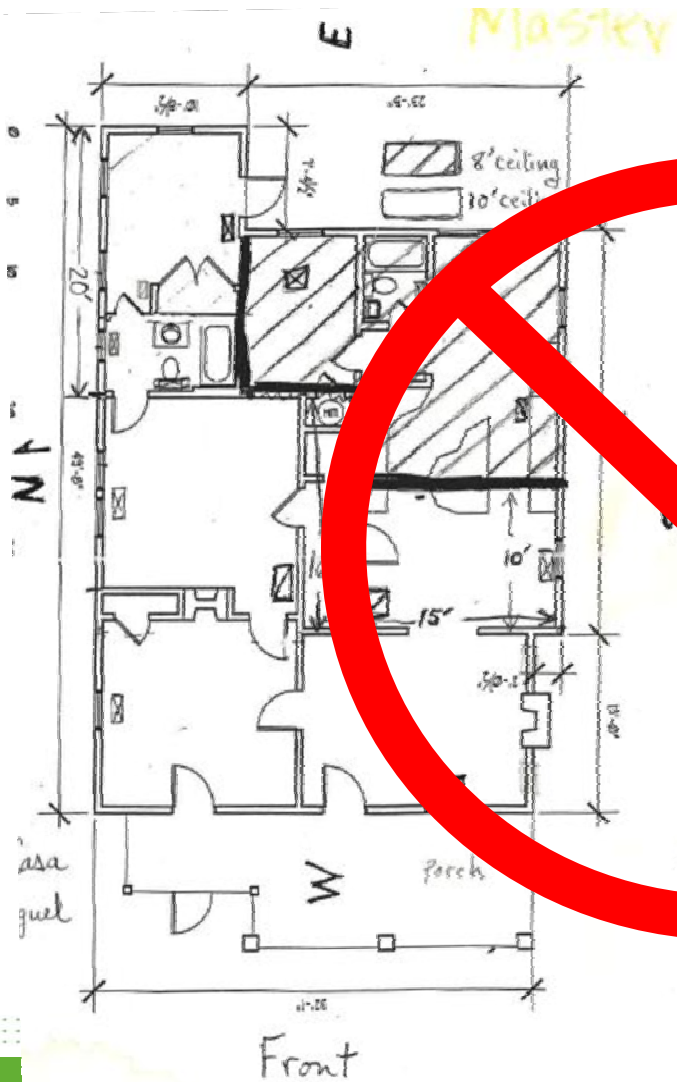
- A: 3'0 x 4'0 DP low-e (U.31, SHGC.24)
- B: 3'0 x 3'0 DP low-e (U.33, SHGC.26)
- C: 4'0 x 5'0 DP low-e (U.32, SHGC.25)
- D: 6'0 x 6'8 DP Sliding Glass Door with sun tint (U.47, SHGC.48)

1500 s.f. RENO House Specs: for entry into RESCheck/Ekotrope

V1.2 -7/30/2021

- 3 Bedroom, 2 bath, 1-story single family house (1920) located at: **1 Govt Drive, St. Louis, MO 63110**
- Create & Save file as “*FINAL - Your Full Name – 2021*” (use current year)
- Create library entries as needed and name things intelligently (add your initials to the entry name).
 - For example, “R-11 g3 Cavity insulation – mb”
 - Make sure the details are correct in the actual library entry
- Create utilities:
 - *HER Elec-Initials*: \$0.13 / kWh , \$10/mo fee
 - *HIS Gas-Initials*: \$0.75 / therm, \$20/mo fee
- Use the Notepad:
 - Be thorough
 - List all assumptions that you make



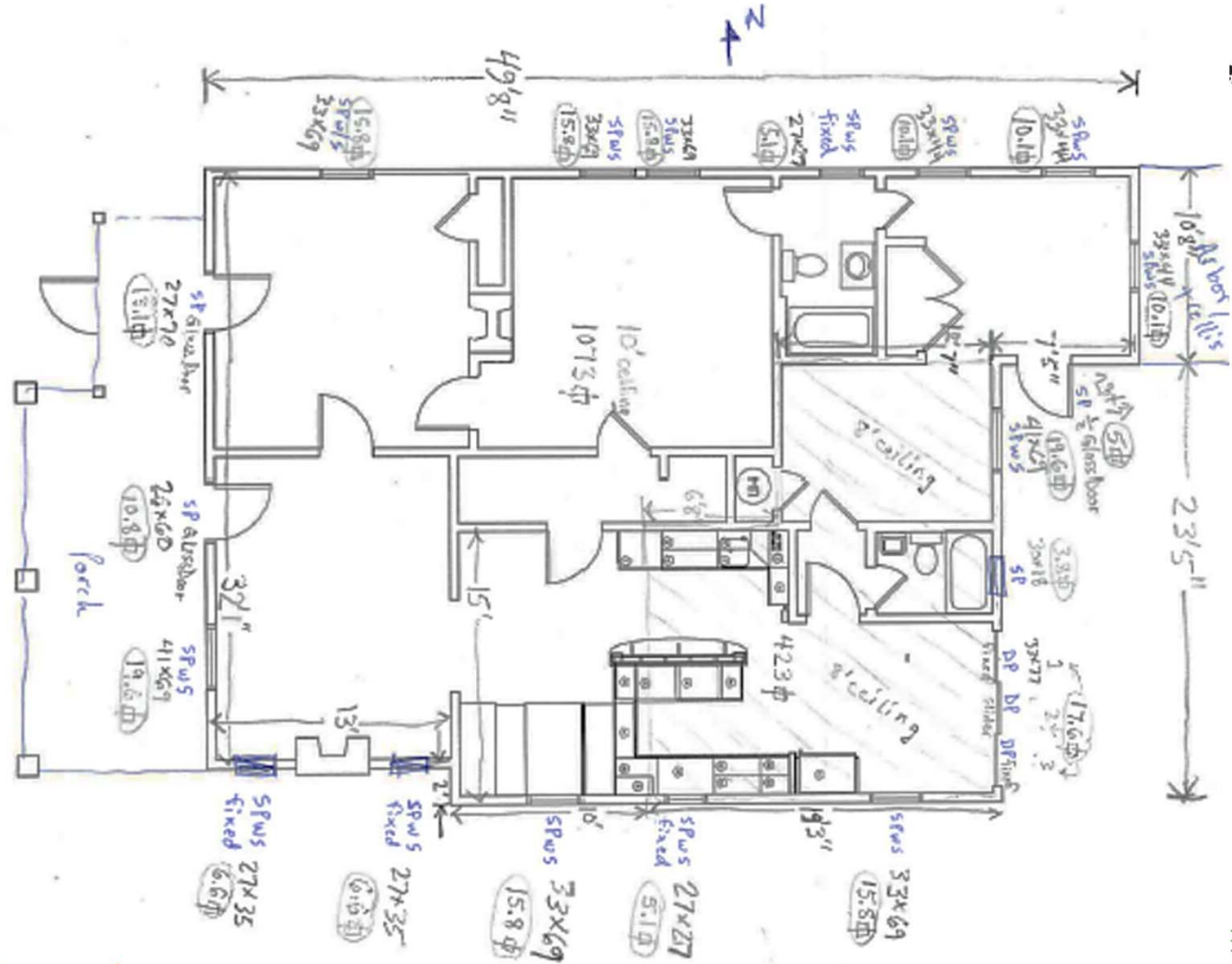


Porch is on Front (West) side and extends 10' (small porch is 6')

- All ceilings 10' except as shown (8')

