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FEBRUARY 6, 2020

The Ghosts Among Us – Reducing Air Infiltration from the Darkest Recesses to Dramatically Improve Comfort and Energy Performance

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Agenda

- Background
- Field Data
- Energy Modeling
- Compelling Economics
- Setting the Goal
- Implementation

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Take - aways

1. It is more cost-effective to air seal than add extra insulation
2. Set a practical air leakage goal
3. Ensure assembly details and material selection match your goal
4. Get everyone on board
5. Test and re-test

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Air Leakage Metrics

- **CFM50** = cubic feet per minute at 50 Pascals pressure difference
  - Most often used as cfm50 per SF of exterior envelope, or 'Normalized Leakage Rate' (NLR)
  - larger buildings – commercial and multifamily
- **ACH50** = air changes per hour at 50 Pascals pressure difference
  - How frequently air volume is replaced in building
  - Often used in smaller, residential buildings
- **ACHn** = natural air changes per hour, as calculated by dividing ACH by LBL factor
  - Often used in mechanical models for sizing

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Definitions and Assumptions

- Air leakage testing data is in CFM50/SF of exterior surface area on all 6 sides.
- Final air leakage testing is done at the completion of a project with a blower door test in depressurization.
- We are not covering bulk water or water vapor movement through assemblies in this presentation, but teams need to consider these factors as well as others.

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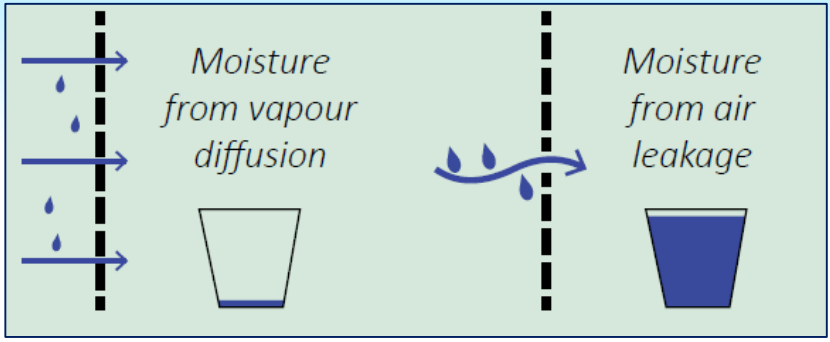
Why Build Airtight?



- Improved building comfort (comfy cozy)
- Lower energy bills
- Spend less on smaller HVAC equipment
- Fewer moisture issues due to **water vapor transport through air**
- Better control of fresh air into the building
- Fewer pests

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Air-sealing between units

or 'Compartmentalization'

It's important because...

- Limits movement of air, moisture, heat, odors, pests and sounds between apartments
- Prevents air from garages, basements and attics from entering living space.
- Reduces 'stack effect', interior drafts, hot and cold spots.

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Q&A Spotlight

What's More Important, Air-Sealing or Insulation?

A reader planning a new house wonders how to best use a limited construction budget

By Scott Gibson | August 25, 2014

To GBA senior editor Martin Holladay "If we boil your question down to its essence — 'What's more important, air sealing or R-value?' — the answer is clear," he adds. **"Air sealing always comes first. So find a contractor who understands the need to pay attention to airtightness."**

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Before air-sealing…

… and after

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Field Data

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Historical Data on Air Tightness

- Multifamily – 128 blower door tests over last 11 years
- Commercial - 63 blower door tests over 10 years

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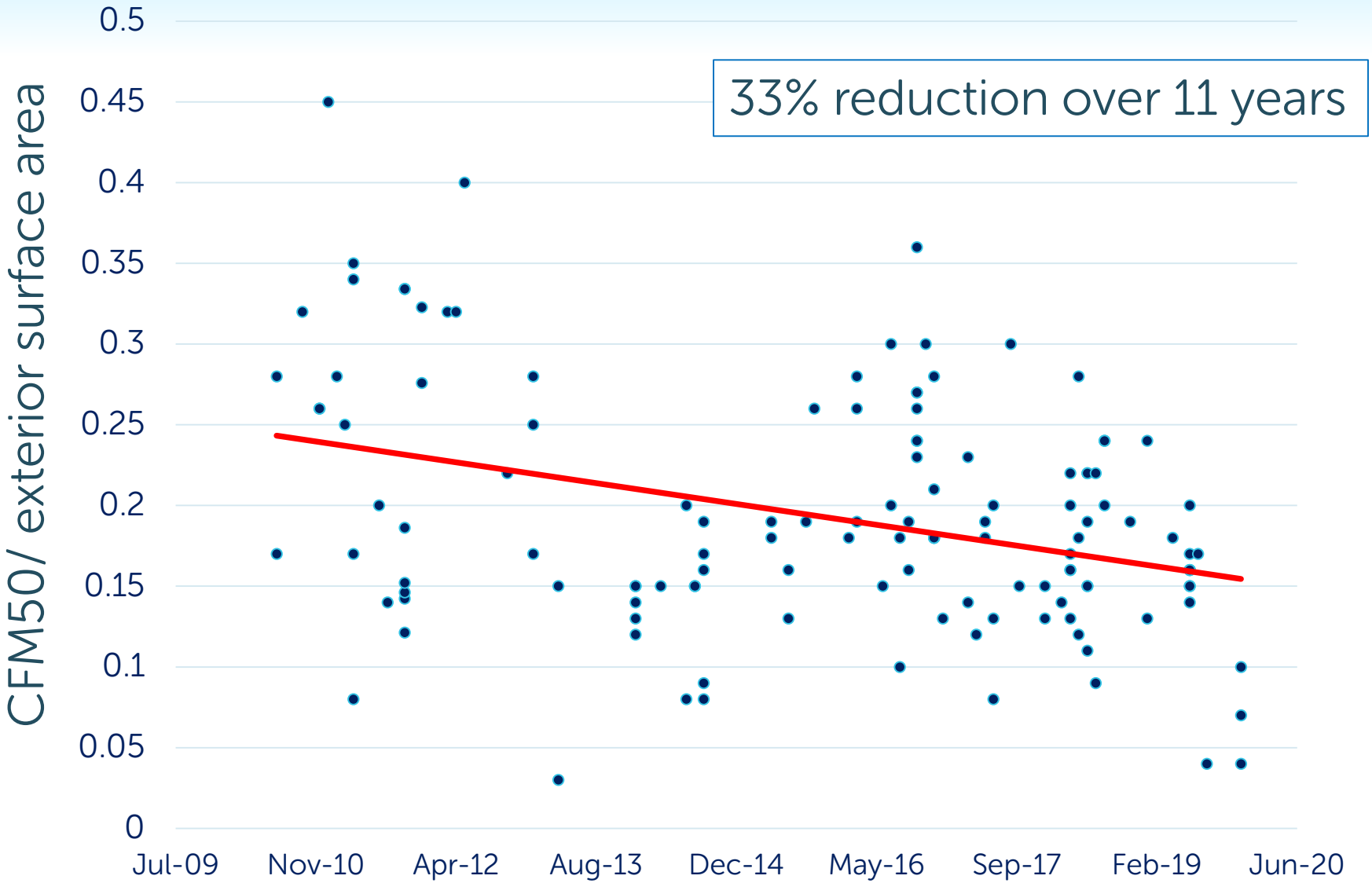
Air Leakage Trends in Multifamily



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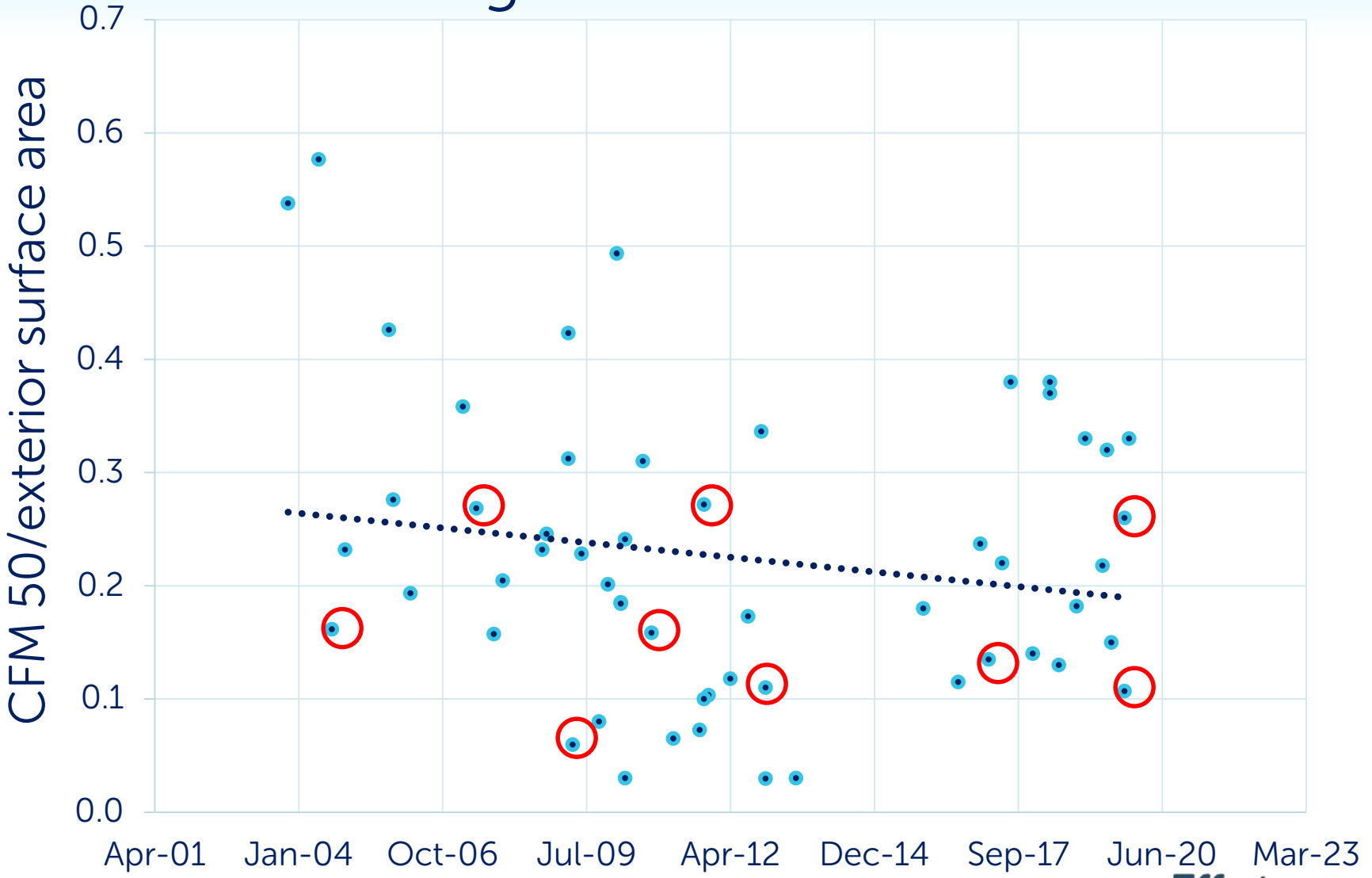
Air Leakage Trends in Commercial



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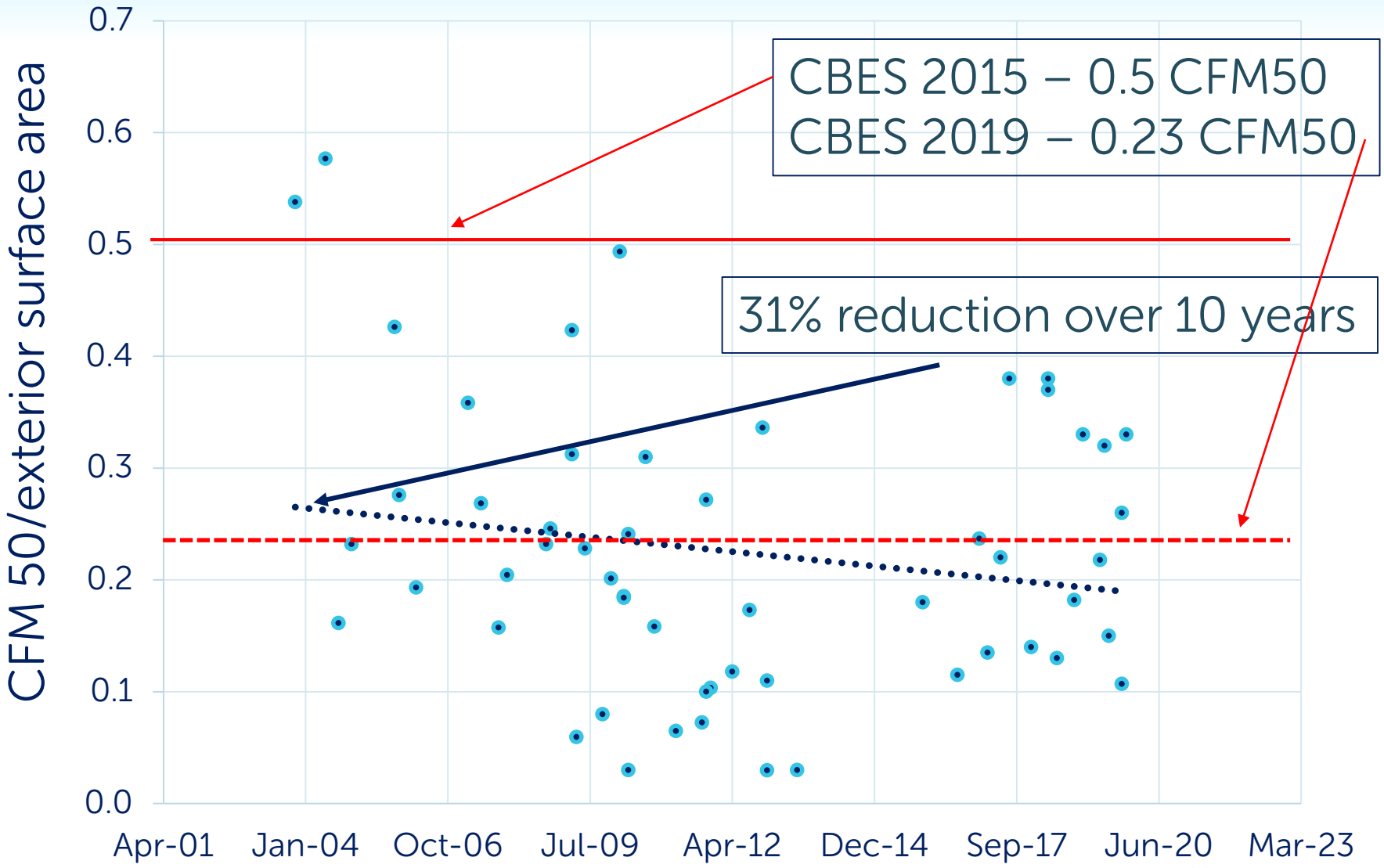
Commercial Buildings – New Construction



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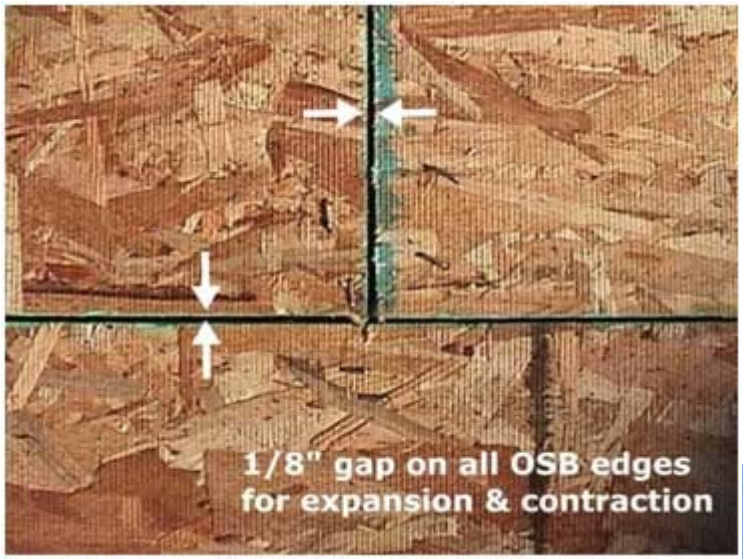
Why are we seeing this trend?



