

# BC Energy Step Code Airtightness Training

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# Outline

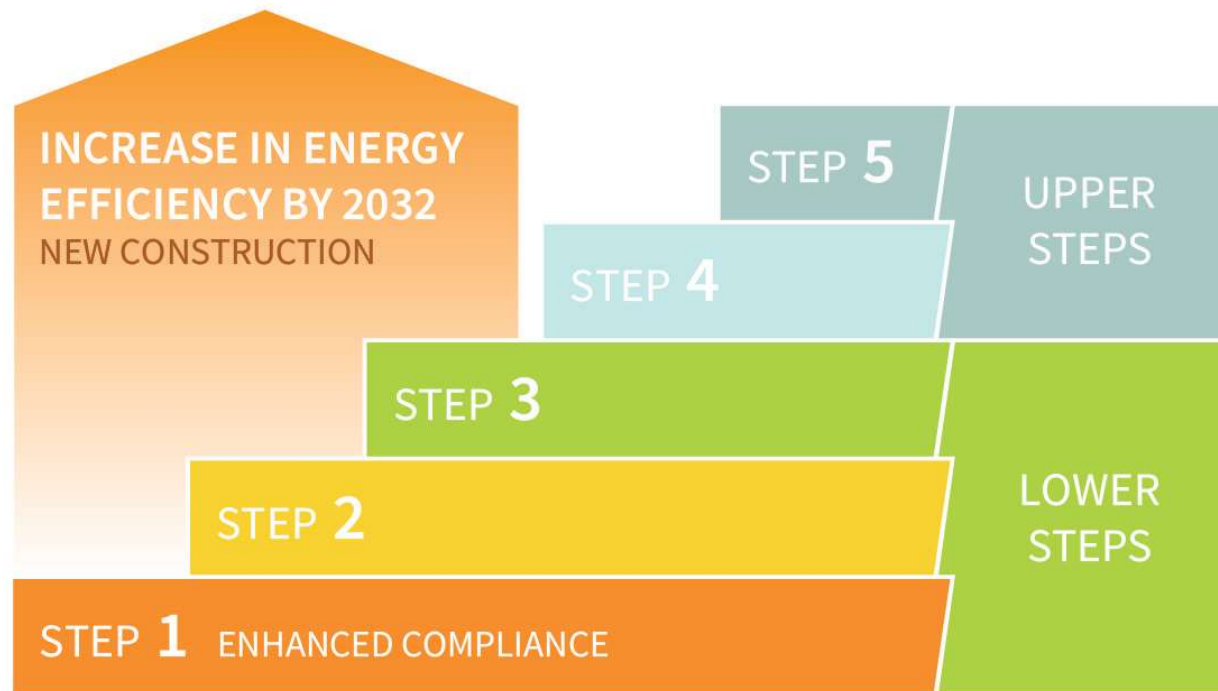
- BC Energy Step Code
- Working with an Energy Advisor
- What is an Air Barrier
- House as a System
- Air Barrier Systems, Materials, Accessories, Components
- Details
- Construction and Quality Control
- Examples & Hands-on Training

# BC Energy Step Code



ENERGY  
**STEP**CODE  
BUILDING BEYOND THE STANDARD

# The BC Energy Step Code Applies Across BC





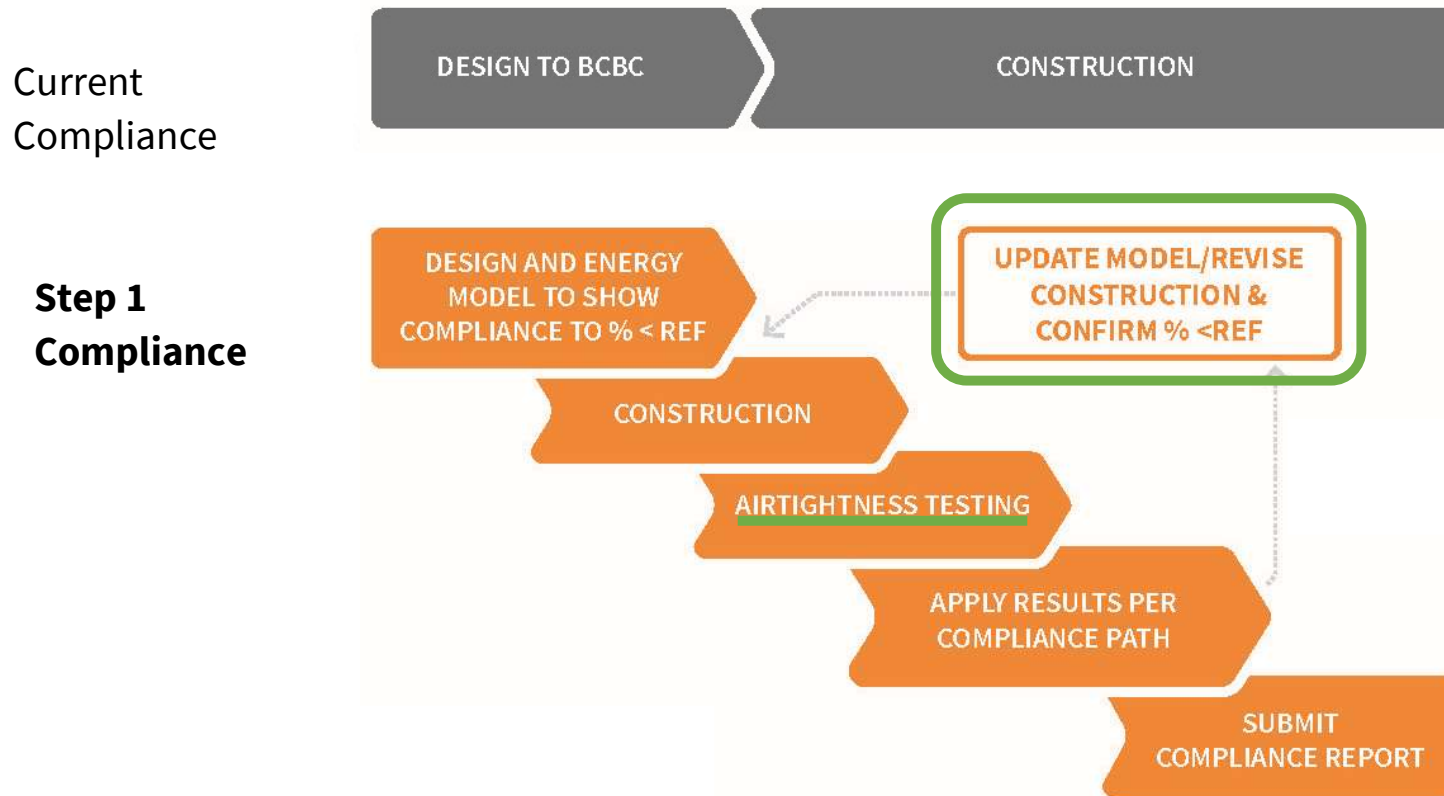
# BC Energy Step Code: Based on Climate Zone



Kelowna

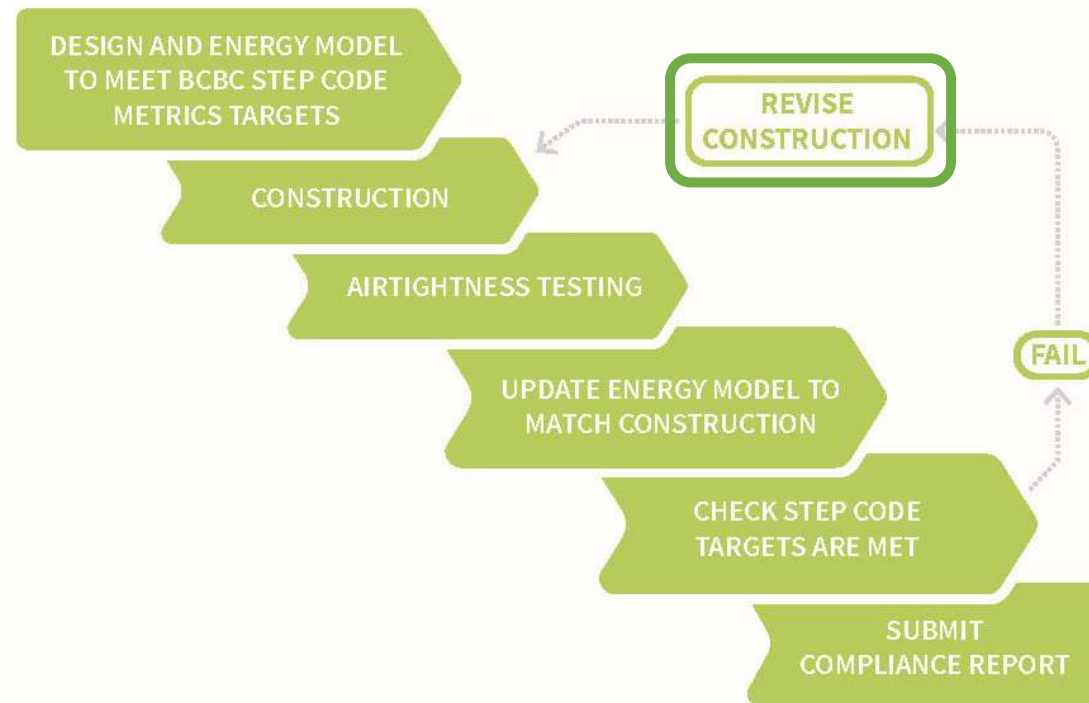
8	> 7,000 HDD
7B	6,000 to 6,999 HDD
7A	5,000 to 5,999 HDD
6	4,000 to 4,999 HDD
5	3,000 to 3,999 HDD
4	< 3,000 HDD

# Changes to the Design and Build Processes

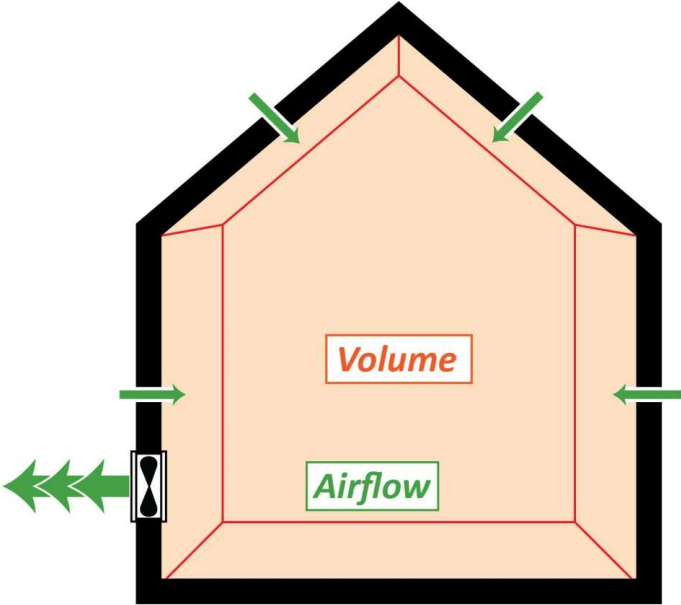


# Changes to the Design and Build Processes

## Step 2 -5 Compliance




# Airtightness



\*Measured as **Air Leakage Rate in Air Changes per Hour (ACH<sub>50</sub>)**


# Step Code Metrics

**Airtightness**



ACH

**Equipment & Systems**




% < REF



MEUI

**Building Enclosure**



TEDI

Performance Based

# Step Code Airtightness



## Air Leakage Rate

STEP 1	?
STEP 2	$\leq 3.0 \text{ ACH}_{50}$
STEP 3	$\leq 2.5 \text{ ACH}_{50}$
STEP 4	$\leq 1.5 \text{ ACH}_{50}$
STEP 5	$\leq 1.0 \text{ ACH}_{50}$

# Step Code Airtightness

## Step 1 Part 9 Airtightness



- **Testing is always required**
- Two compliance paths:

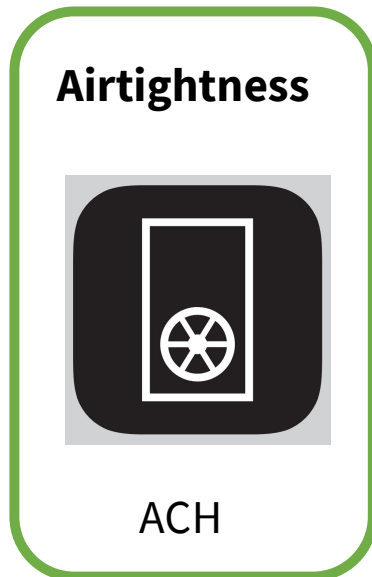
1. The **EnerGuide Rating System (ERS)** reference house uses **2.5 ACH<sub>50</sub>**. This target must be met, unless other offsetting energy performance improvements are achieved. The ERS building energy model must always include the as-built airtightness.

**OR**

2. The **9.36.5** reference house also uses **2.5 ACH<sub>50</sub>** as its baseline reference air leakage rate. **However...**

# Step Code Airtightness

## Step 1 Part 9 Airtightness

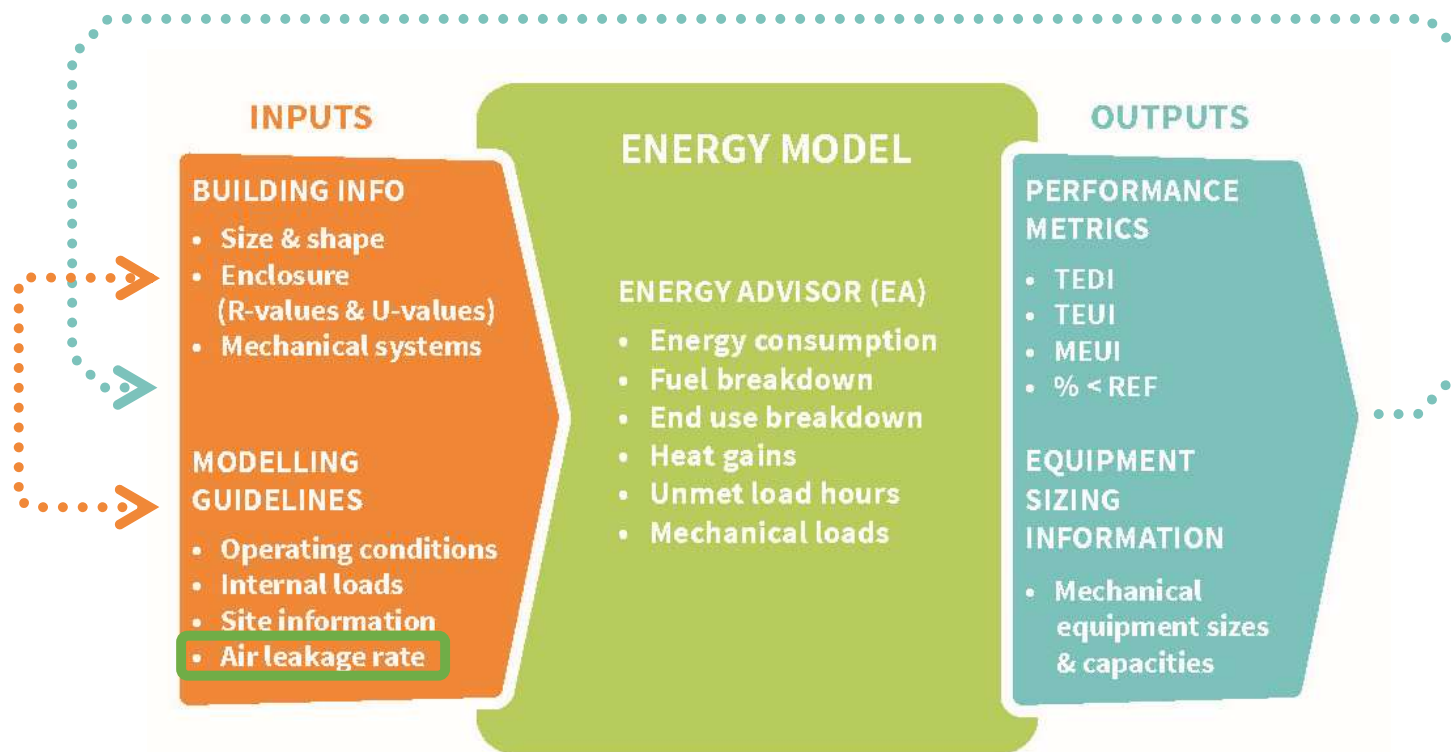


- ...The 9.36.5 proposed house sets the assumed building air leakage rate at:
- **4.5 ACH<sub>50</sub>** when built in accordance with Section 9.25.  
or
- **3.5 ACH<sub>50</sub>** when built in accordance with 9.25.3. and 9.36.2.9. - 10.  
or
- The as-built air leakage rate **can be used** for the building energy model if the energy performance targets of Step 1 are met.





# Working with Energy Advisor



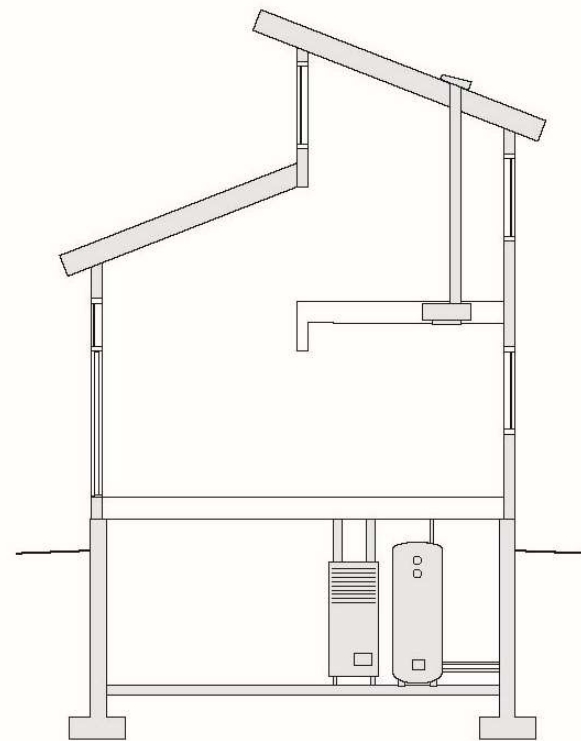
# Working with Energy Advisor

- Get them involved as early as possible
- Ask questions:
  - Experience hitting target airtightness?
  - Good trade-off options?
  - Airtightness testing schedule?
- **Track all design decisions/iterations** to avoid confusion/delay or risk not hitting targets (2.5 or 3.5 or 4.5 ACH?)
- Keep clear list of most up-to-date model inputs
  - R-values/U-values, airtightness, heating/cooling, hot water, window, ventilation

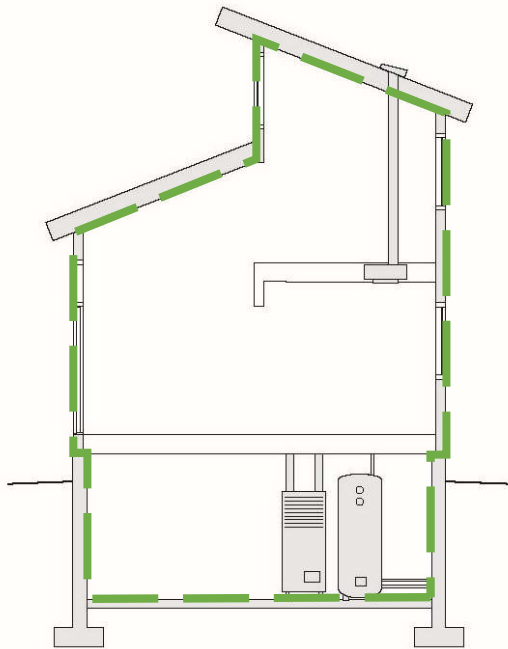


# Working with Energy Advisor – Example Models

- Hot2000 Energy Model Example
  - Medium-size house
  - Climate Zone 5
  - Targeting Step 1



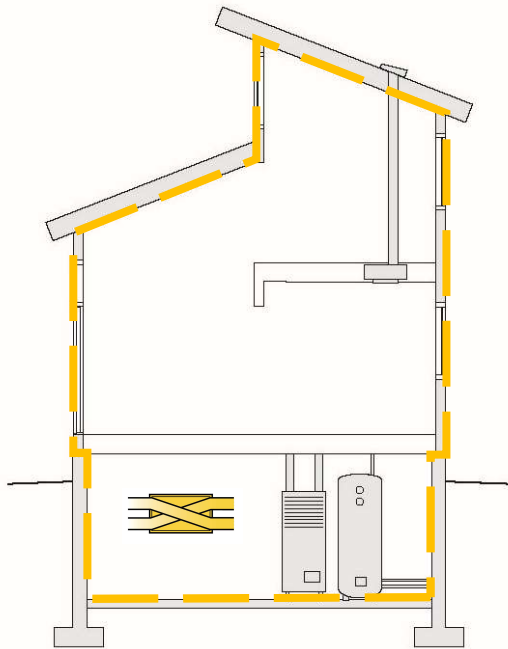
# Working with Energy Advisor – Example Models



## Reference House (Target)

- 9.36.5 compliant
- **2.5 ACH**
- Standard code-minimum insulation/windows
- Furnace heating
- Hot water tank
- No HRV
- Lowest Cost

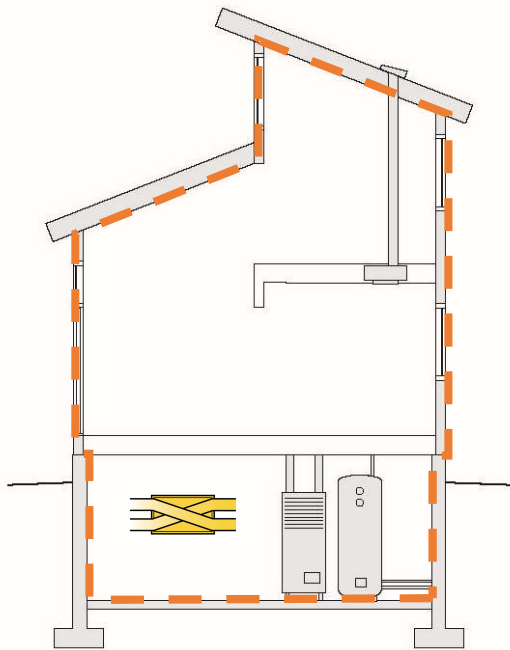
# Working with Energy Advisor – Example Models



## Alternate Approach 1: Less Airtight

- **3.5 ACH**
- **R-22** effective walls or an **HRV** required to meet Step 1
- More expensive

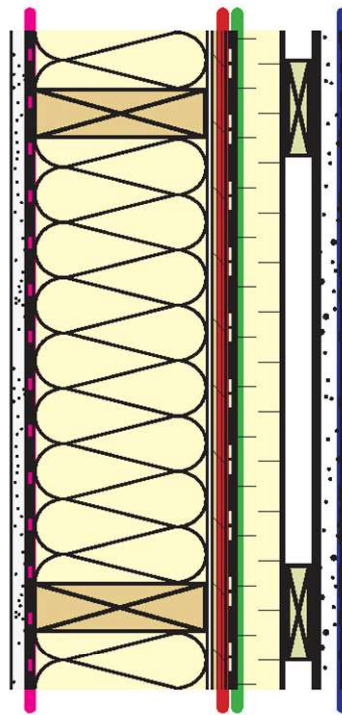
# Working with Energy Advisor – Example Models



## Alternate Approach 2: Even Less Airtight

- **4.5 ACH**
- **R-28** effective walls or an **HRV + better windows** required to meet Step 1
- Most expensive

# What is an Air Barrier?



## 5 Essential Barriers

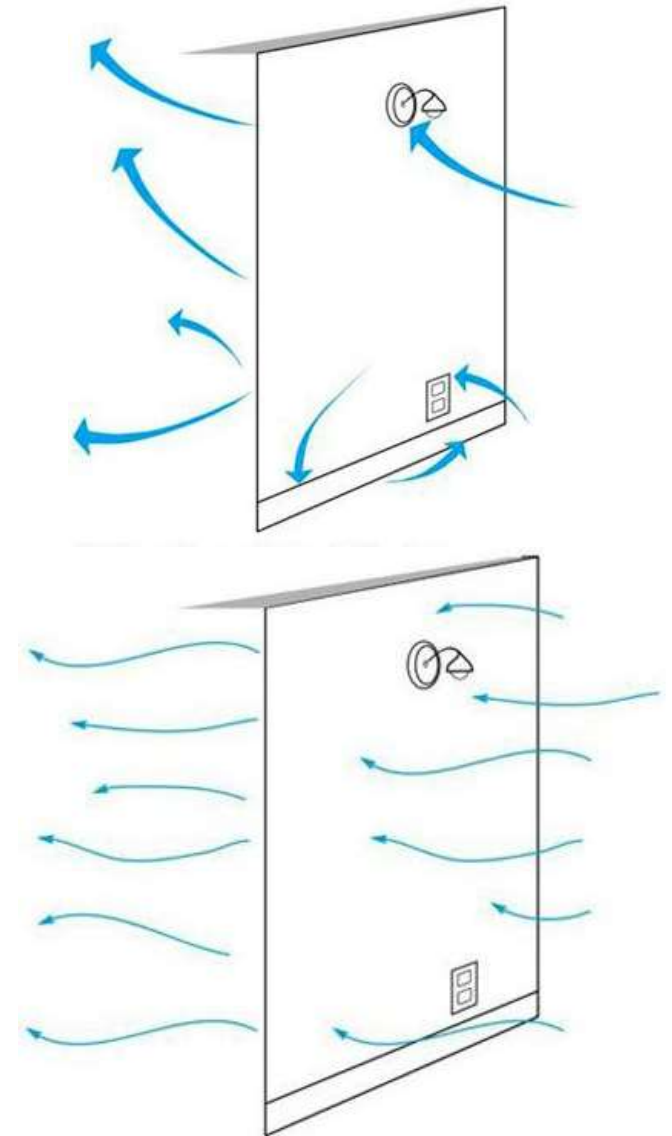
- Water Shedding Surface
- Water Resistive Barrier
- **Air Barrier**
- Vapour Retarder
- Thermal Insulation



# What is an Air Barrier?

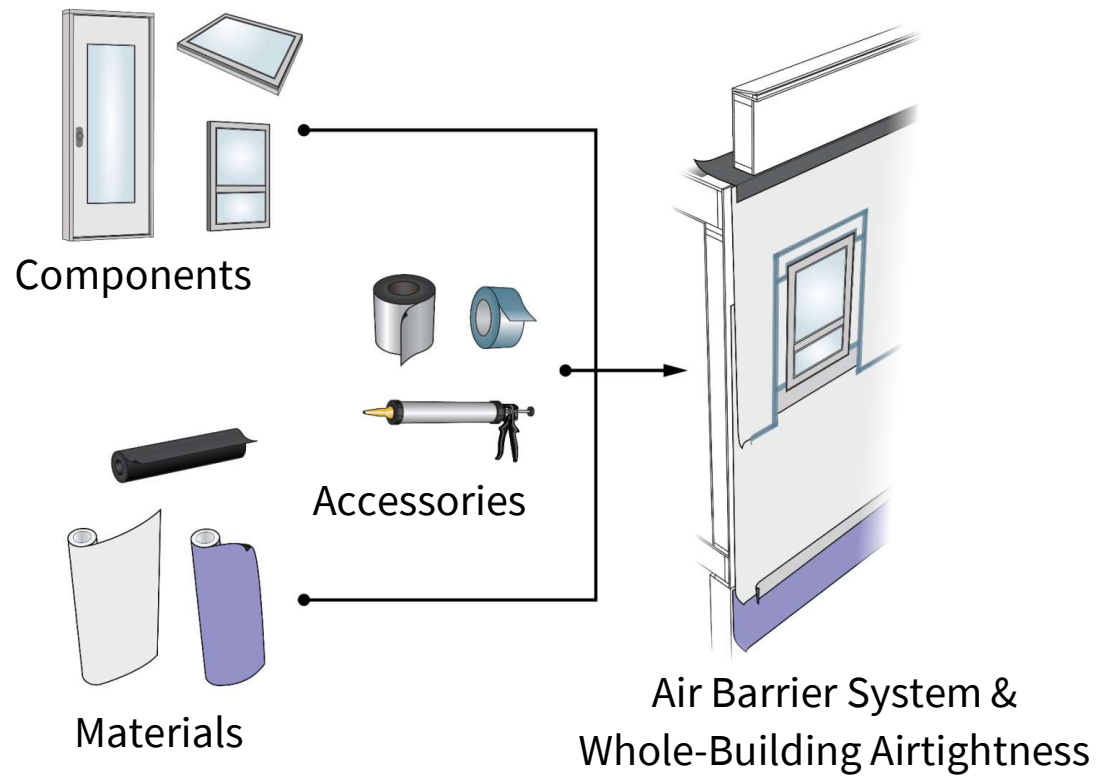
## Air vs Vapour

- An Air Barrier stops air leakage.
  - Air leakage can carry moisture, and heat or cold.
  - Multiple air barriers can be present.
- A Vapour Barrier stops diffusion of moisture.
  - Only one vapour barrier should be present.
- Breathable
  - A material is 'breathable' when vapour can diffuse through.
  - Breathable DOES NOT refer to air leakage.



The difference between air barriers and vapour barriers © Ecohome

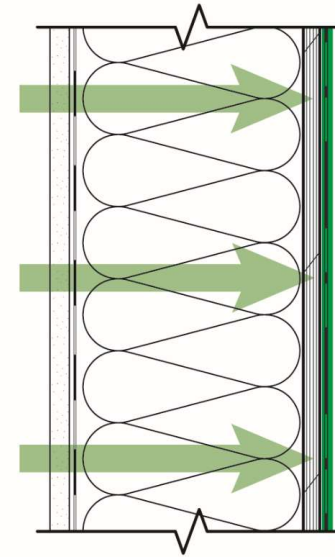
# What is an Air Barrier?