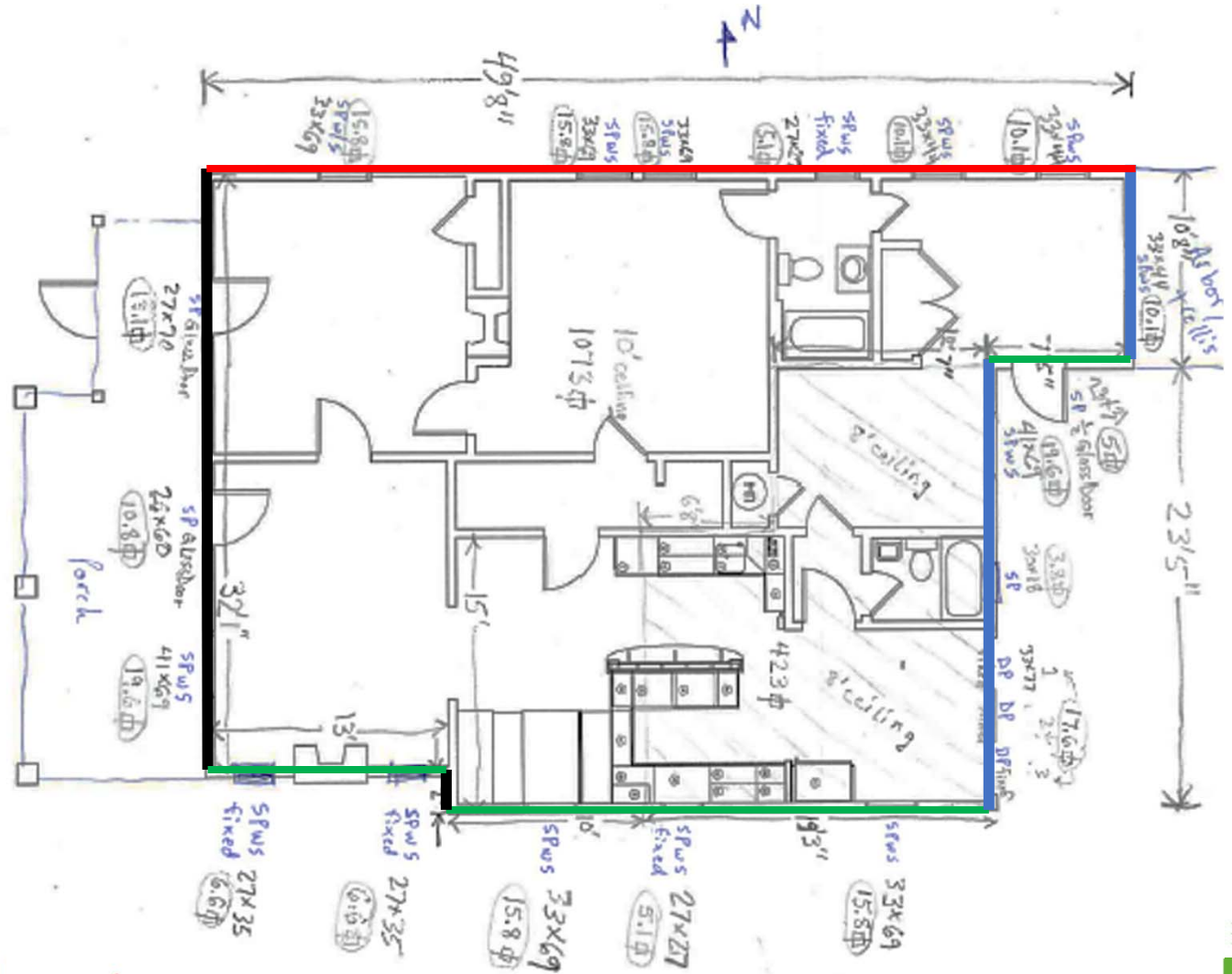
Large image, Rotated

- The 2x4 (16" o.c.) exterior walls are pumped with cellulose (R-13 G3) & interior is 1/2" drywall

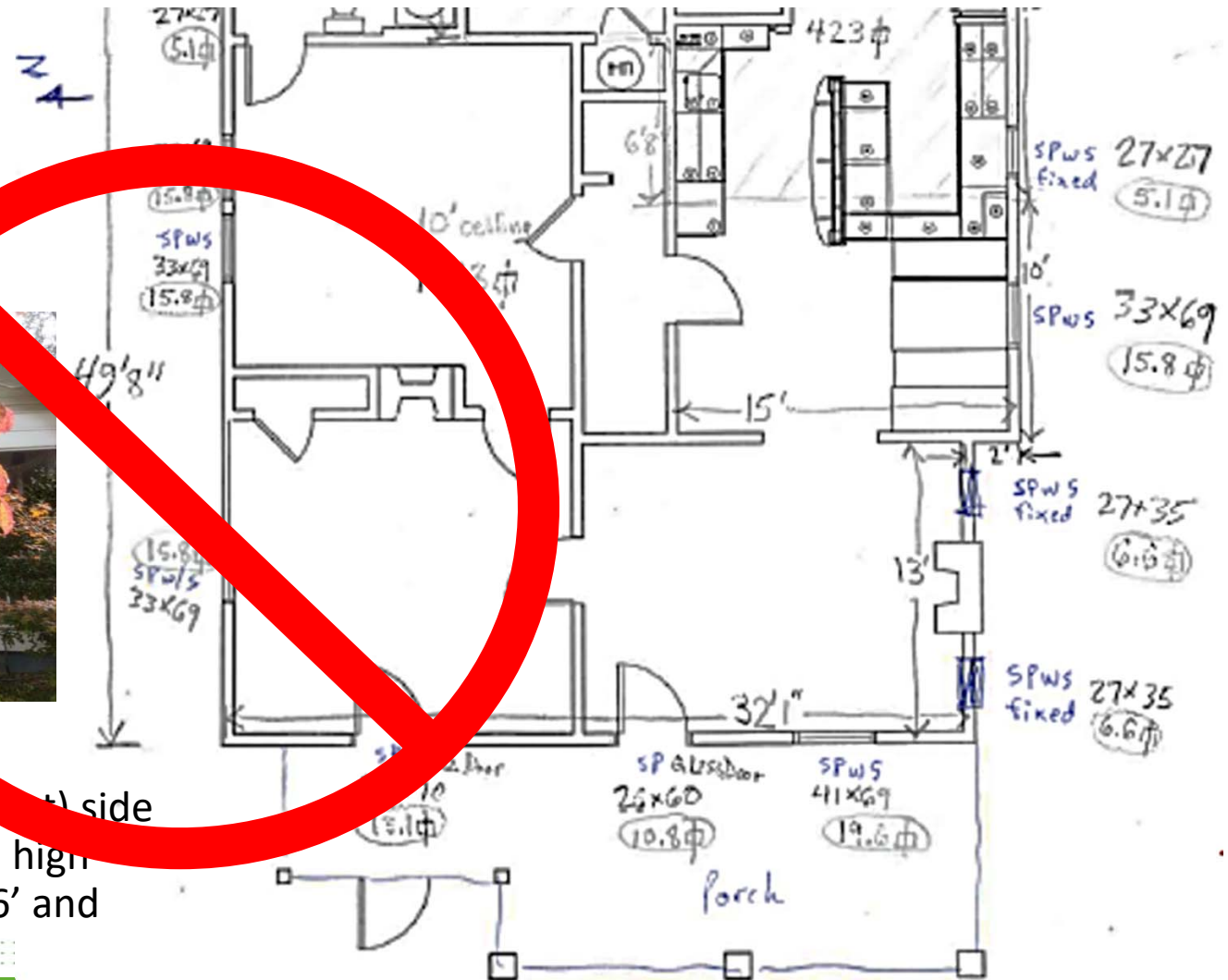


Exterior Walls

- Red/Green = $49.7' \times 10' = 497$ s.f.
- Black/Blue = $34.1' \times 10' = 341$ s.f.