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Zip vs. Spray vs. Fiberglass

4,800 cfm50

- 2x6 wall
- Zip sheathing & tape
- Mineral Wool Batts

5,500 cfm50

- 2x6 wall
- OSB sheathing
- Housewrap
- Closed Cell Spray Foam

12,000 cfm50

- 2x6 wall
- OSB sheathing
- Housewrap
- Fiberglass Batts

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10-building comparison

Set of 10 multifamily buildings with 3 different strategies for air sealing and insulating

- Walls system (see next slide):
  - 5 rely on *spray foam* for air sealing
    - 3 flash + fiberglass batt
    - 2 spray foam (entire cavity)
  - 5 rely on *ZIP system* for air sealing
    - Zip-R + tape + mineral wool
- 8 buildings are the same size, 2 slightly smaller
- Nearly identical in design and construction contractor

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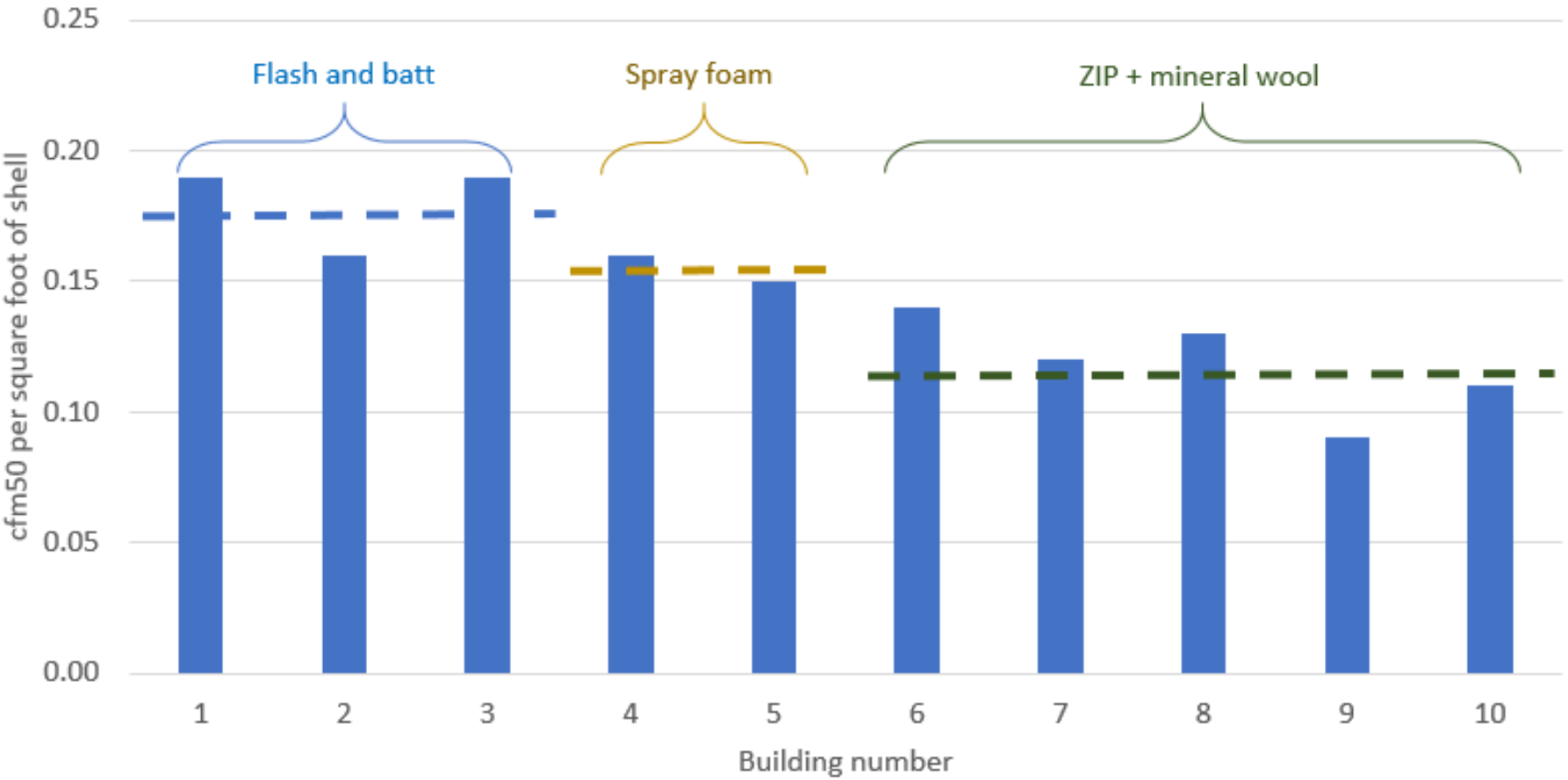
10-building comparison



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Modeling Data

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Energy Modeling

- What is the impact of air tightness on energy usage
- What is the impact of building heating and cooling loads?

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Commercial Building

10,000 sq ft in VT
Packaged VAV with Re-Heat

	Baseline	Proposed
Walls	R-20	R-40
Roof	R-30	R-60
Foundation	R-15	R-15
Windows	U-0.28	U-0.28
Airsealing	0.5 cfm50/sf	0.05 cfm50/sf

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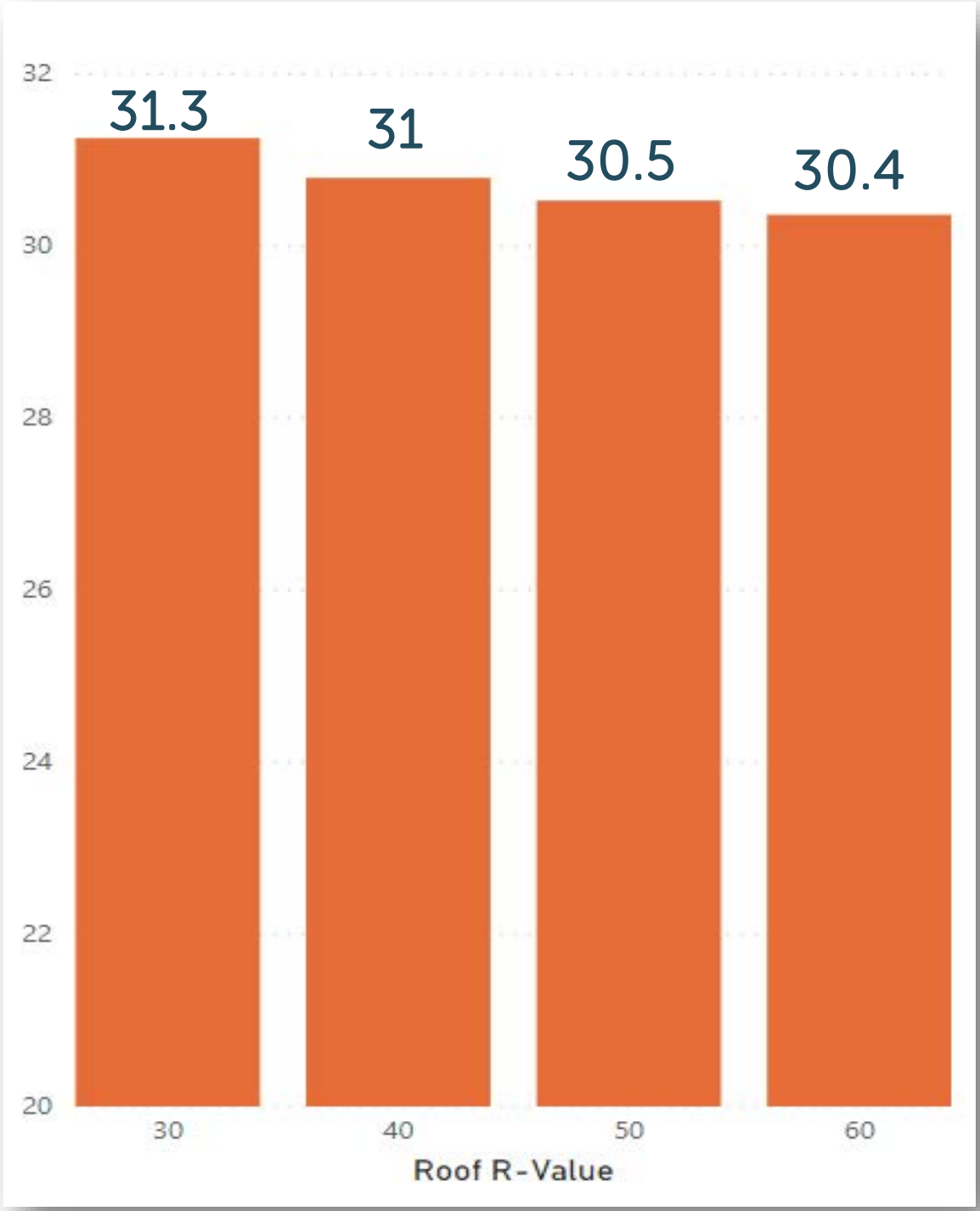
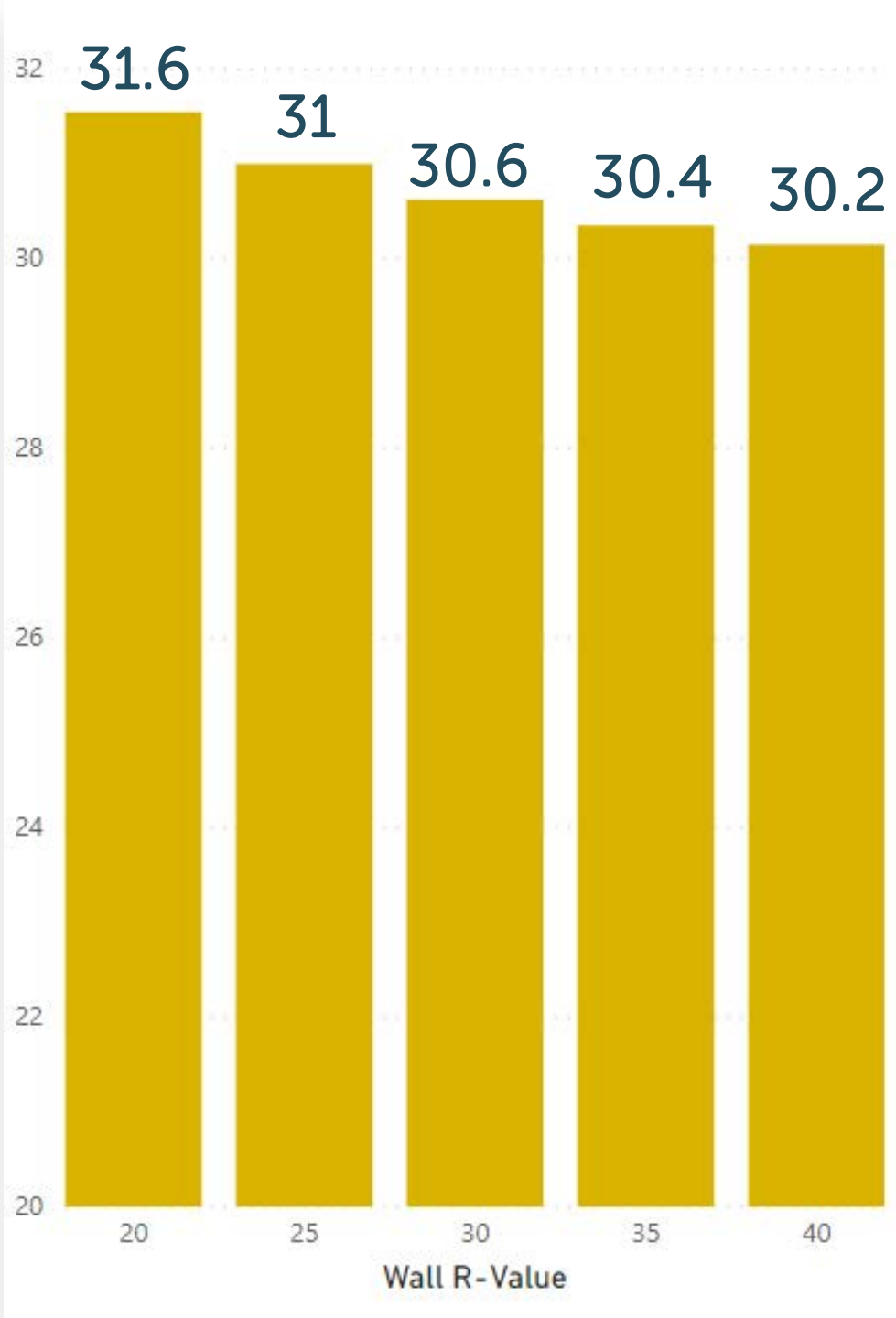
Commercial