# Four Principles of the Air Barrier:

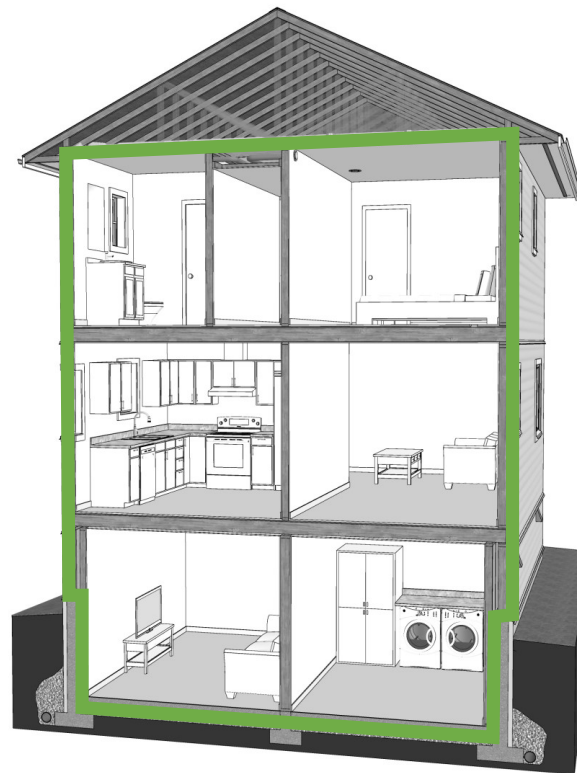
## #1: Air Impermeable

- Material, Assembly, and Whole Building!



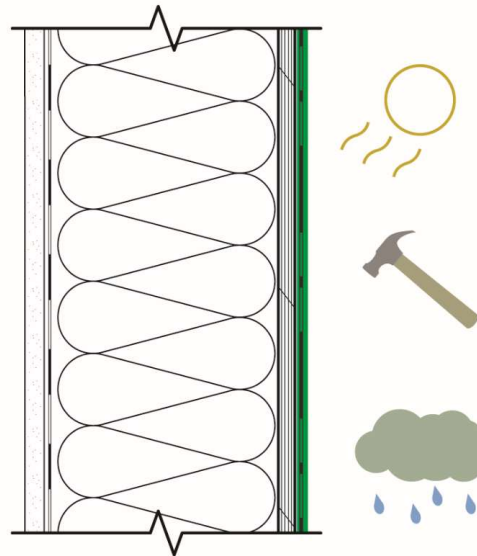
# Four Principles of the Air Barrier:

## #2: Continuous



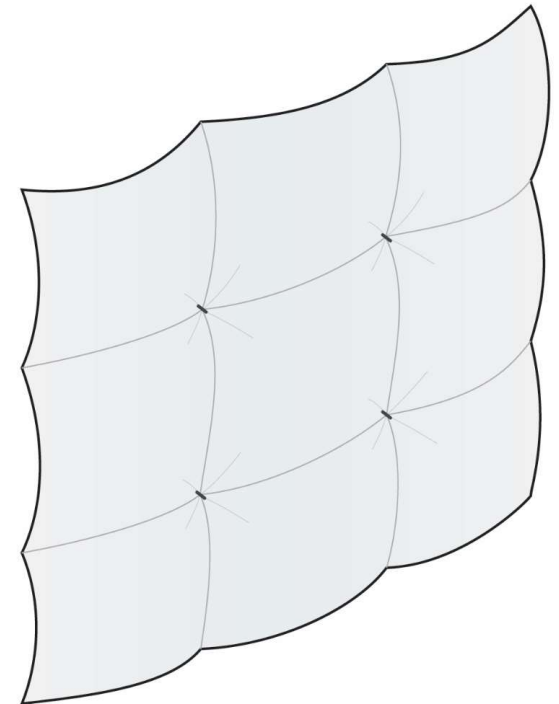
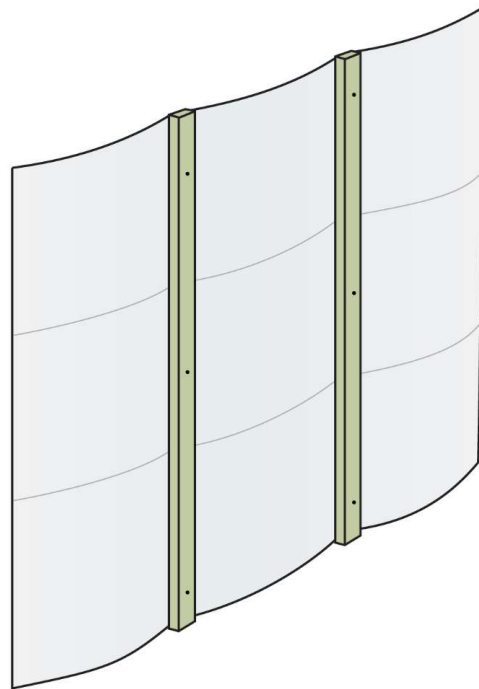
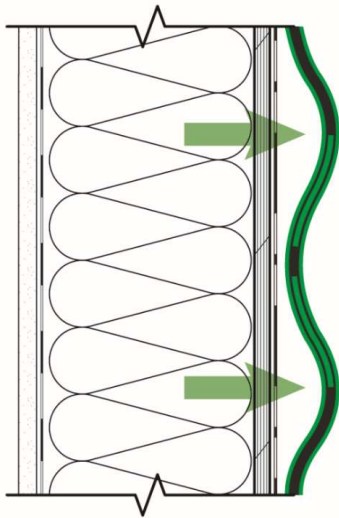
# Four Principles of the Air Barrier:

## #3: Durable

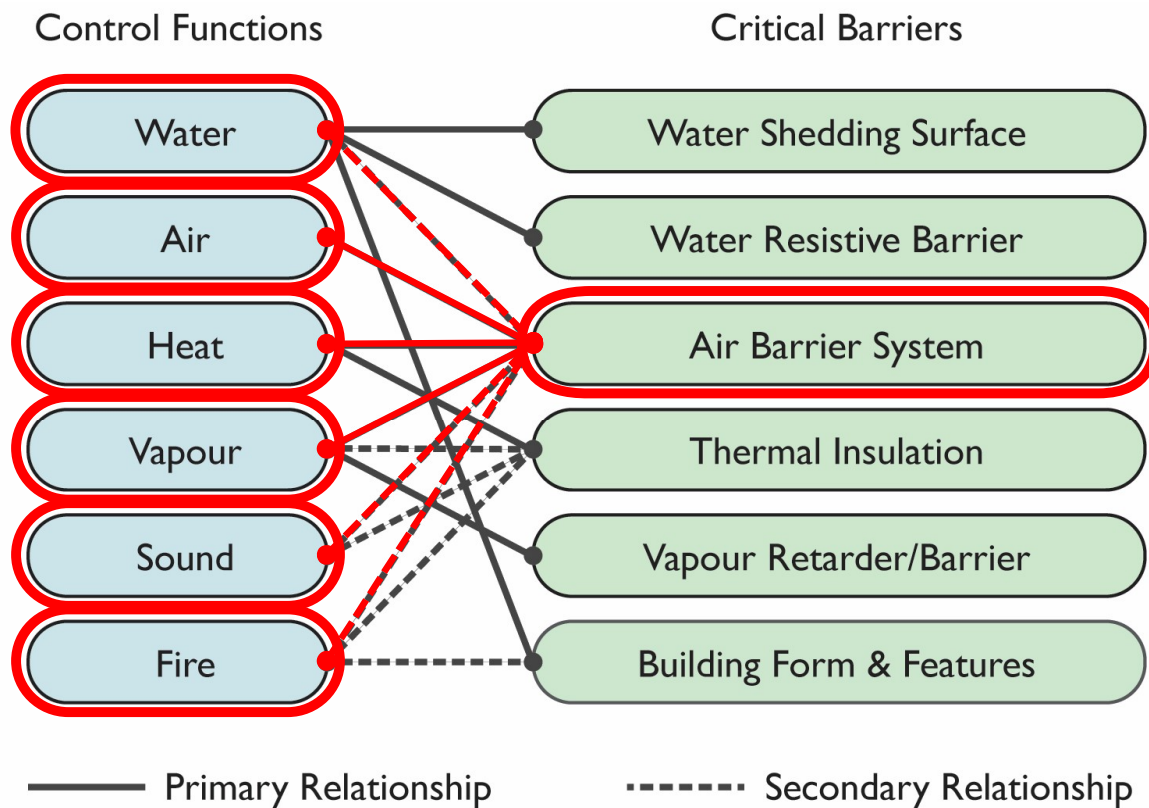


# Four Principles of the Air Barrier:

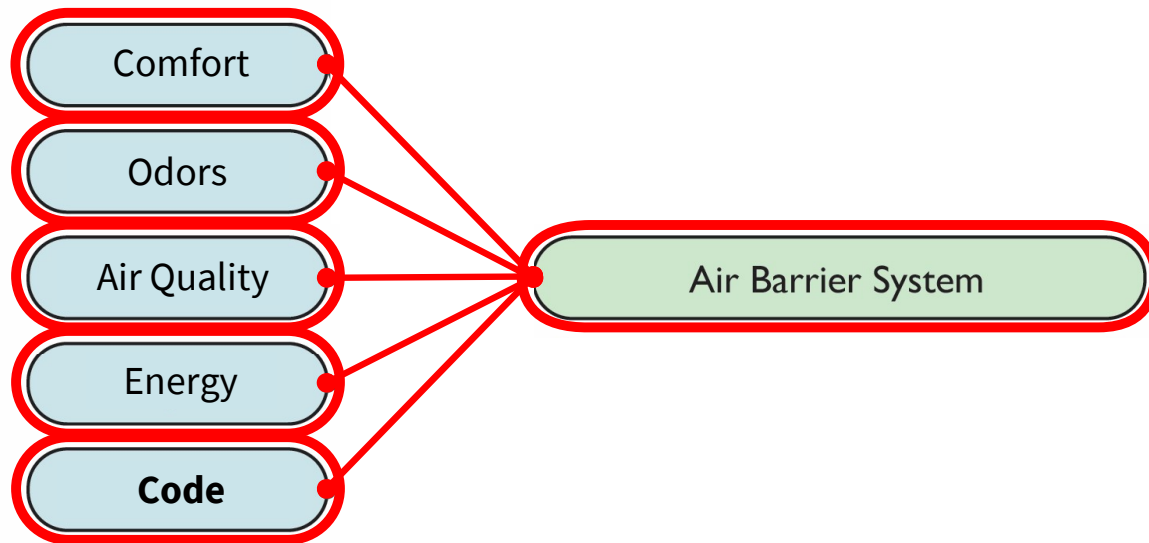
## #4: Stiff and Strong



# Why Build an Air Barrier?



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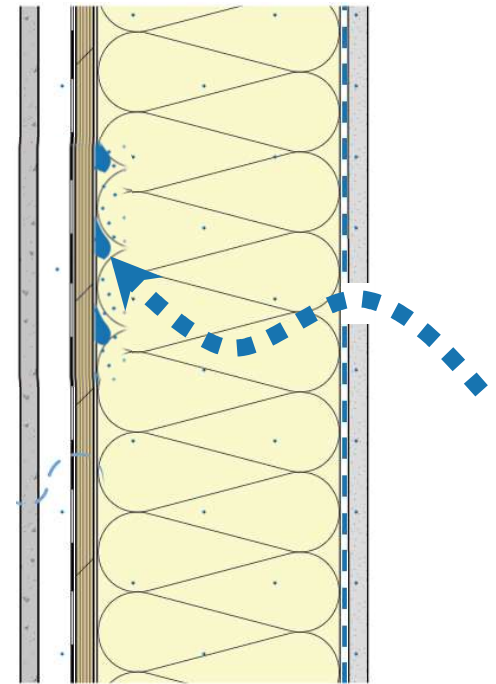


# Why Build an Air Barrier?

- Reduce condensation risk within assemblies
- Reduce heat loss/heat gain & save energy
- Maintain adequate indoor air quality
- Increase thermal and acoustic comfort
- Required by code

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# Condensation in Assemblies



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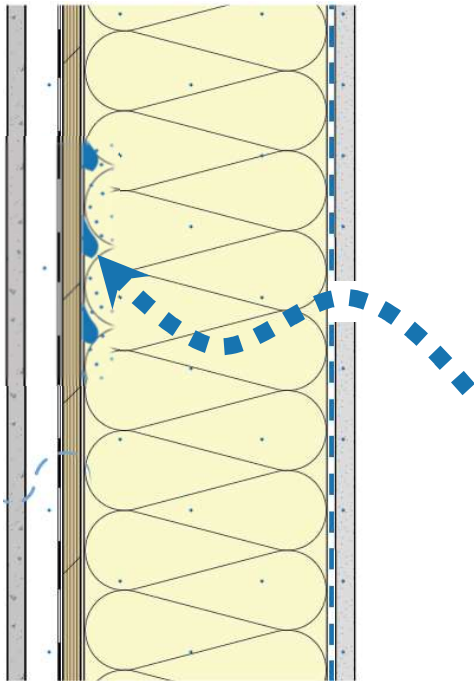
# Condensation in Assemblies



# Condensation in Assemblies



# Condensation in Assemblies



How much water could flow in air through a hole the size of a Loonie over the course of one winter?



# Condensation in Assemblies



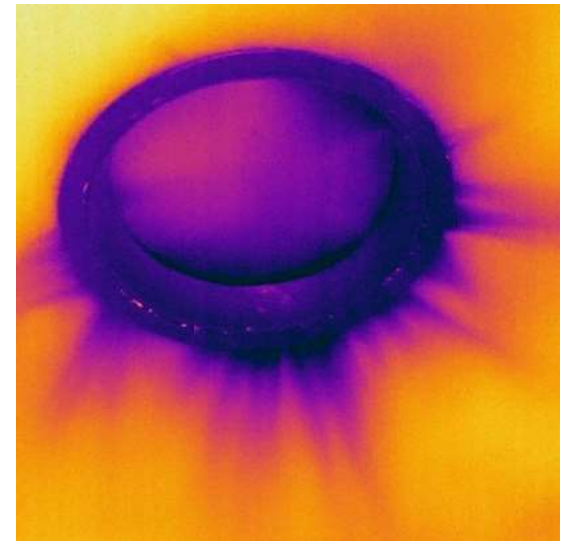
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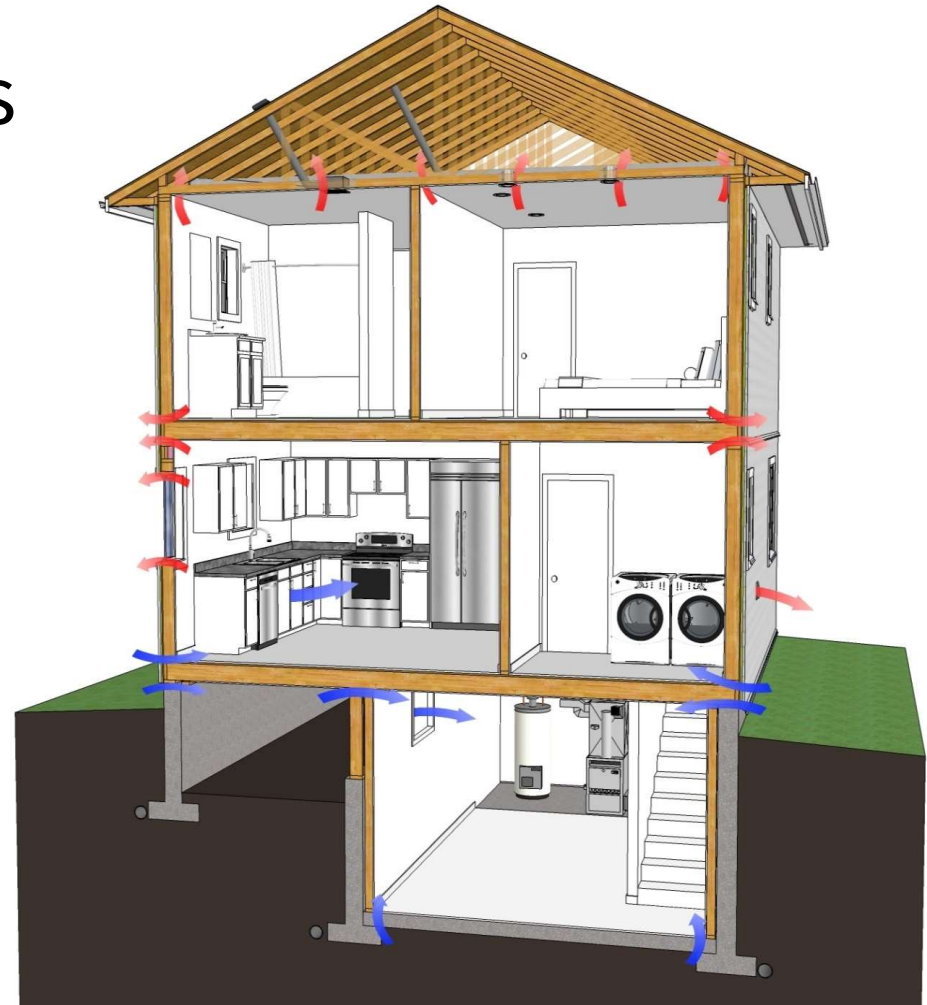
# Why Build an Air Barrier?

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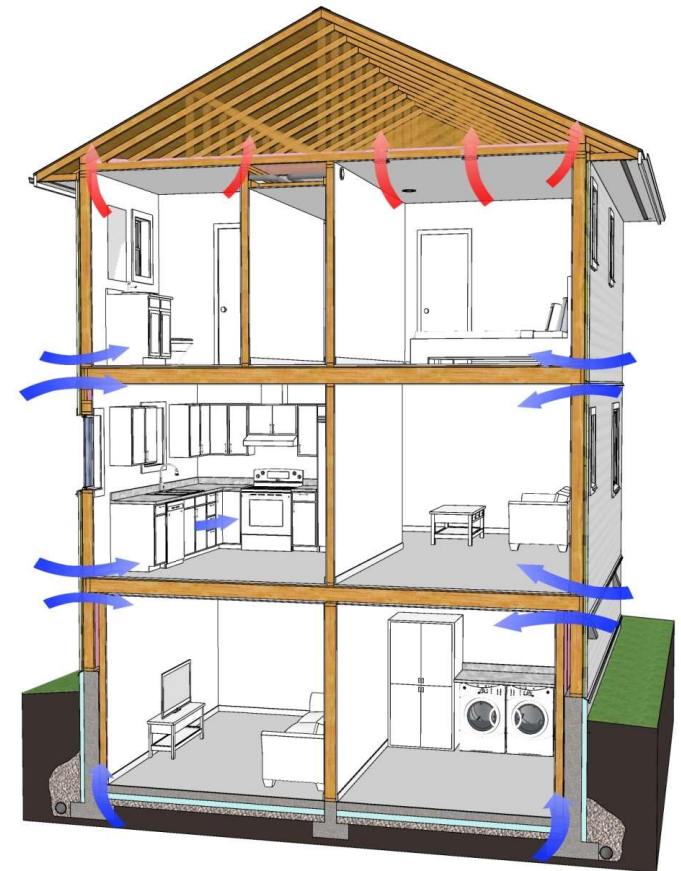
# Heat Loss = Energy Loss

When air leaks out,  
the heat (or cool)  
leaks with it.

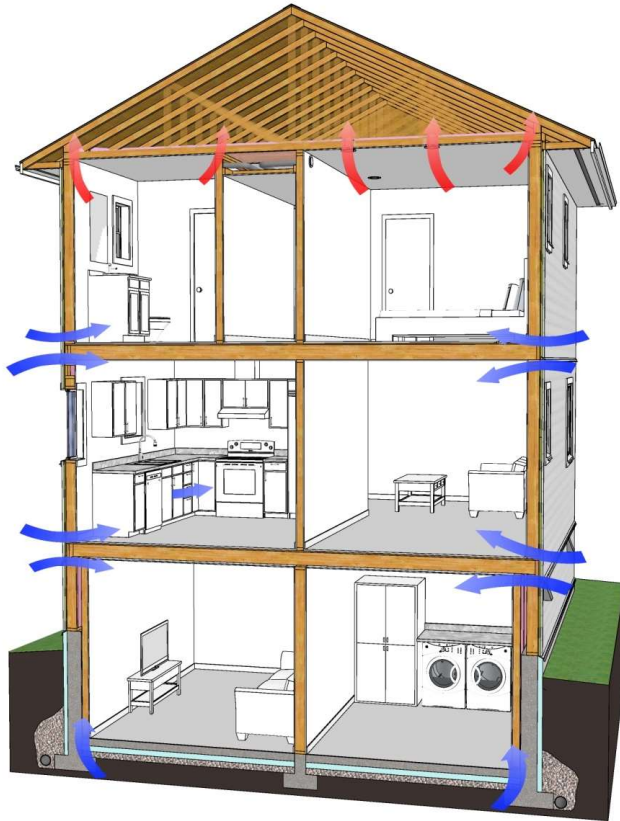


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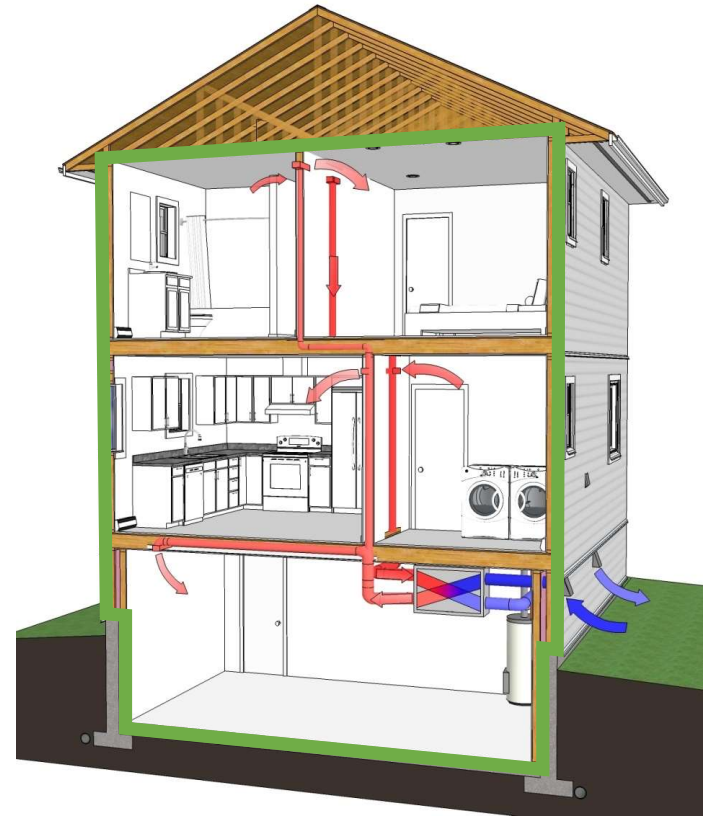
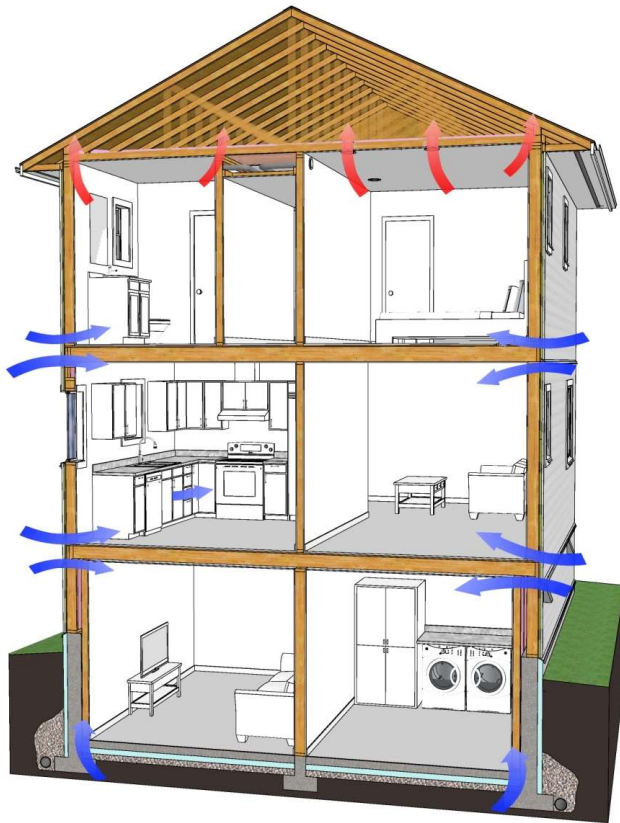


# Airtightness & Controlled Ventilation



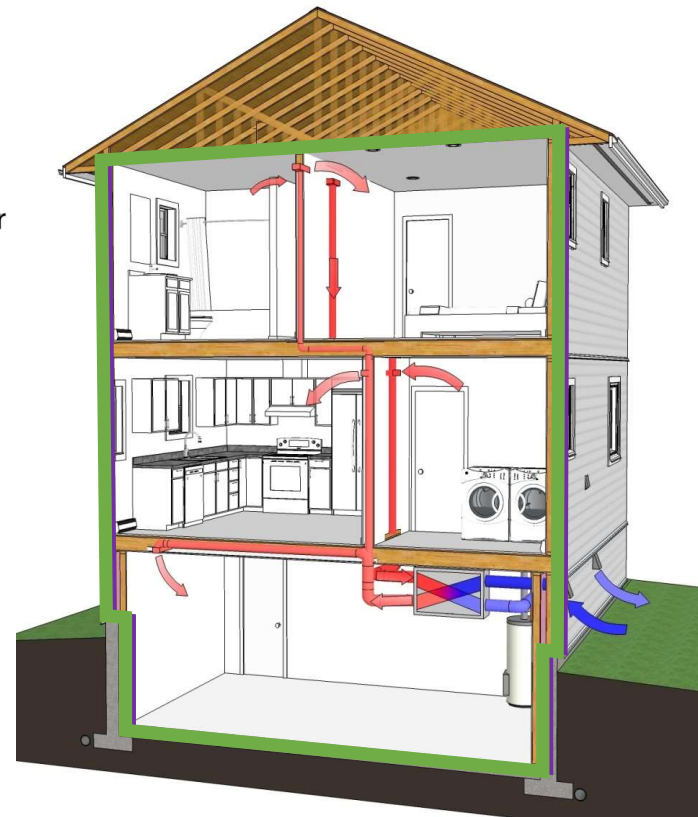
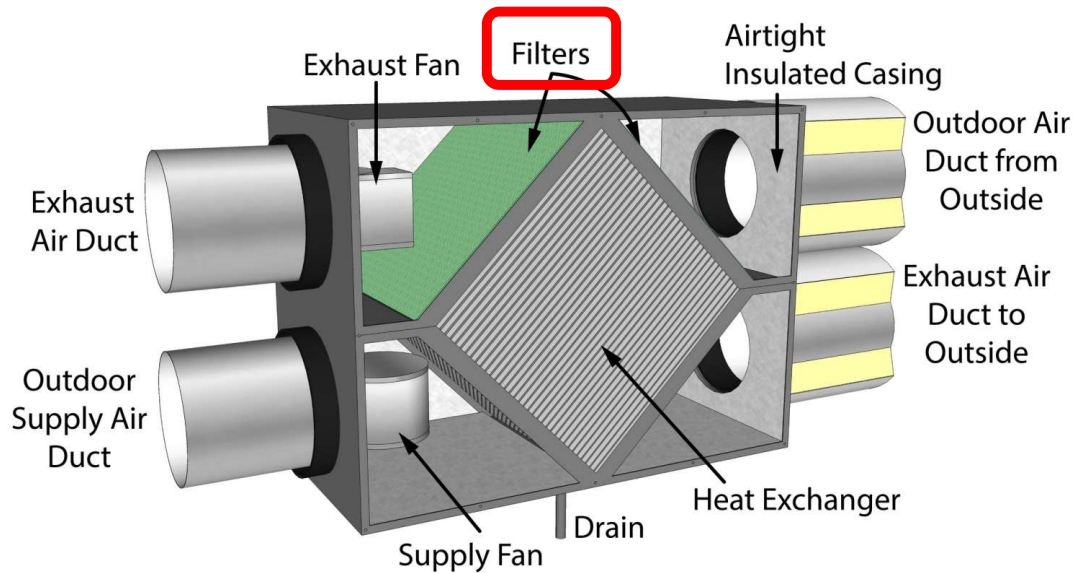
Outdoor air pulled into house through enclosure with no filters.

# Airtightness & Controlled Ventilation



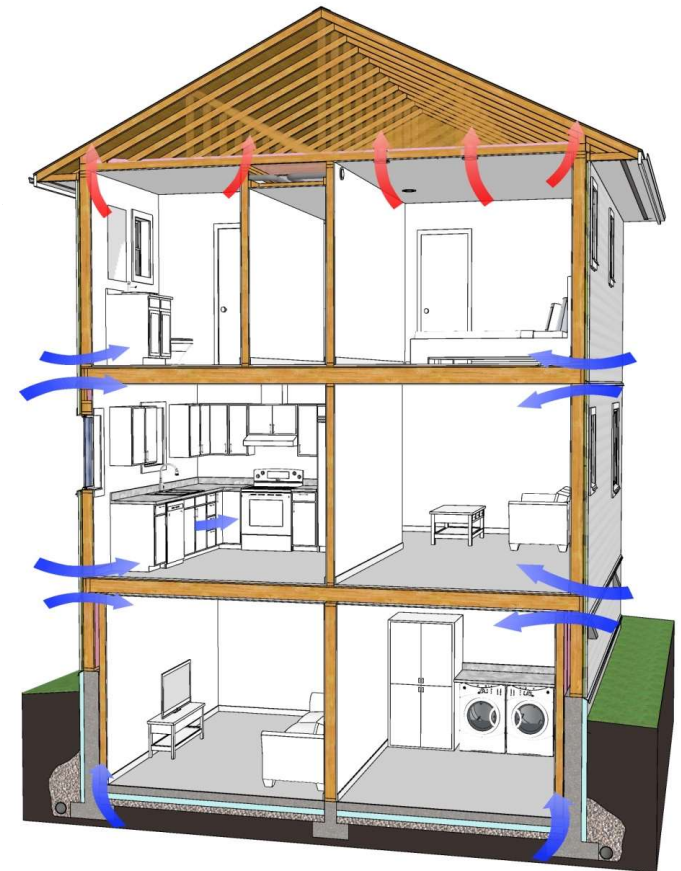
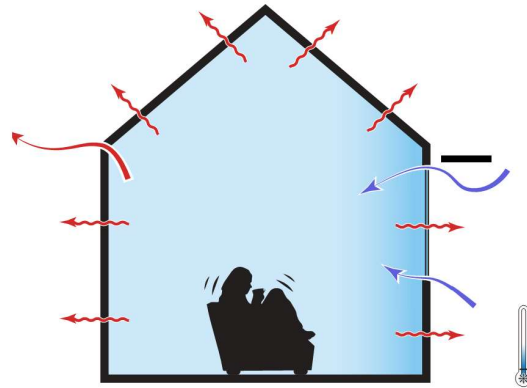


# Airtightness & Controlled Ventilation



# Why Build an Air Barrier?

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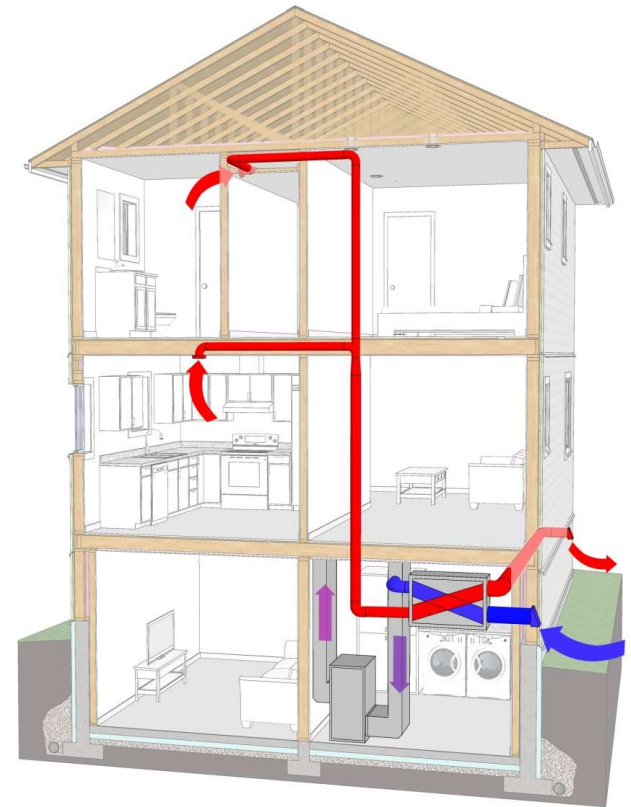


Where is the source of Air Leakage?