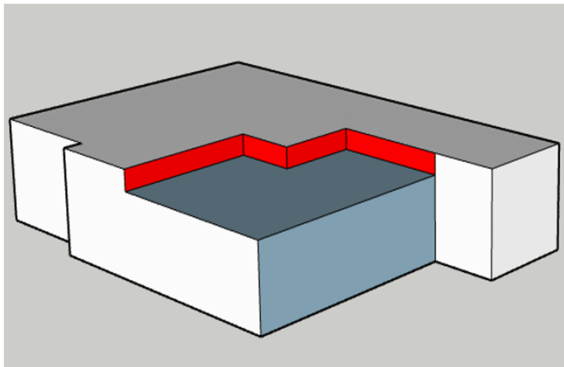


- Large image,
- Front (West)

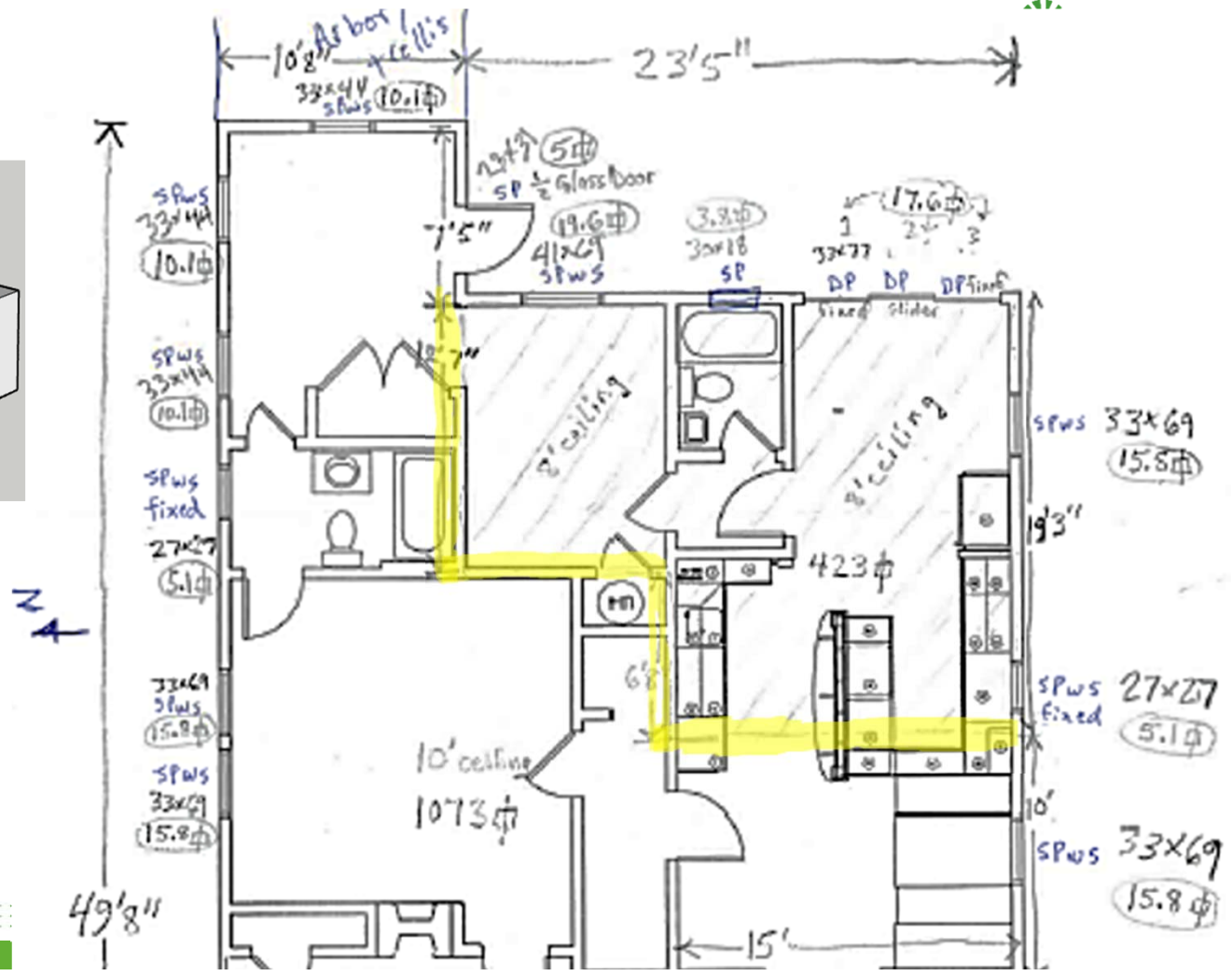


- Main porch is on Front (West) side and extends 10' and is 10' high (the small porch extends 6' and assume it is 10' high)

Large image,
Back (East)



- Note that most of the ceilings are 10'
- There's a 2' kneewall between the 8' and 10' sections (42'8 length)
- Assume this R-13+R-8 cont. kneewall is 2x4 (16" o.c.)
- Exterior wall area = 1590 s.f.



- Vented crawlspace has R-30 underfloor insulation
- 2x10 16" OC floor joists
- NO RIM/BAND SHOULD BE MODELED:
 - Because this is a 1 story house, and
 - Because framed floor is building thermal envelope (no rim and band entry required for a vented crawlspace)



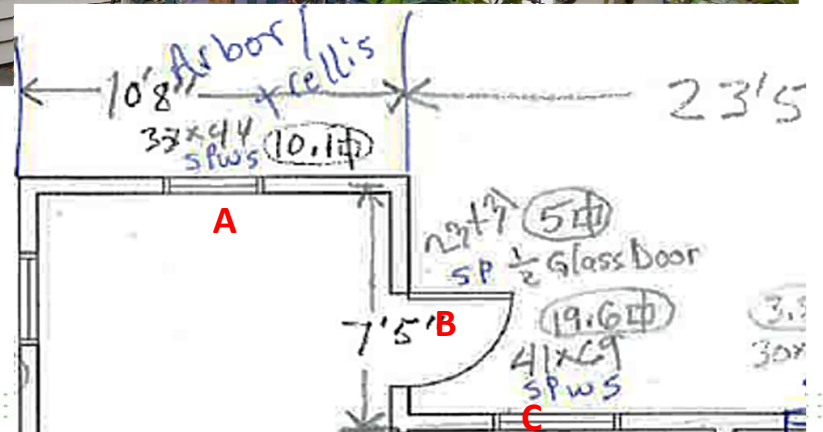
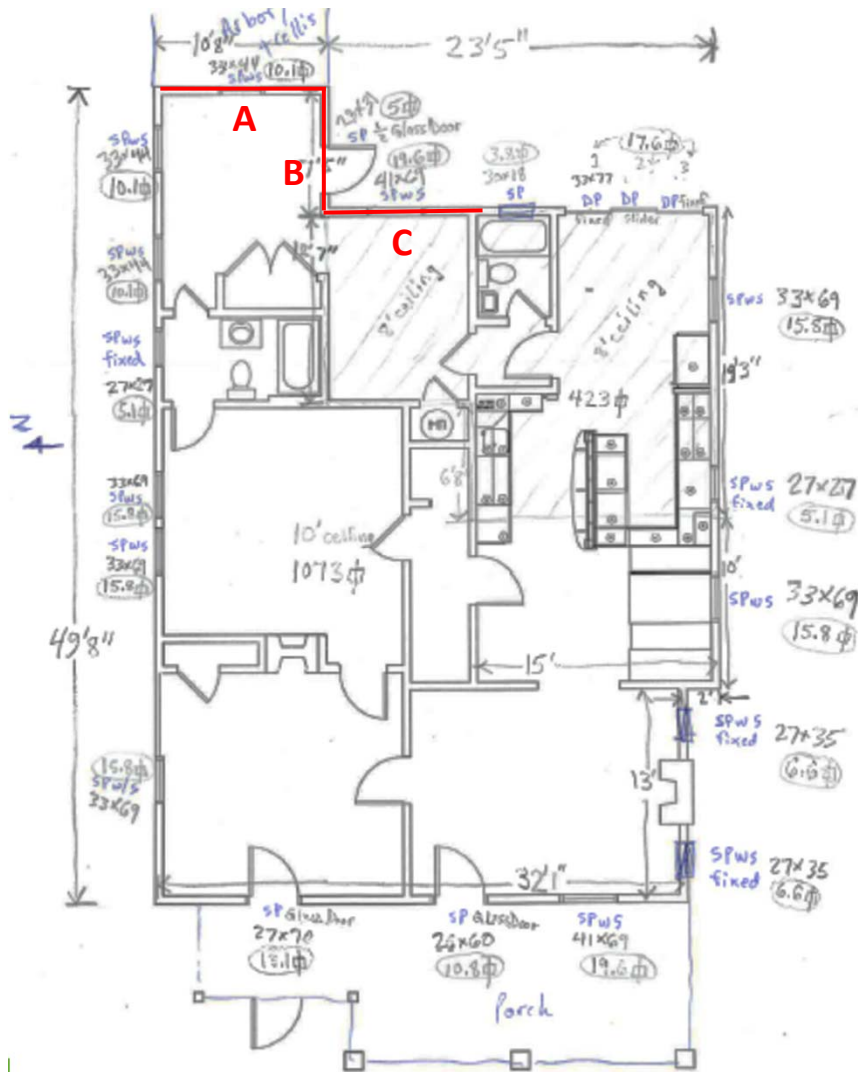
- Majority of flat ceilings are insulated to ~R-60+
 - Radiant Barrier: Yes
 - 12" Loose continuous Cellulose (R3.7 per inch)
 - 2x6 16"OC wood ceiling joists filled with 5.5" Loose cavity Cellulose (R3.7/inch) **Grade III**
 - 1/2" gypsum board interior
- Radiant barrier is installed at the (10:12 pitch) roof
- Use the pitch info to estimate roof surface area