EUI – KBTU/sq ft



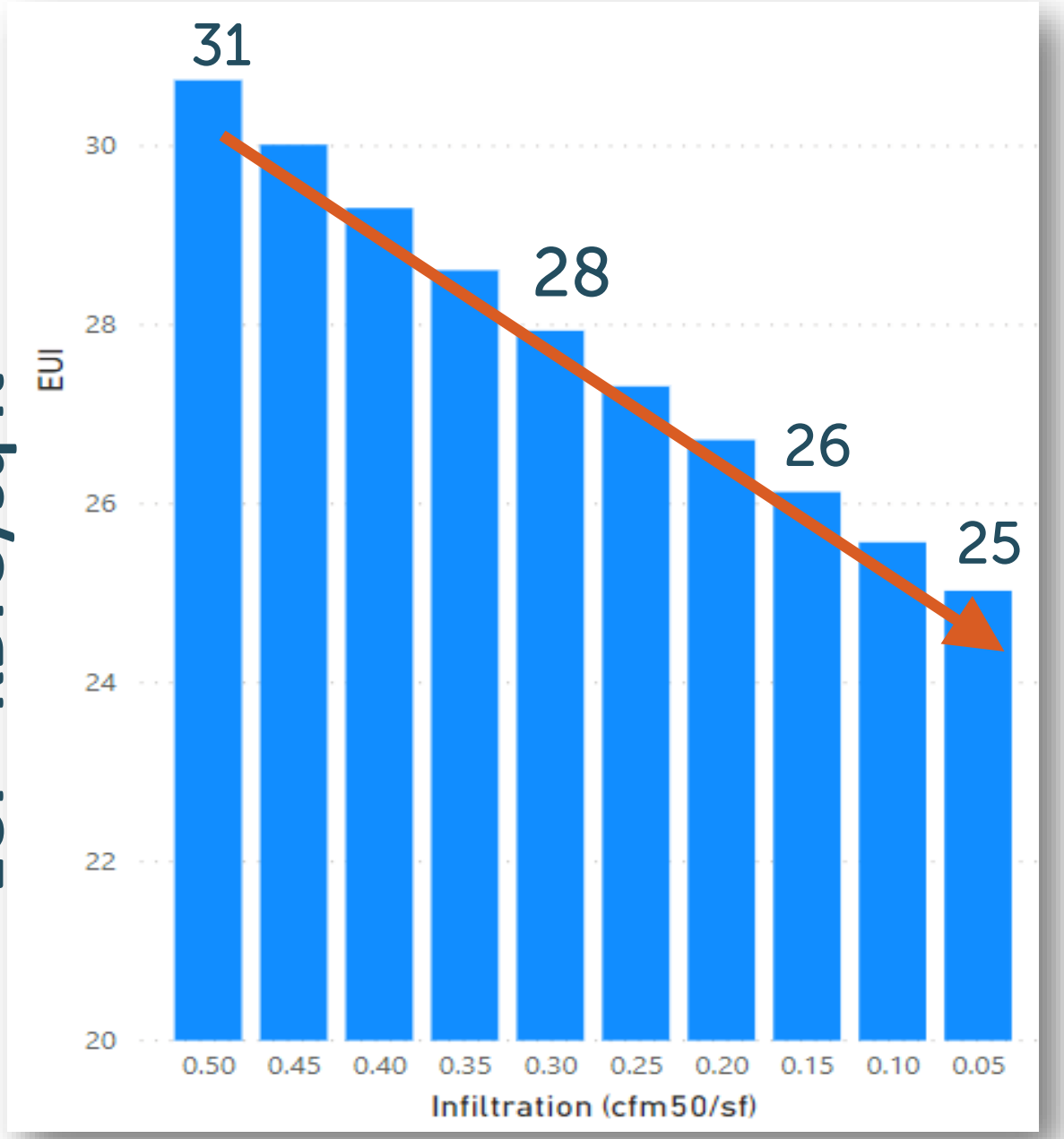
Commercial

Walls



Commercial

Infiltration



Multifamily Building

33,470 sq ft - 30 units in VT
Boiler w/baseboard hot water & AC

	Baseline	Proposed
Walls	R-20	R-40
Roof	R-30	R-60
Foundation	R-10	R-10
Windows	U-0.35	U-0.35
Airsealing	0.5 cfm50/sf	0.05cfm50/sf

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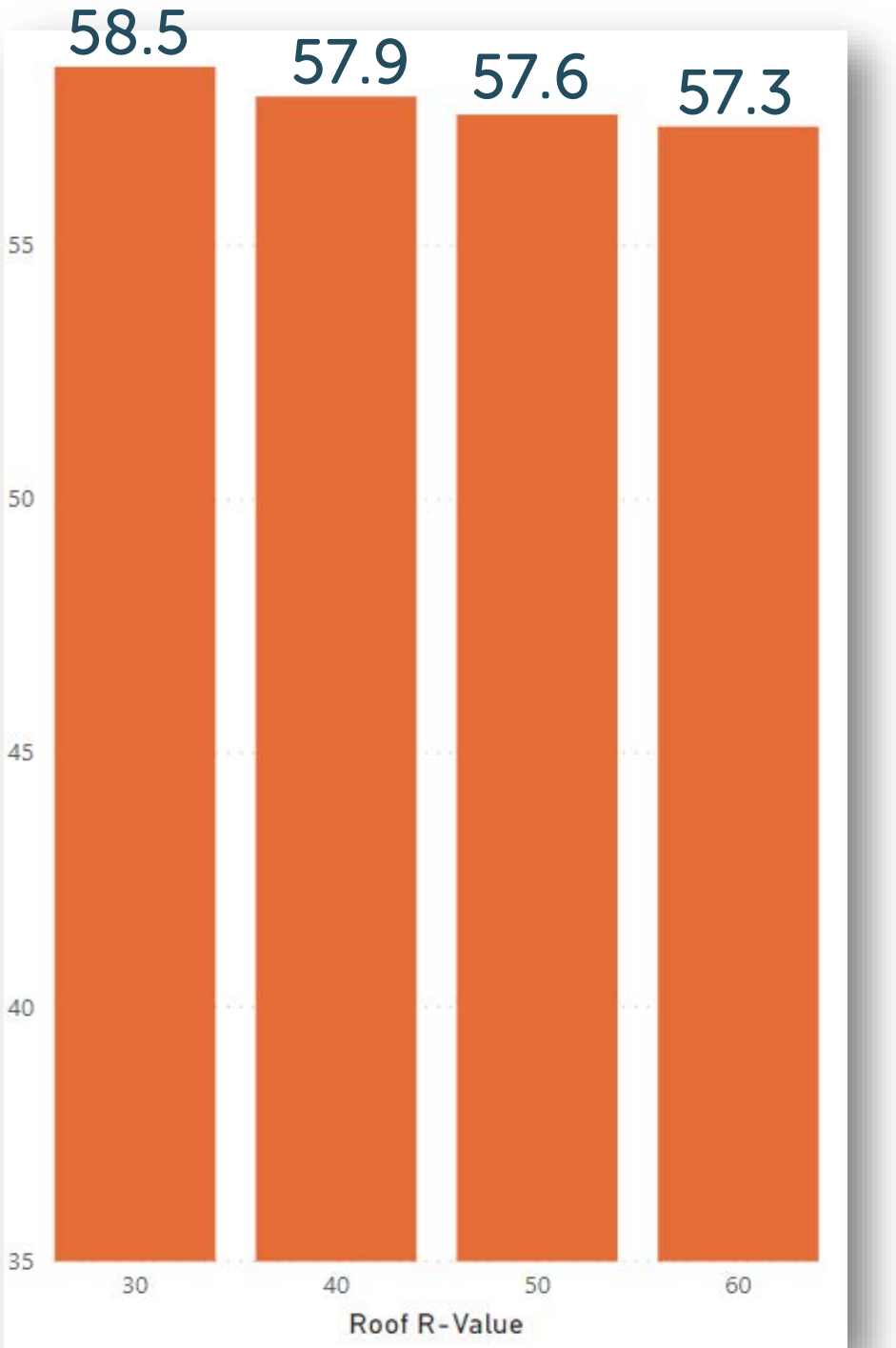
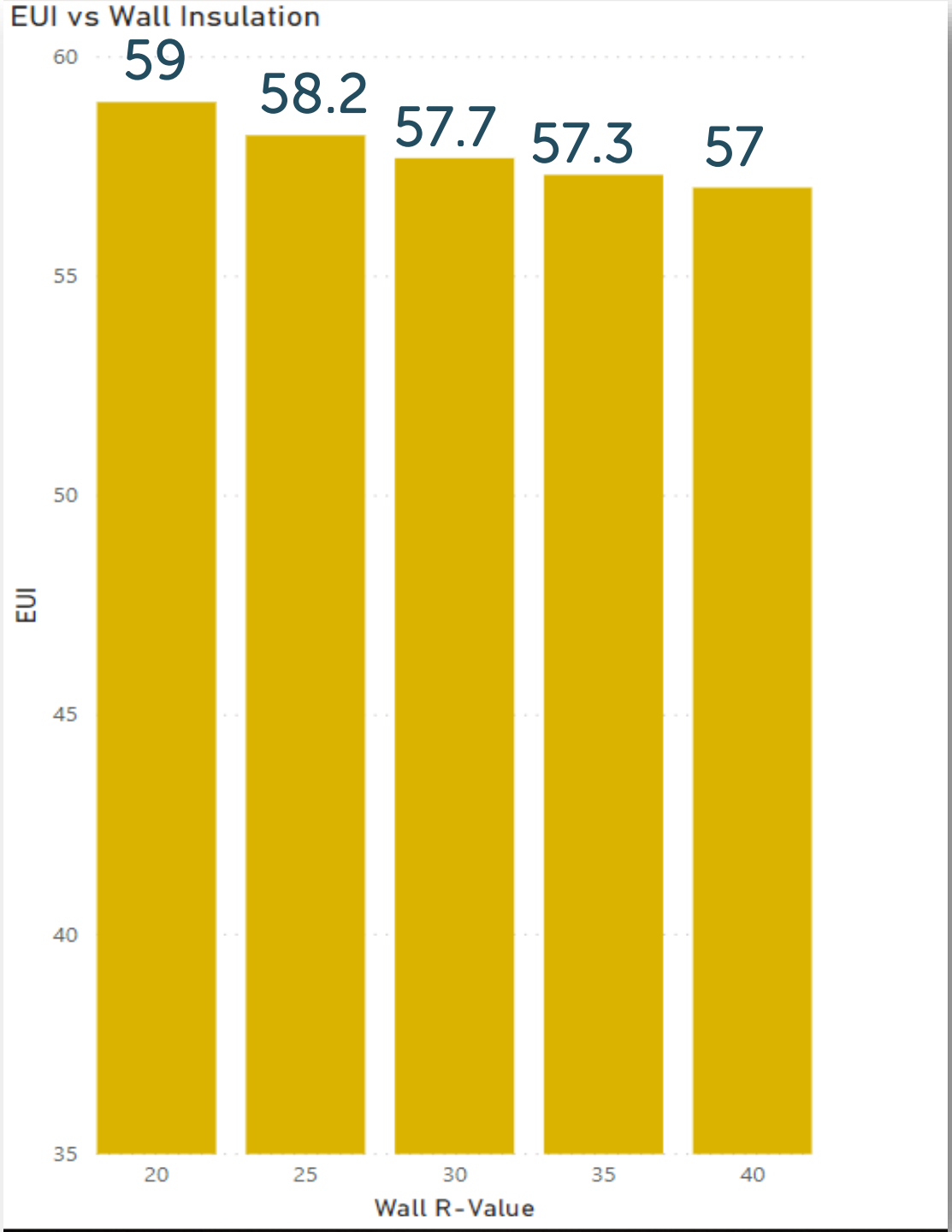
Multifamily Roof