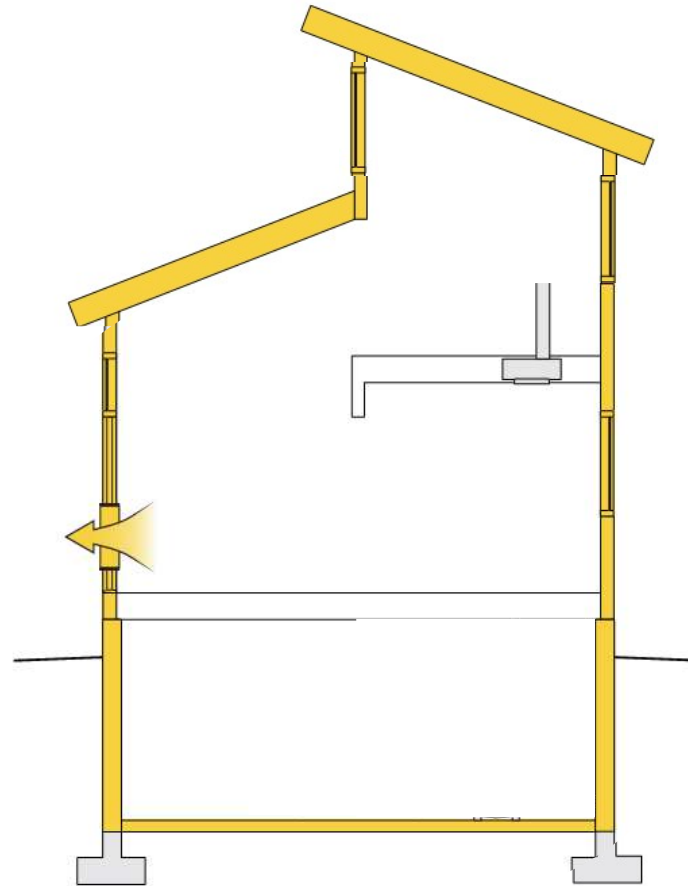
# House as a System

- Building airtightness is a good step in overall building energy efficiency
- Part of an “Enclosure First” approach
- Optimized when **combined** with energy efficient heating/cooling and ventilation systems – move towards high-performance building



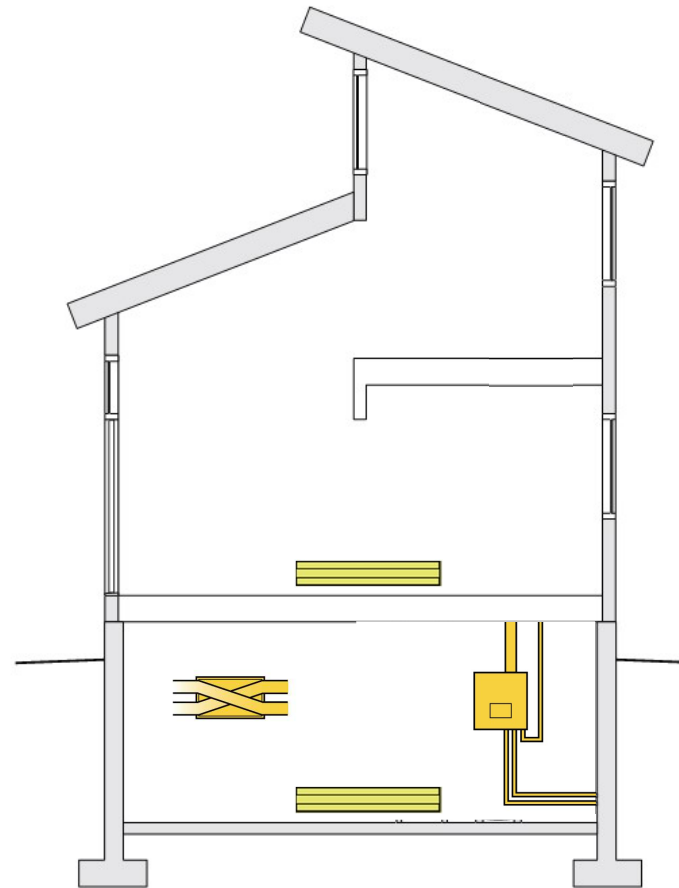
# House as a System

- Enclosure first:
  - **Airtightness**
  - Windows & Doors
  - Walls/Roofs/Floors



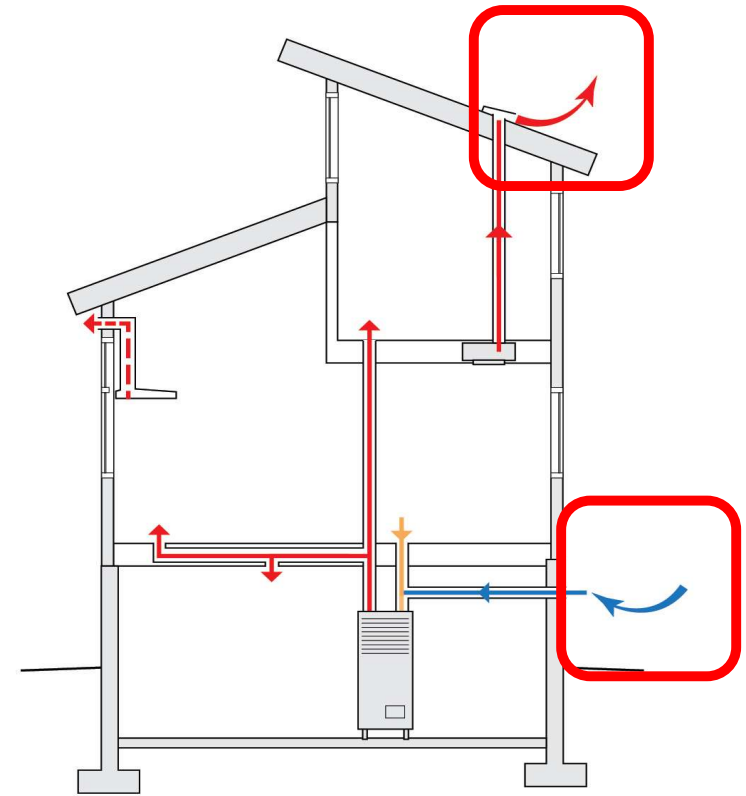
# House as a System

- Mechanical:
  - **Ventilation**
  - Heating/Cooling
  - Hot water



## House as a System: Airtightness & HRVs

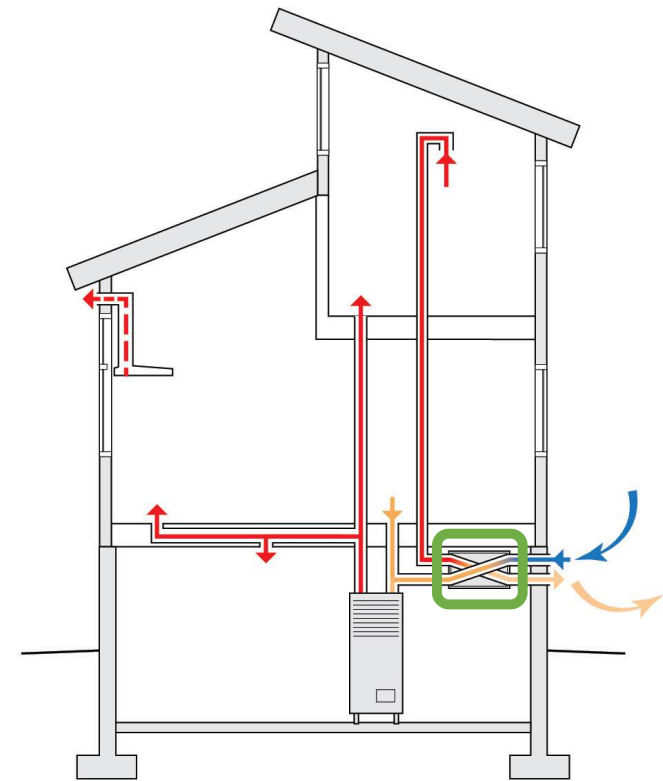
- Mechanical ventilation is always required
- Conventional systems exhaust conditioned air directly and waste energy
- HRVs can be used to recover the heat from exhaust air and transfer it to incoming ventilation air



Conventional

## House as a System: Airtightness & HRVs

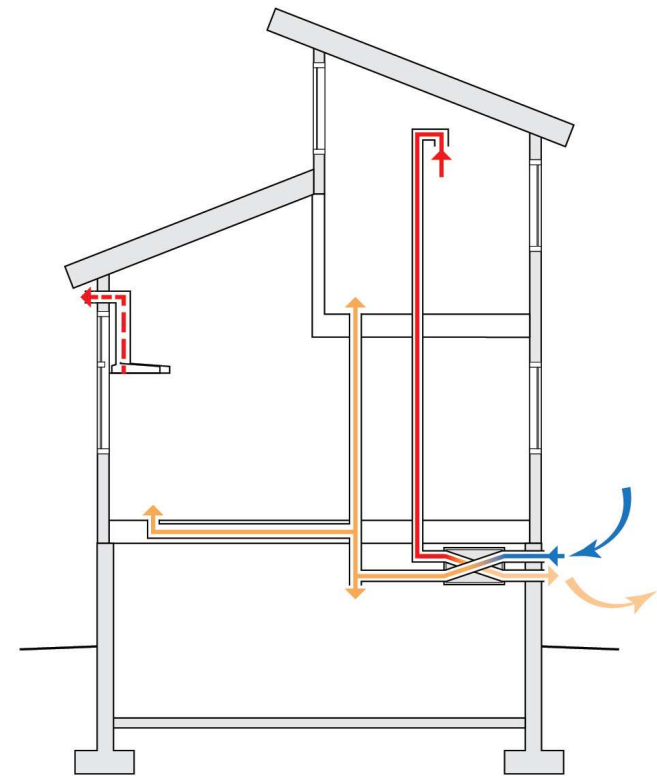
- HRVs can be used to recover the heat from exhaust air and transfer it to incoming ventilation air
- HRVs can be integrated with the ducted heating/cooling system or installed as a standalone system.
  - Return air from bathrooms instead of bathroom fans
  - No return from kitchen fan



Heating/Cooling + HRV

## House as a System: Airtightness & HRVs

- HRVs can be used to recover the heat from exhaust air and transfer it to incoming ventilation air
- HRVs can be integrated with the ducted heating/cooling system or installed as a standalone system.
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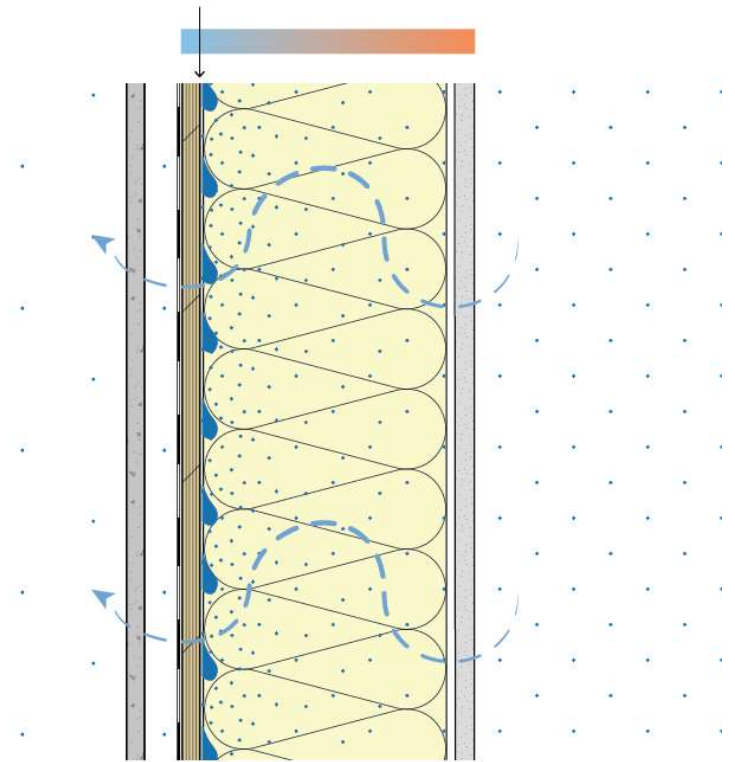
Standalone HRV System



# Does the Insulation Type and Ratio Matter?

## Condensation in Assemblies:

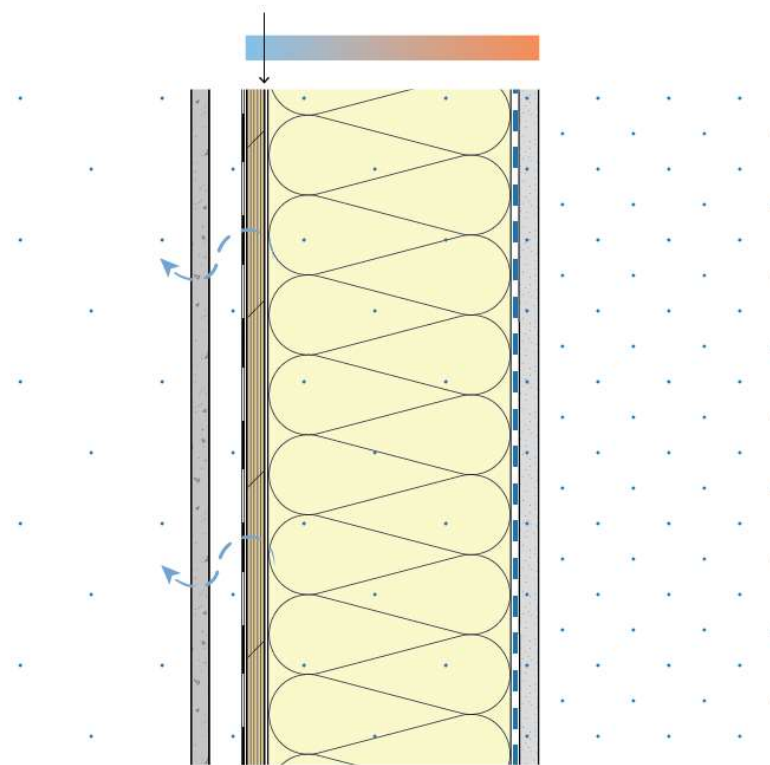
- During wintertime, vapour flow can occur outwards through an insulated enclosure assembly
- Increased flow occurs in homes with high interior RH and colder exterior conditions.
- Adding a vapour retarder at the interior slows the outward flow enough so that condensation risk within the cavity is reduced
- Incidental moisture can still escape outwards if no exterior vapour impermeable layers are used.





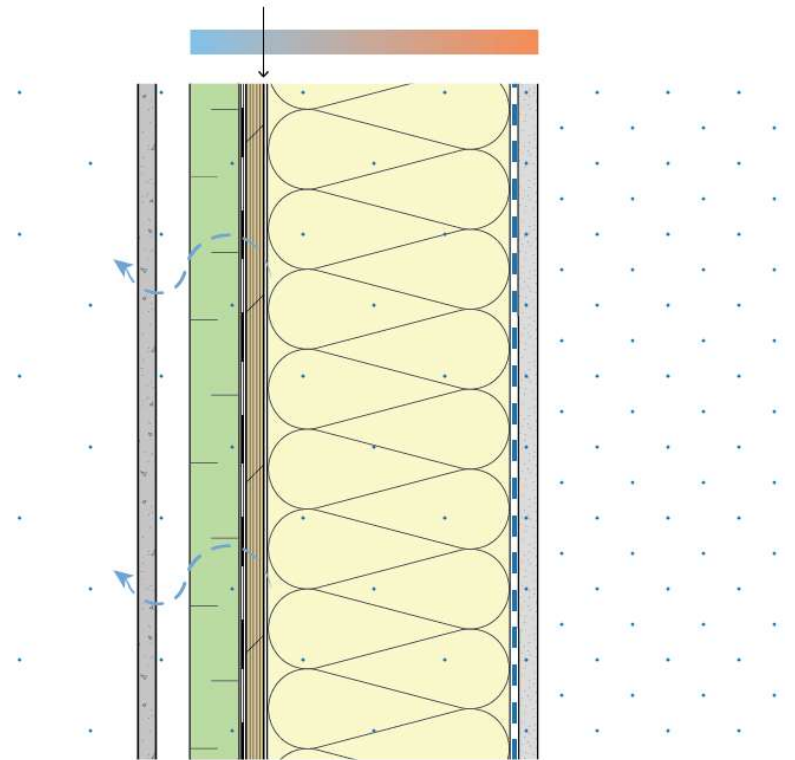
# Does the Insulation Type and Ratio Matter?

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# Does the Insulation Type and Ratio Matter?

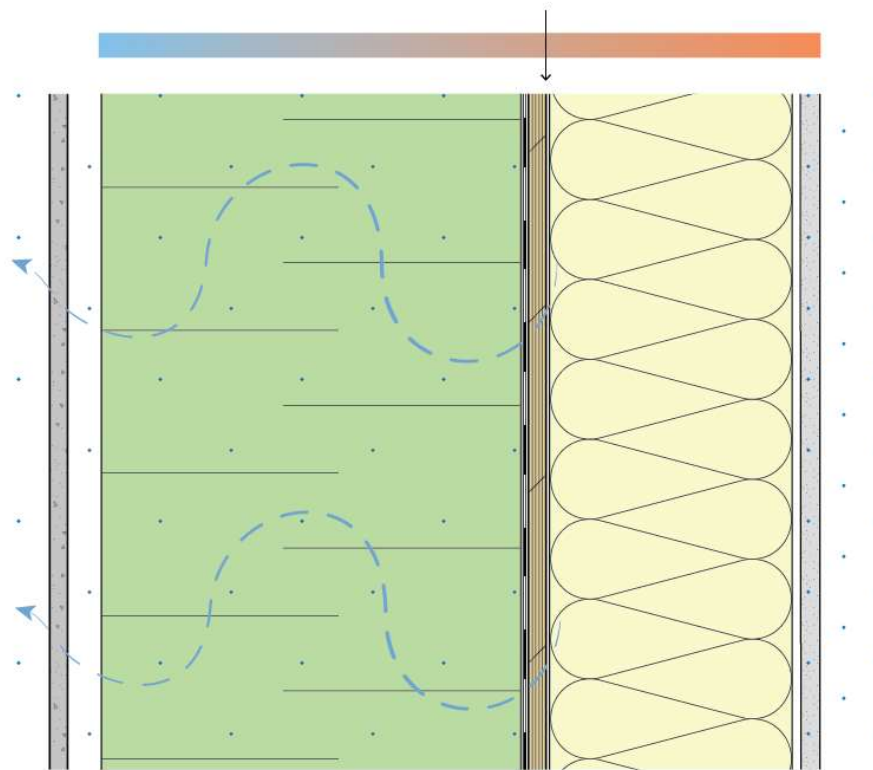
- Adding any type of exterior insulation warms up the sheathing, lowering the potential for condensation.
- Permeable exterior insulation allows vapour to flow through to the exterior if needed.



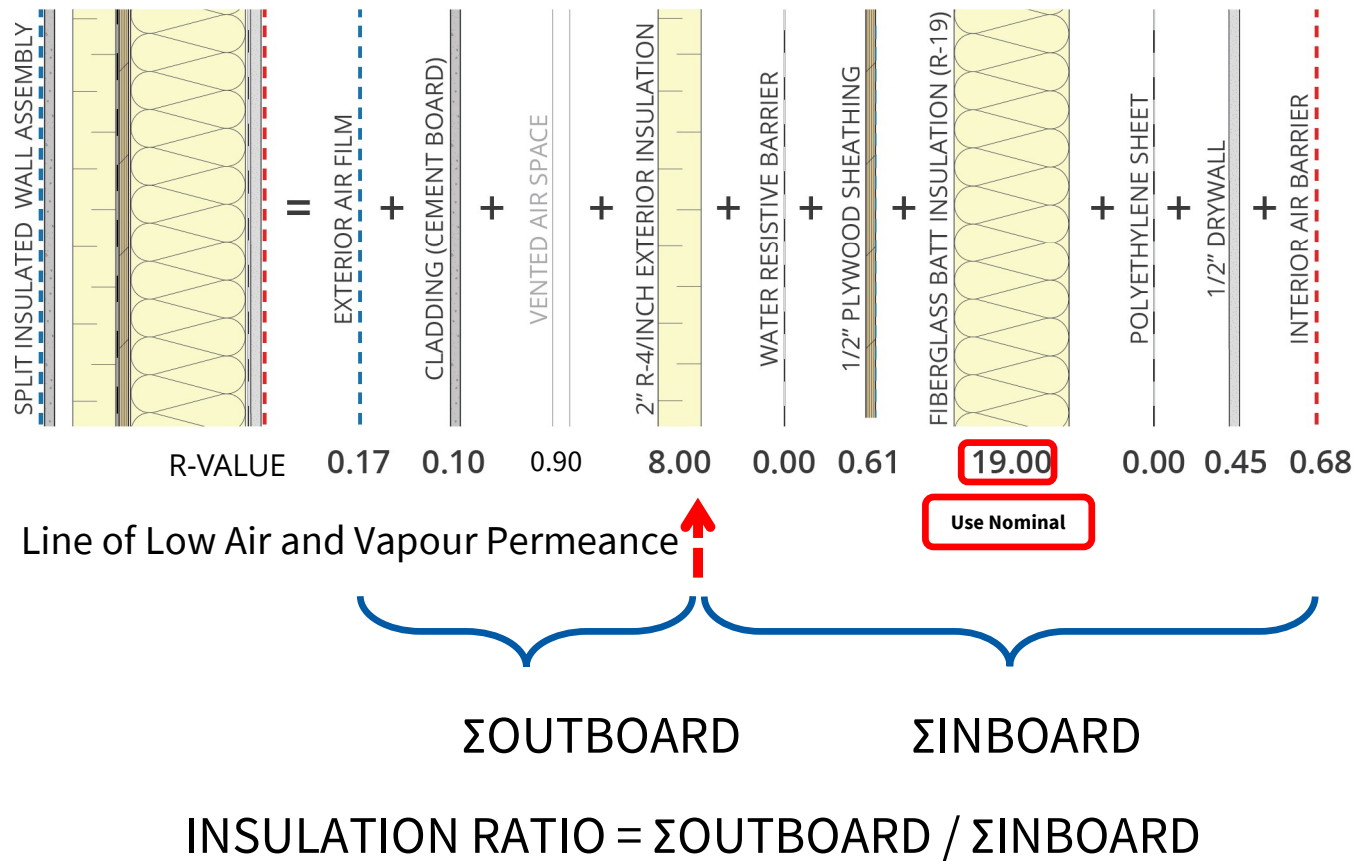


# Does the Insulation Type and Ratio Matter?

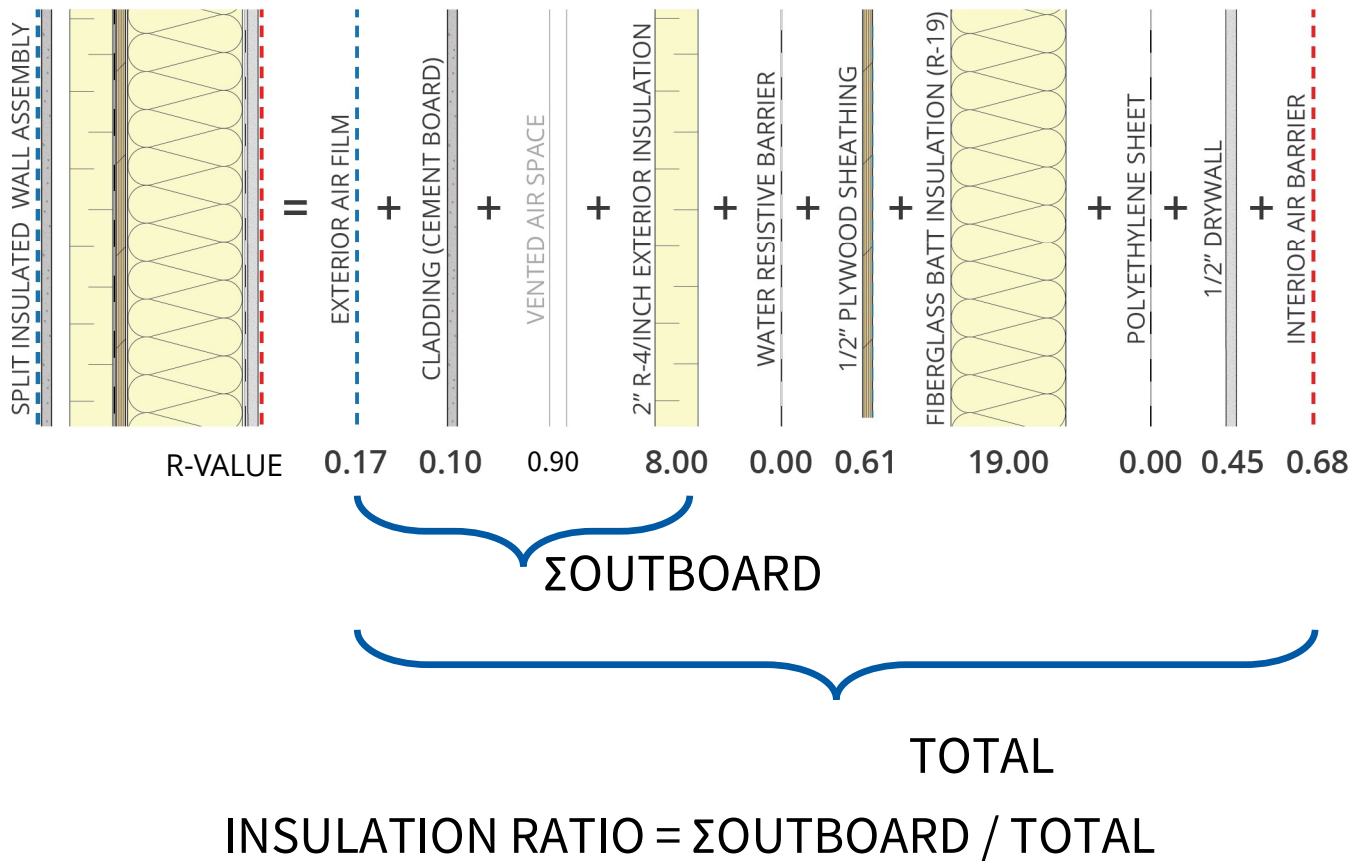
- With high ratio thicknesses of any type of exterior insulation, the sheathing will be above the interior dewpoint.
- Not at risk of vapour diffusion condensation or air leakage condensation – allows for high degree of design flexibility and redundancy



# Insulation Ratio Calculations: Outboard to **Inboard R-value**

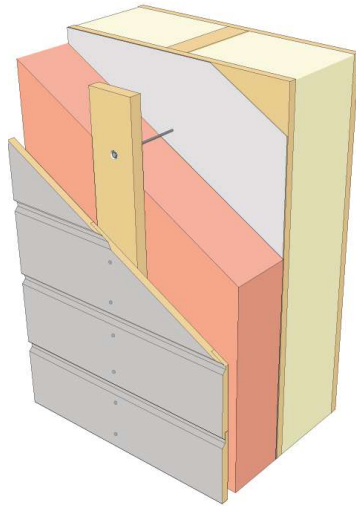


# Insulation Ratio Calculations: Outboard to **Total R-value**



# Exterior Insulation Types

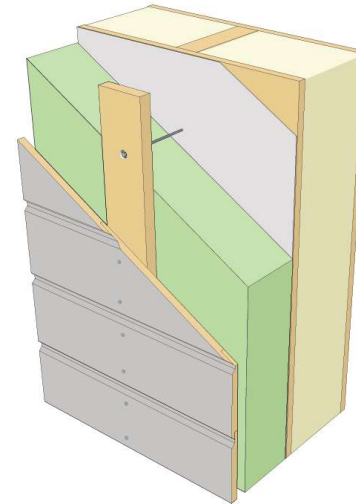
Impermeable



XPS | Polyiso | EPS\* | ccSPF

Must comply with Table 9.25.5.2  
**(insulation ratios)**

Vapour Permeable



Mineral Wool | Wood Fibre |  
Cellulose Fibre | Fibreglass

Not required to comply with  
9.25.5.2

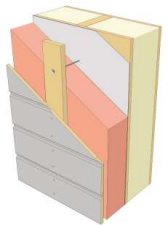
# Vapour Permeance of Various Exterior Insulations