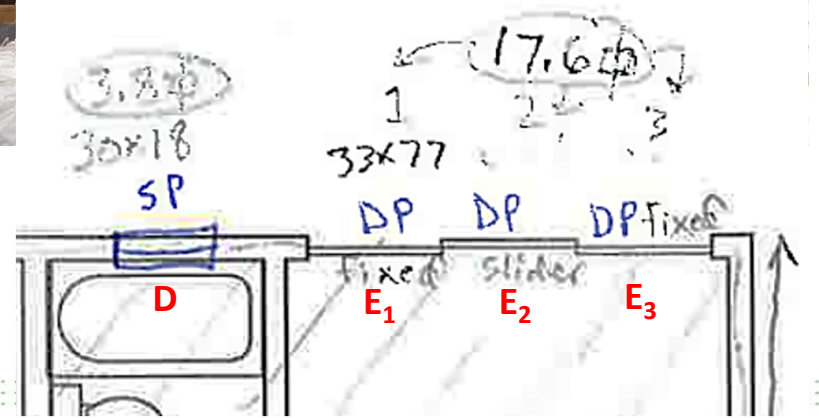
• Glazing Summary

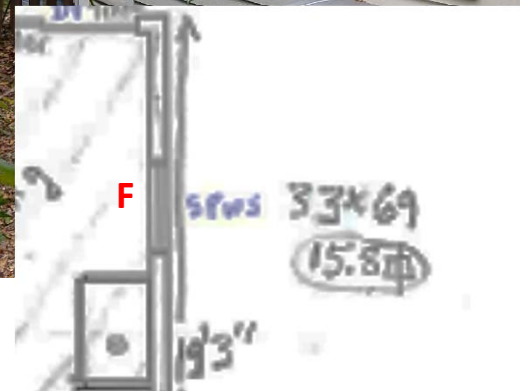
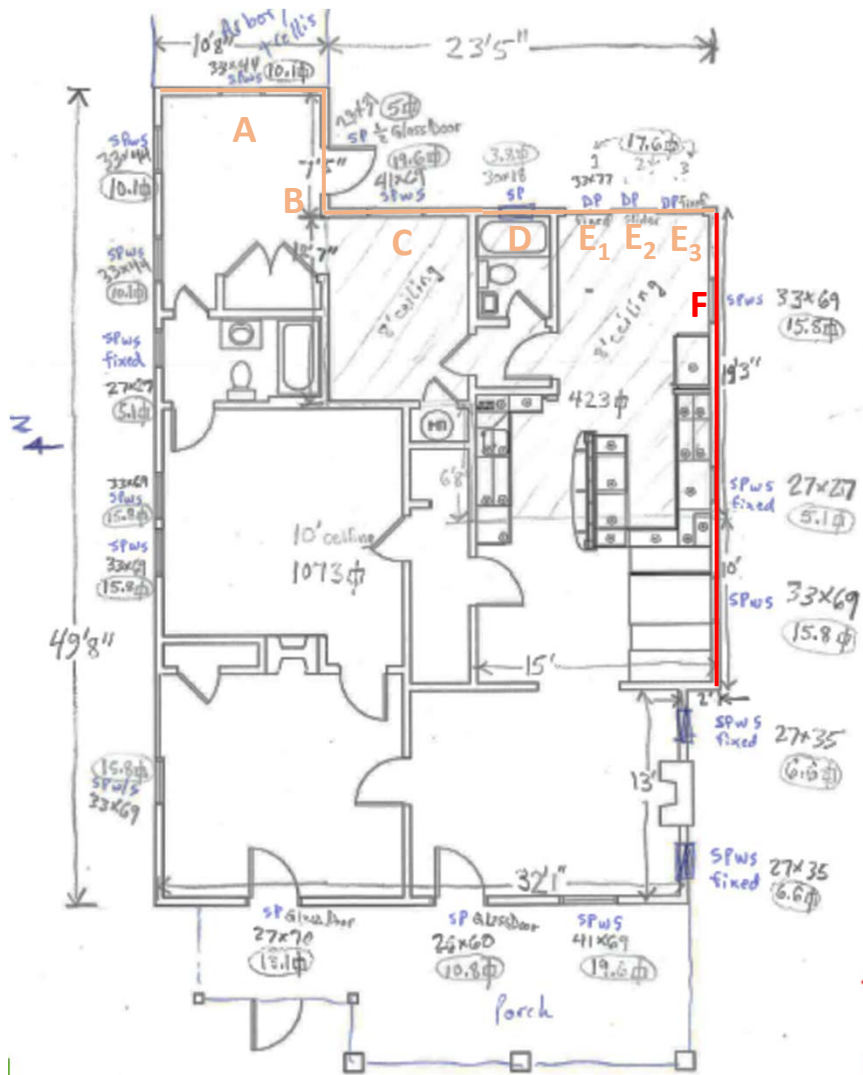