EUI – KBTU/sq ft



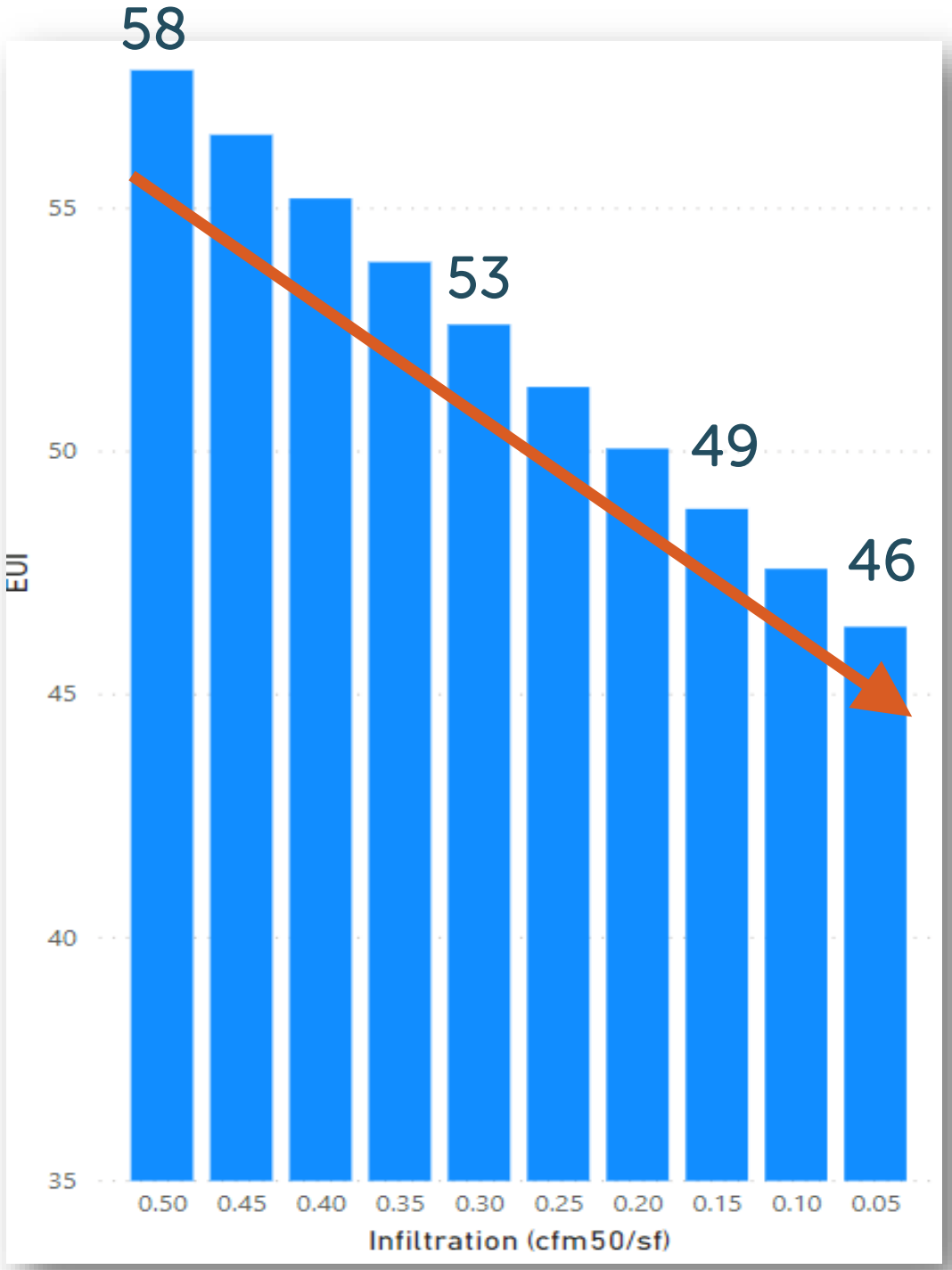
Multifamily Walls

EUI – KBTU/sq ft

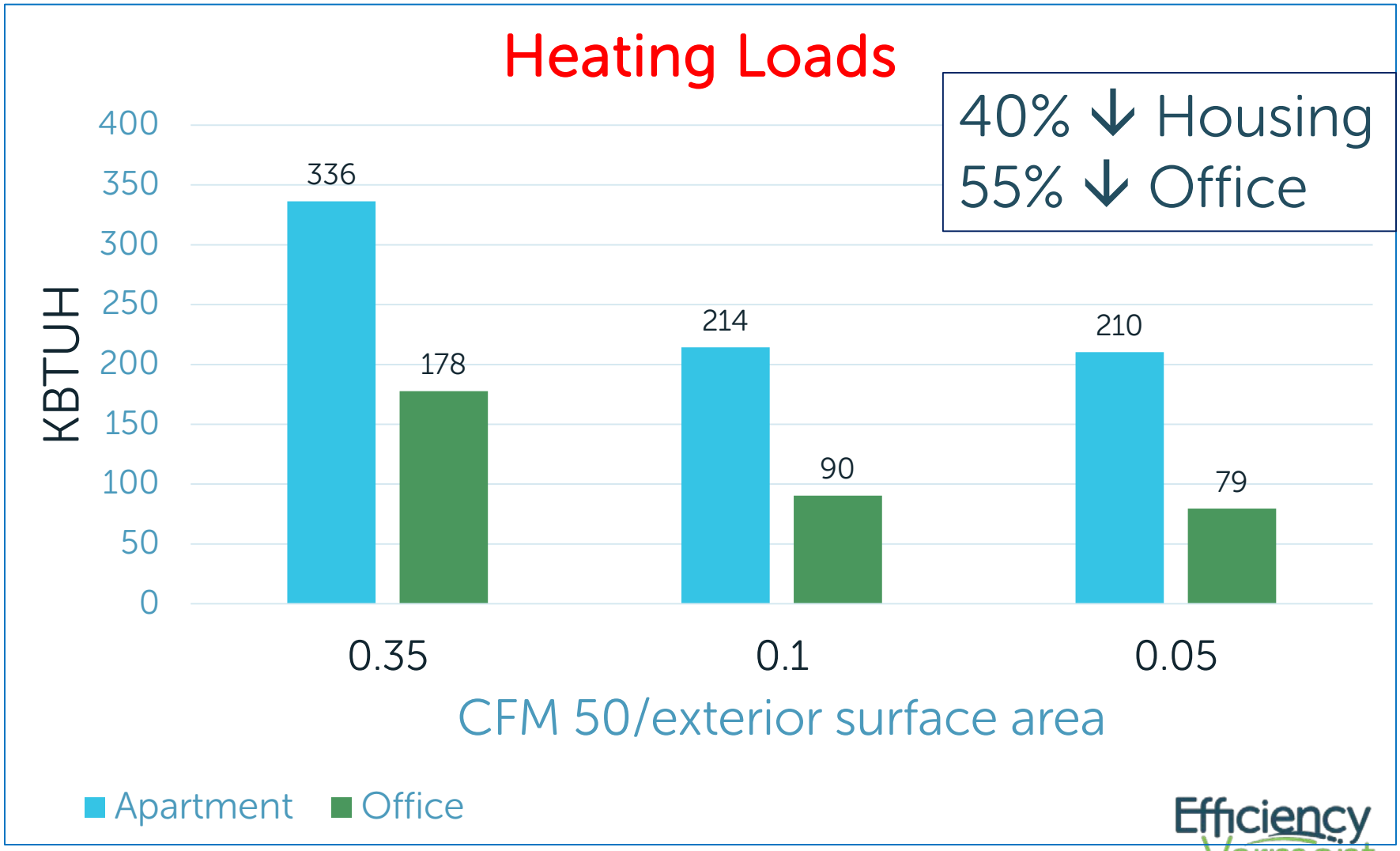


Multifamily Infiltration

EUI – KBTU/sq ft



Heating Load Impact of Airsealing



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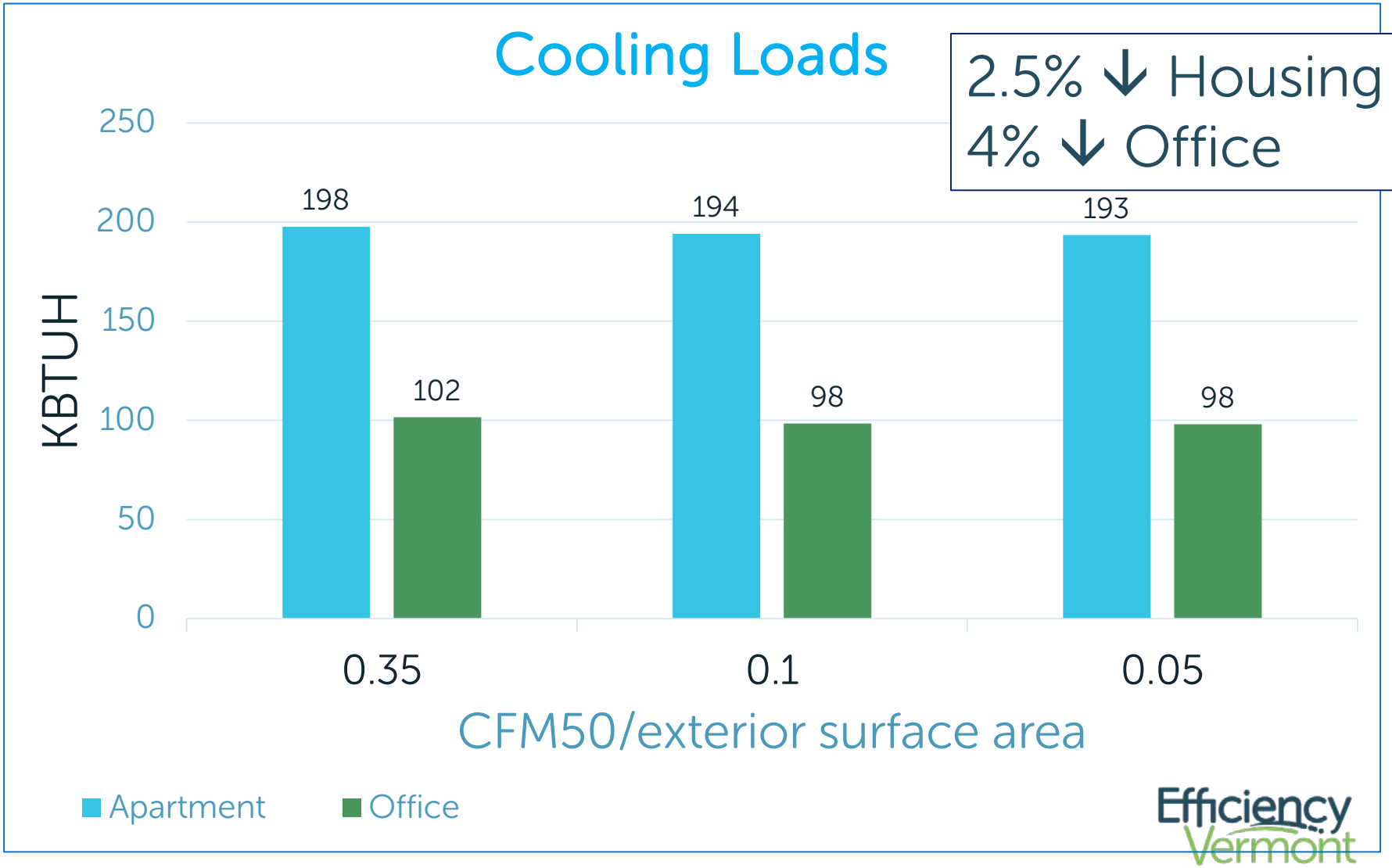
Cooling Load Impact of Airsealing



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What does it cost? Is it worth it?

Commercial Building

Building Component	Energy Savings, $	Incremental Cost, $	Payback, Yrs
Wall	$360	$26,290	72.2
Roof	$240	$17,450	72.7
Infl to 0.35	$570	$2,700	4.7
Infl to 0.1	$1,390	$6,000	4.3
Infl to 0.05	$1,540	$11,000	7.1

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What does it cost? Is it worth it?

Multifamily Building

Building Component	Energy Savings, $	Incremental Cost, $	Payback, Yrs
Wall	$1,300	$67,830	52.3
Roof	$780	$30,940	39.4
Infl to 0.35	$2,620	$2,700	1.0
Infl to 0.1	$6,820	$6,000	0.9
Infl to 0.05	$7,620	$11,000	1.4

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Top 5 Strategies

To Ensure a Tight Building Enclosure

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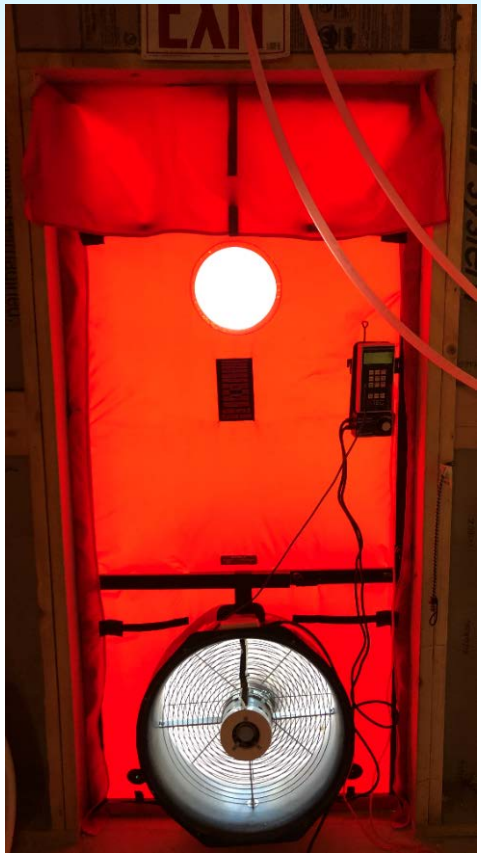
Top 5 Strategies

1. Set a Goal
2. Design to your Goal
3. Select for your Goal
4. Prepare to Reach your Goal
5. Verify your Achievement



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BUT FIRST...

Strike a Balance

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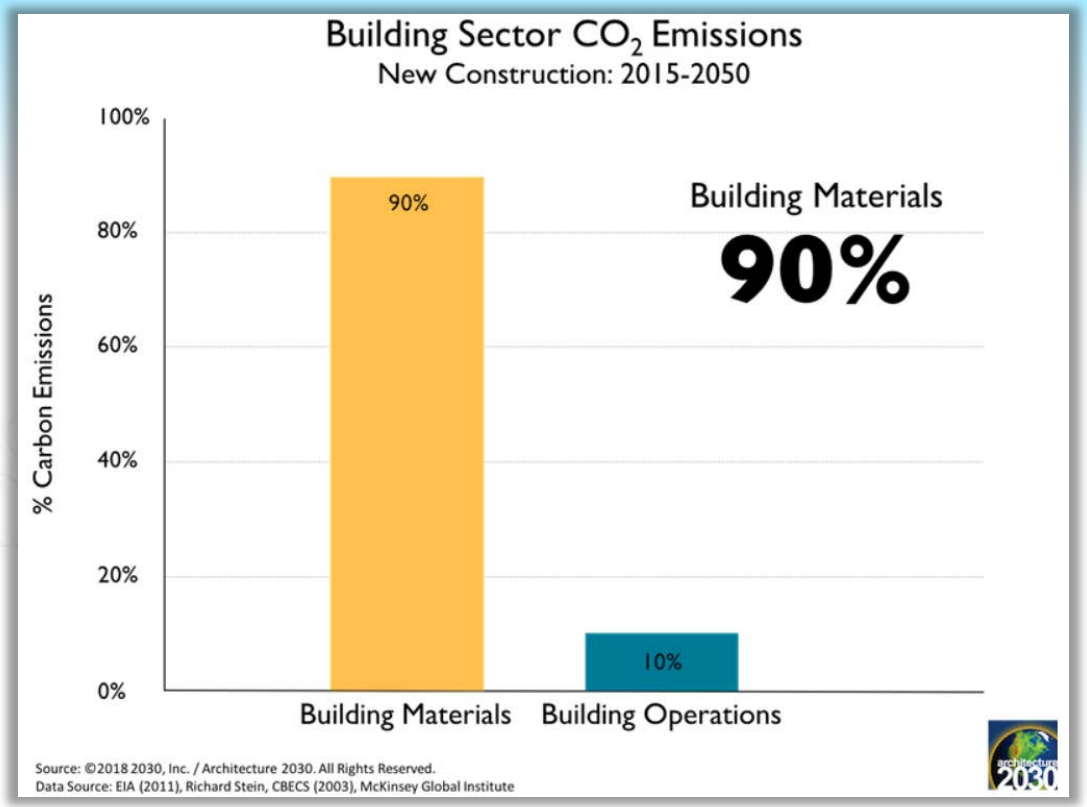