Insulation Type	Permeance (US Perms)							
	1"	2"	3"	4"	5"	6"	7"	8"
XPS	0.9	0.4	0.3	0.2	0.2	0.1	0.1	0.1
Closed Cell Sprayfoam	1.7	0.9	0.6	0.4	0.3	0.3	0.2	0.2
Polyiso with Paper Facers	2.0	1.0	0.7	0.6	0.4	0.4	0.3	0.3
Polyiso with Foil Facers	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EPS (Type 1)	3.5	1.8	1.2	0.9	0.7	0.6	0.5	0.4
Wood Fiber Board	9.1	4.6	3.0	2.3	1.8	1.5	1.3	1.1
Open Cell Sprayfoam	60.2	30.1	20.1	15.1	12.0	10.0	8.6	7.5
Rigid Stone Wool	88.8	49.5	29.6	22.2	17.8	14.8	12.7	11.1
Cellulose	92.3	46.1	30.8	23.1	18.5	15.4	13.2	11.5
Rigid Fiberglass	145.1	72.5	48.4	36.3	29.0	24.2	20.7	18.1



## Required Ratio of **Outboard to Inboard** Thermal Resistance from BCBC 9.25.5.2

Heating Degree Days	Minimum Ratio of Total Thermal Resistance Outboard of Material's Inner Surface to Total Thermal Resistance Inboard of Materials Inner Surface	Outboard to Total Ratio
Up to 4999	0.20	0.17
5000 – 5999	0.30	0.23
6000 – 6999	0.35	0.26
7000 – 7999	0.40	0.29
8000 – 8999	0.50	0.33
9000 – 9999	0.55	0.35
10000 – 10999	0.60	0.38
11000 – 11999	0.65	0.39
12000 or higher	0.75	0.43

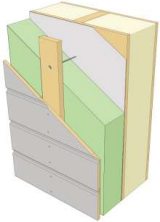


Note: these ratios apply to assemblies with a **Type II interior vapour retarder** ( $60 \text{ ng/Pa} \cdot \text{s} \cdot \text{m}^2$ ) and interior relative humidity of ~50% or less

Recommended Ratio of **Outboard to Total** Thermal Resistance  
to Limit Condensation Risk

Winter Design Temperature	Indoor Wintertime Relative Humidity				
	20%	30%	40%	50%	60%
0	0.0	0.12	0.32	0.47	0.60
-10	0.23	0.40	0.54	0.64	0.73
<b>-20</b>	<b>0.41</b>	<b>0.55</b>	<b>0.65</b>	<b>0.73</b>	<b>0.80</b>
-30	0.53	0.64	0.72	0.78	0.84
-40	0.66	0.70	0.76	0.82	0.86

Kelowna

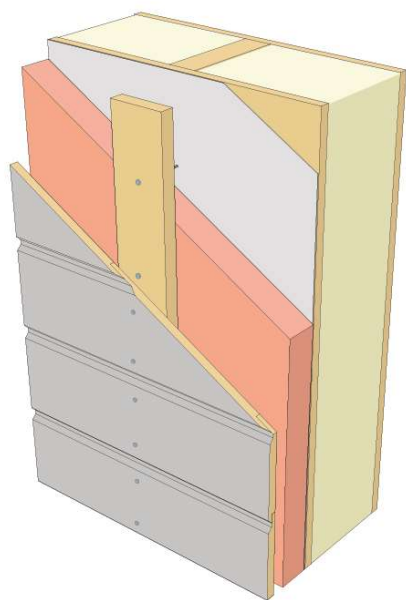


Note: Ratios assume no interior vapour control layer and allow for any type of exterior insulation, sheathing or WRB on the exterior of the cavity, as they raise the temperature of the sheathing above the indoor dewpoint and lower the risk of vapour diffusion/air leakage condensation

***Assess at Average Wintertime conditions and expected indoor RH levels***



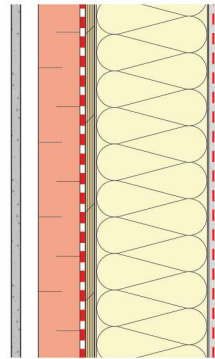
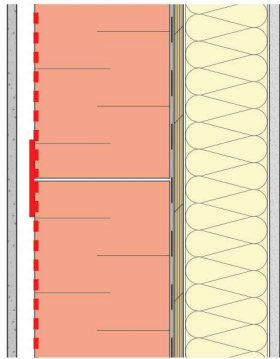
## Exterior Insulation – What 9.25.5 Doesn't Cover



- **Air Barrier method/placement**
- Water Resistive Barrier placement
- Incidental moisture?
- Cladding attachment/type

# Air Barrier Position and Exterior Insulation

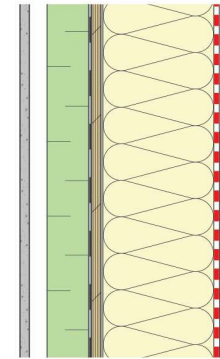
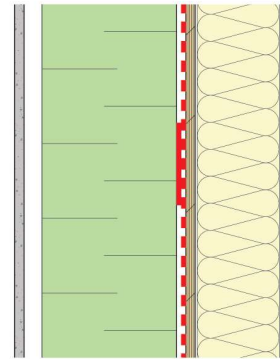
**Impermeable**  
Insulation



**Safe**  
(High Ratios)

**Cautionary**  
(Low Ratios)

Relatively **Permeable**  
Insulation



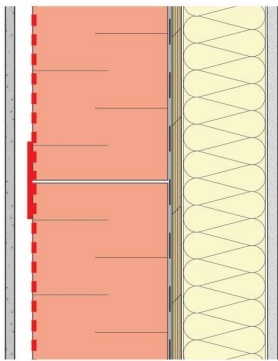
**Safe**  
(High Ratios)

**Cautionary**  
(Low Ratios)

# Air Barrier Position and Exterior Insulation

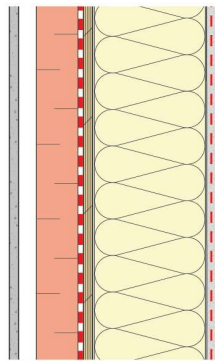
Exterior or mid-wall approaches most desirable

- Taped/sealed foam insulation
- Sealed Sheathing
- Sealed Sheathing Membrane



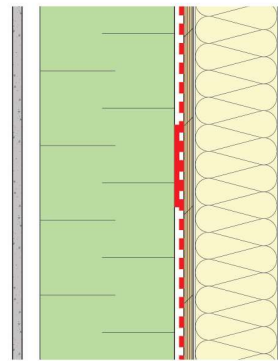
Risk of convective looping within cavity, provide some interior airtightness

- Sealed Sheathing
- Sealed Sheathing Membrane
- **Airtight drywall/smart vapour retarder to limit convection potential**



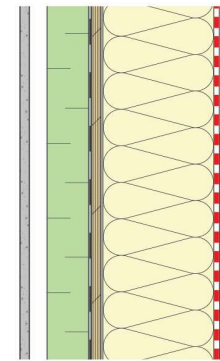
Mid-wall sheathing air barrier approaches most desirable

- Sealed Sheathing
- Sealed Sheathing Membrane
- Interior AB possible



Risk of convective looping within cavity, provide some interior airtightness

- Sealed Sheathing
- Sealed Sheathing Membrane
- Sealed Polyethylene, Drywall, or Interior Sheathing



# Exterior Insulation Resources

## ILLUSTRATED GUIDE

### R22+ Effective Walls in Residential Construction in British Columbia

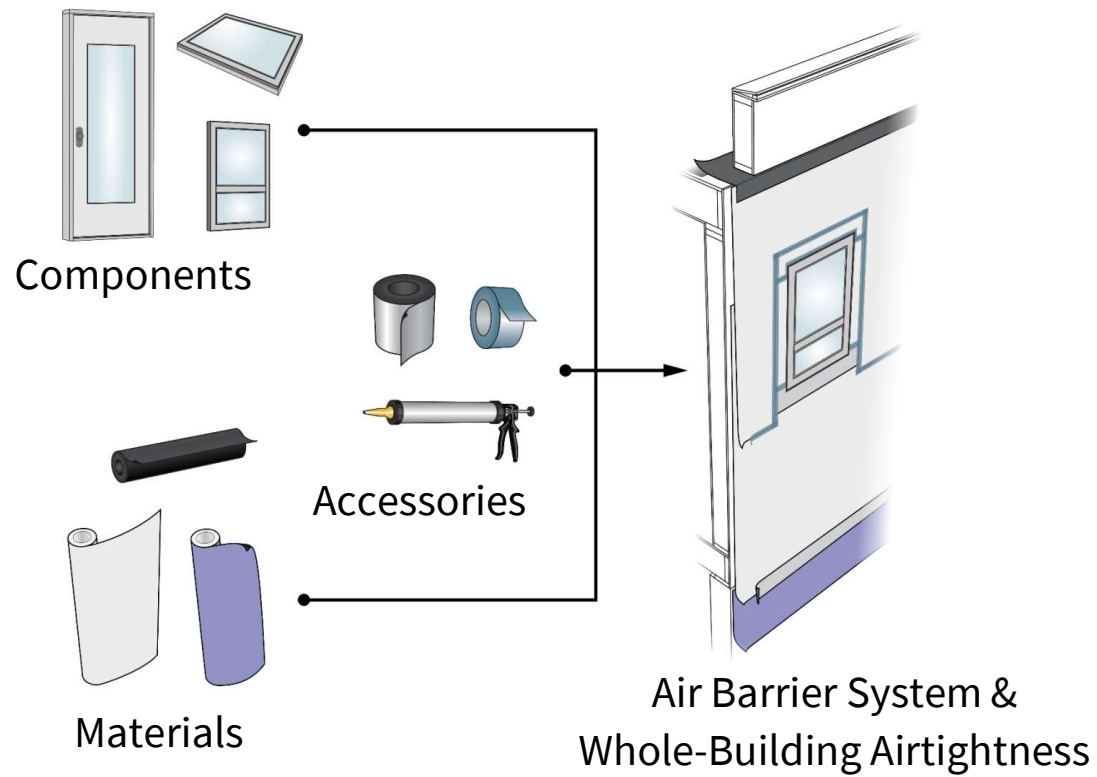
NOVEMBER 2017



This guide was developed to assist builders and designers to construct walls that achieve R22 or higher thermal performance. The information included in this guide is relevant for low- and mid-rise residential buildings across British Columbia.

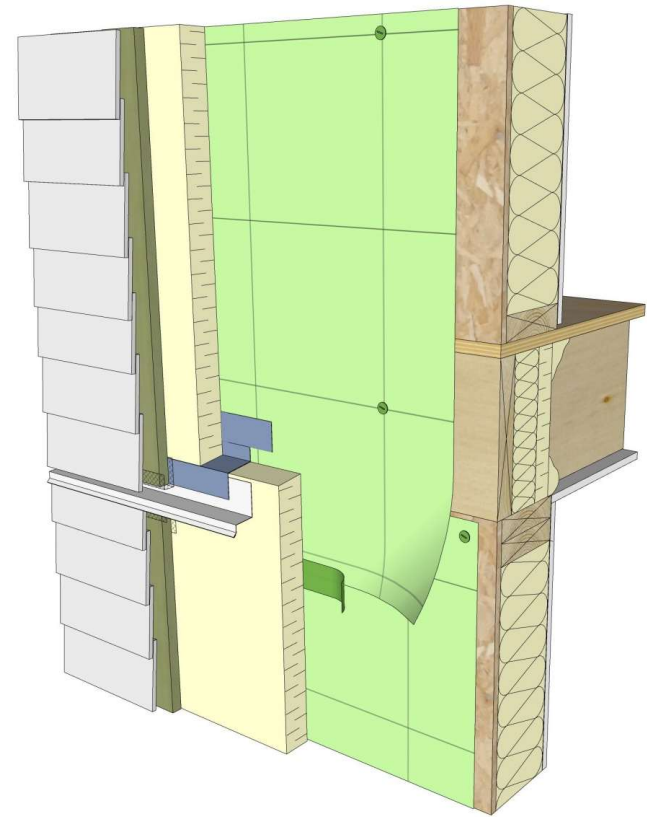


# What Materials Comprise the Air Barrier?



# Air Barrier Materials

- **BCBC 9.25.3.2. Sentence 1**
- **BCBC 9.36.2.10 Sentence 1**
- Materials intended to provide the principal resistance to air leakage must be air impermeable.

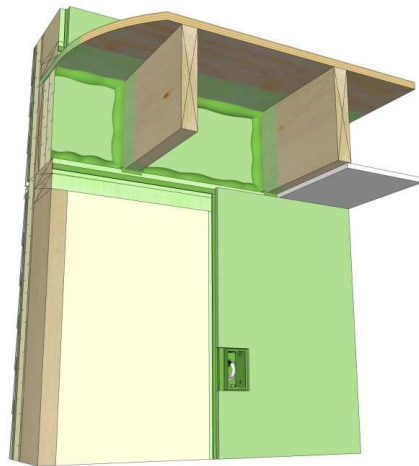




# Wall Air Barrier Approaches: Interior



Spray Foam\*



Airtight Drywall



Sealed Polyethylene



Sealed Sheathing  
**(with service cavity)**

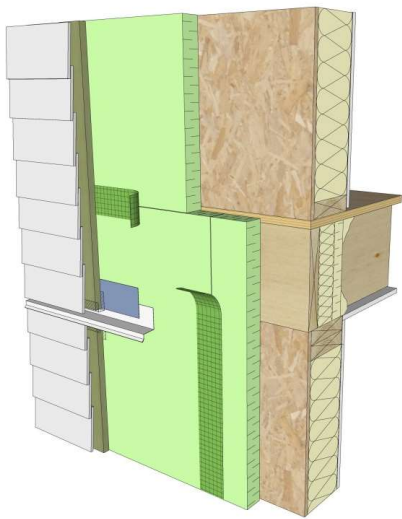
CONSTRUCTABILITY



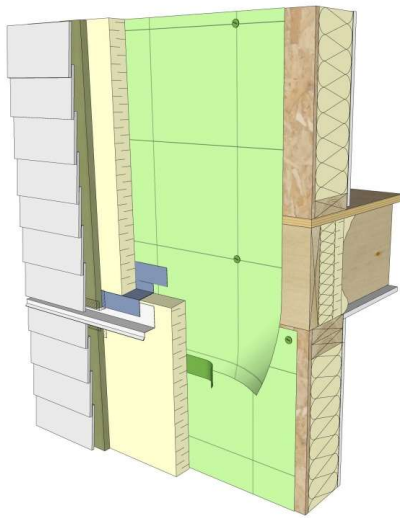
AIRTIGHTNESS



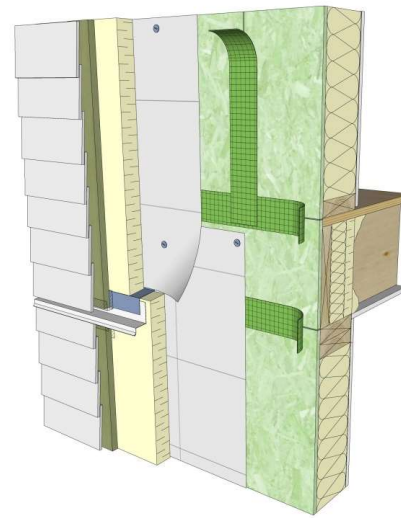
# Wall Air Barrier Approaches: Exterior



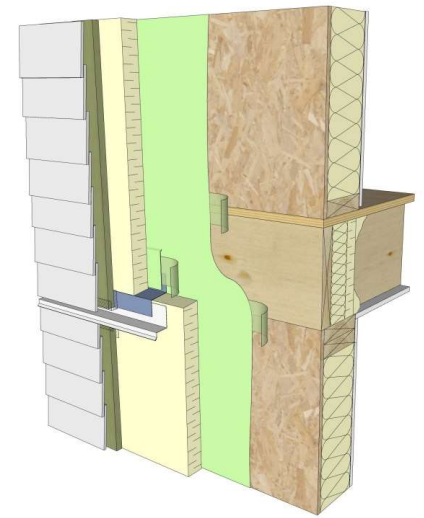
Sealed Insulation



Sealed Sheathing Membrane



Sealed Sheathing



Liquid Applied

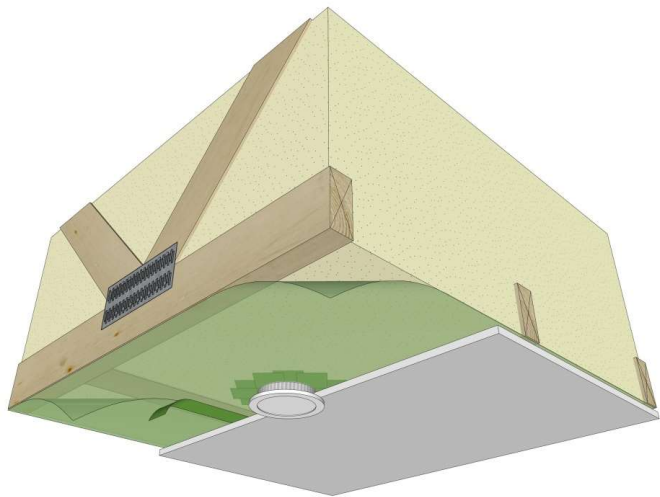
CONSTRUCTABILITY



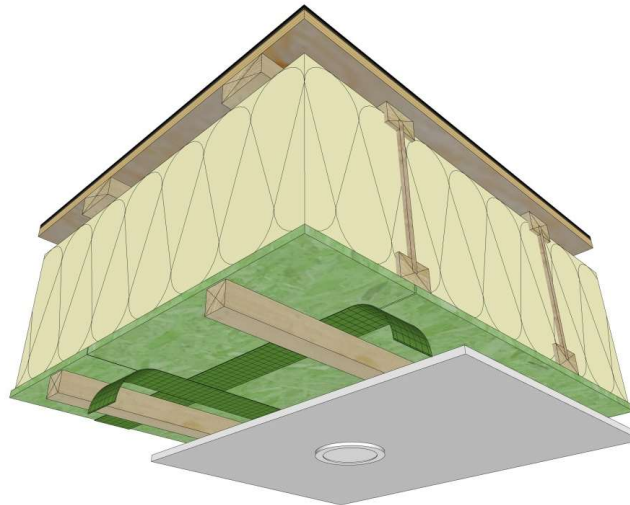
AIRTIGHTNESS



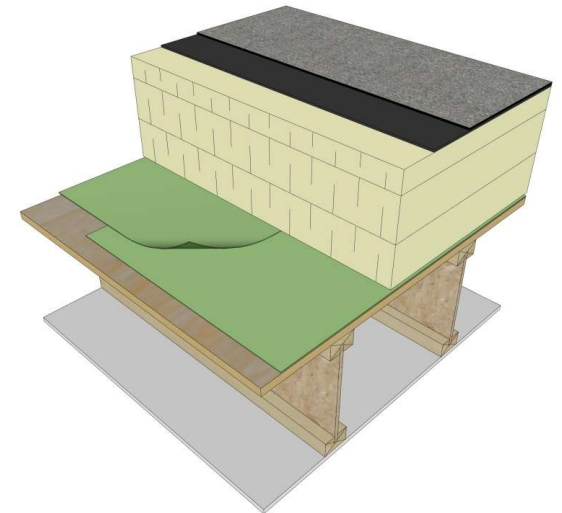
# Roof/Ceiling Air Barrier Approaches



Sealed Interior Polyethylene



Sealed Interior Sheathing  
**(with service cavity)**



Self-adhered Exterior  
Membrane\*

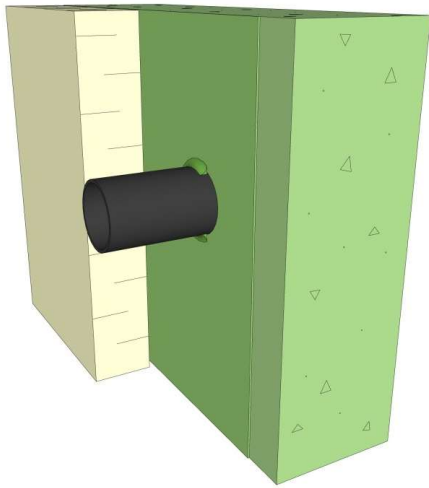
CONSTRUCTABILITY



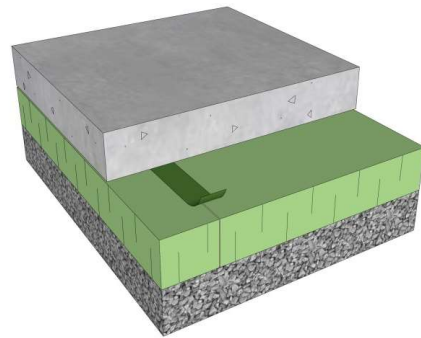
AIRTIGHTNESS



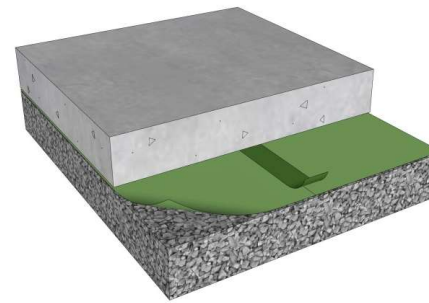
# Below-Grade Air Barriers



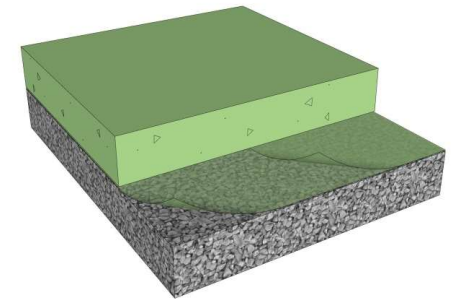
Foundation Wall



Sealed Insulation



**Sealed** Polyethylene



Slab + Polyethylene

CONSTRUCTABILITY



AIRTIGHTNESS





# Air Barrier Accessories



Tapes

- Standard acrylic tape (blue/red)
- Self-adhered membrane
- High-performance sheathing/detailing tape



# Air Barrier **Accessories**



Sealant

- Consumer-grade
  - Acrylic/Latex
- Construction-grade
  - Acoustic sealant
- Commercial grade sealants
  - Silicone
  - Urethane
  - Hybrid



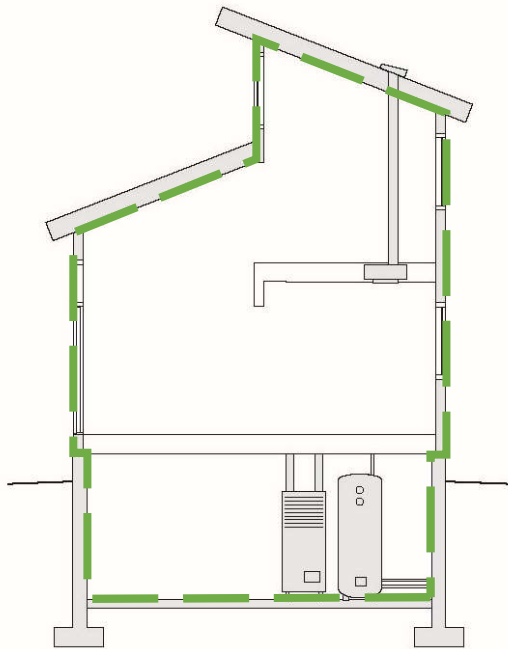
# Air Barrier Accessories



Spray Foam

- Consumer-grade
  - Spray can/straw applicator
- Construction-grade
  - Two-part pre-packaged polyurethane
- Commercial-grade
  - Two-part truck-based applications
    - Open-cell
    - Closed-cell

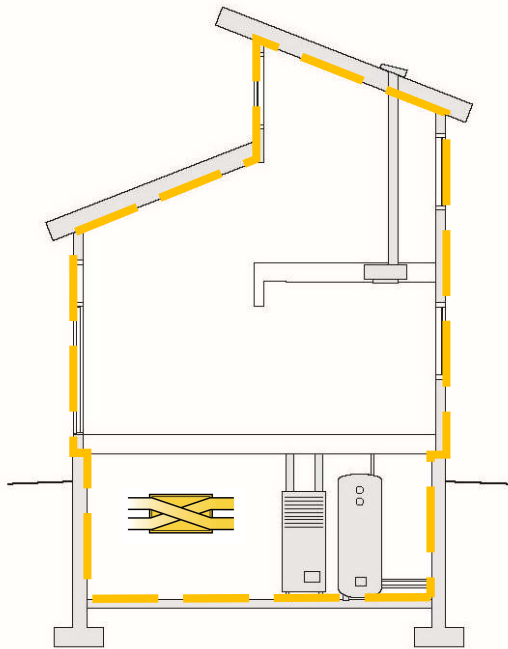
# Cost? See Example Models



## Base Case – Hot2000 Medium House

- 9.36.5 compliant
- **2.5 ACH**
- Standard code-minimum insulation/windows
- Furnace heating
- Hot water tank
- No HRV

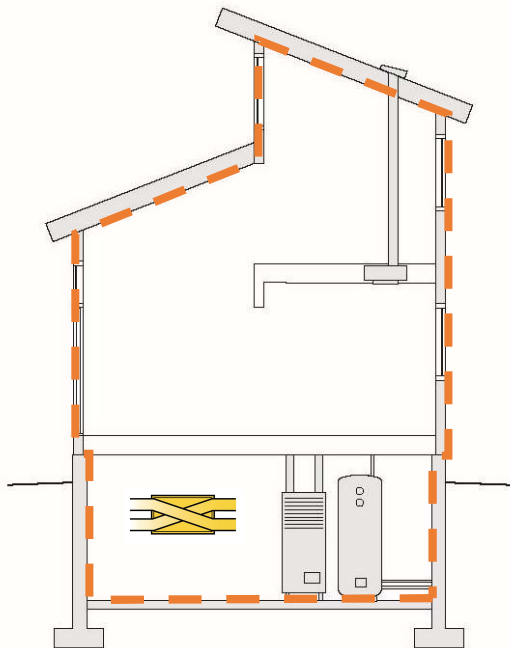
# Cost? See Example Models



## Example 1: Less Airtight

- **3.5 ACH**
- **R-22** effective walls or an **HRV** required to meet Step 1

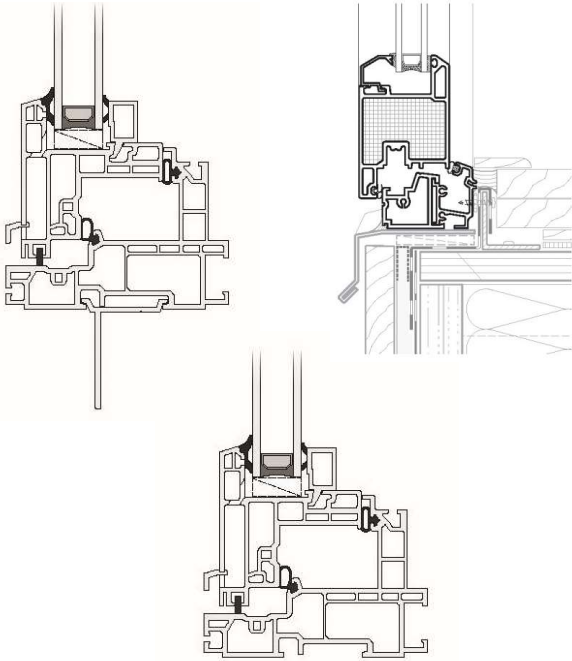
# Cost? See Example Models



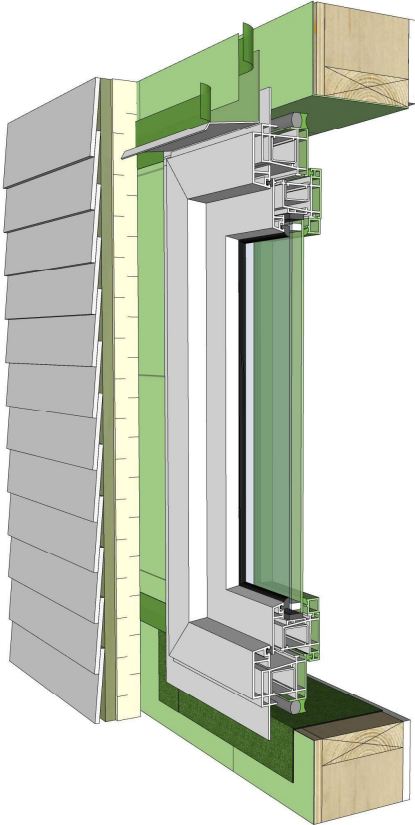
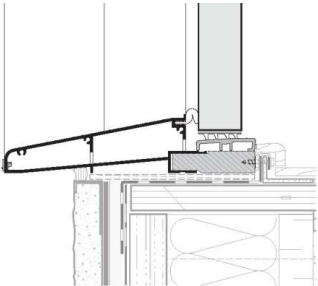
## Example 2: Even Less Airtight

- **4.5 ACH**
- **R-28** effective walls or an **HRV + better windows** required to meet Step 1

# Air Barrier Components



Windows & Doors

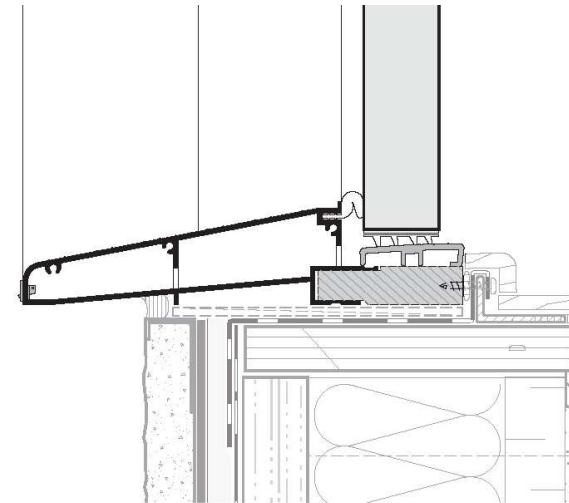


AIRTIGHTNESS?