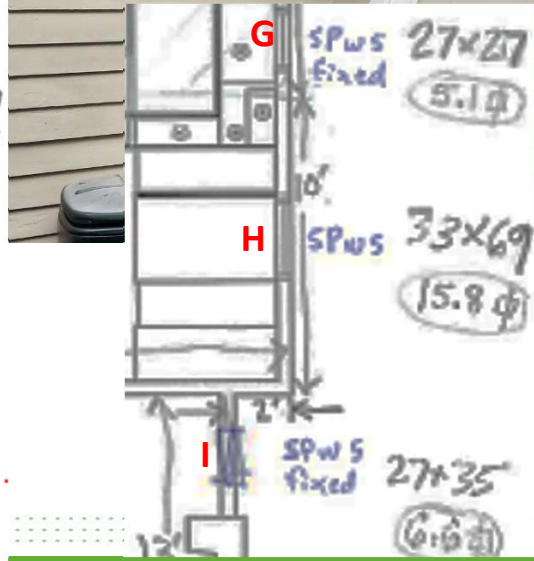
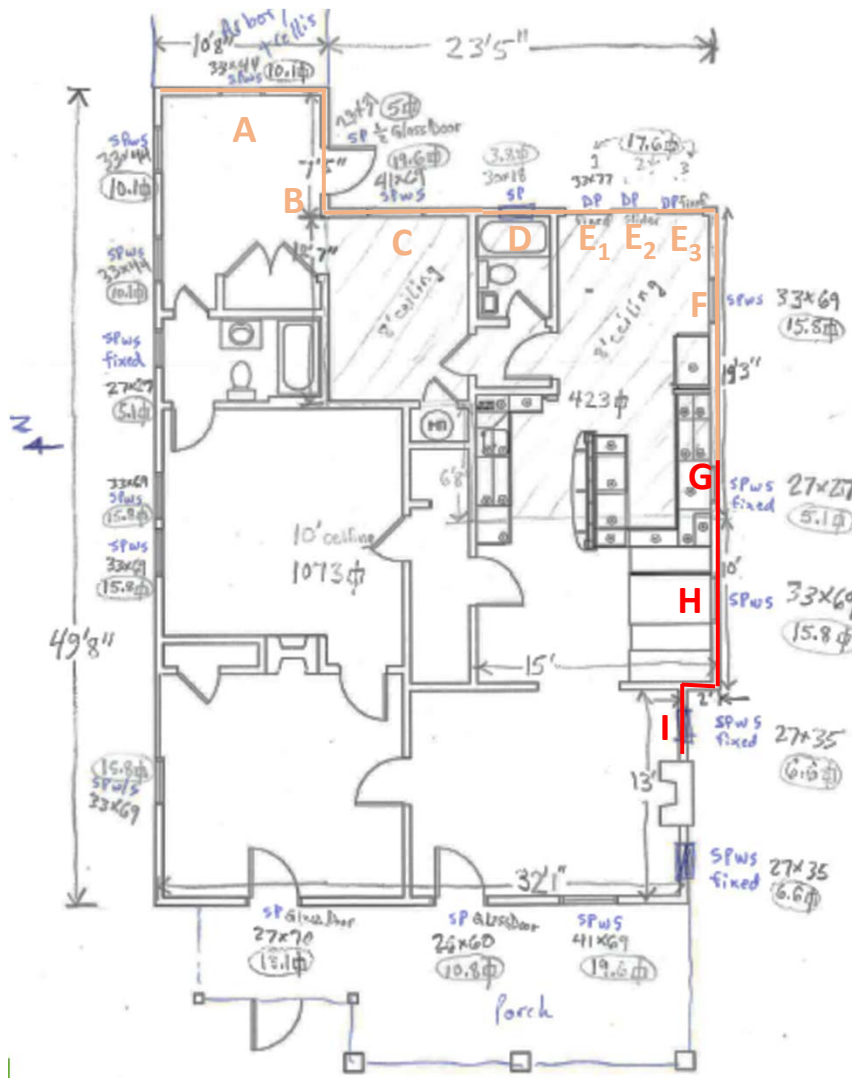
- Take your time and get the windows right! Use correct U-values and SHGC for wood frame windows.
- Window summary: you will need to look at the elevation photos to estimate the distances from the overhang (~1.5') to the tops of the window. Main porch extends 10' (small porch extends 6' & assume is 10' high)
- Don't forget that portions of the two front doors (L&M) are opaque doors. Also, most of door B is opaque.

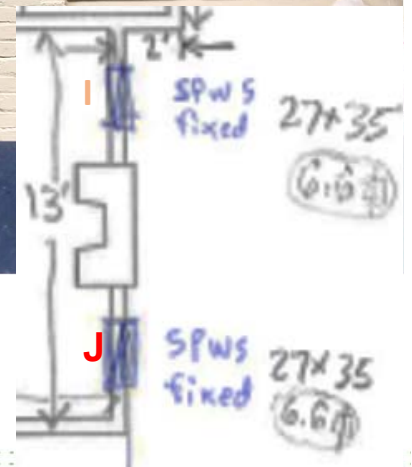
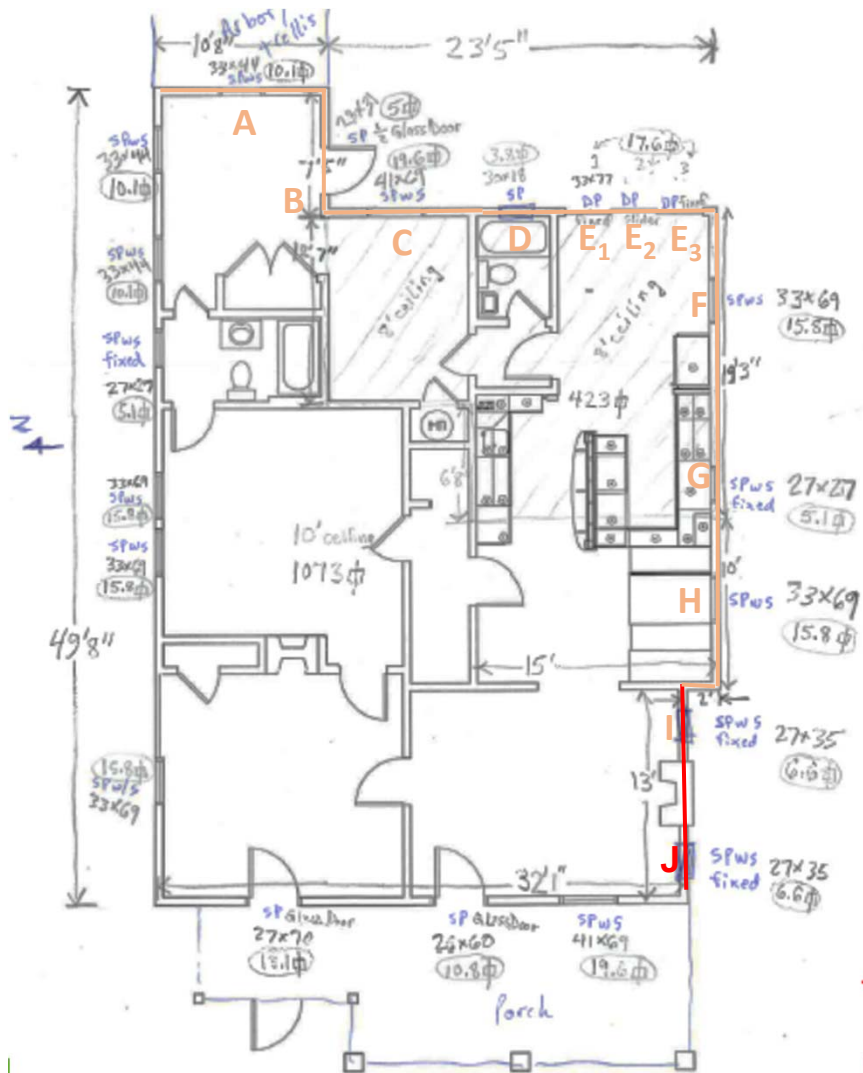
- A: DP low-e (U.3 S.3), 33x44, 10.1 s.f.
- B: SP clear (U.9 S.7) in door, 23x31, 5 s.f.
- C: DP low-e (U.31 S.32), , 41x69, 19.6 s.f.
- D: DP low-e (U.31 S.32), 30x18, 3.8 s.f.
- E₁₂₃: DP low-e (U.3 S.27), 33x77, 17.6 s.f. each
- F: DP low-e (U.28 S.28), 33x69, 15.8 s.f.
- G: DP low-e (U.28 S.28), 27x27, 5.1 s.f.
- H: DP low-e (U.28 S.28), 33x69, 15.8 s.f.
- I-J: DP low-e (U.31 S.32), 27x35, 6.6 s.f. each
- K: DP low-e (U.31 S.32), 41x69, 19.6 s.f.
- L: SP clear (U.9 S.7) in door, 26x60, 10.8 s.f.
- M: SP clear (U.9 S.7) in door, 27x70, 13.1 s.f.
- N₁₂₃: DP low-e (U.28 S.28), 33x69, 15.8 s.f. each
- O: DP low-e (U.28 S.28), 27x27, 5.1 s.f.
- P₁₂: DP low-e (U.3 S.3), 33x44, 10.1 s.f. each