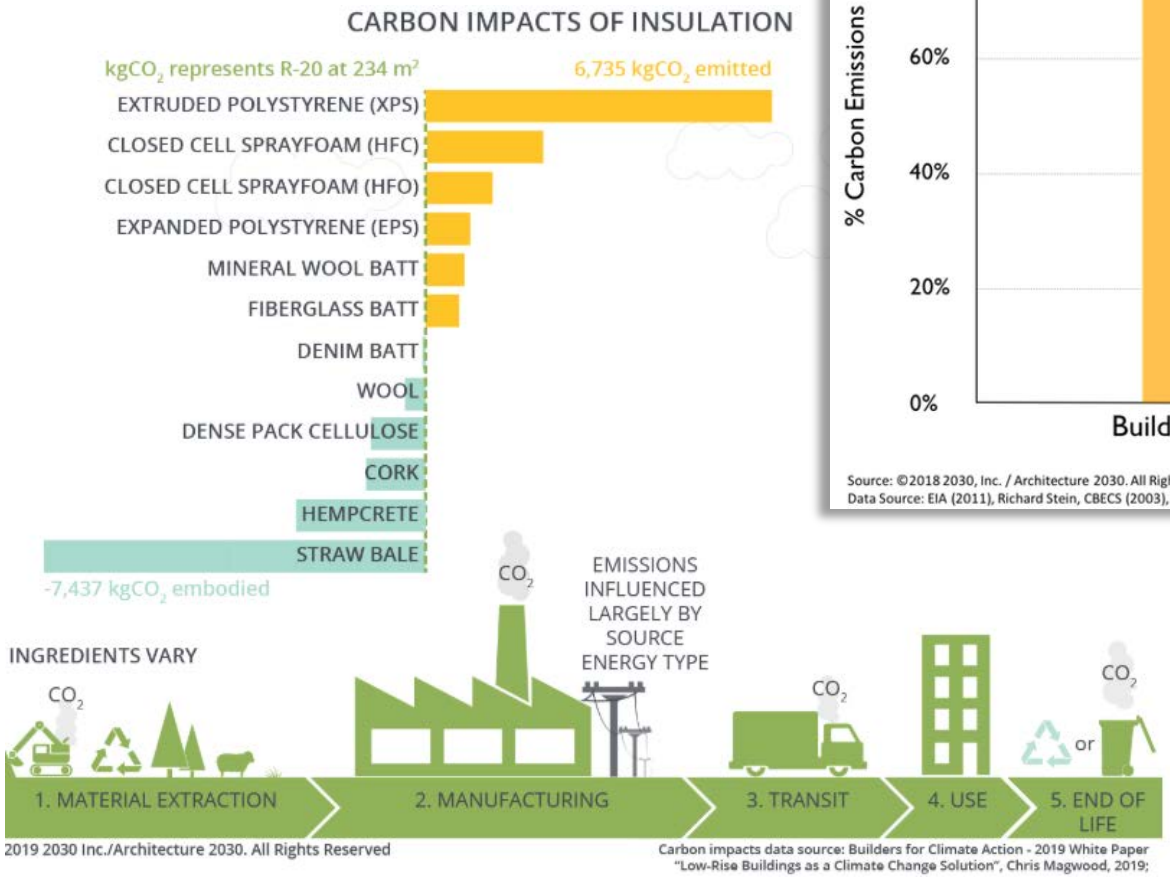

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Air sealing should not be the ONLY focus

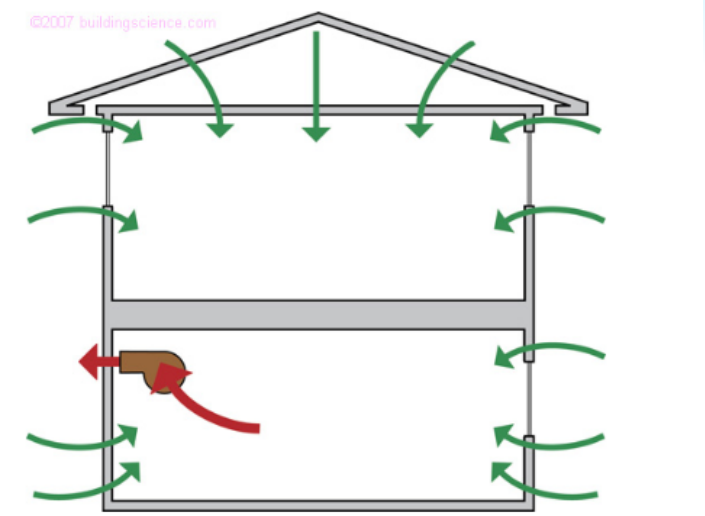

Figure 9: Enclosure Mass Balance
(Mass flow rate out equals mass flow rate in)

Consider:

- Embodied Carbon
- Ventilation
- Durability of Assemblies
- Thermal Bridges
- Compartmentalization

https://www.buildingscience.com/documents/insights/bsi-039-five-things

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Everything works together

- You can’t insulate unless you air seal
- You have to insulate
- If you air seal, you need ventilation
- Nothing else matters if you can’t keep water out of your wall

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1. Set a Goal

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Some Goal Options

- VT Commercial Energy Code
  - 2019: 0.30 cfm75/SF envelope (or 0.23 cfm50/SF envelope)
- Efficiency VT High Performance Multifamily Program
  - 0.10 cfm50/SF envelope
- Passive House
  - 0.06 cfm50/SF envelope
  - 0.08 cfm75/SF envelope

Set a Goal

Consider:

- Commitment (designer, engineer, etc.)
- Budget
  - Can added cost be offset with reduced mechanicals?
- Builder Experience
- Ventilation Strategy
- Enclosure Commissioning

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Is 0.05 cfm50 per SF the right target?

- Passive House US (PHIUS) 2018 max:
  - **0.06 cfm50 per SF** of envelope area
  - **0.08 cfm75 per SF** of envelope area
- If it costs much more, is this the best use of dollars?
- If it requires a lot of high GWP (global warming potential) foam, is this the best application of materials?

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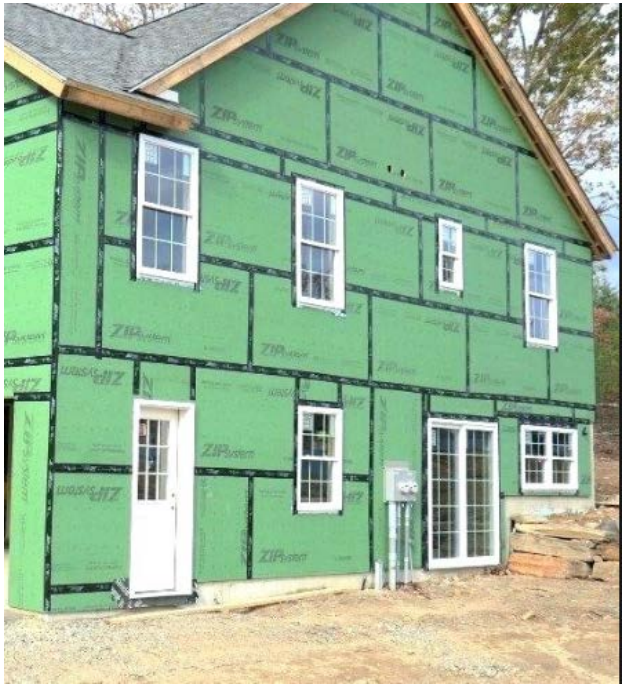
What is right for your building?



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2. Design to your Goal

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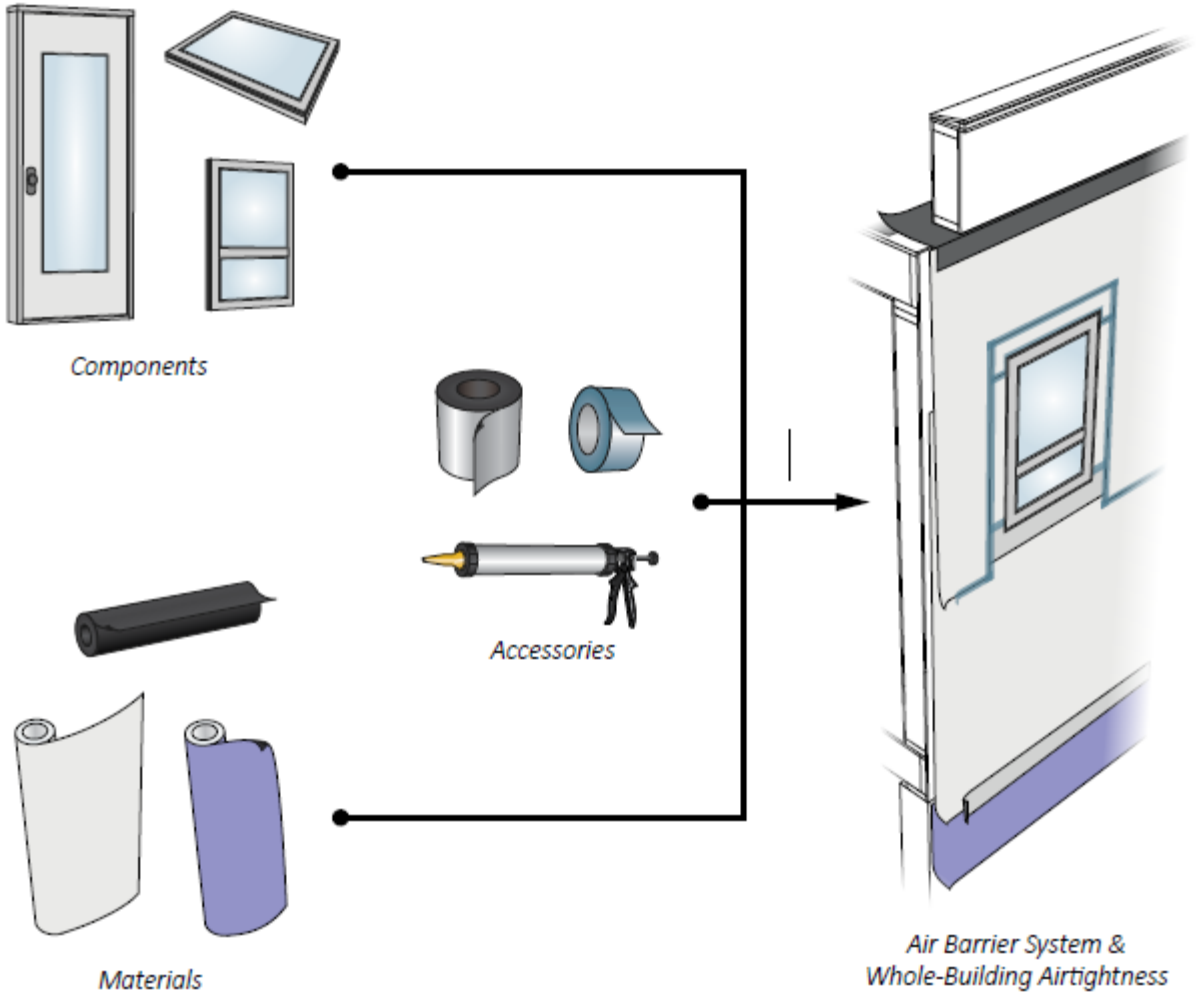
Materials, Components, and Accessories Combined



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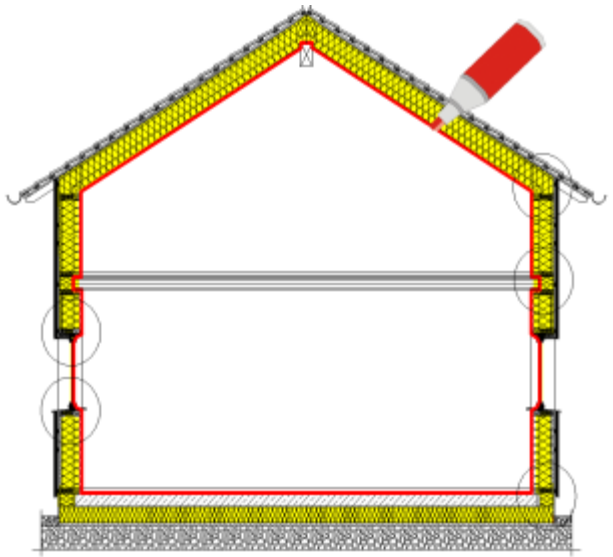
What Makes a Good Air Barrier?

Materials, Components and Accessories which combine to control air leakage and have the following features:

- Air Impermeability
- **Continuity**
- Durability
- Strength and Stiffness
- Easy to install well



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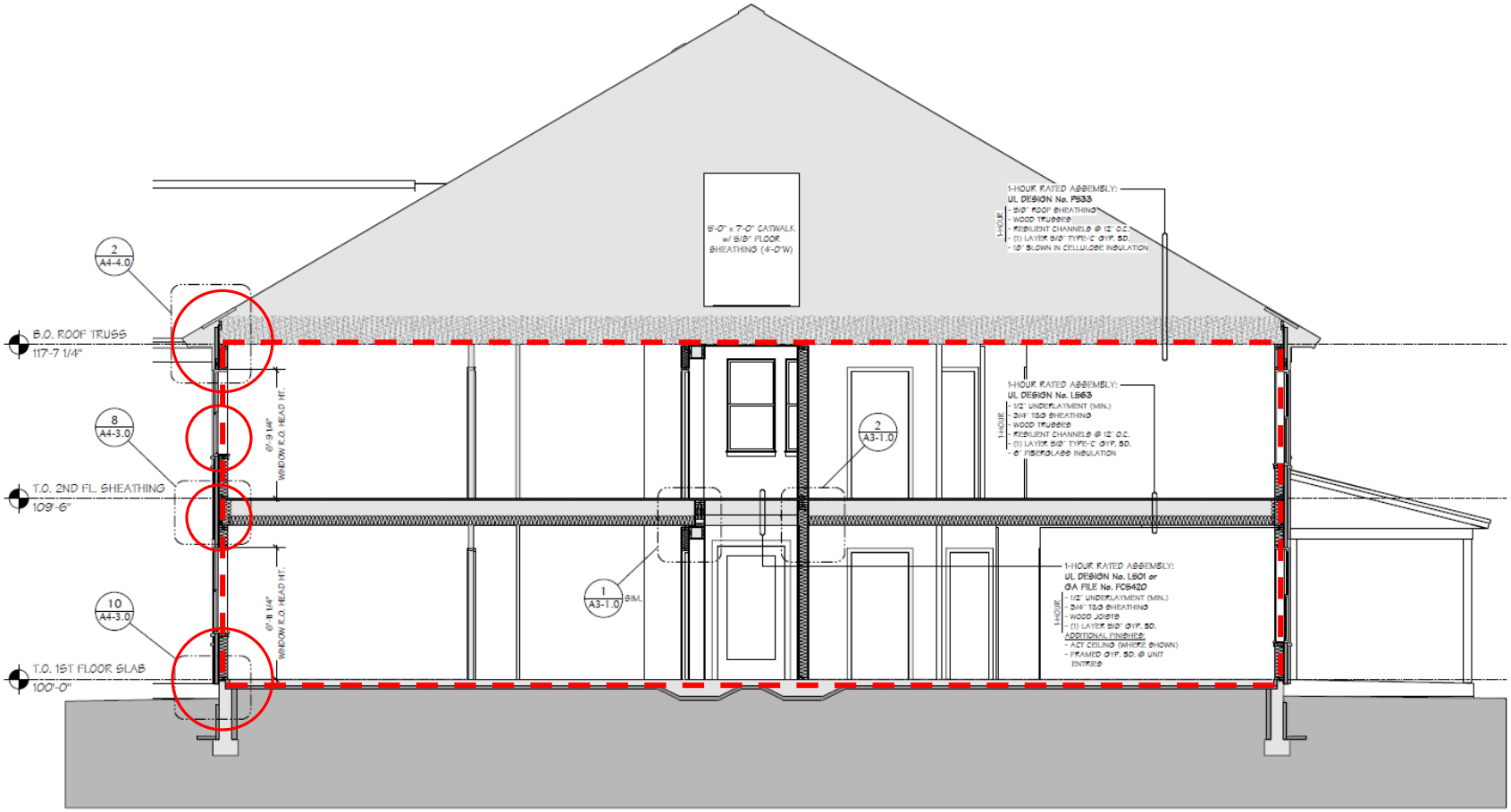
Drawings: Continuous Red Line Air Barrier