# Air Barrier Components

- Ratings for airtightness of windows and doors is based on NAFS requirements.
- Manufacturers should provide the test data/certification
- **Airtight front entry doors** can be difficult to source, but look for NAFS airtightness rating data



# Air Barrier **Components** – NAFs Airtightness Ratings

**“A2”**

$\leq 1.5 \text{ L/s}\cdot\text{m}^2$   
(0.30 cfm/ft<sup>2</sup>)

**“A3”**

$\leq 0.5 \text{ L/s}\cdot\text{m}^2$   
(0.10 cfm/ft<sup>2</sup>)

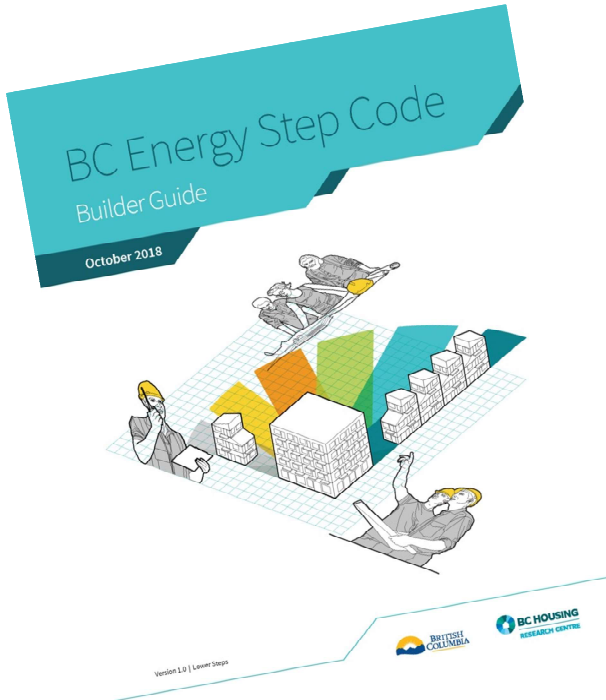
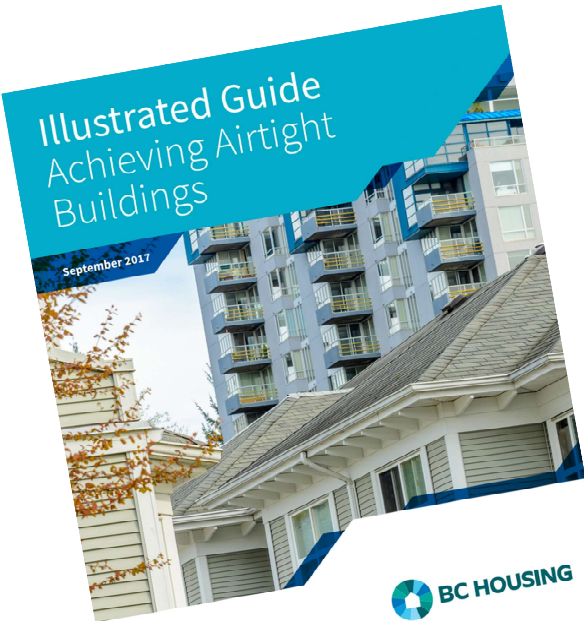
**“Fixed”**

$\leq 0.2 \text{ L/s}\cdot\text{m}^2$   
(0.04 cfm/ft<sup>2</sup>)





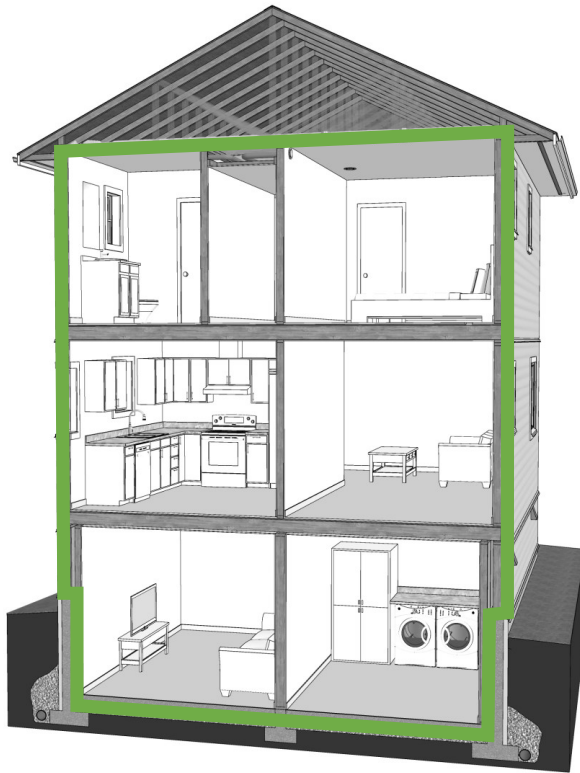
# Air Barrier Resources



The air barrier  
must be continuous,  
or it does not work...

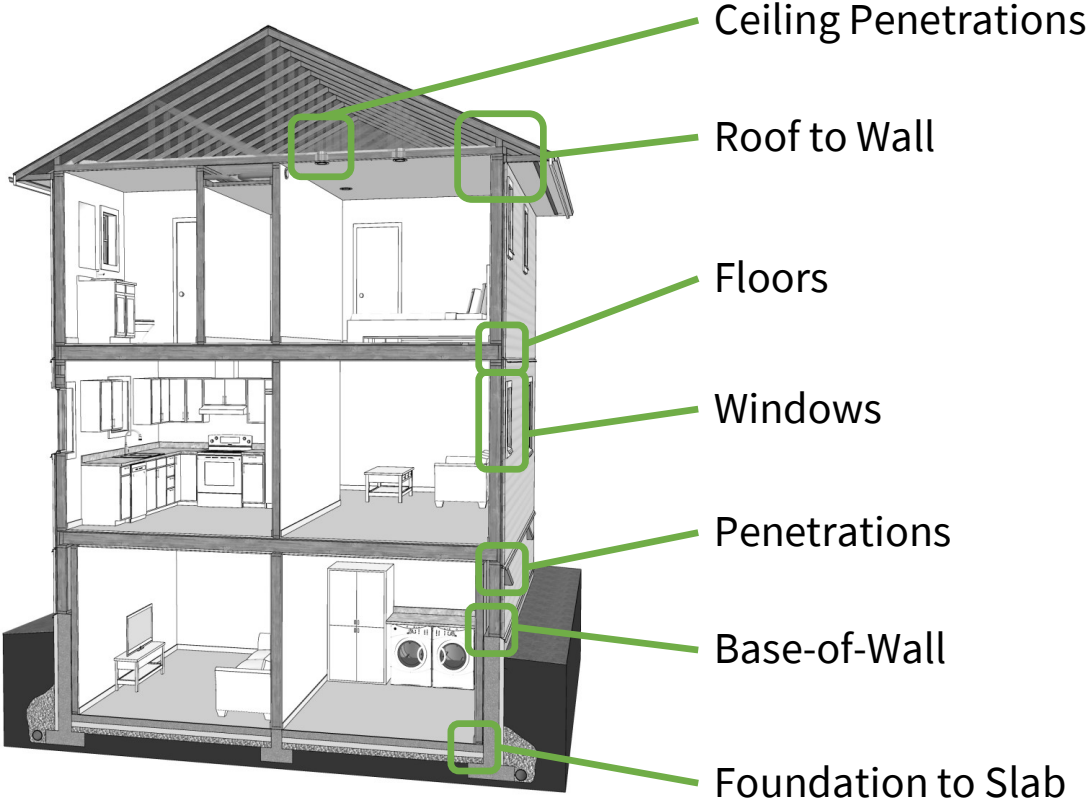


# Air Barrier Details & Planning



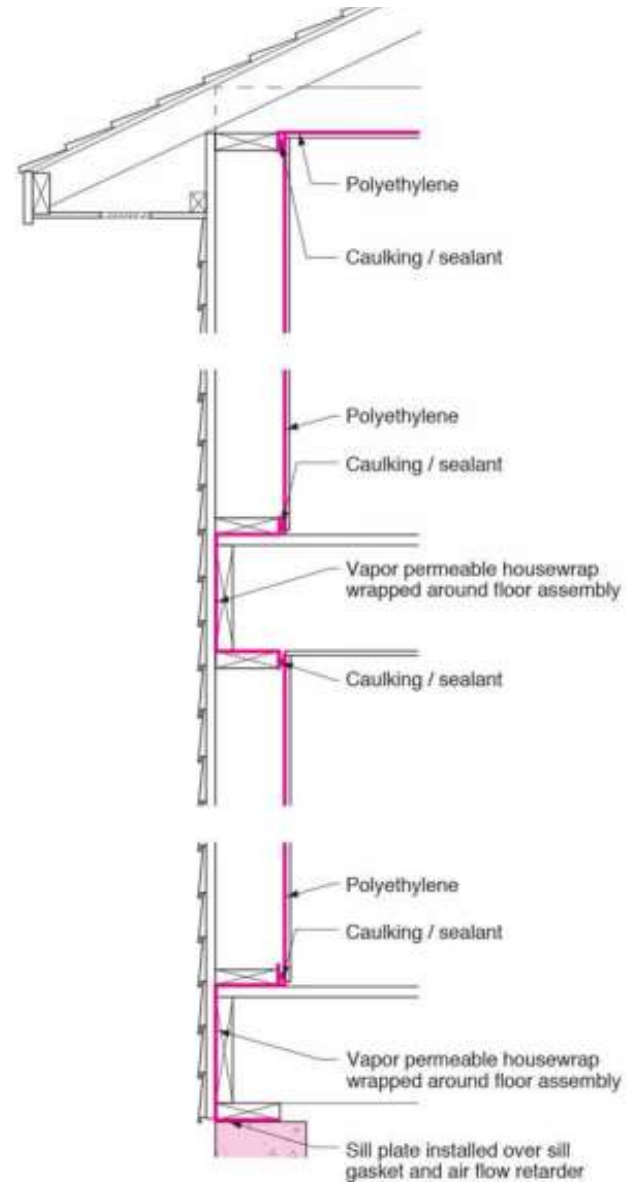
- Continuity around the whole building
- Sequencing & constructability
- Details at transitions and penetrations
- Which trades/applicators?

# Air Barrier Details & Planning



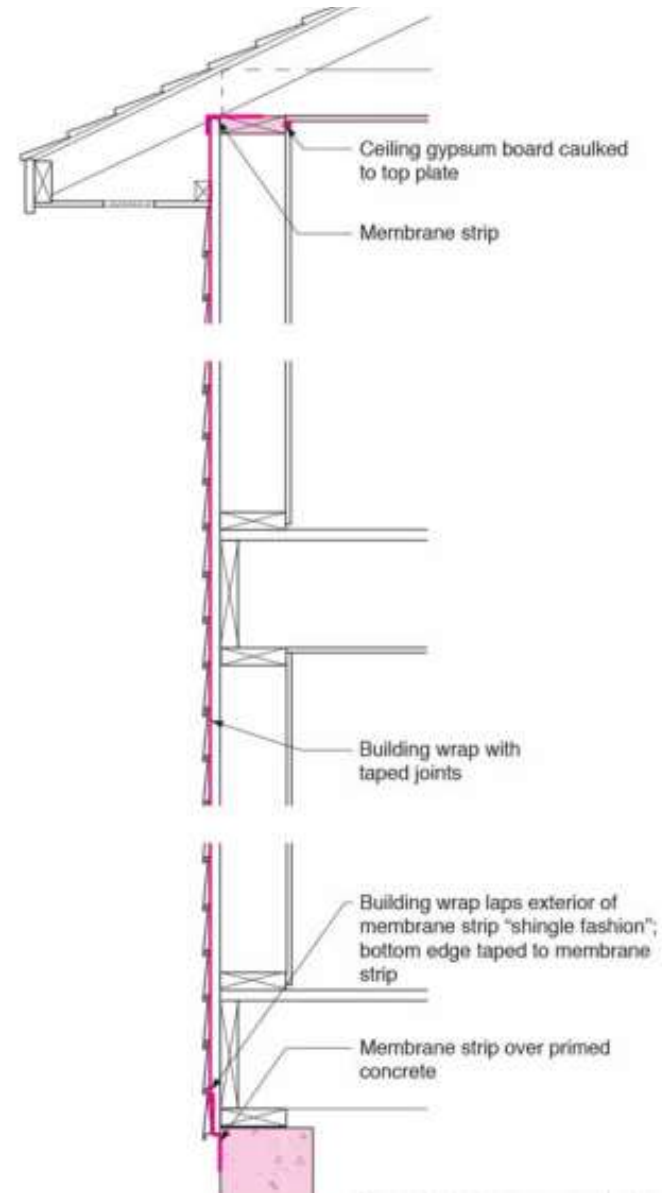
# Air Barrier Details & Planning

- Vapour Retarder as Air Barrier
- 'Classic' interior approach

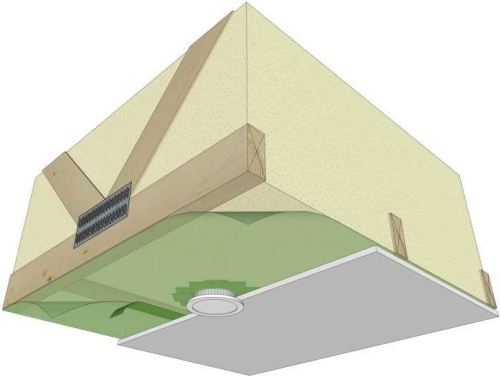


# Air Barrier Details & Planning

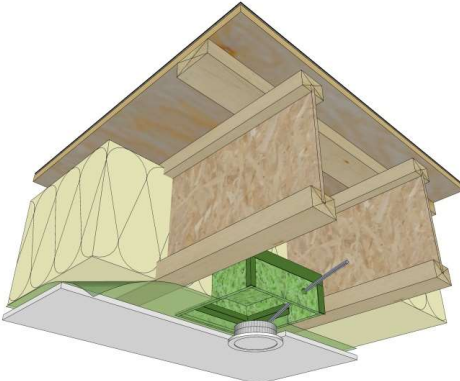
- Water Resistive Barrier as Air Barrier
- Common exterior approach



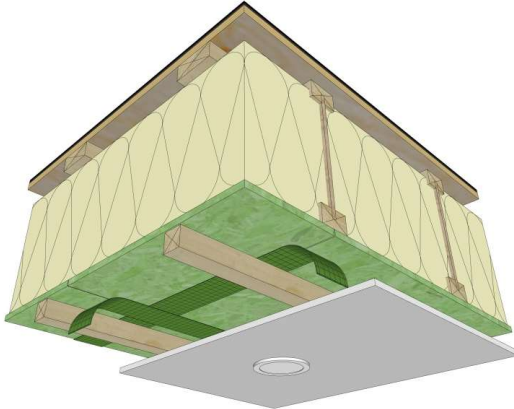
# Air Barrier Details: Ceiling Penetrations



Direct seal



Airtight boxes



Service cavity

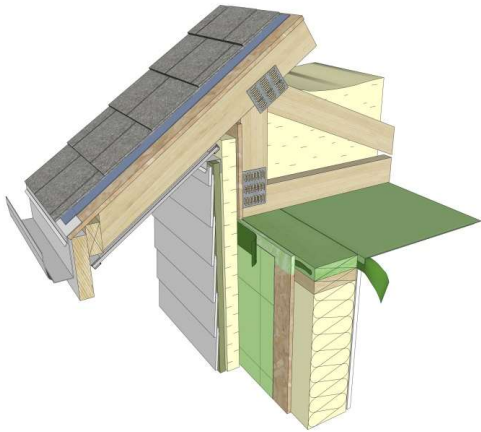
AIRTIGHTNESS



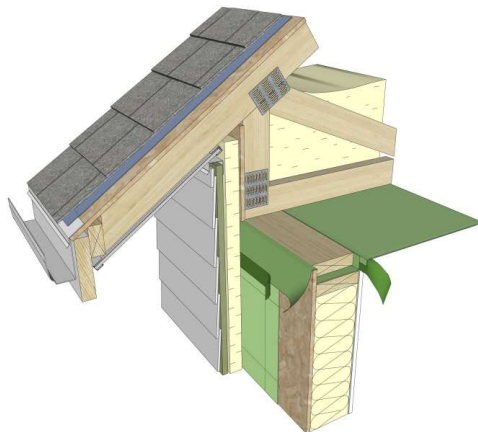


# Air Barrier Details: Roof to Wall

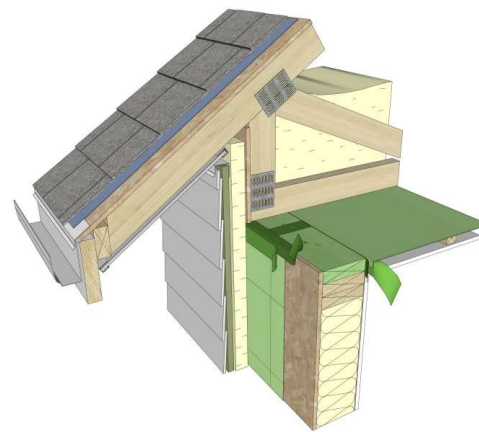
*(more to come on this)*



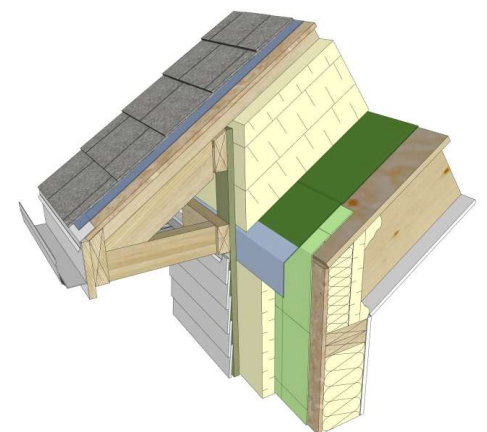
Sealant



Membrane Pre-strip



Taped top plate



Exterior

AIRTIGHTNESS



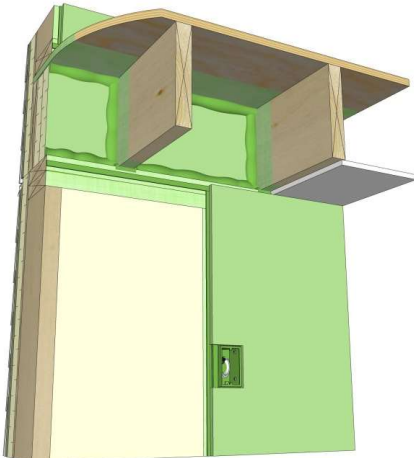
# Air Barrier Details: Floors

Not shown:

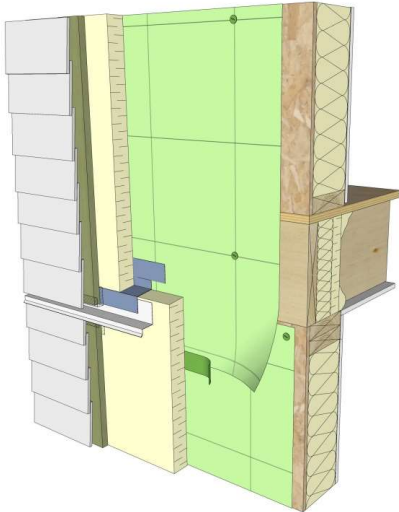
- sealed polyethylene
- membrane pre-strip



Spray foam



Sealed insulation blocks

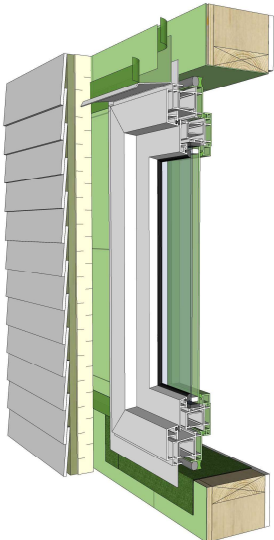


Exterior

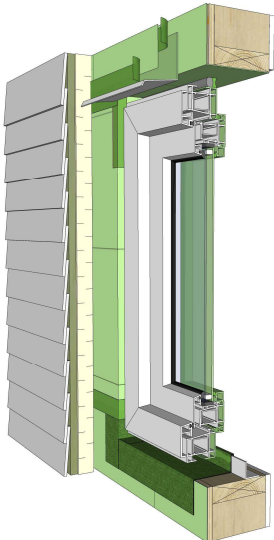
AIRTIGHTNESS



# Air Barrier Details: Windows



Perimeter sealant

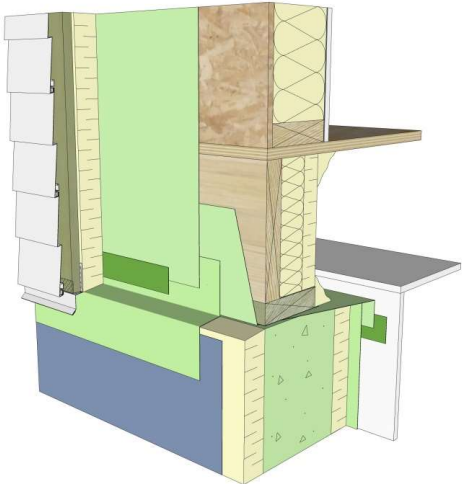


Sealant + sill angle

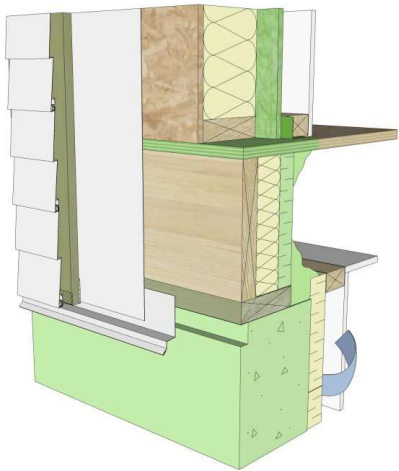
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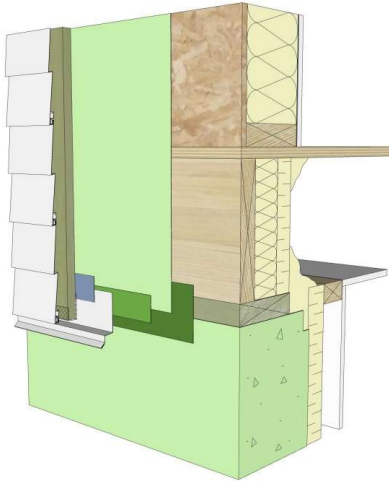
# Air Barrier Details: Base of Wall



Pre-strip



Interior seal (with foam or **tape**)

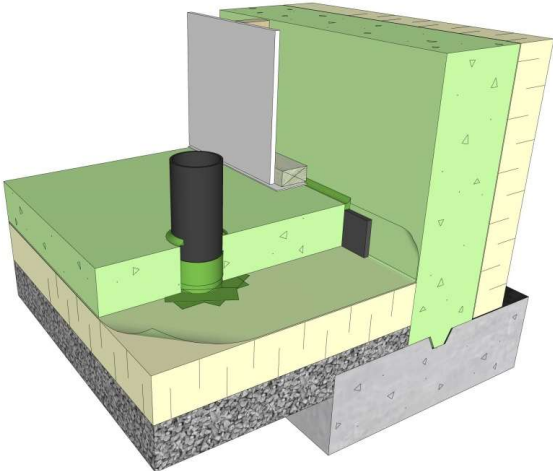


Exterior

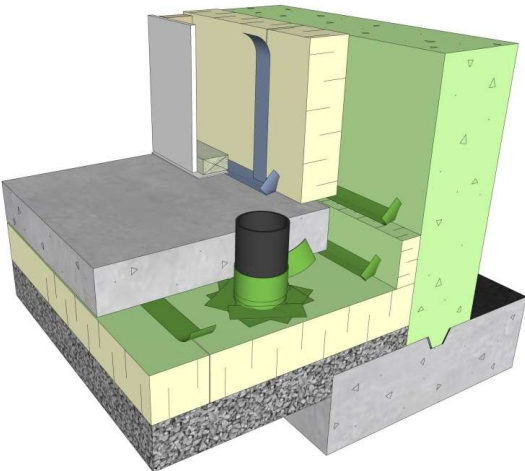
AIRTIGHTNESS



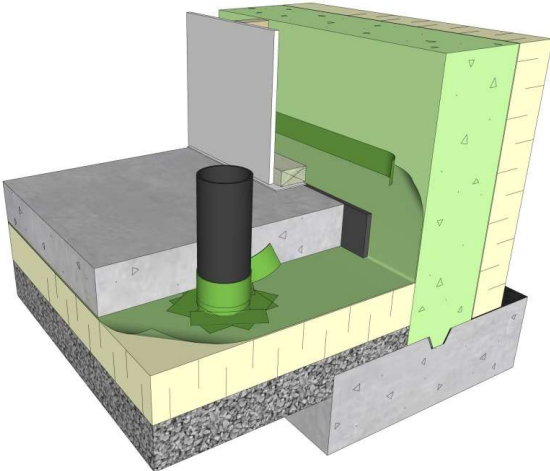
# Air Barrier Details: Foundation to Slab



Slab sealant



Taped insulation

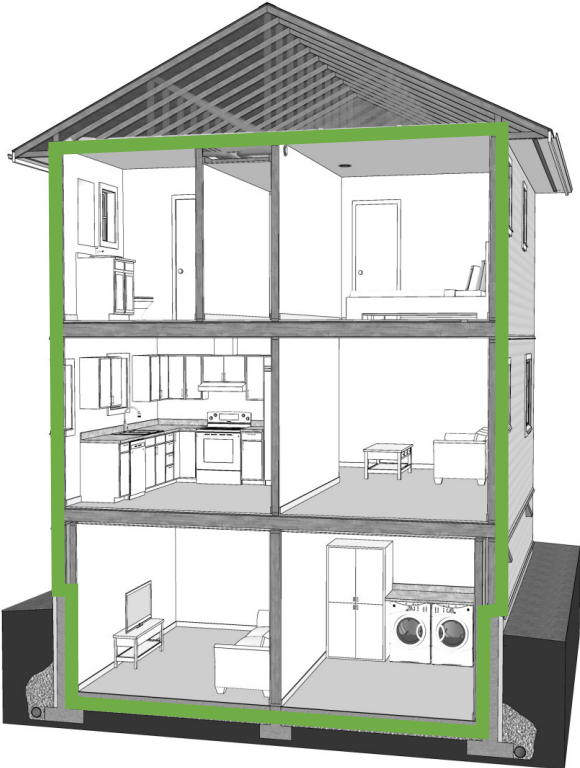


Taped membrane

AIRTIGHTNESS



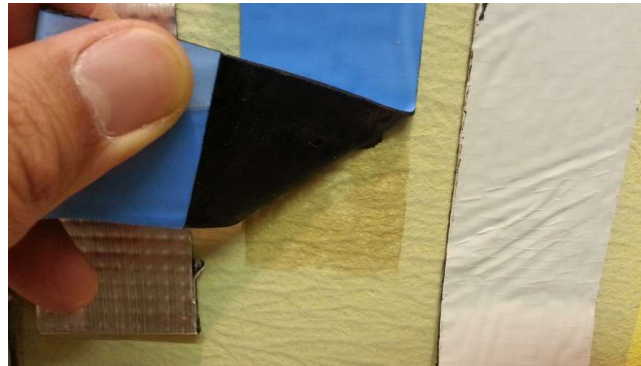
# Air Barrier Construction



# Use compatible materials

## BCBC 9.36.2.10 Sentence 2

- Materials shall be
  - a) compatible with adjoining materials, and
  - b) free of holes and cracks.





# Seal all joints

## BCBC 9.36.2.10 Sentence 3

- Where the air barrier system consists of rigid panel-type material, all joints shall be sealed.

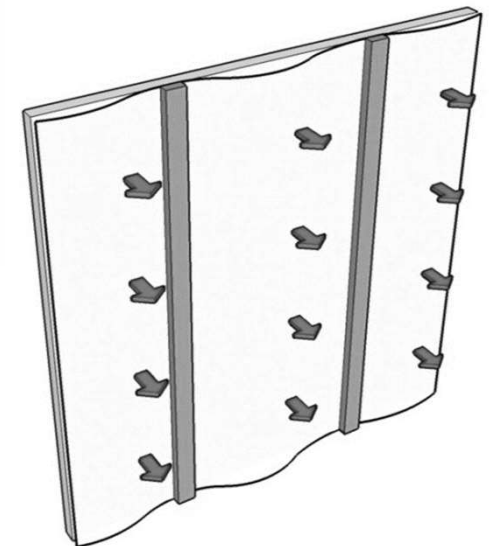
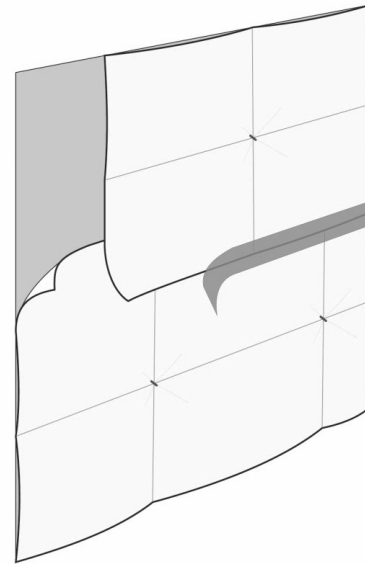




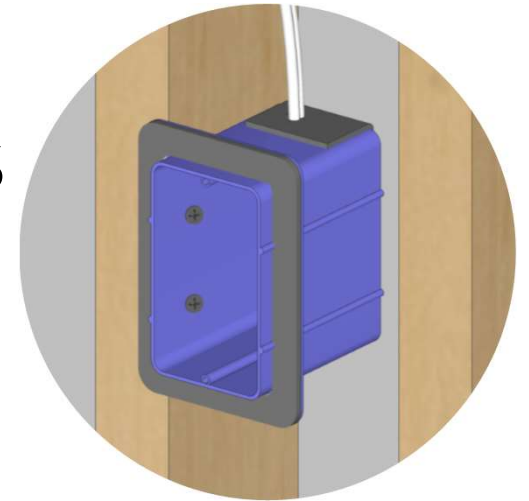
# Overlap sheets and fully support them

## BCBC 9.36.2.10 Sentence 5

- Where the air barrier system consists of flexible sheet material, all joints shall be
  - a) lapped not less than 50 mm,
  - b) sealed, and
  - c) structurally supported.