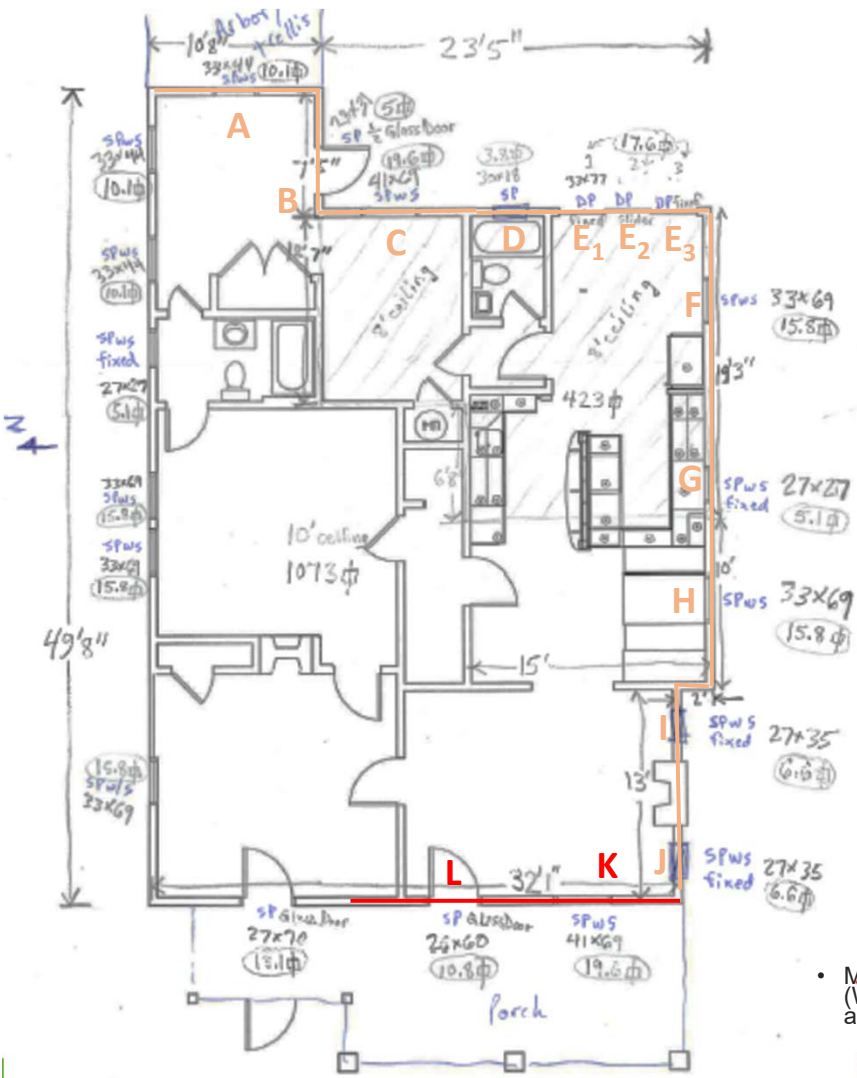




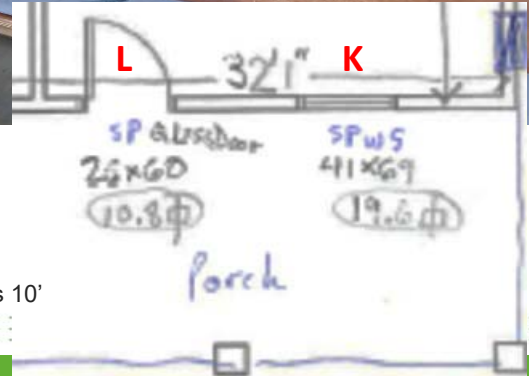
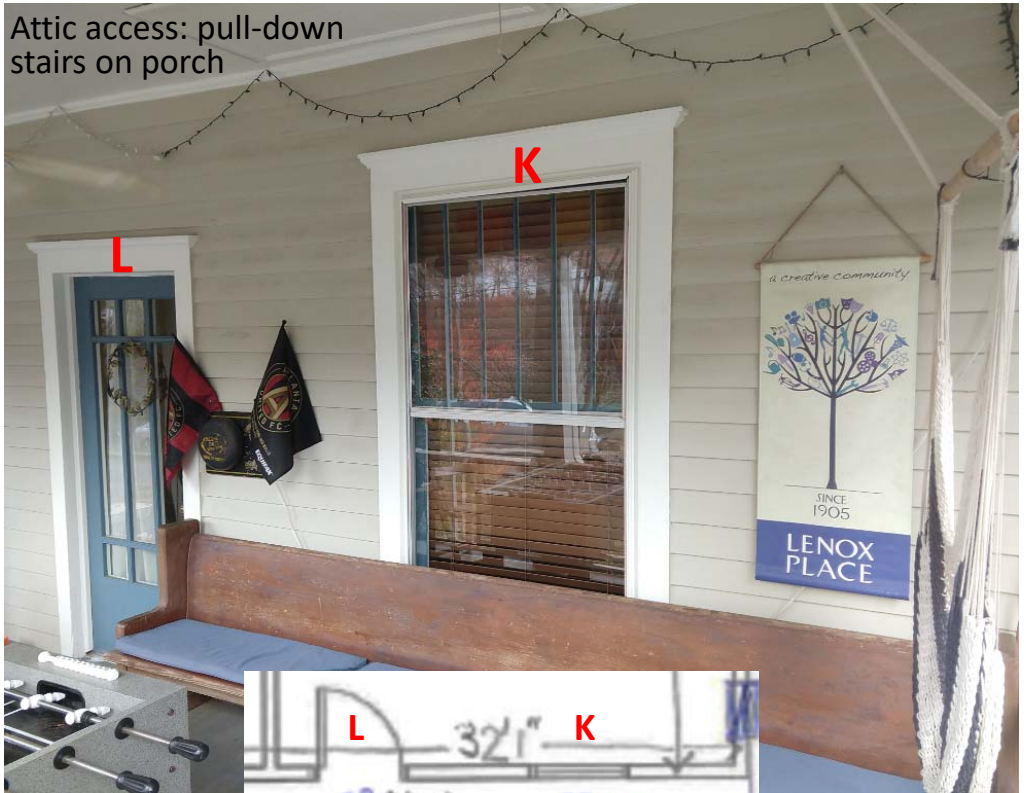