A SCHEMATIC BUILDING SECTION - A
Scale: 1/4" = 1'-0"

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Which is easier to air-seal?

or

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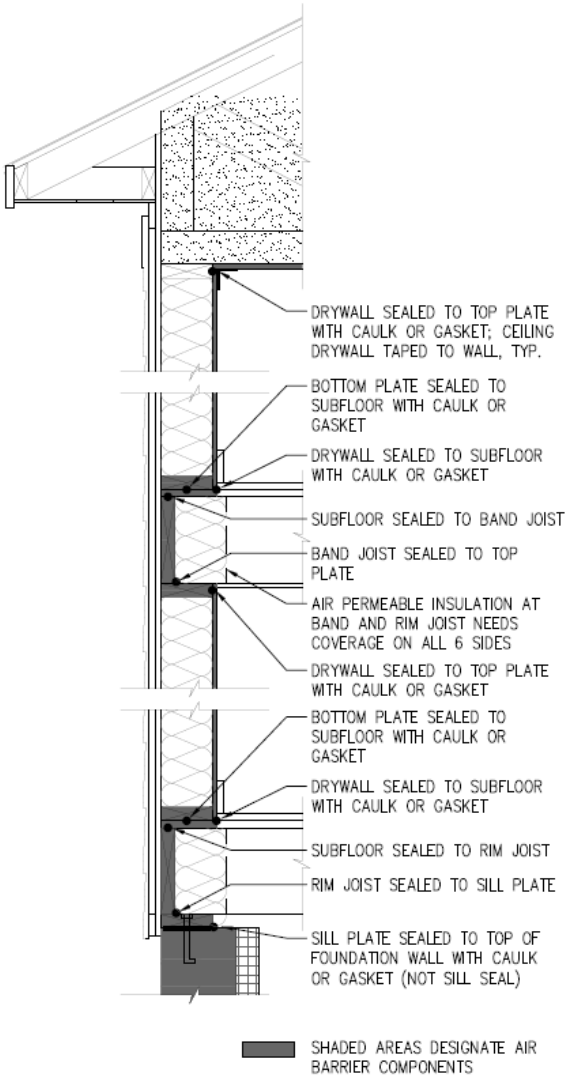
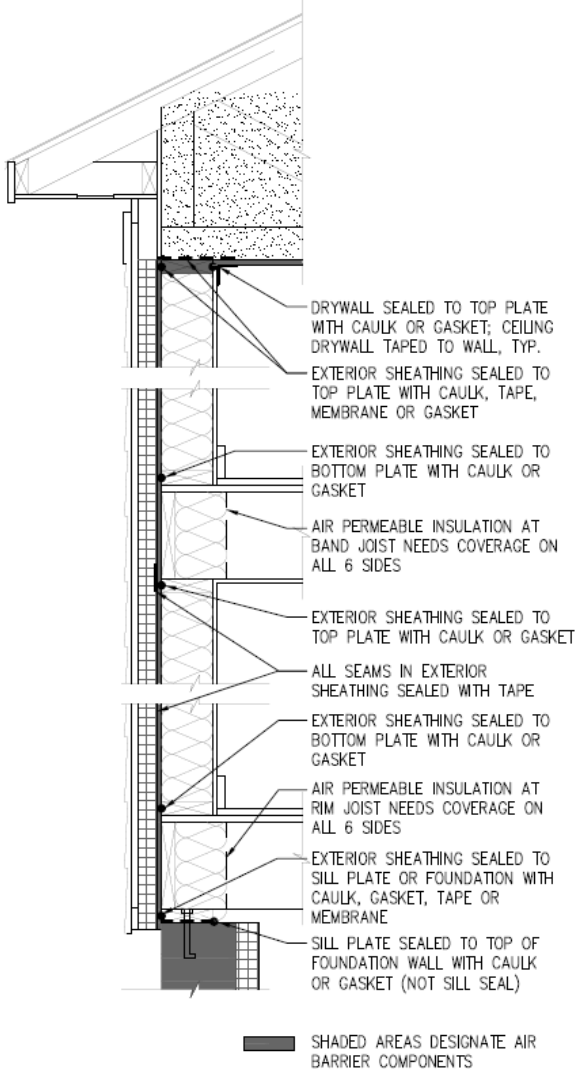
‘Air-tight’ Drywall vs. Exterior Air Barrier





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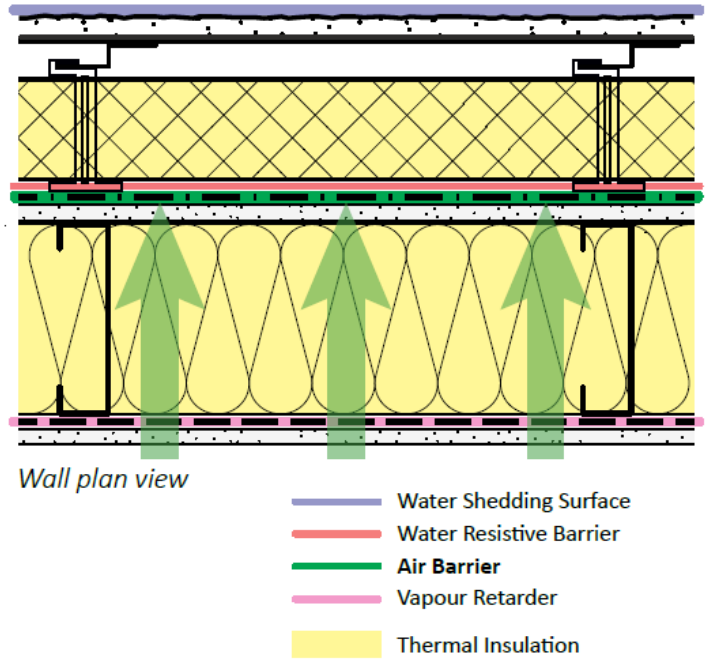
Simplify, Simplify

Existing Plaster May be a Useful Air Barrier: Where the plaster was sound it is left in place and acts as a component in the new continuous air barrier.



https://foursevenfive.com/blog/how-to-make-that-old-leaky-masonry-row-house-airtight/

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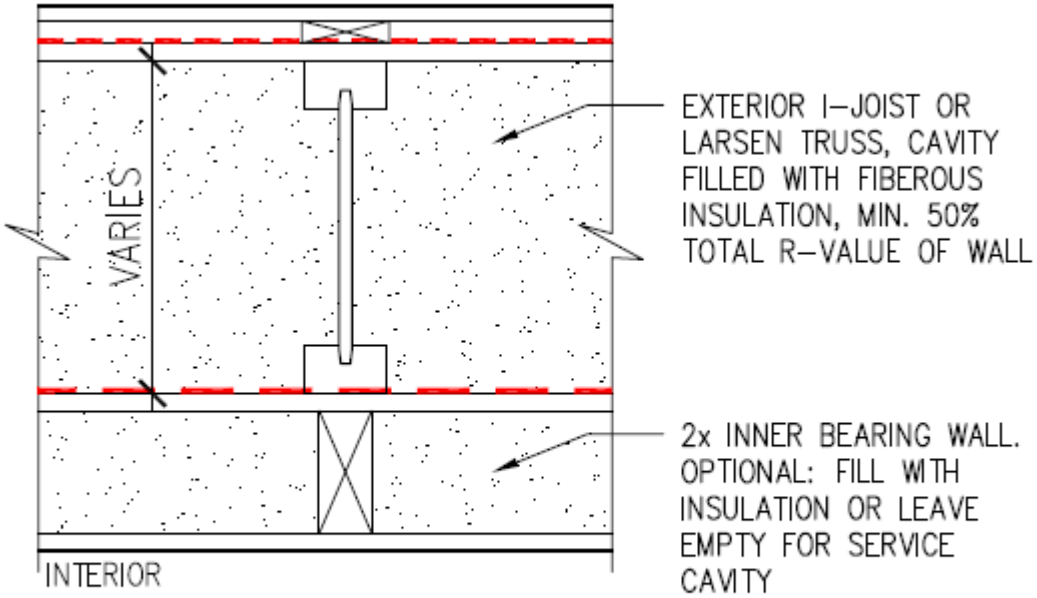
Combined Barriers



ARTIC / TJI / LARSEN TRUSS WALL

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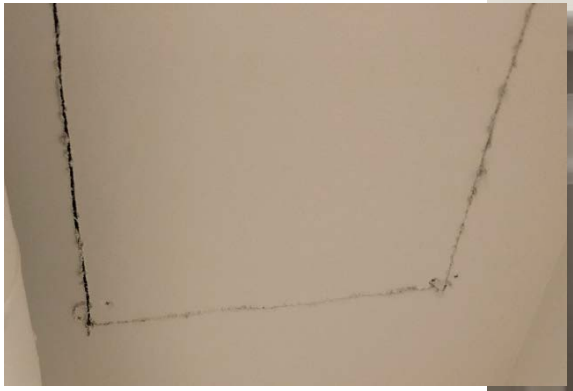
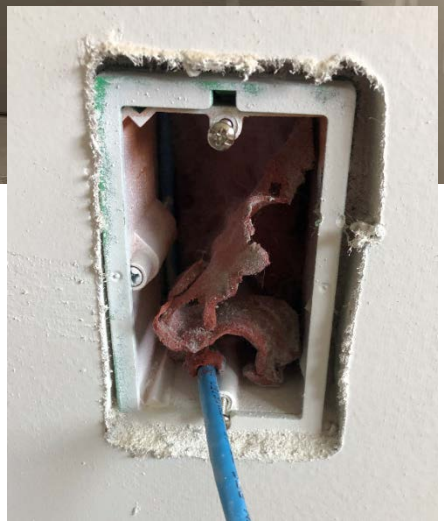
Drywall is not a great air barrier





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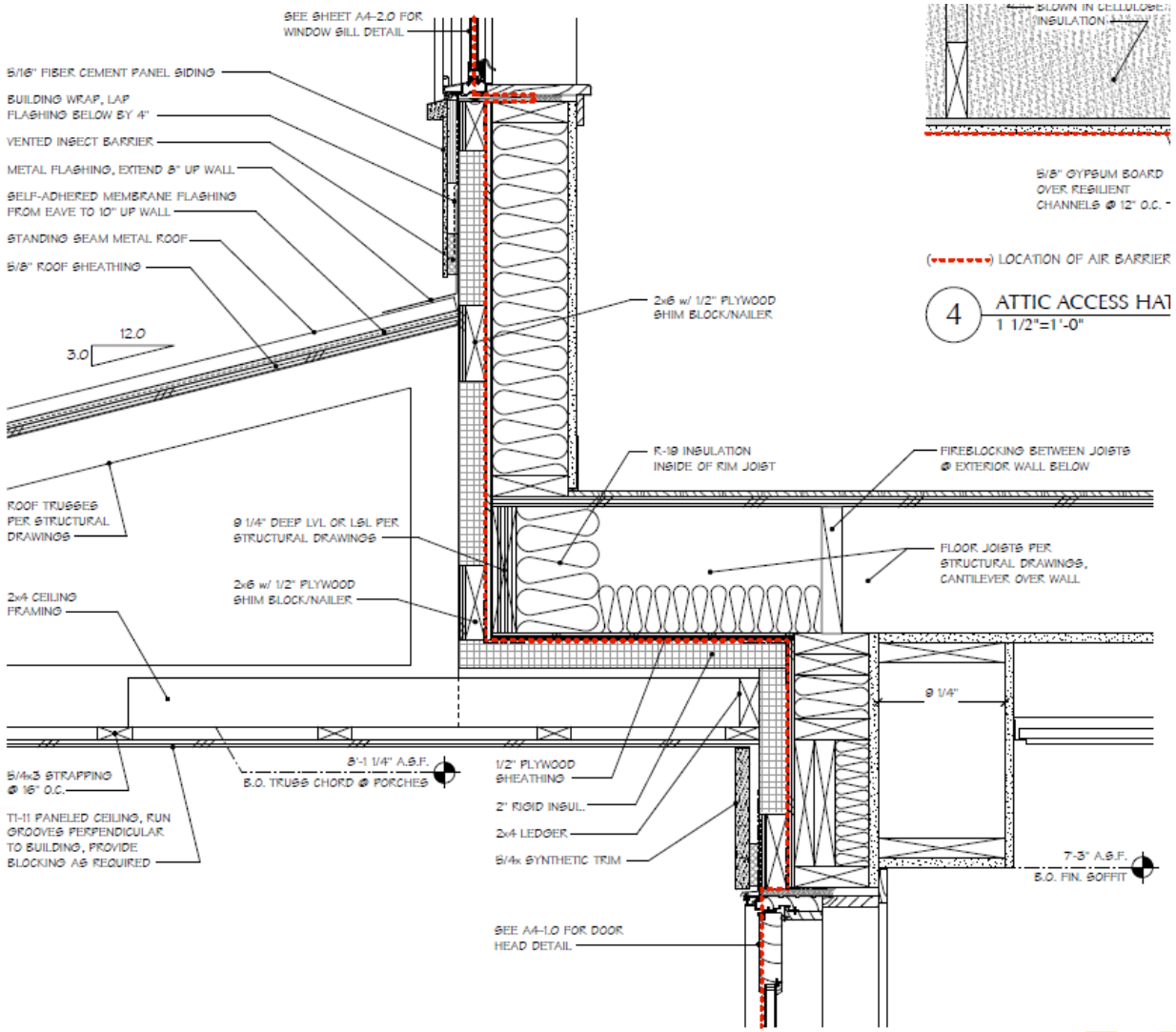
Follow it through all intersections