# Completely seal electrical boxes



## BCBC 9.36.2.10 Sentence 7:

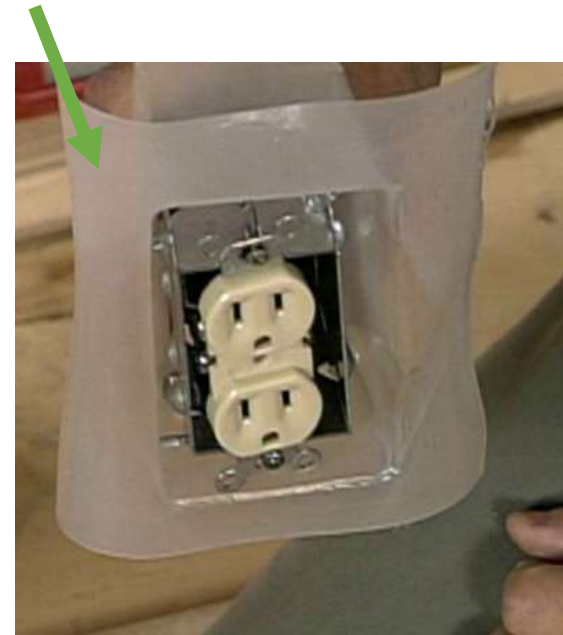
- Penetrations by electrical wiring, outlets, switches or recessed light fixtures through the plane of airtightness shall be constructed airtight
  - a) where the component is designed to provide a seal against air leakage, by sealing the component to the air barrier material, or...
  - b) where the component is not designed to provide a seal against air leakage, by covering the component with an air barrier material and sealing it to the adjacent air barrier material.



# Completely seal electrical boxes

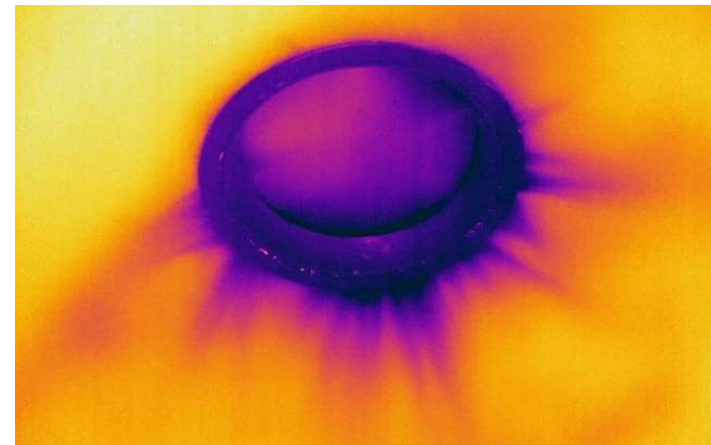
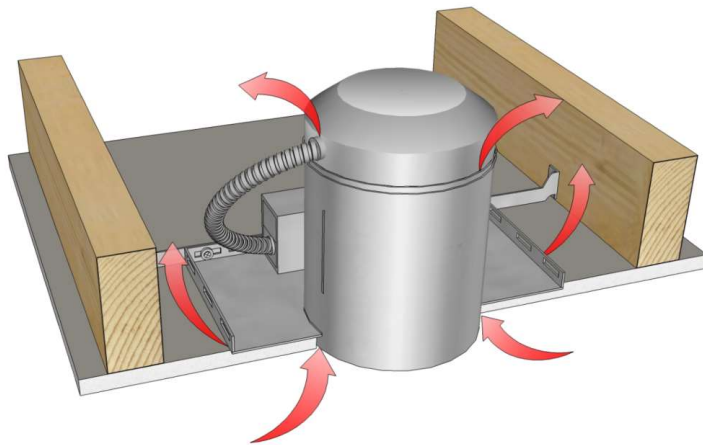
## BCBC 9.36.2.10 Sentence 7:

- Penetrations by electrical wiring, outlets, switches or recessed light fixtures through the plane of airtightness shall be constructed airtight
- b) where the component is not designed to provide a seal against air leakage, by covering the component with an air barrier material and sealing it to the adjacent air barrier material.



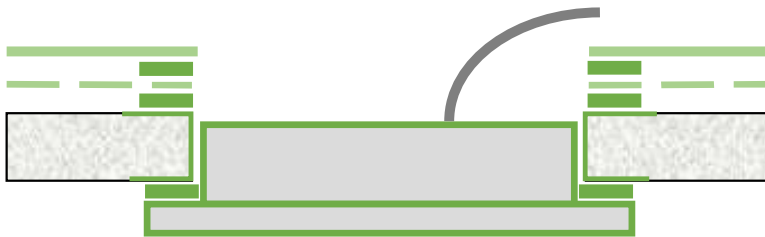
# Pot lights are common air leakage points

- Do not rely on the “airtightness” of airtight pot lights
- High-performance air barriers use airtight boxes or ceiling service cavities



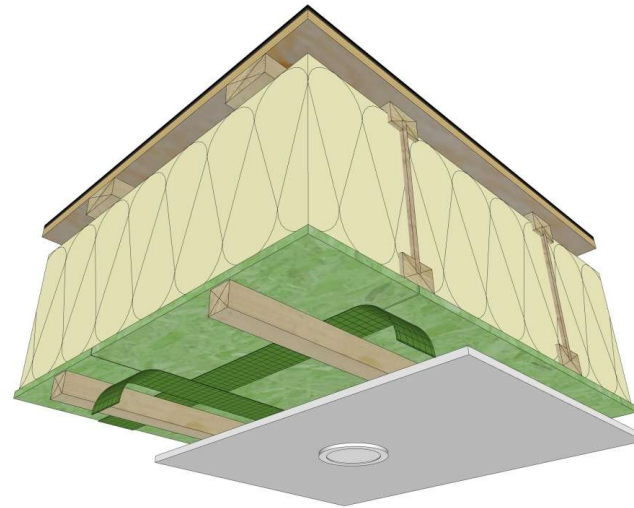
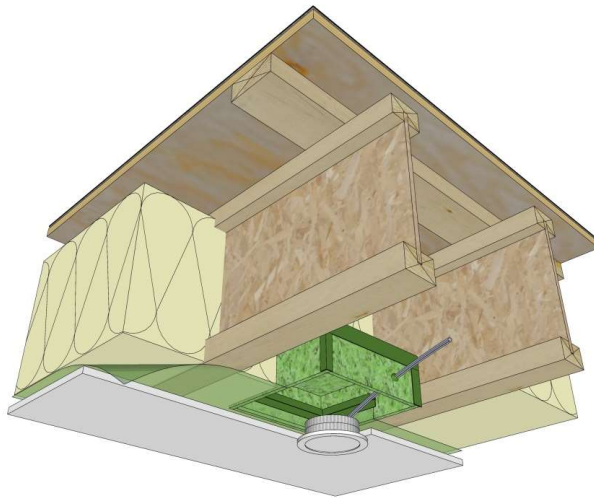
# Pot lights are common air leakage points

- LED puck lights can be integrated with the ceiling air barrier



# Pot lights are common air leakage points

- High-performance air barriers use airtight boxes or ceiling service cavities

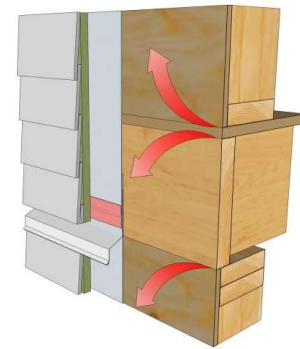
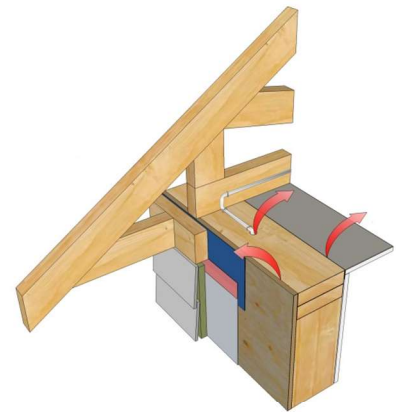




# Seal all joints and junctions

## BCBC 9.36.2.10 Sentence 8:

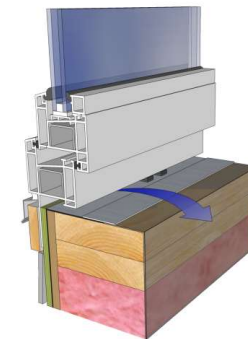
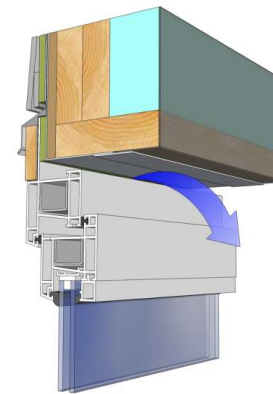
- The joints between the foundation wall and the sill plate, between the sill plate and rim joist, between the rim joist and the subfloor material, and between the subfloor material and the bottom plate of the wall above shall be constructed airtight by
  - a) sealing all joints and junctions between the structural components, or
  - b) covering the structural components with an air barrier material and sealing it to the adjacent air barrier material.



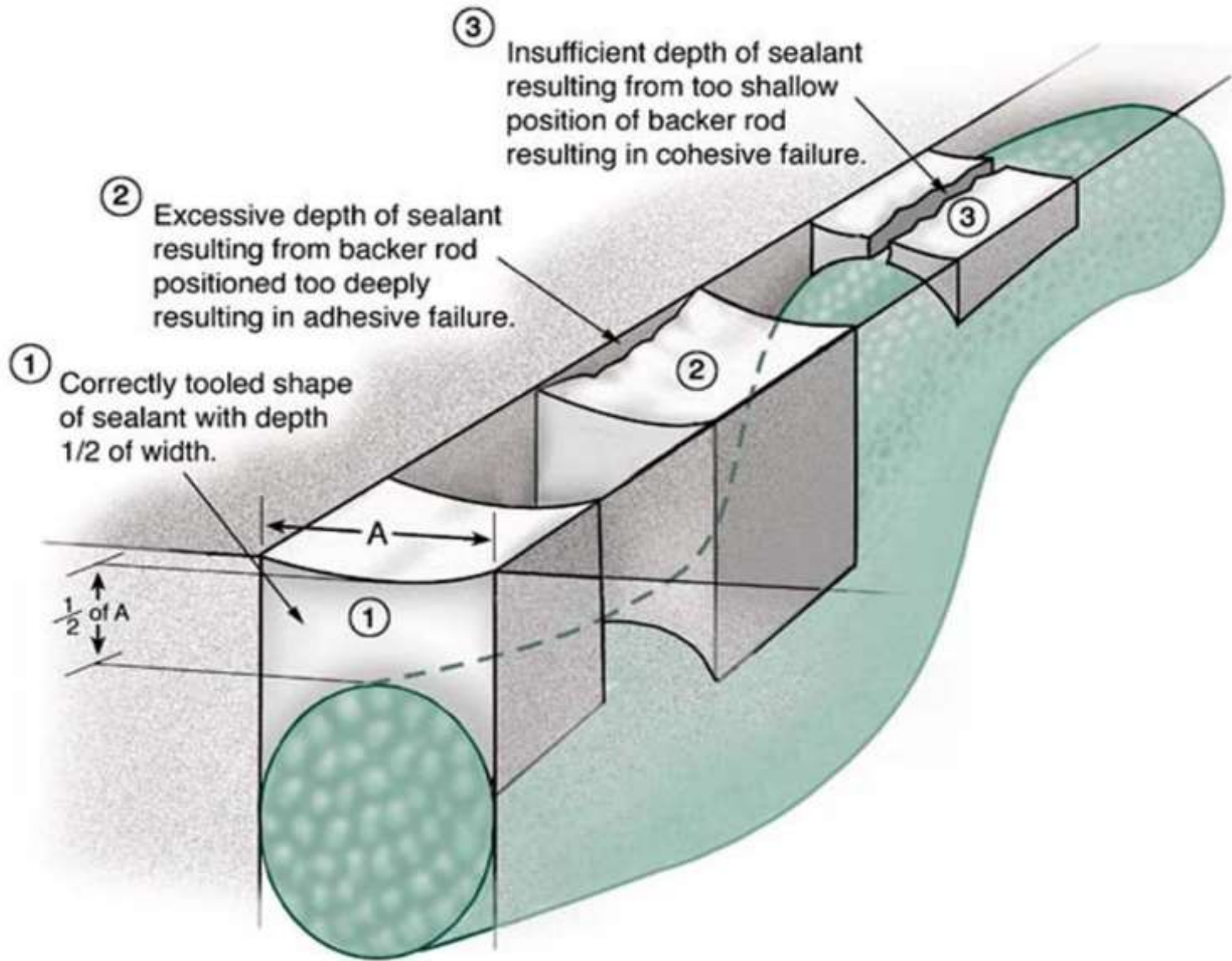
# Seal windows and doors to air barrier material

## BCBC 9.36.2.10 Sentence 9:

- The interfaces between windows, doors and skylights and wall/ceiling assemblies shall be constructed airtight by sealing all joints and junctions between the air barrier material in the wall and the window, door or skylight frame.





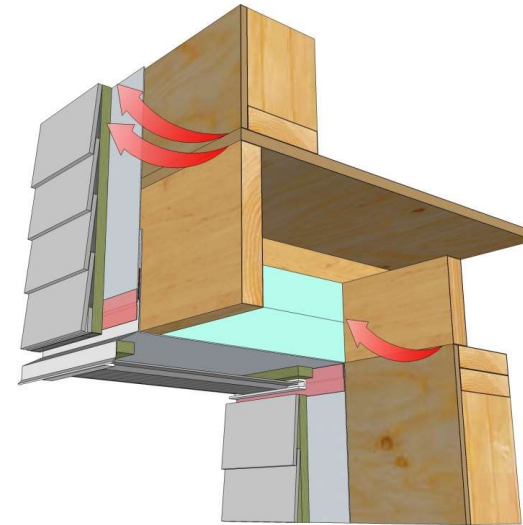




# Seal or cover exposed floors

## BCBC 9.36.2.10 Sentence 10:

- Cantilevered floors and floors over unheated spaces or over the exterior shall be constructed airtight by one of the following methods or a combination thereof:
  - a) sealing all joints and junctions between the structural components, or
  - b) covering the structural components with an air barrier material and sealing it to the adjacent air barrier material.

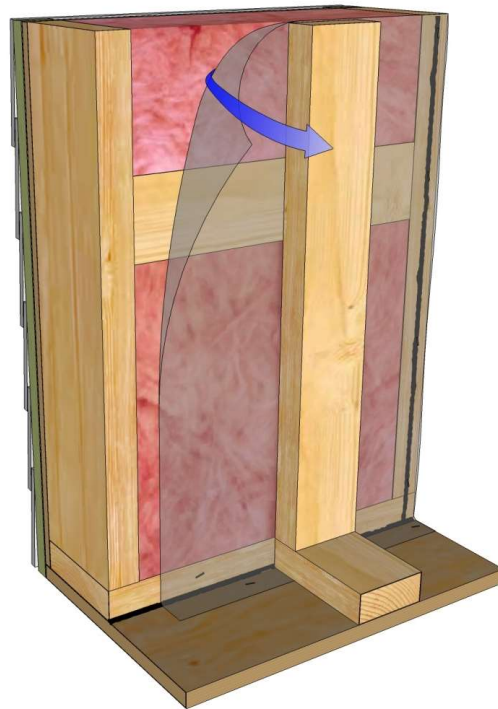


# Don't let interior walls interrupt the air barrier

## **BCBC 9.36.2.10 Sentence 11:**

- Interior walls that meet exterior walls or ceilings whose plane of airtightness is on the interior of the building envelope and knee walls that separate conditioned space from unconditioned space shall be constructed airtight by
  - a) sealing all junctions between the structural components,
  - b) covering the structural components with an air barrier material and sealing it to the adjacent air barrier material, or
  - c) maintaining the continuity of the air barrier system above or through the interior wall or below or through the knee wall, as applicable.

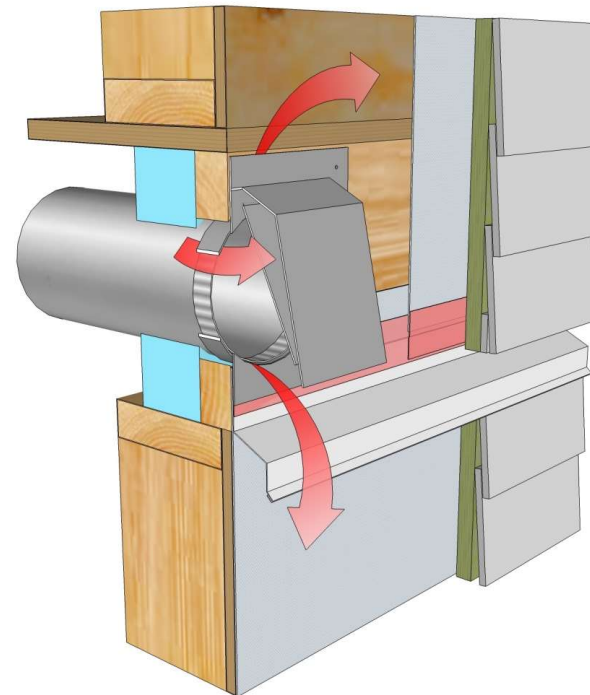
# Don't let interior walls interrupt the air barrier



*(more to come on this)*

# Seal all ducts

- **BCBC 9.36.2.10 Sentence 14:**
- Ducts that penetrate the building envelope shall be constructed airtight by sealing the penetration through the building envelope.





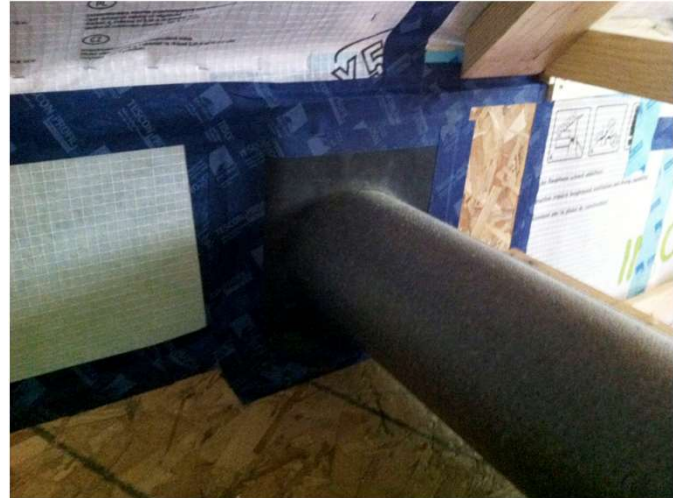
té énergétique accrue  
durée de vie de votre maison







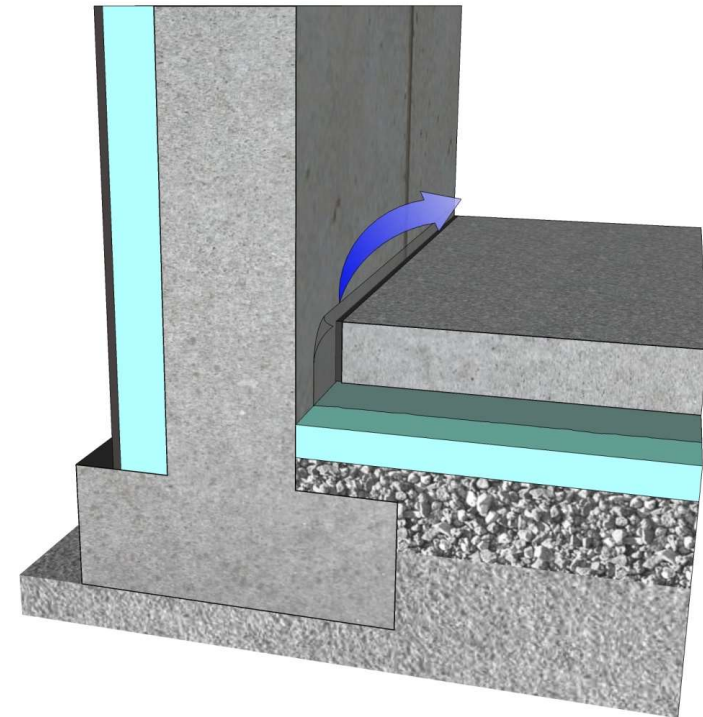




# Seal to concrete

## BCBC 9.36.2.10 Sentence 17:

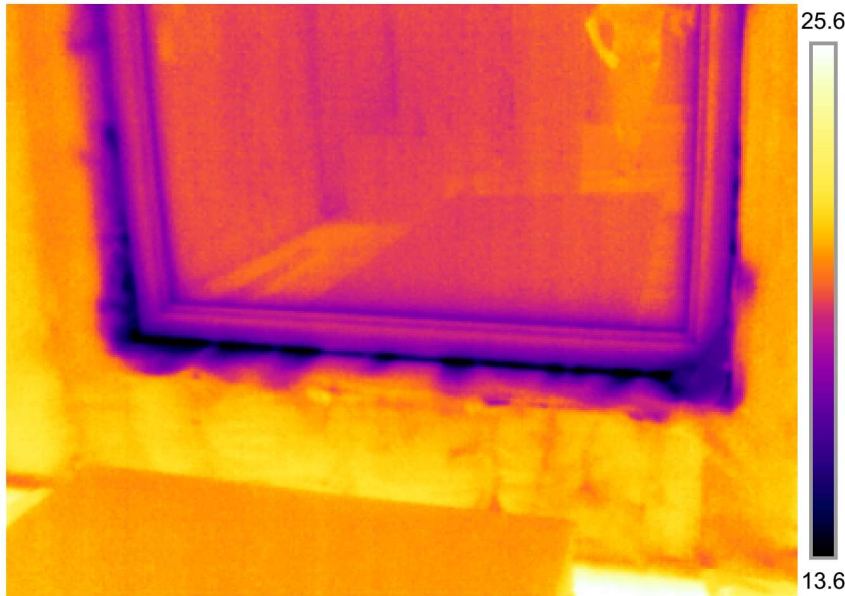
- Where the concrete in a flat insulating concrete form wall acts as the air barrier, the continuity of the plane of airtightness shall be maintained between the concrete and adjacent air barrier materials.





# Common Mistakes: Windows

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FLIR E60bx

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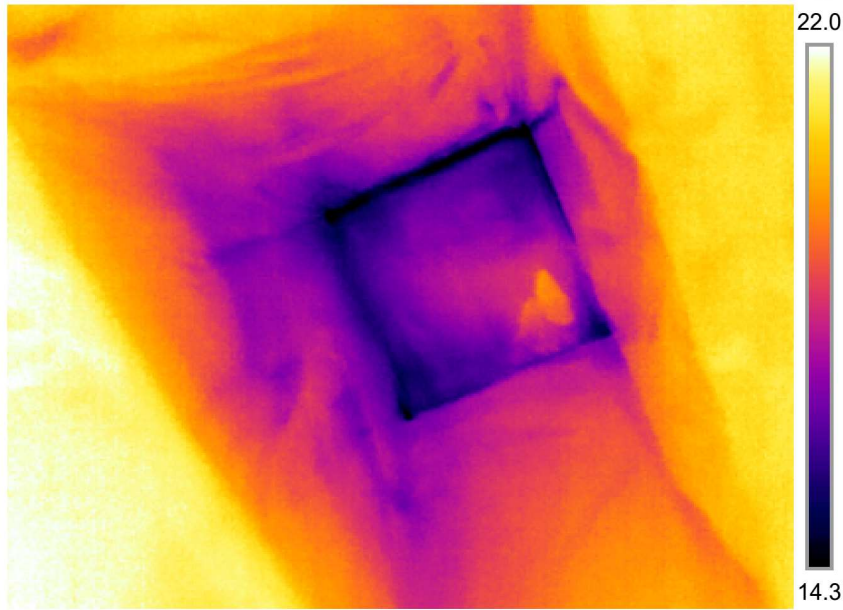
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Missing perimeter seals

# Common Mistakes: Skylight shafts

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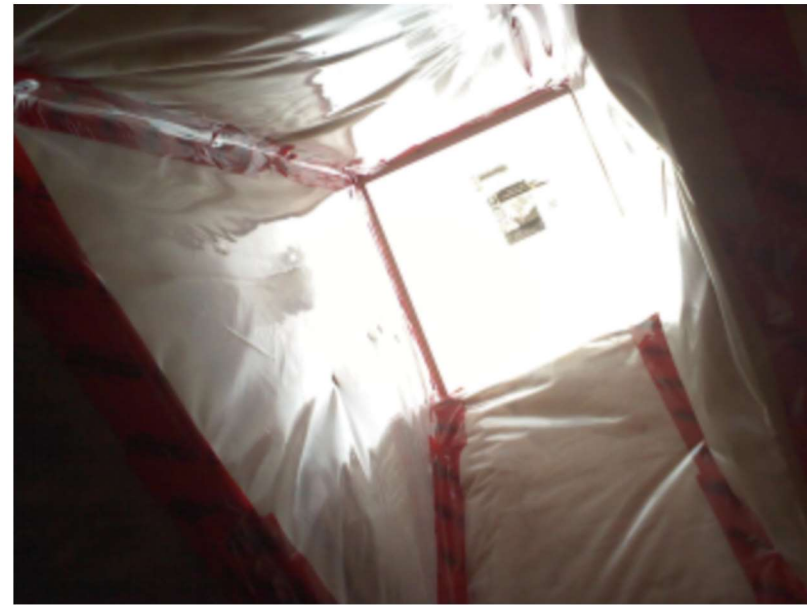


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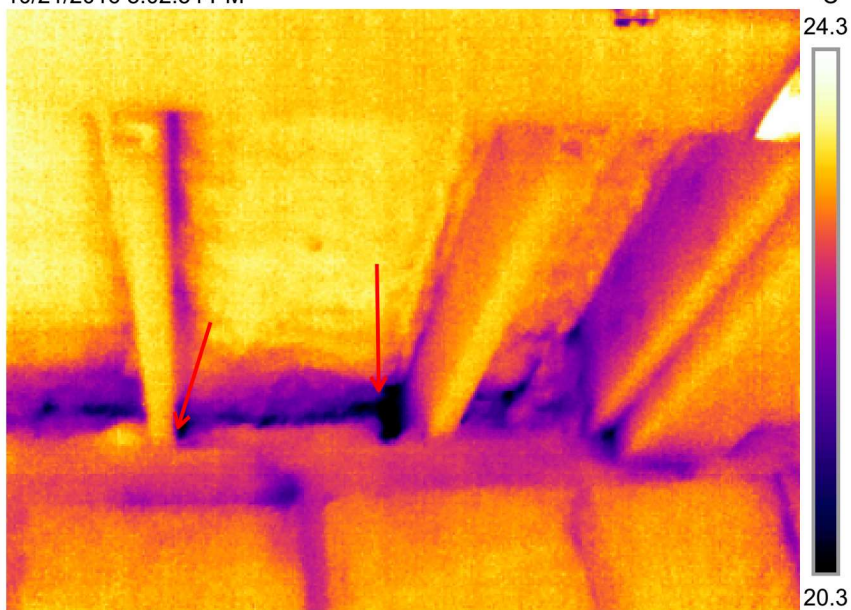
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Missing perimeter seals

# Common Mistakes: Rim Joists

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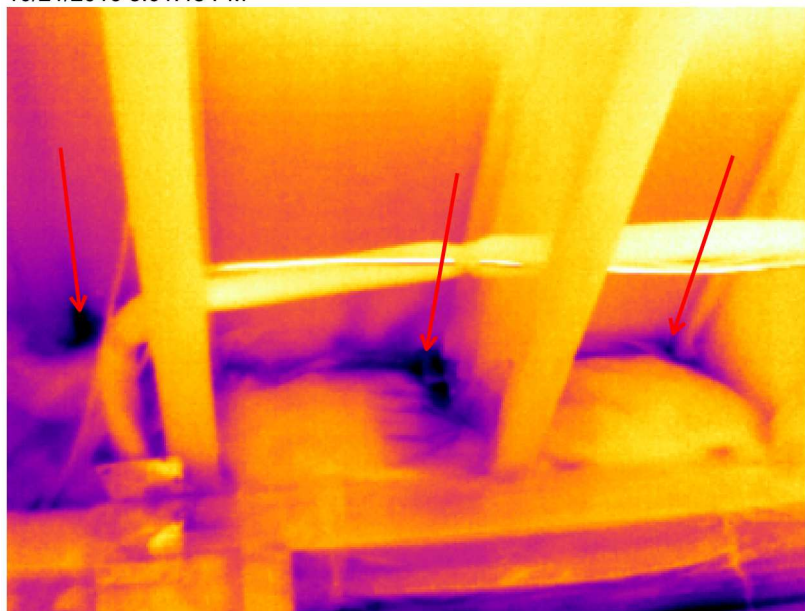
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Discontinuities in spray foam



# Common Mistakes: Rim Joists

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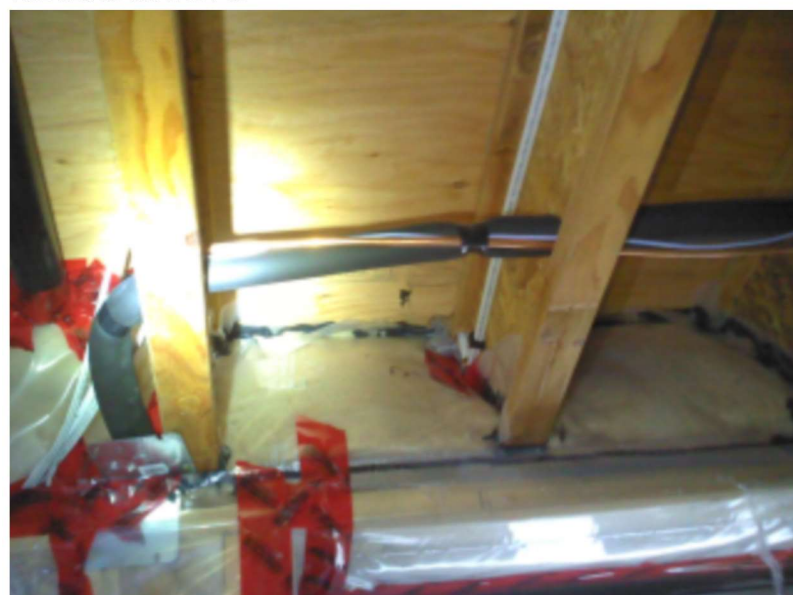