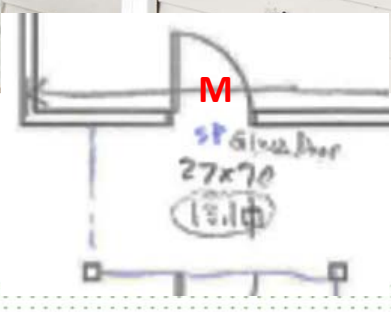
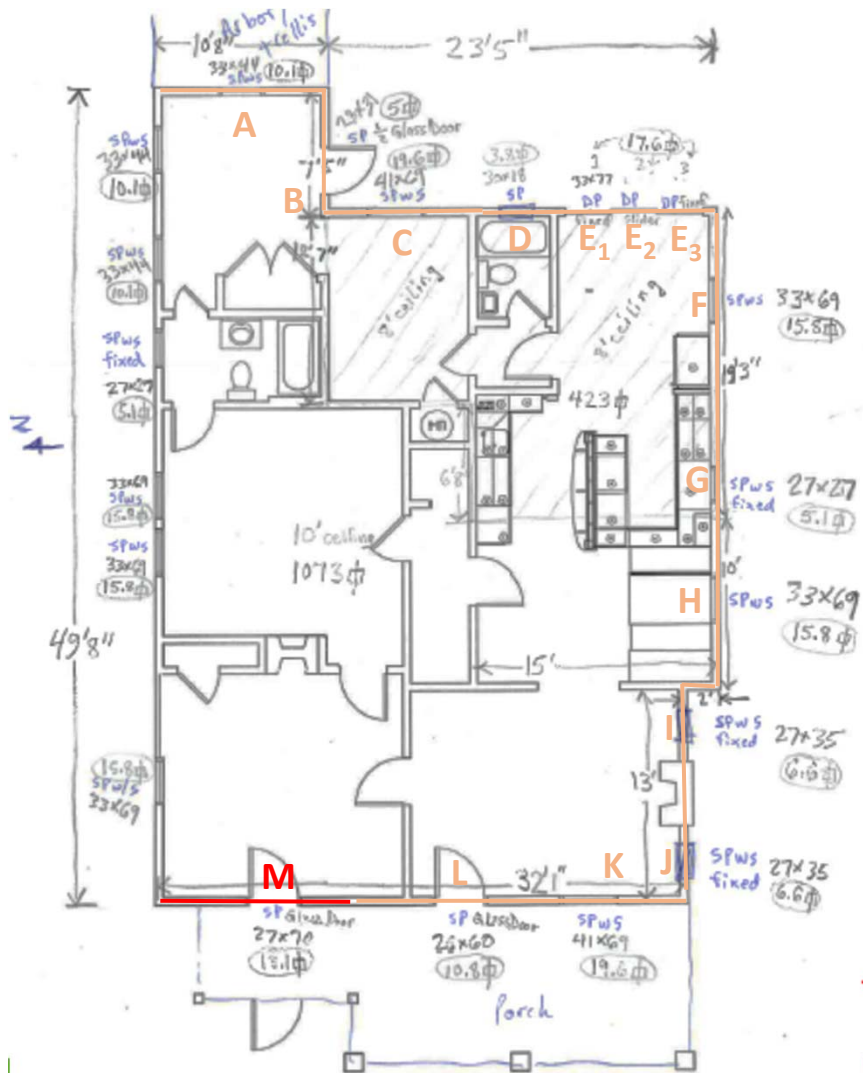




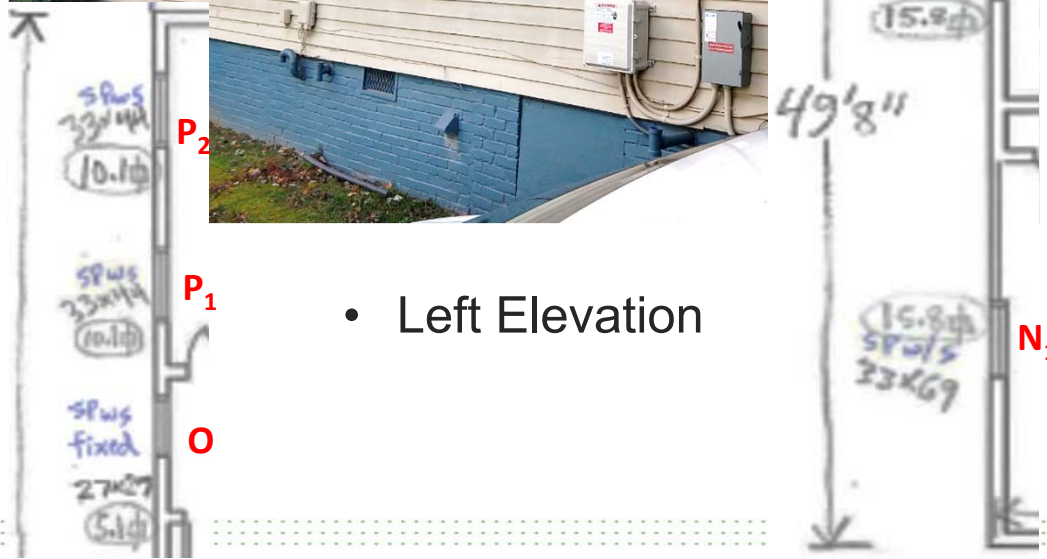
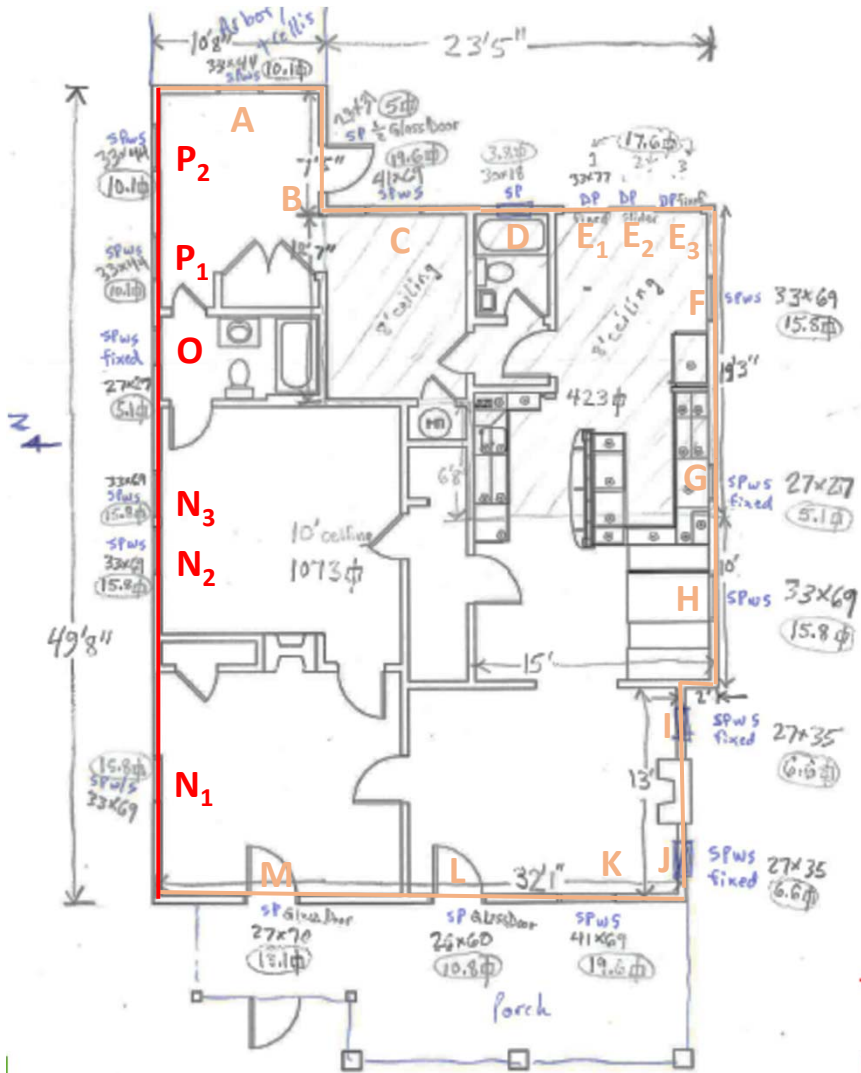
Attic access: pull-down stairs on porch