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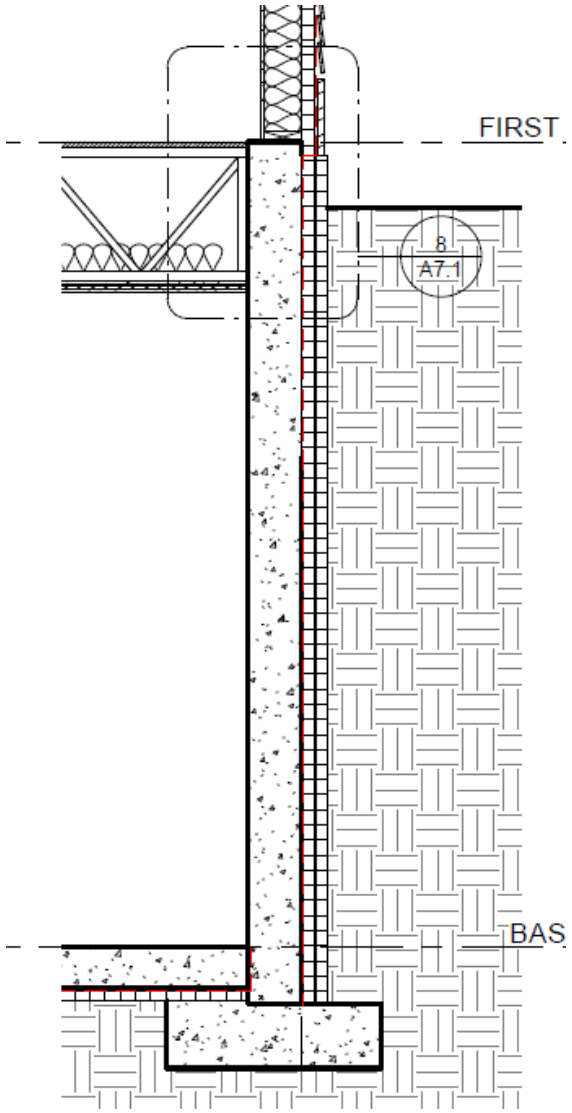
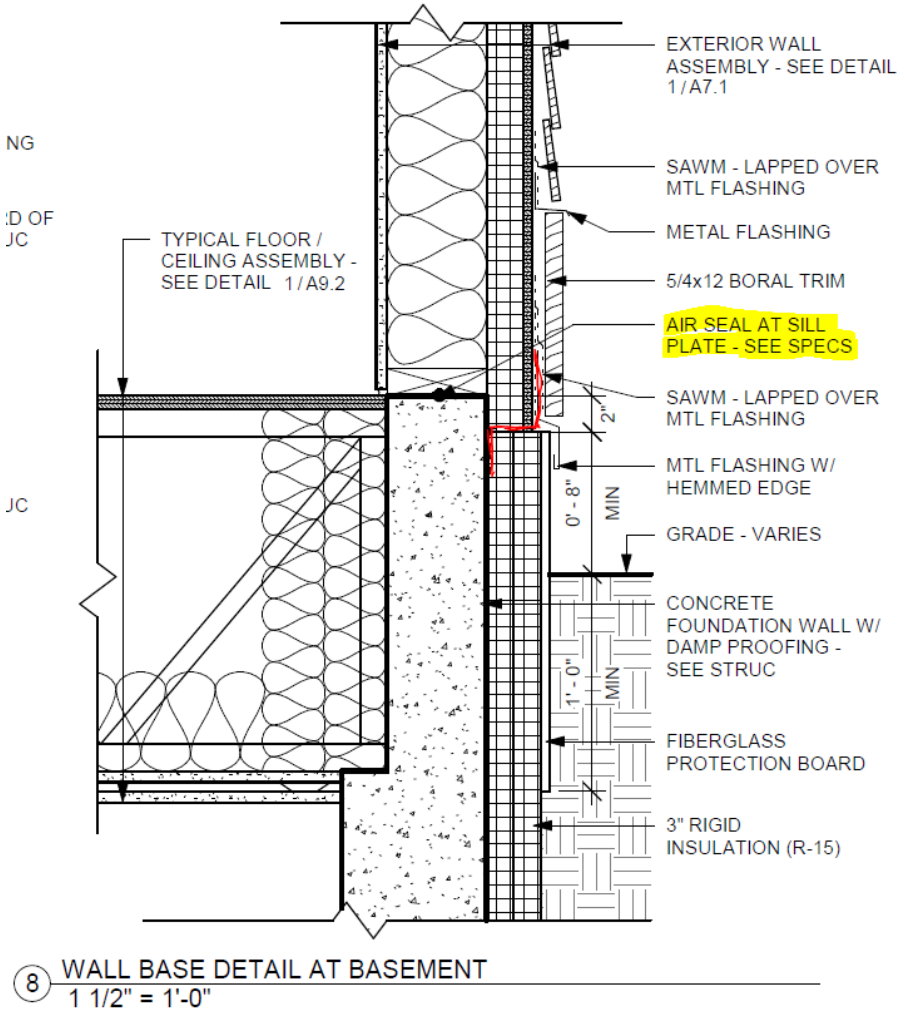
Consider Sequencing





8 WALL BASE DETAIL AT BASEMENT
1 1/2" = 1'-0"

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Specifications

3.04 PERFORMANCE STANDARDS

A. The work of this Section shall achieve the following standard, through the use of blower door testing as specified in 1.06 above:
1. Acceptable air leakage rate is 0.10 (or less) CFM/SF of above grade thermal envelope area at -50 Pascals with respect to ambient conditions. Above grade thermal envelope includes all walls above grade and all roof surfaces.

B. Final Certification - By Efficiency VT (EffVT) based on blower door test.

3.05 BLOWER DOOR TESTING

A. Perform blower door test as specified. If blower door test does not demonstrate compliance with criteria established in 3.04 above, perform additional work as required to bring into compliance. Verify compliance with additional blower door test if initial test varies from specified amount by more than 10% (i.e., >0.11 instead of 0.10 CFM/SF).

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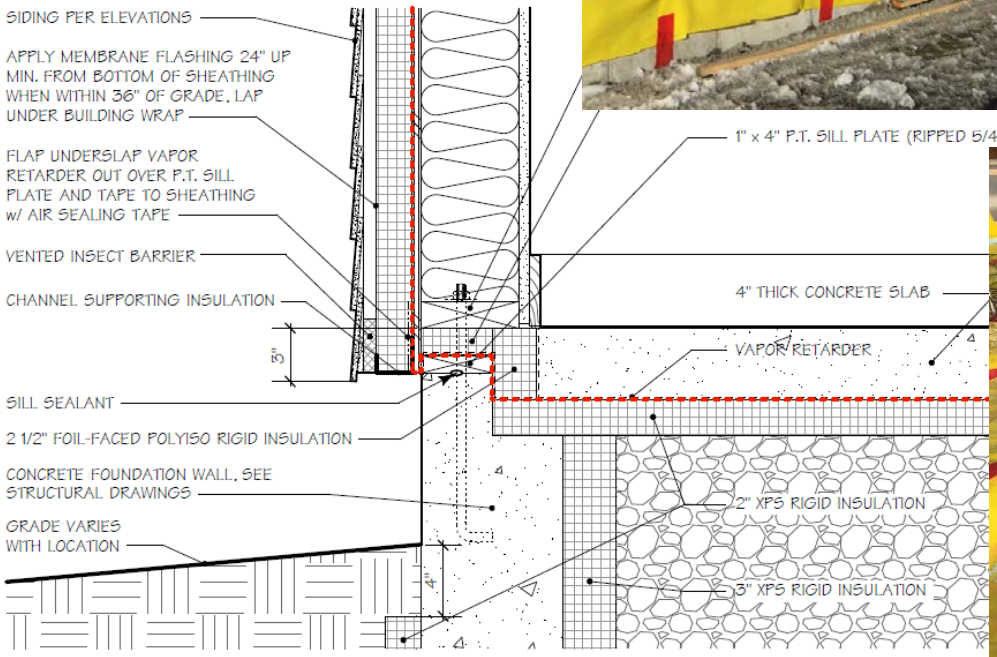
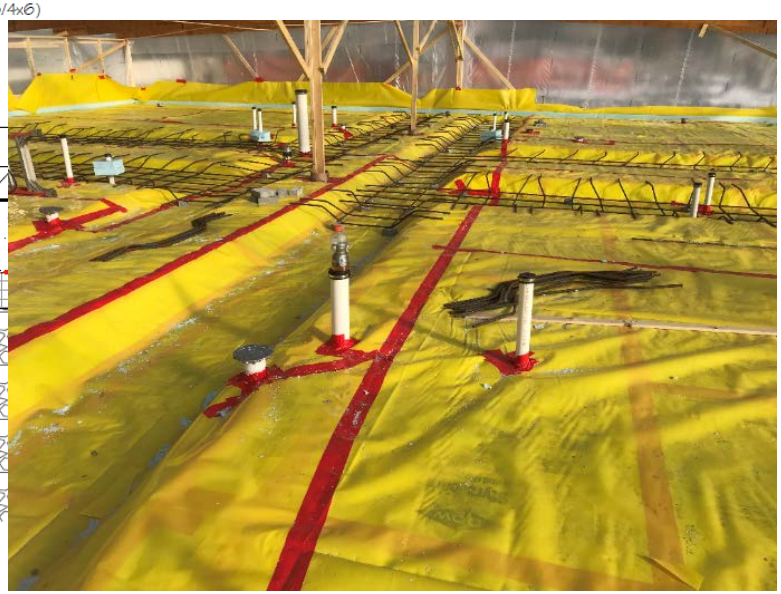
Examples: Slab





10 SLAB @ FOUNDATION WALL

1 1/2"=1'-0"

(•••••••) LOCATION OF AIR BARRIER, TYP.

18plex

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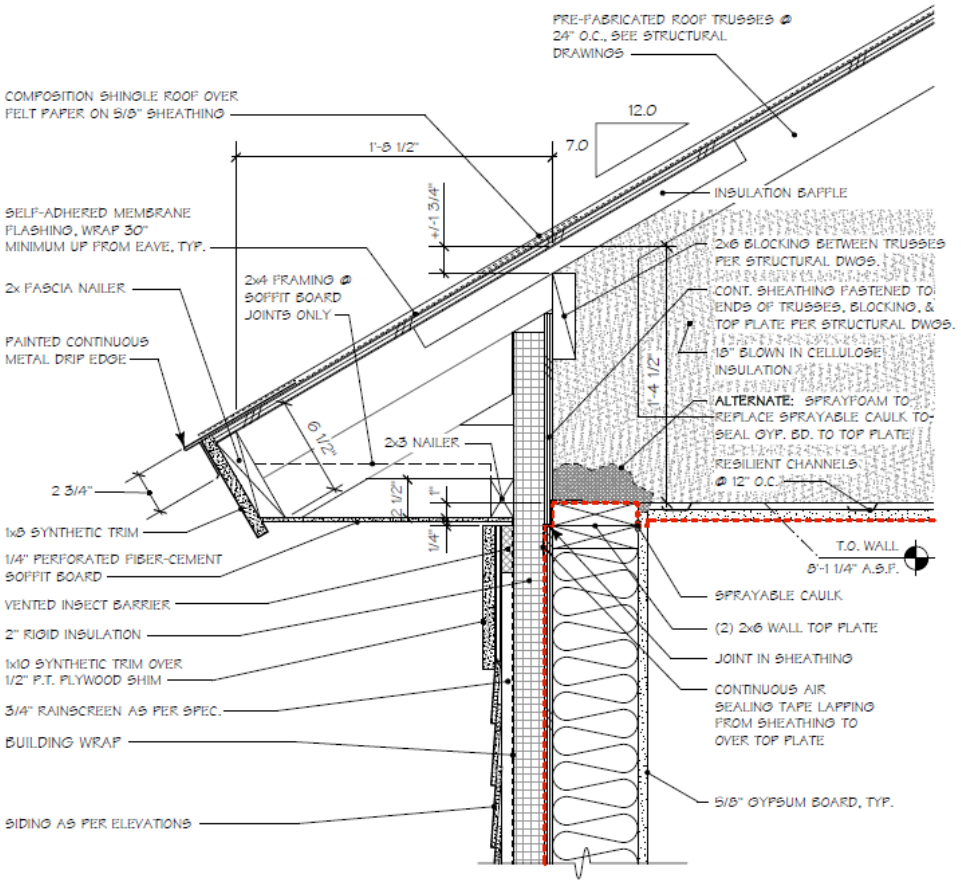
Air sealing at attic plane



1 TOP OF WALL / ROOF EAVE DETAIL (-------) LOCATION OF AIR BARRIER, TYP.

SCALE: 1 1/2" = 1'-0"

18plex

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Air sealing at attic plane

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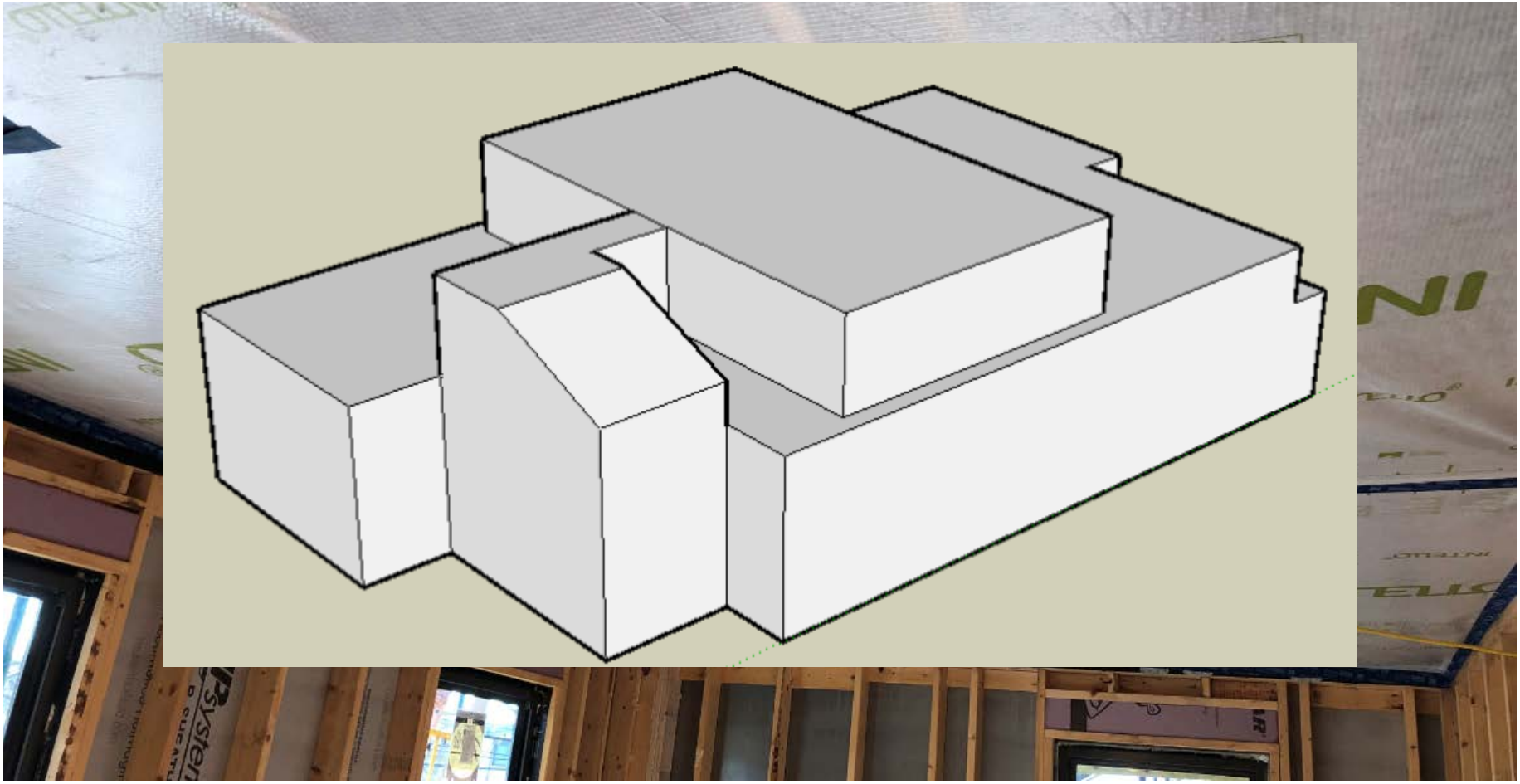
Specifying a Material Doesn't Guarantee Results



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NTELLO®
ZIPSystem


TESCON


TESCON
pro clima


INTELLO

3. Select for your Goal

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Air Barriers – What Works?