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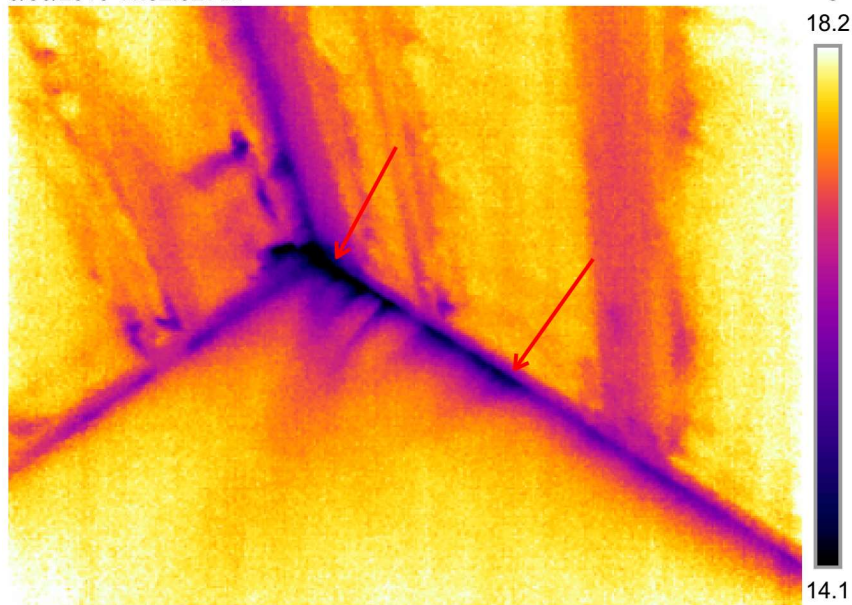
FLIR E60bx

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Using only poly + sealant

# Common Mistakes: Sub-floor and Bottom Plate

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9/30/2016 11:52:02 AM



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FLIR E60bx

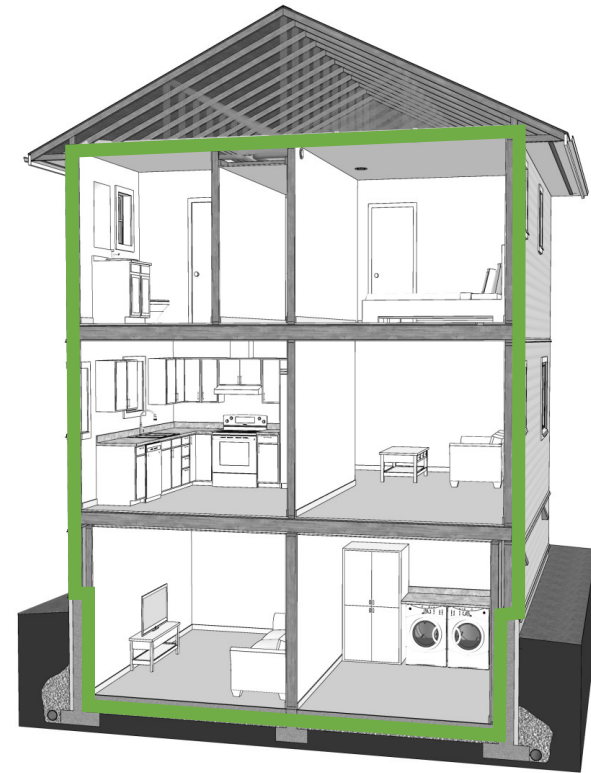
64504474

No seal at bottom of wall



# Air Barrier Best Practices

- Separate framing work from air barrier components wherever possible
- Use approaches that don't drastically change common construction sequencing
- Use “inspectable” approaches that don't rely on blind seals
- Keep it simple and buildable



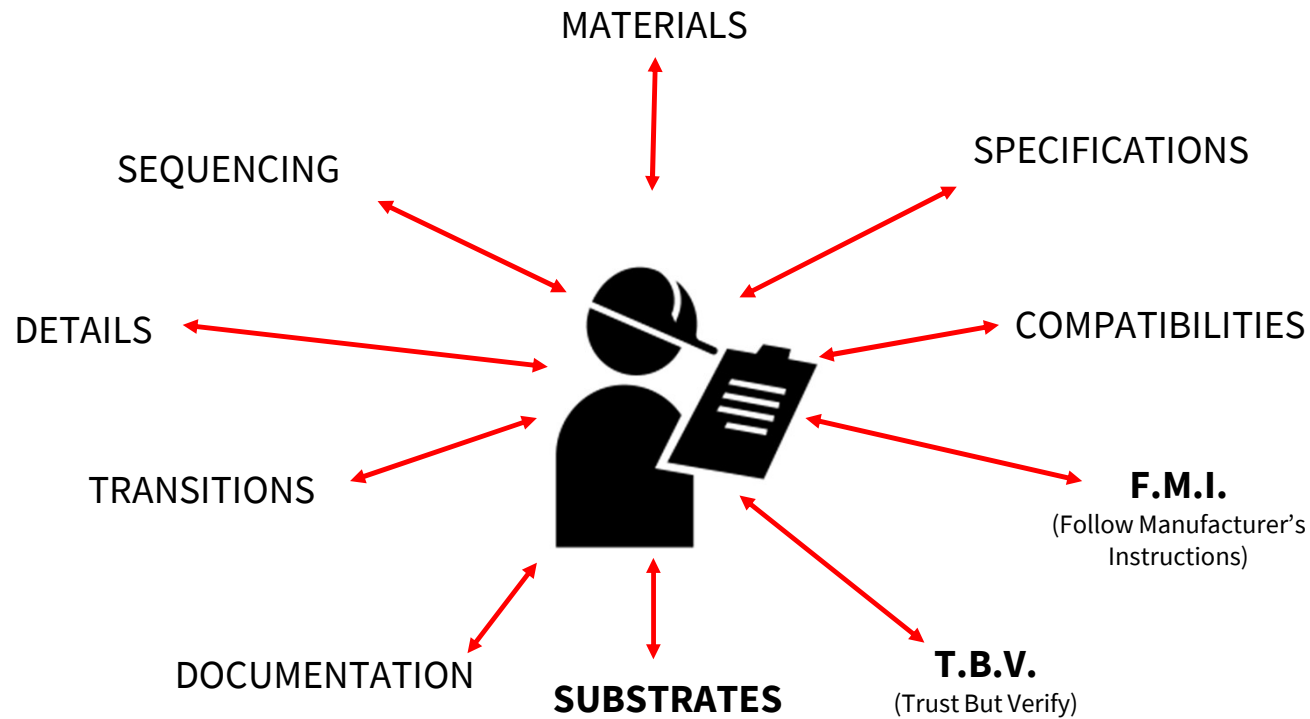
# Air Barrier Best Practices

- Architects/Designers
  - Show Air Barrier in all sections
  - Show transitions between materials
  - Identify all materials
- Builders
  - “Air Boss”
  - Penetrations checklist
  - Use the right material for the job
  - Subcontractors do not put holes in Air Barrier
  - Communication among trades
  - **Show up for mid-construction test**
  - **Have a Plan**

# Air Barrier Installation

## Building Envelope Supervisor – “The Air Boss”

Employed by Contractor - Oversees All Installers



# Quality Control

- Noticeable improvements as soon as somebody cares – specific people designated to look at air barrier
- Coordination between all team members essential



Air Boss

# Quality Control: Subtrades

- **Framing** - top floor partition walls, exterior pre-stripping?
- **Electrical** – receptacles, upper floor ceiling fixtures
- **Plumbing** – vent stacks, fixtures on exterior walls
- **HVAC** – service vents/ducts
- **Insulation/Poly/Drywall** – floor joists, partition walls, receptacles/fixtures, ceiling poly, finishing/cutting
- **Cladding** – exterior penetrations, sealed exterior membrane?



What's the Plan?





What's the Plan?



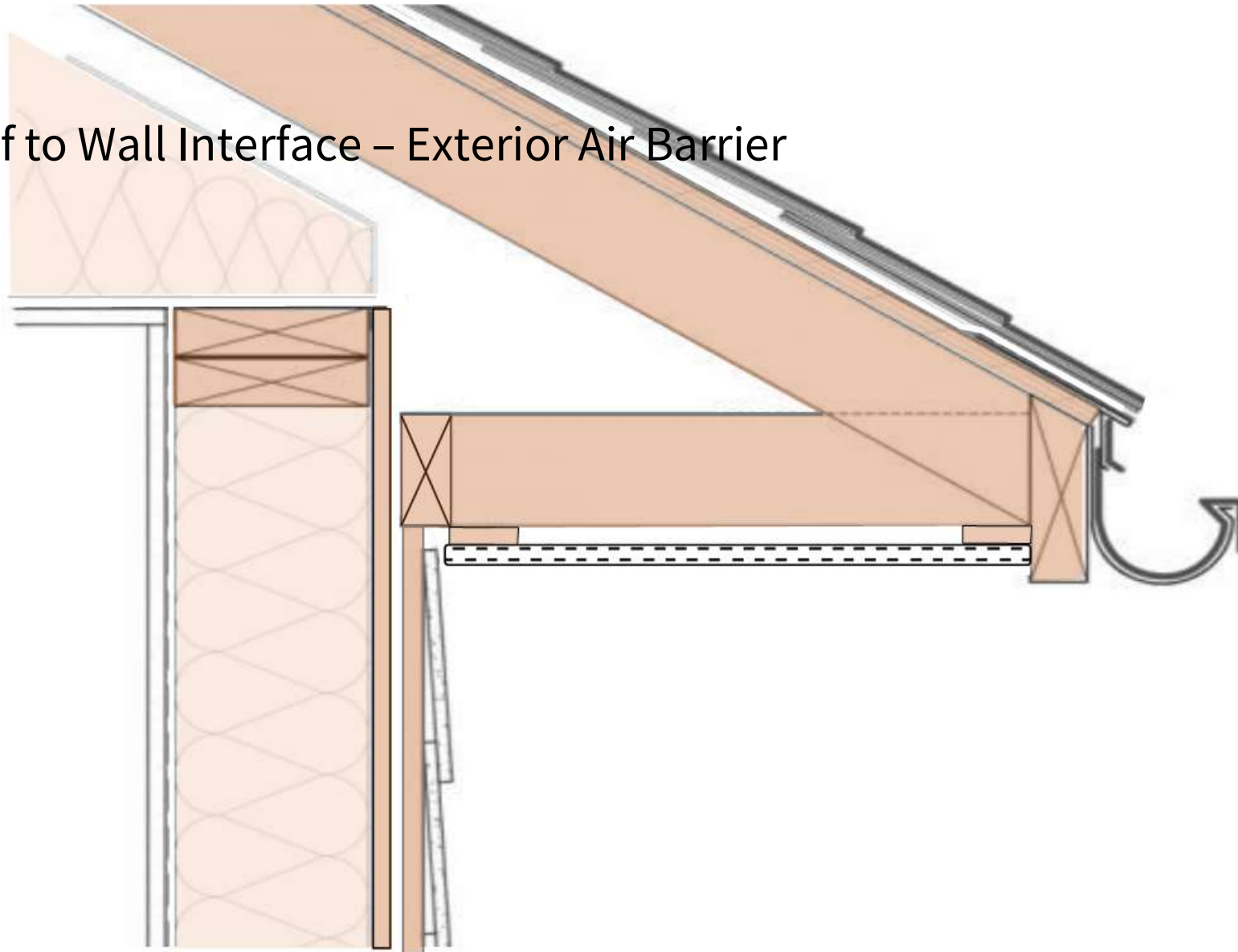


# What's the Plan?

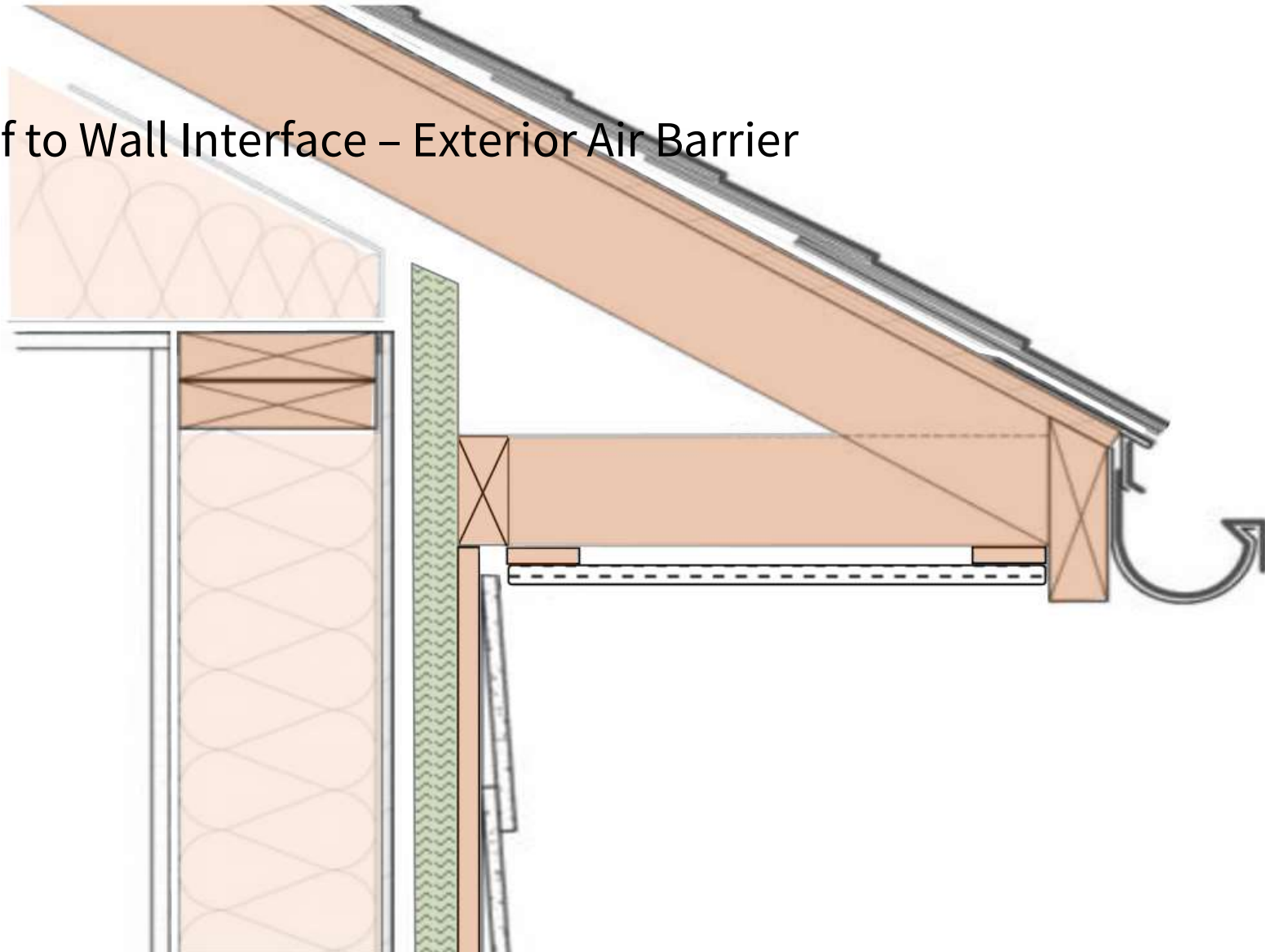




## Roof to Wall Interface – Exterior Air Barrier



## Roof to Wall Interface – Exterior Air Barrier

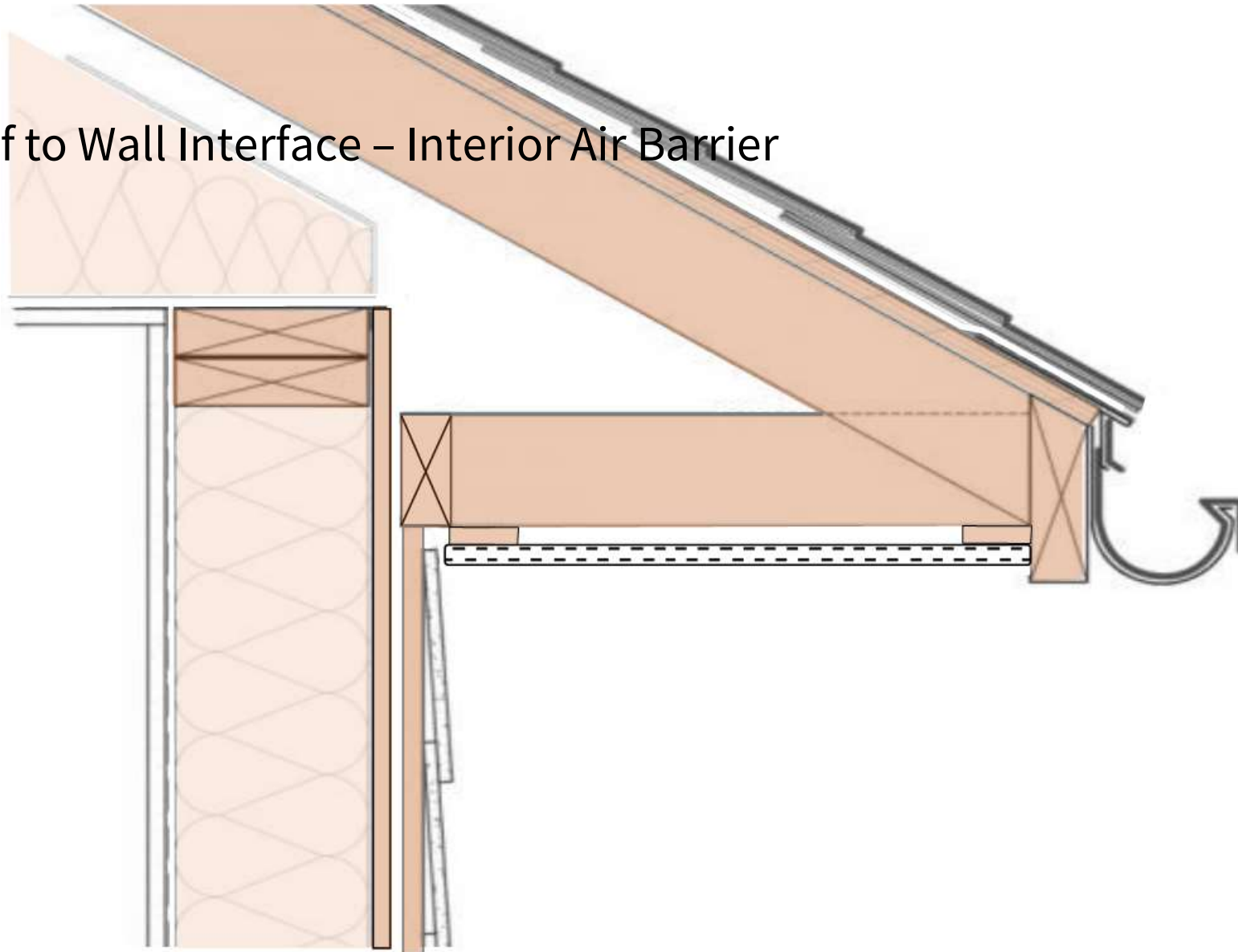




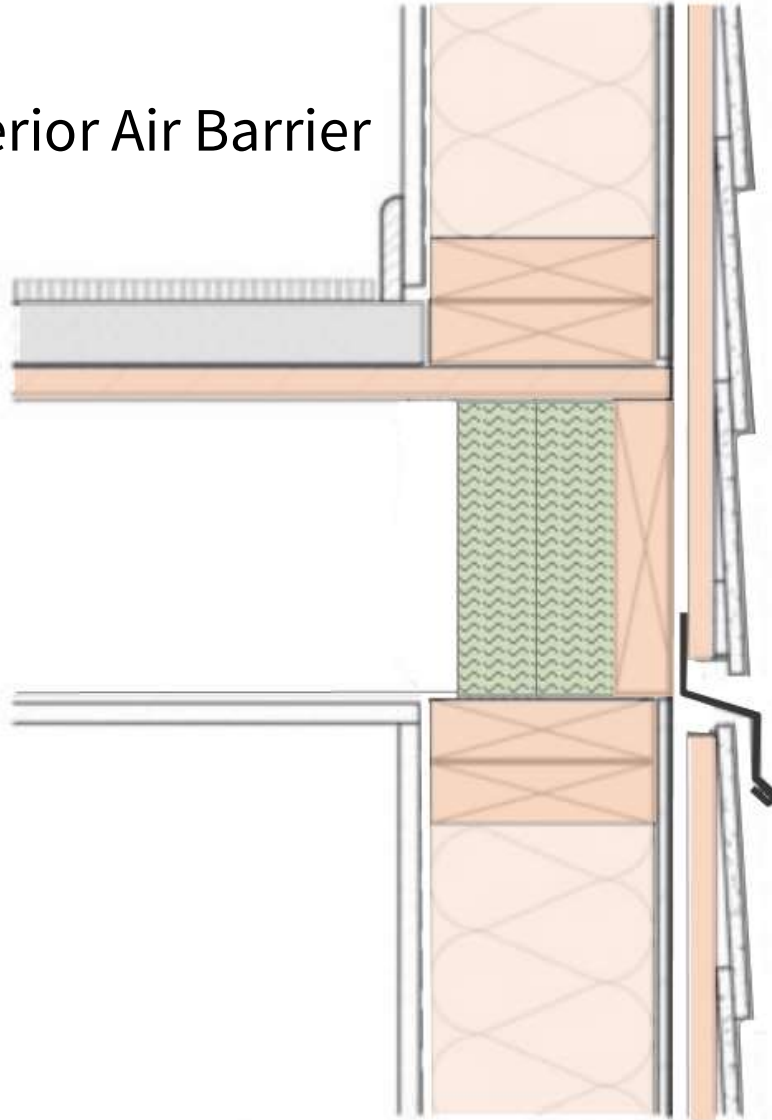




## Roof to Wall Interface – Interior Air Barrier

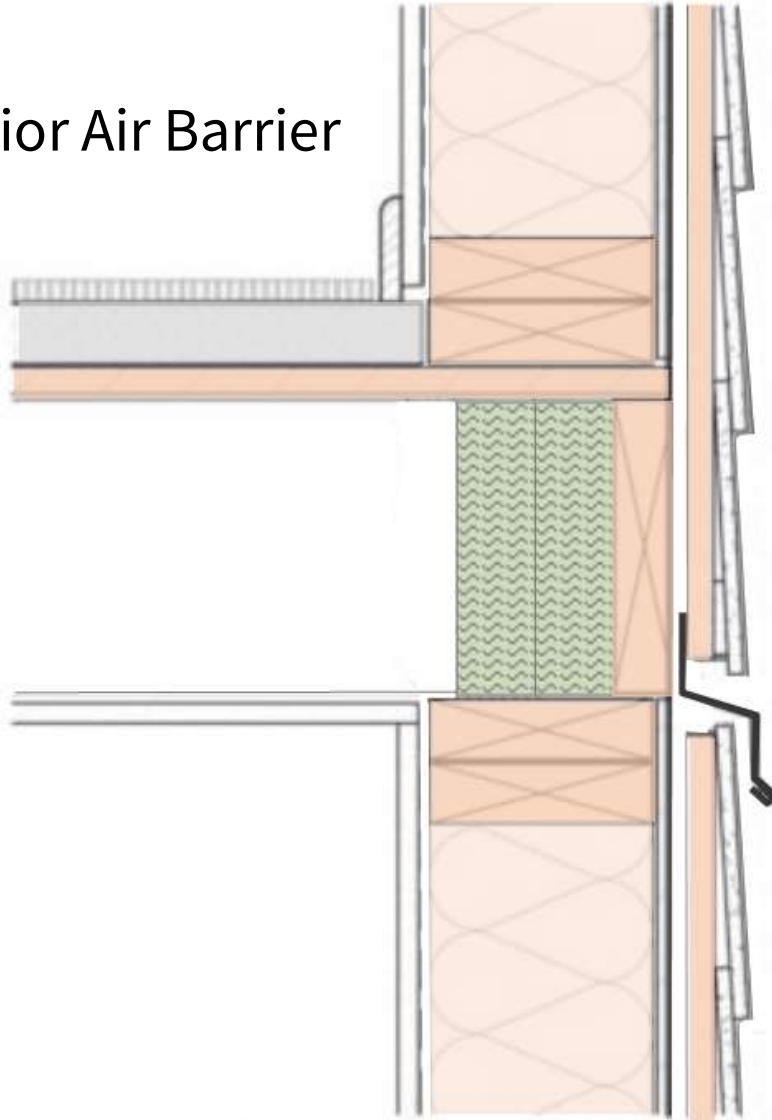


## Rim Joist Interface – Interior Air Barrier

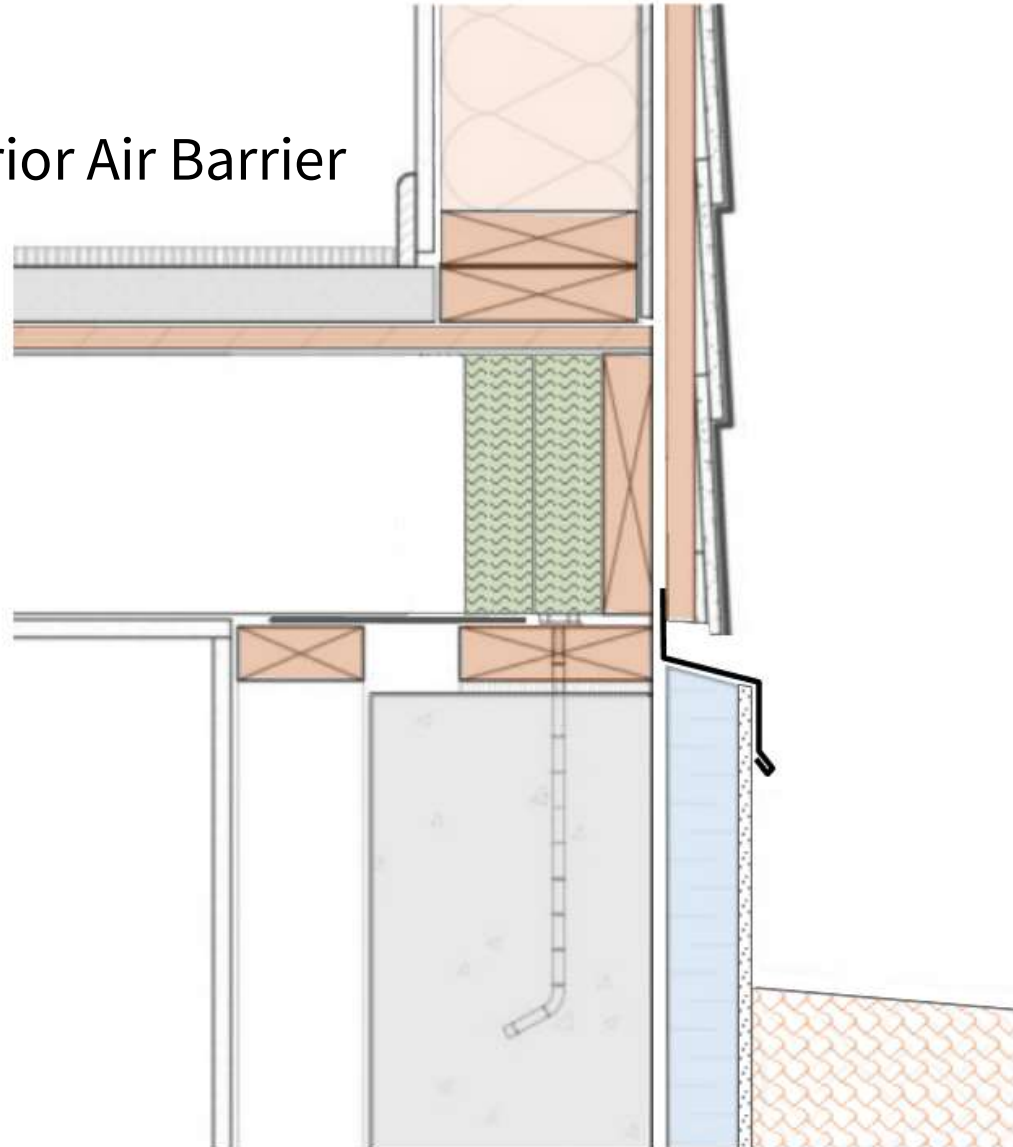




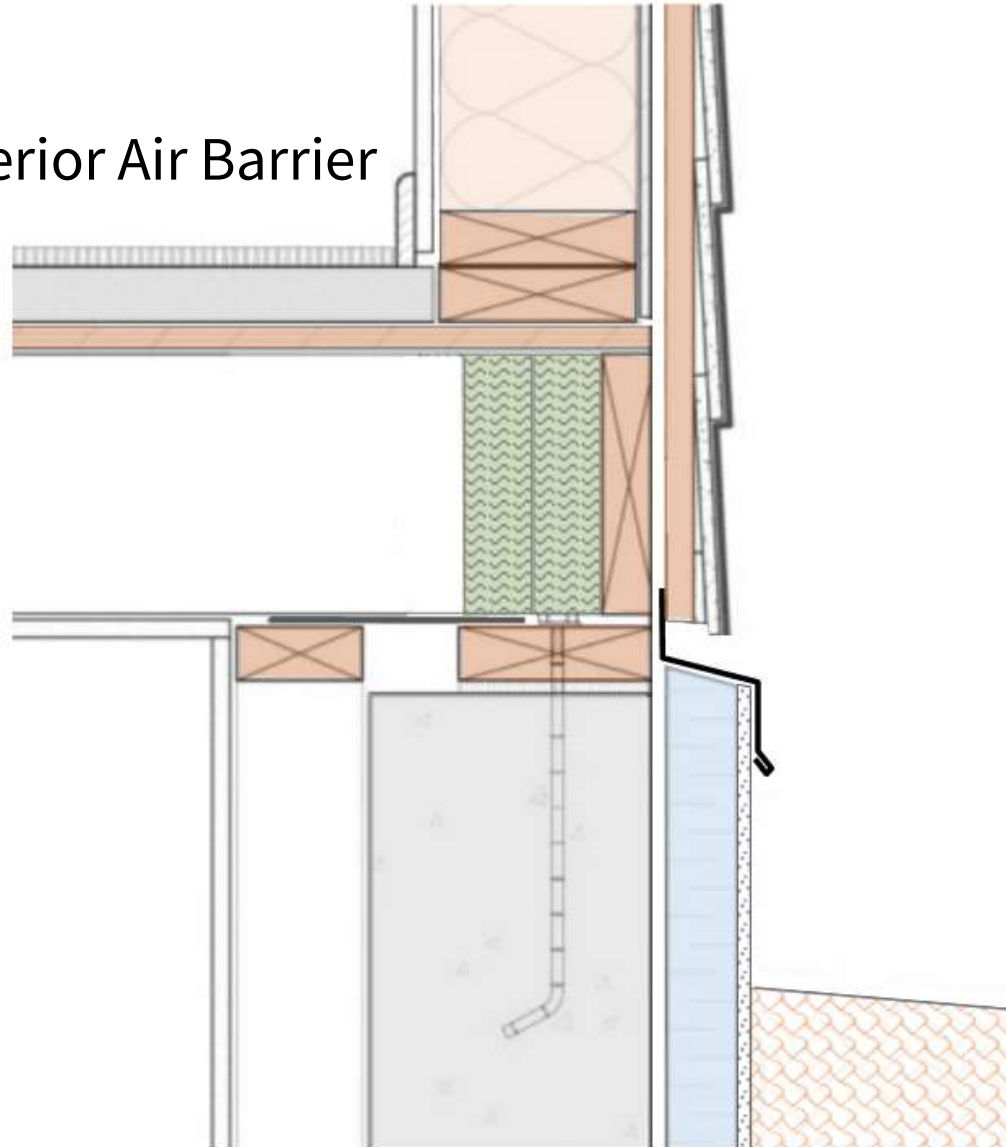
## Rim Joist Interface – Exterior Air Barrier