- Main porch is on Front (West) side and extends 10' and is 10' high



- Small porch is on Front (West) side and extends 6' and assume is 10' high



• Left Elevation

Testing

- Use the same numbers you obtained for the BD and db Field exam for when you test this house



- Unless you did a multi-point test, don't forget to adjust your BD result by 1.1 for single point test.
- Also, adjust for temperature and elevation (such as in Ft. Collins, CO). Generally, if elevation is < 1,000' and temperature difference is < 30°F, the environmental correction will be small but be sure to apply the corrections unless your software/app does it for you. See 380 Standard and use the Excel calculator tool!!
- Document your raw BD number and your corrections in the Notes. Enter the corrected CFM50 number

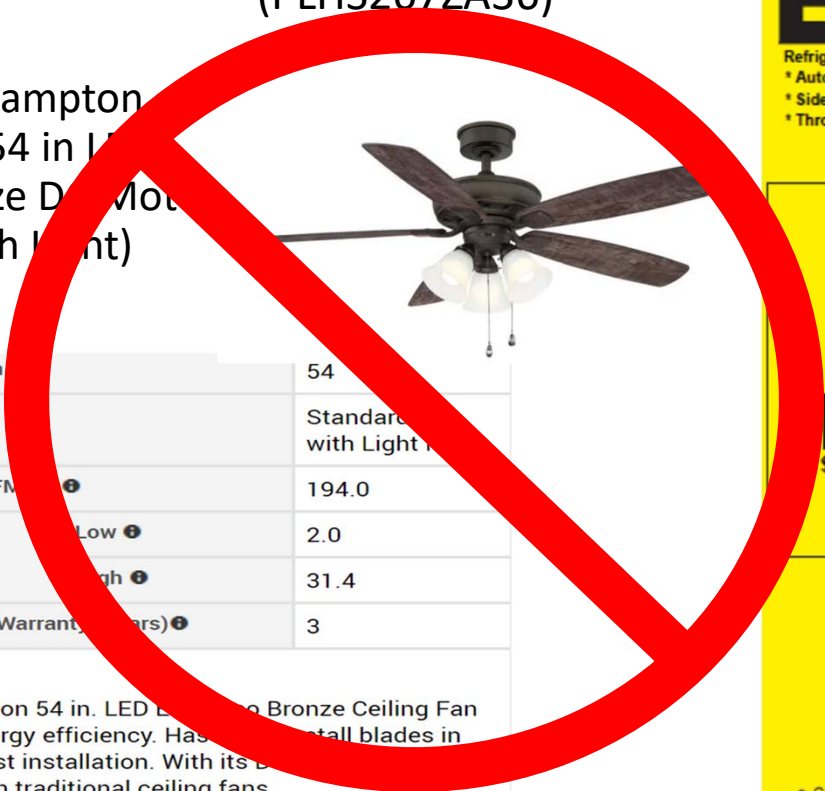
Appliances

- 100% LED lights installed
- Cooking: electric convection oven (gas range)
- LG gas clothes dryer (DLGX371W), LG Front loading washer (WM3471HWA)
- Dish Washer: General Electric (PDT715S1N2FS)
- Both showers are 1 gpm low-flow showerheads
- Faucets are low-flow
- Water heater from Rinnai (V65iN)
- Gas tankless WH in attic (no solar thermal) to furthest fixture: 40'
- All hot water pipes R-3



Appliances

- **Refrigerator: Frigidaire (PLHS267ZA36)**
- **Ceiling Fans: Hampton Bay (Wellton 54 in LED Espresso Bronze DC Motor Ceiling Fan with Light)**



Blade Span (Diameter) (in)		54
Product Type		Standard with Light Kit
Ceiling Fan Efficiency (CFM/W)		194.0
Power Consumption(W)	Low	2.0
	High	31.4
Ceiling Fan Components Warranty (Years)		3

Features
 The Hampton Bay Wellton 54 in. LED Espresso Bronze Ceiling Fan has a DC motor for energy efficiency. Has reversible colors for fast installation. With its LED lighting, it is 70% more efficient than traditional ceiling fans.



\$119.00 - \$139.00

U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
 * Automatic Defrost
 * Side-Mounted Freezer
 * Through-the-Door-Ice-Service

Electrolux
 PLHS267ZA*
 Capacity: 25.9 Cubic Feet

Estimated Yearly Operating Cost

\$ 70

\$73 The estimated yearly operating cost of this model was not available at the time the range was published. \$99
 Cost Range of Similar Models

654 kWh
 Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost, side-mounted freezer, and through-the-door-ice-service
- Estimated operating cost based on a 2007 national average electricity cost of 10.65 cents per kWh. PART NO. 218791400
- For more information, visit www.ftc.gov/appliances.

Mechanicals Summary

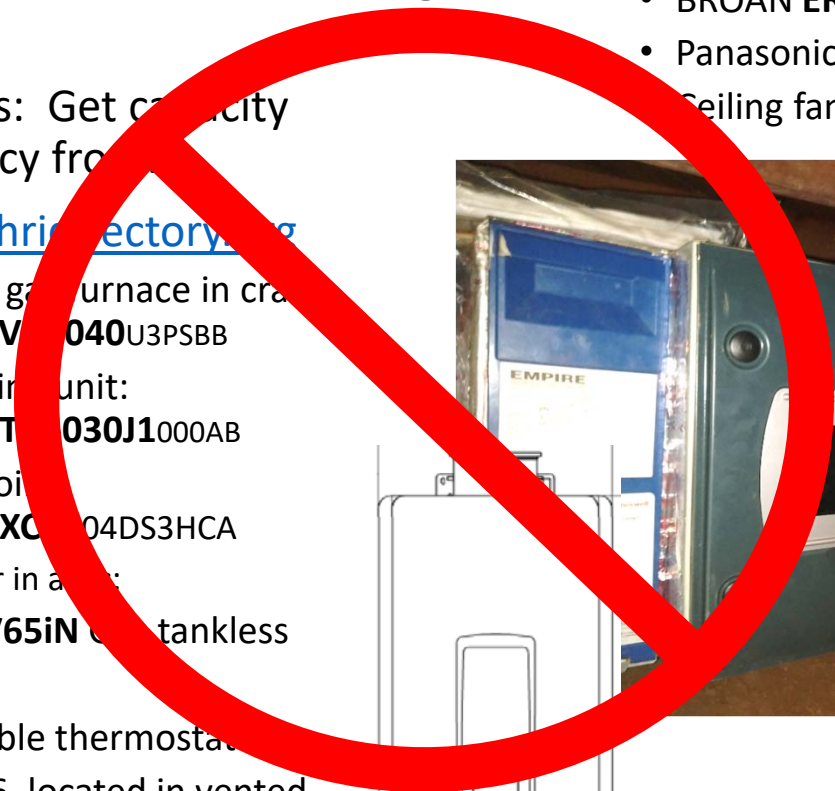
- Mechanicals: Get capacity and efficiency from

www.ahrincfactory.com

- Condensing gas furnace in crawlspace
Trane **S9V0040U3PSBB**
- AC condensing unit:
Trane **4TT0030J1000AB**
- AC indoor coil:
Trane **4TXC004DS3HCA**
- Water Heater in crawlspace:
Rinnai **V65iN** tankless

- Programmable thermostat
- All ducts R-6, located in vented crawlspace, 3 return registers

- Ventilation:
 - BROAN **ERV70S**: 20 minutes per hour, Low speed
 - Panasonic FV-70 exhaust fans in bathrooms
 - Ceiling fans in most rooms



• PV System

- 4kW array consists of 15 panels (270 W each) facing due South on a 12° sloped roof
- Microinverters installed at each panel
- Assume default derate factor for PV system





FOCUSED ENERGY. *For life.*