- Plywood
- Supported flexible barriers/ membranes
  - Fabric or spray applied
- Spray foam/ Rigid foam
- Gypsum wall board
- Concrete
- OSB?

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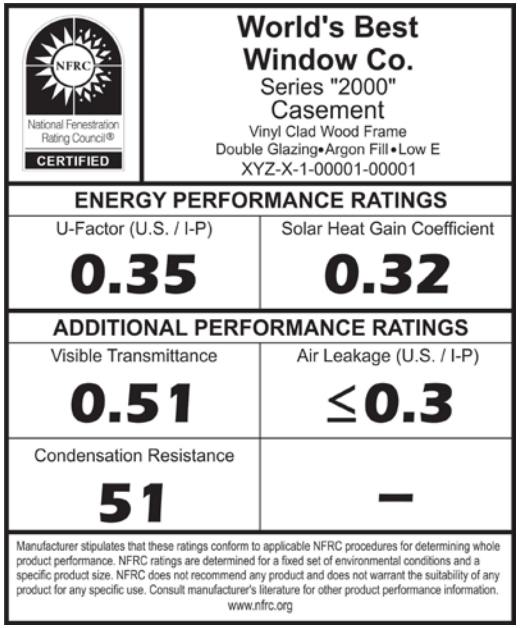
Window Air Leakage

- Testing is voluntary, not required by NFRC
- Energy Star requires max **0.30 cfm75 per SF** (0.23 cfm50/SF) for most windows
- Testing must comply with

  ASTM E283 (tested at 75 Pa)
- Ask manufacturer for testing

  report to support claims



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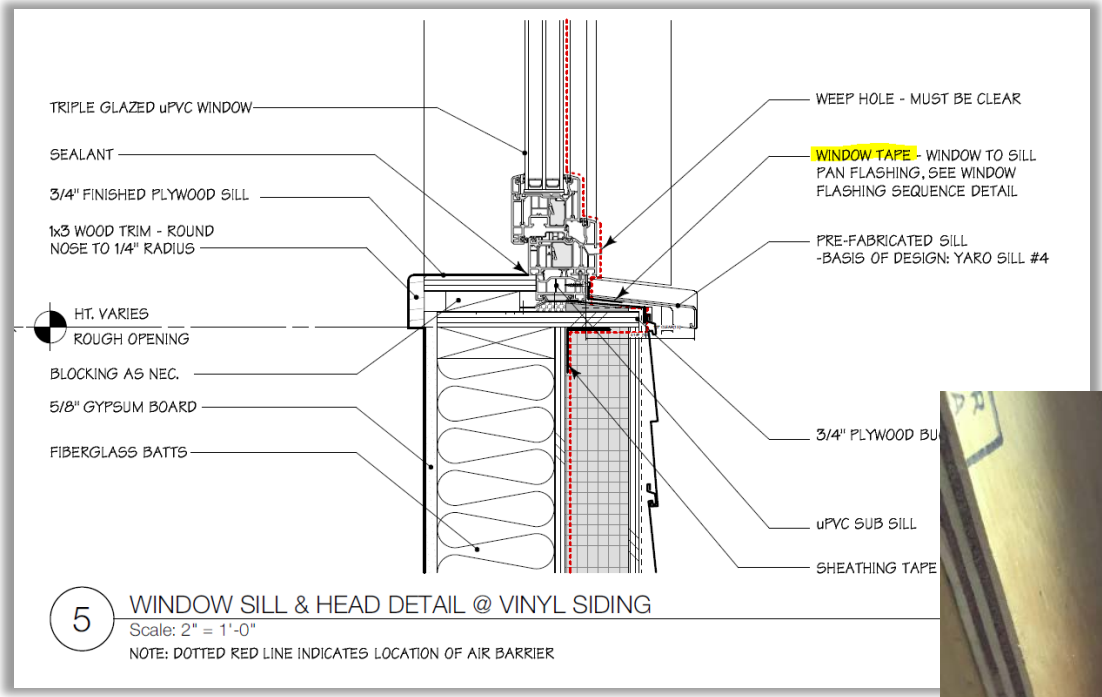
Foam vs. Tape



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Durability is Key

- Caulk/
- Tape
- Spray Foam
- Backer rod
- Gaskets
- Membranes
- Sheet goods
- Sheet metal
- Plastic sheeting
- Weatherstripping
- Mastic
- Foil-facing

HOW LONG DO THEY LAST?

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4. Prepare to Reach your Goal

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Prepare for Construction

- Kick-off meeting
- Sub-contractor meetings
- Mock-up building section
- Schedule periodic inspections and progress testing

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How will air sealing be woven into the different phases of construction?

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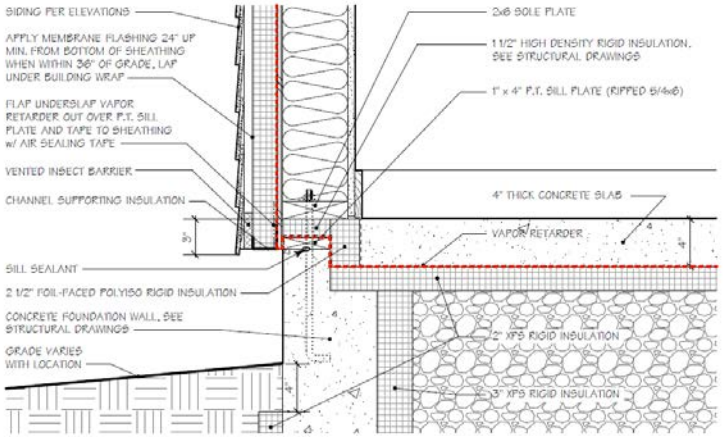
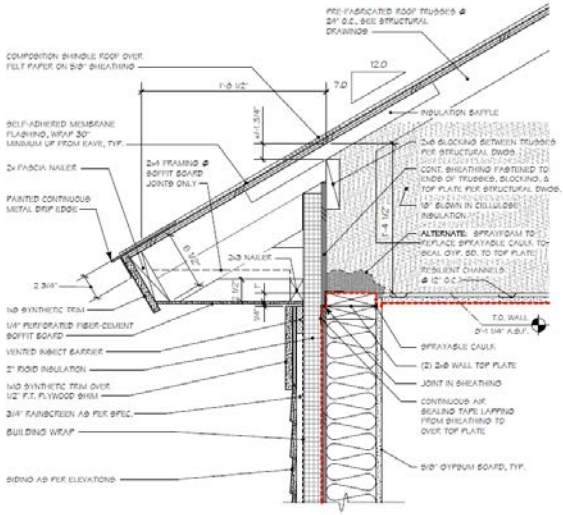
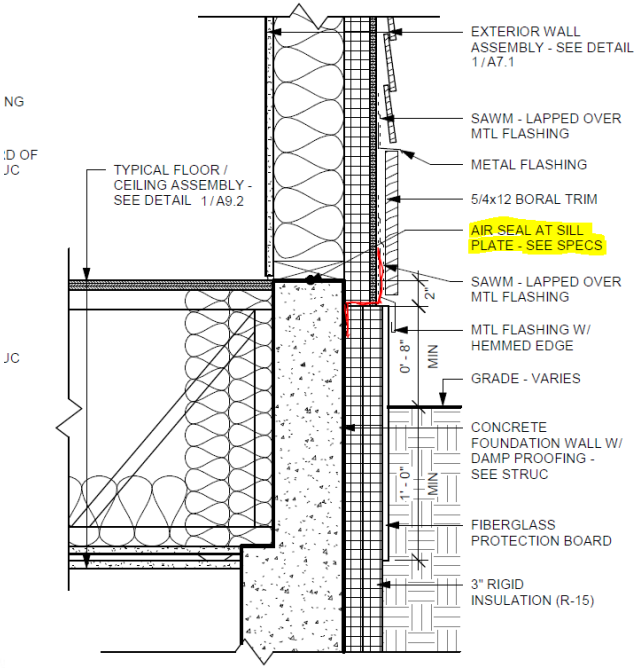
Identify ‘Problem’ Areas



10 SLAB @ FOUNDATION WALL
1 1/2"=1'-0"



1 TOP OF WALL / ROOF EAVE DETAIL
SCALE: 1 1/2" = 1'-0"
LOCATION OF AIR BARRIER, TYP.
18plex



8 WALL BASE DETAIL AT BASEMENT
1 1/2" = 1'-0"

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Who Owns What

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The value of the mock up

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5. Verify your Achievement

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Enclosure Commissioning

Building Enclosure Commissioning Agent (BECx)

- 3rd party
- Includes review of the drawings for possible problem areas during design
- Regular meetings on site, progress testing, first instance testing
- Reports and follow-up with solutions, re-test
- Final Testing

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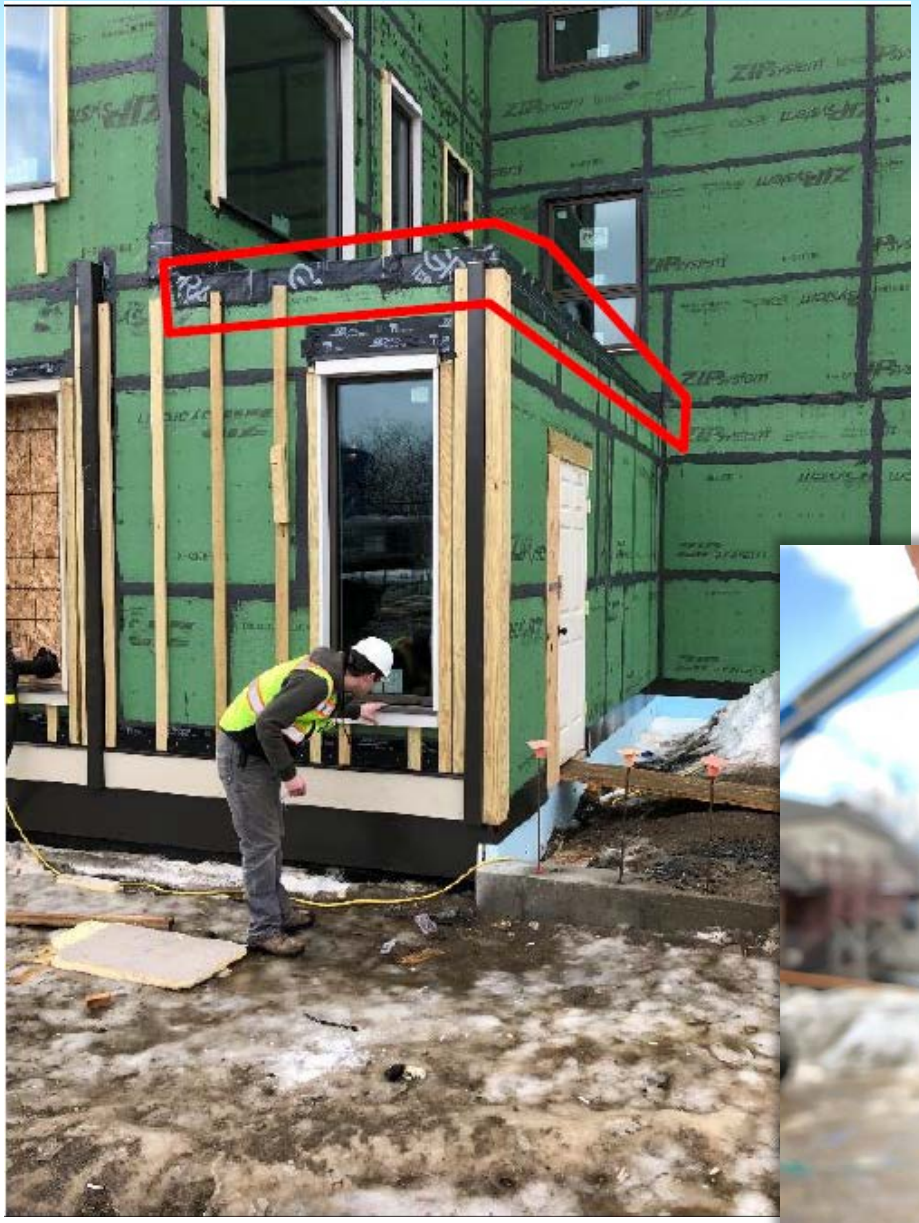

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Final Testing Challenges

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Testing Celebrations

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Wrap Up

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Take - aways

1. It is more cost-effective to air seal than add extra insulation
2. Set a practical air leakage goal
3. Ensure assembly details and material selection match your goal
4. Get everyone on board
5. Test and re-test

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Resources

- Illustrated Guide – Achieving Airtight Buildings
- Building Science Corp: Understanding Air Barriers
- 475 Building Assembly Guides - emphasize foam free assemblies
- Green Building Advisor: Questions and Answers About Air Barriers

Compartmentalization:

- Steven Winter Assocs. article

Testing:

- Blower Door Applications Guide: Beyond Single Family Residential

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Thank you!

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