# Foundation Wall – Interior Air Barrier



# Foundation Wall – Exterior Air Barrier

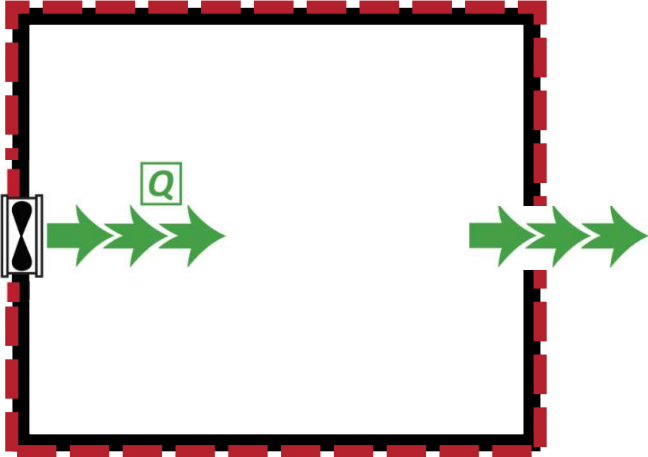


# Airtightness Testing



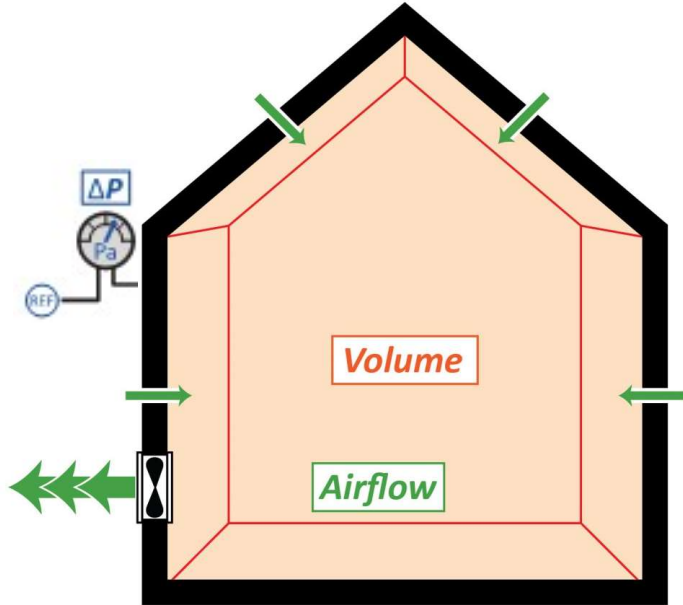
# Airtightness Testing & Metrics

Airflow In = Airflow Out



# Airtightness Testing & Metrics

Airflow In = Airflow Out



Air Change Rate:

$$ACH_{\Delta P} = \frac{Q_{\Delta P}}{V} \cdot (\text{hourly airflow conversion})$$



# Airtightness Testing – Building Prep?

- Multiple test standards available
- Confirm method with Energy Advisor
- Most common approach uses “in service” conditions, with mechanical vents left as is (CAN-CGSB 149.10)
- Some approaches require sealing mechanical vents (ASTM E779 /USACE)





Lots of Gear....

# Mid-Construction Airtightness Test

- Used to verify building airtightness targets air likely to be met (before finishes)
- Often required by jurisdictions and offered by Energy Advisors
- **Only useful if the air barrier is substantially complete**
  - **All windows, doors, mechanical/plumbing/electrical penetrations installed and sealed?**
  - **Ceiling poly installed?**
  - **Laps taped and sealed?**
  - **Plumbing traps filled?**
- Should be attended by installers and site superintendent

# Airtightness Testing - Qualitative

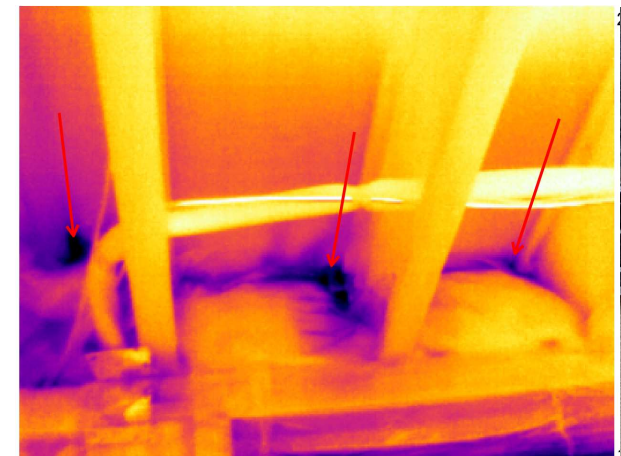
- “Pre-drywall” testing
- Smoke tracer testing
  - Fog generator
  - Vape
  - Incense
  - Feather?
  - Smoke pencil
- Thermographic Camera





# Airtightness Testing - Qualitative

- Smoke tracer testing:
  - Pressurize/depressurize with fan(s)
  - Apply smoke at suspected leakage points
  - Review airflow pathway on the other side
- Thermographic Camera:
  - Pressurize/depressurize with fan(s)
  - Scan building on low pressure side for thermal anomalies
  - Scan again with no pressure and compare
  - Requires additional training



# Airtightness Testing - Qualitative

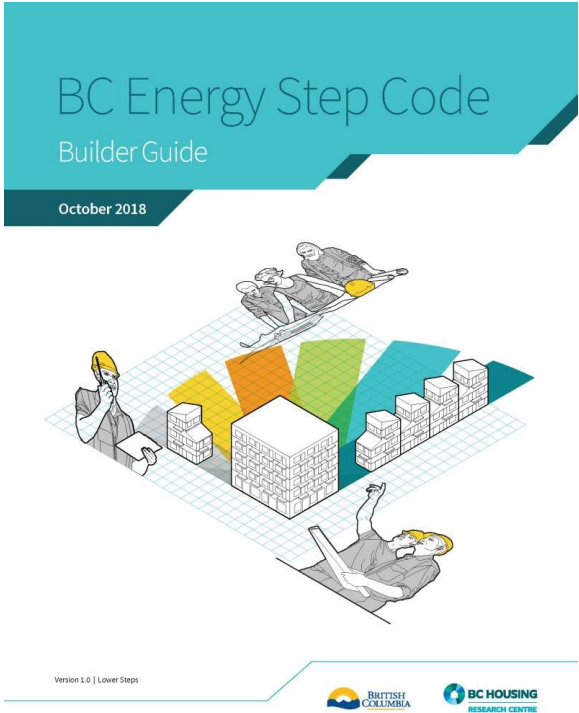
- Basic qualitative testing/investigation should be offered by your **Energy Advisor**
- Walk-through to identify areas of concern





# Additional Resources

- *BC Energy Step Code Builder Guide*



# Additional Resources

- *Illustrated Guide – R22+ Effective Walls in Residential Construction in BC*
- *Building Enclosure Design Guide*

## ILLUSTRATED GUIDE



# Additional Resources

- *Building Envelope Guide for Houses*
- *Guide for Designing Energy-Efficient Building Enclosures*

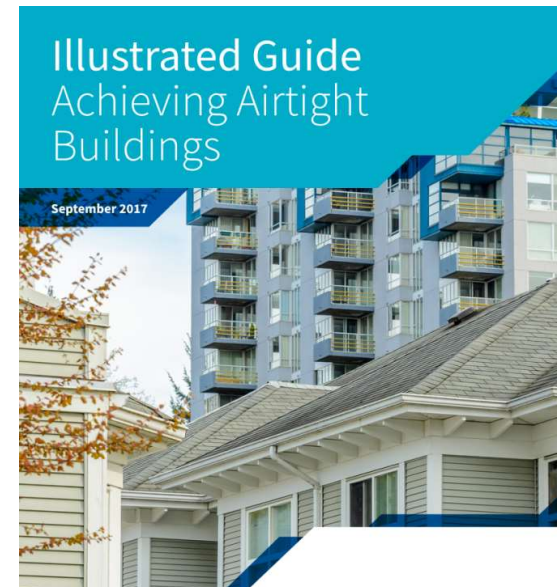
## Building Envelope Guide for Houses

PART 9 RESIDENTIAL CONSTRUCTION



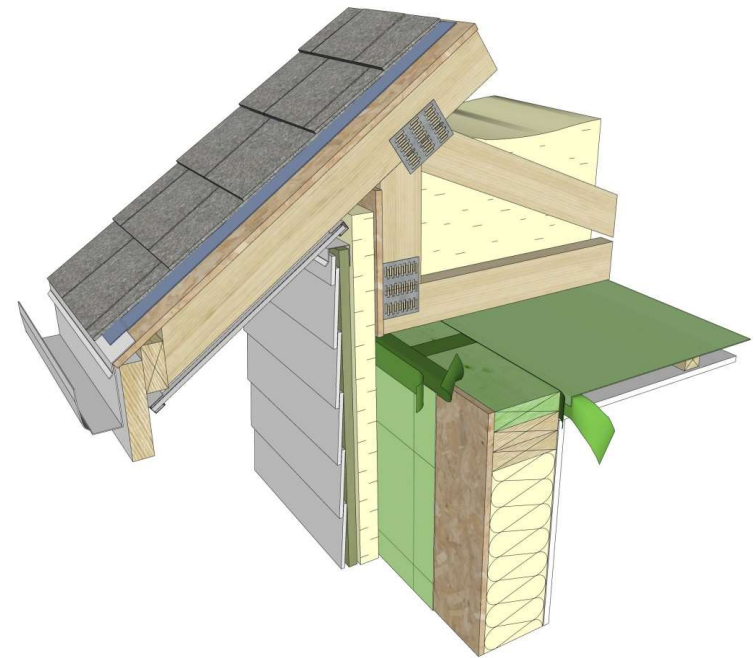
# Additional Resources

- *Illustrated Guide – Achieving Airtight Buildings*



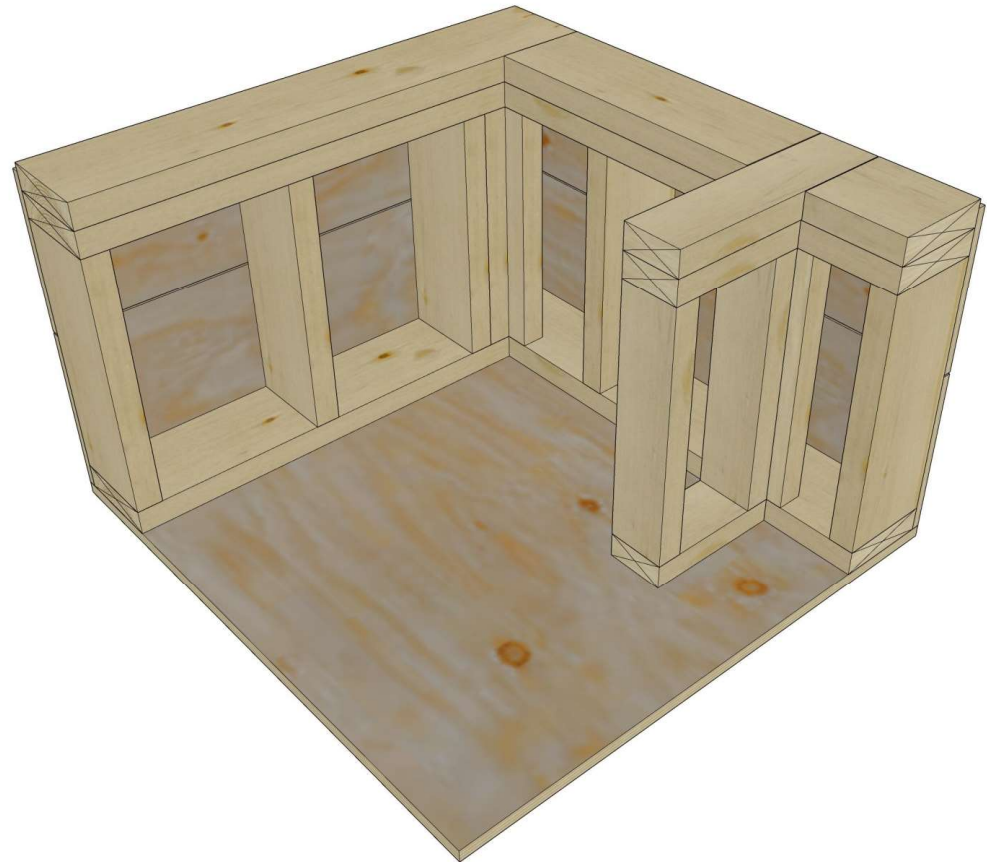
# Important Detail: **Roof to Wall**

- **Exterior** wall air barrier to **interior** ceiling air barrier is a common approach
- Requires careful coordination, materials, and well-planned methods
- Aim should be to avoid extra work for framers, insulators, and cladders



## Important Detail: **Roof to Wall**

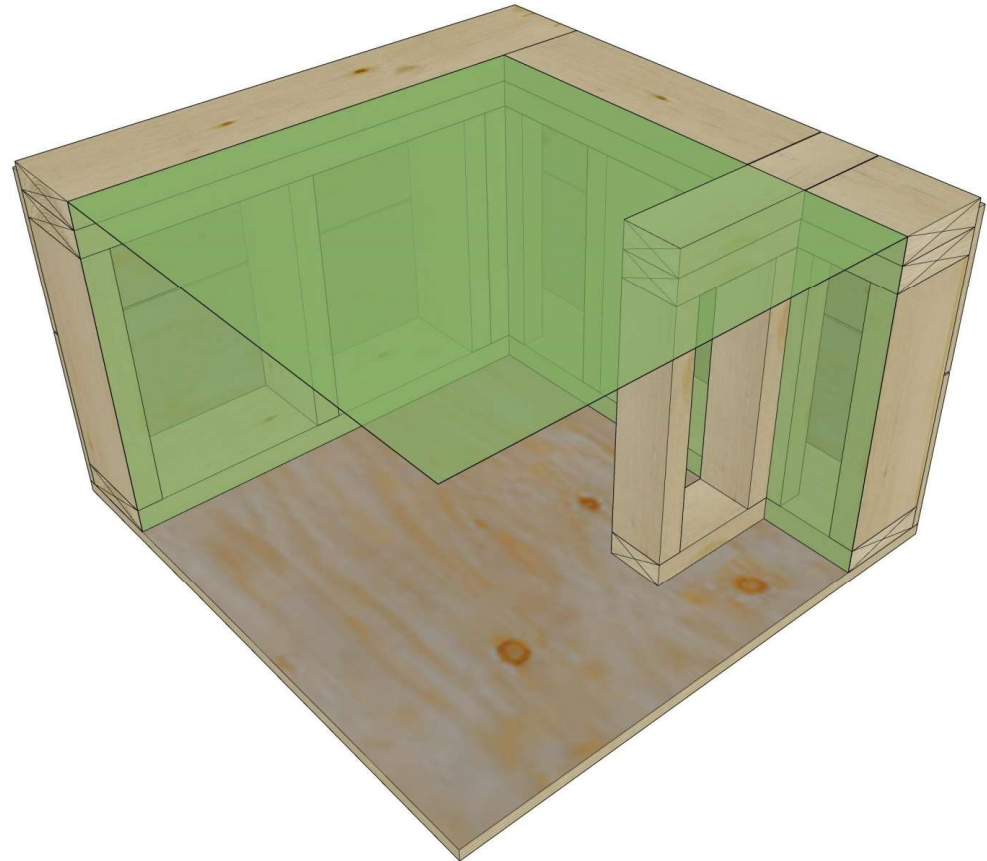
- “Traditional” methods are problematic:
  - No methods to seal top plate pre-strips
  - Sealing poly behind partition walls is not consistent





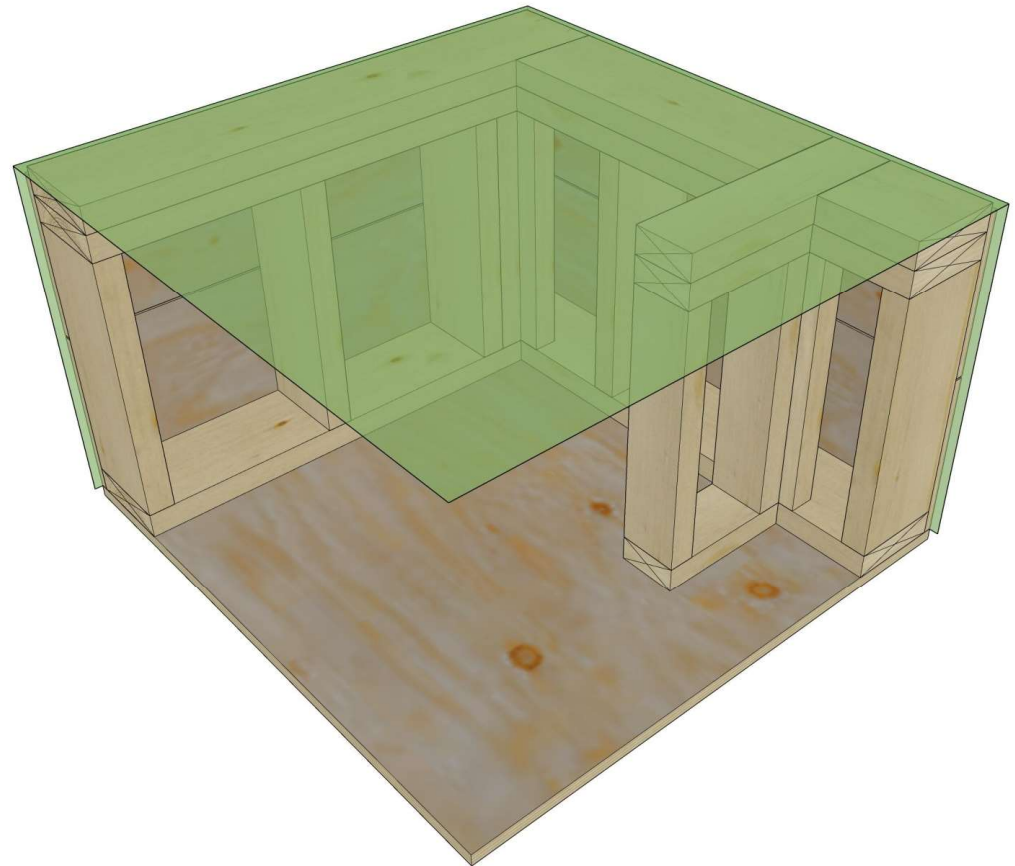
# Important Detail: **Roof to Wall**

- Interior partition walls are always in the way



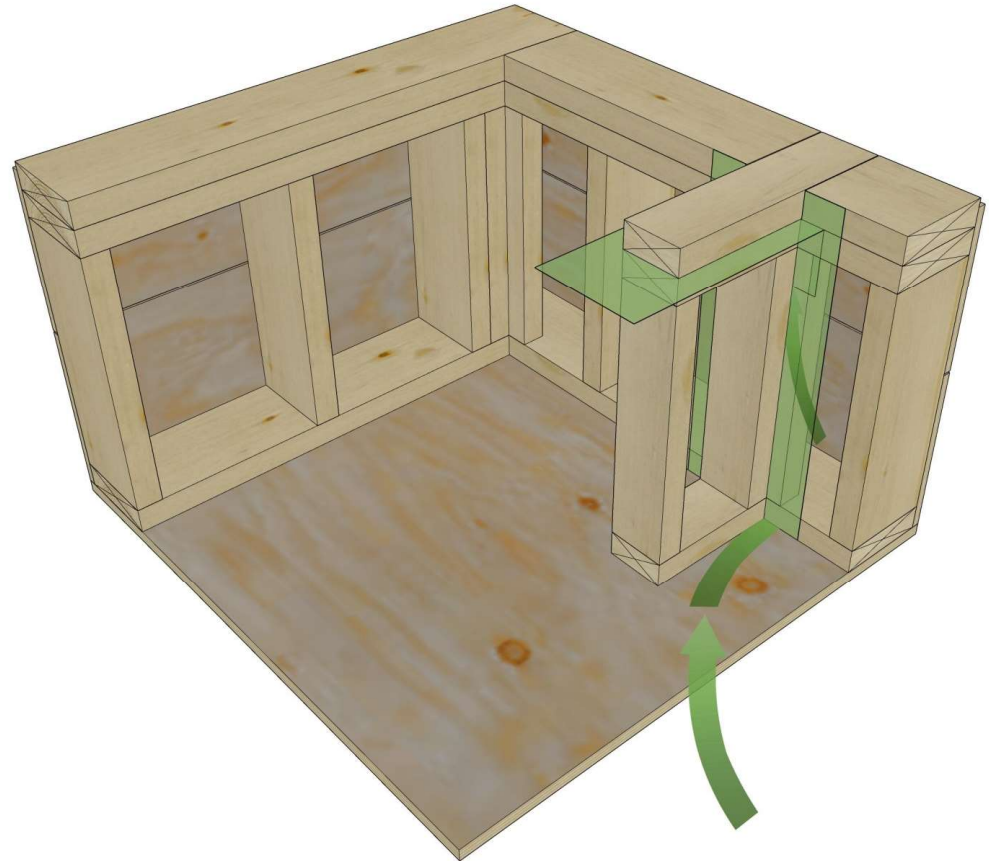
# Important Detail: **Roof to Wall**

- Interior partition walls are always in the way



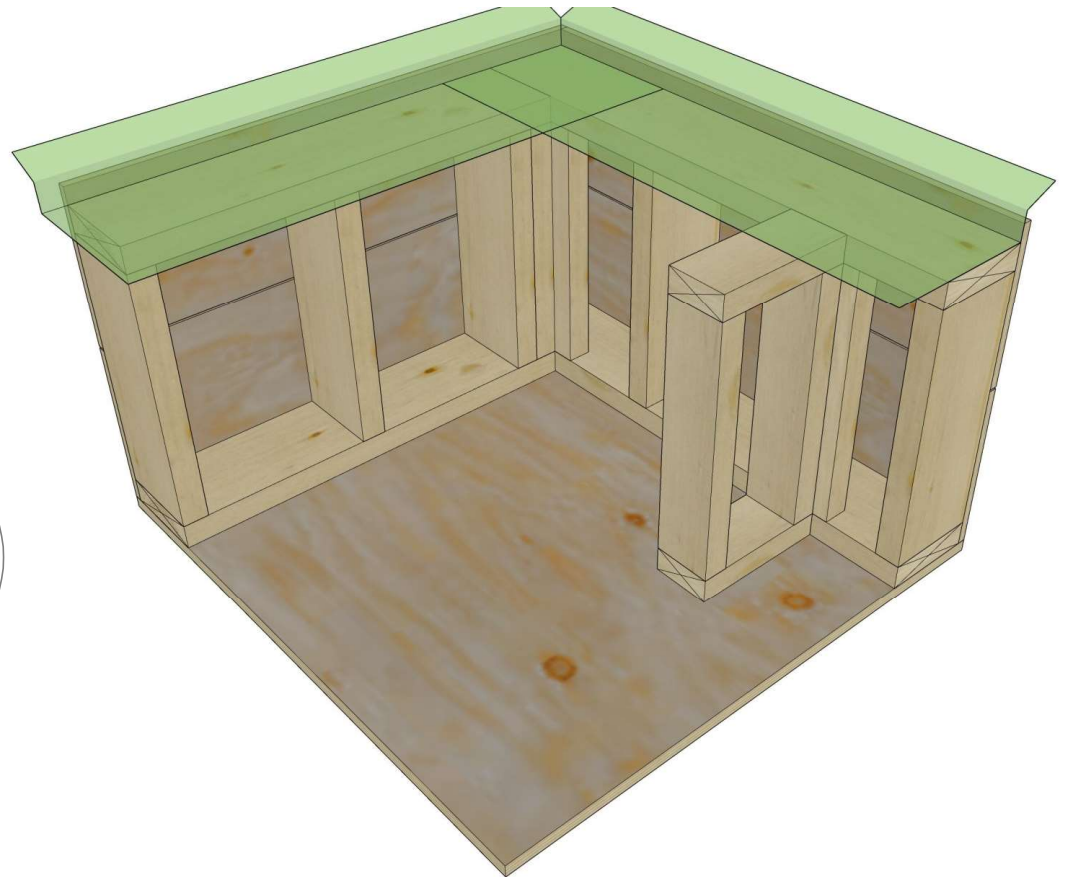
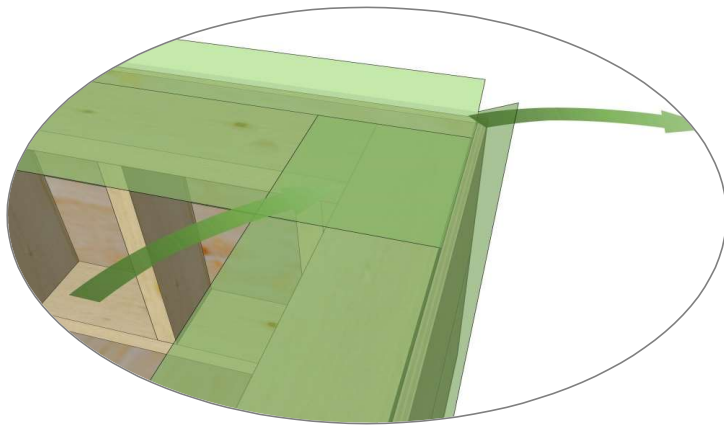
# Important Detail: **Roof to Wall**

- Interior partition walls must be sealed behind before they are installed



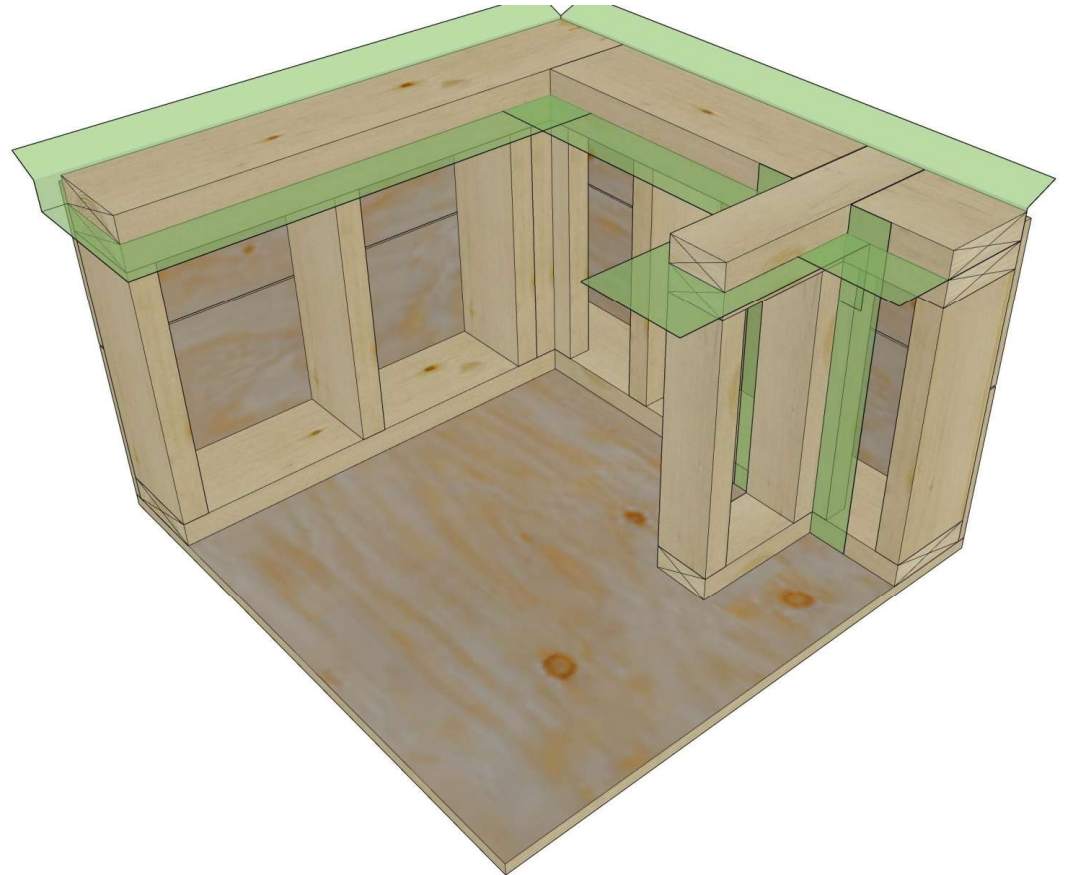
# Important Detail: **Roof to Wall**

- Top plate pre-strip is difficult to make airtight



# Important Detail: **Roof to Wall**

- Need to re-think this approach...

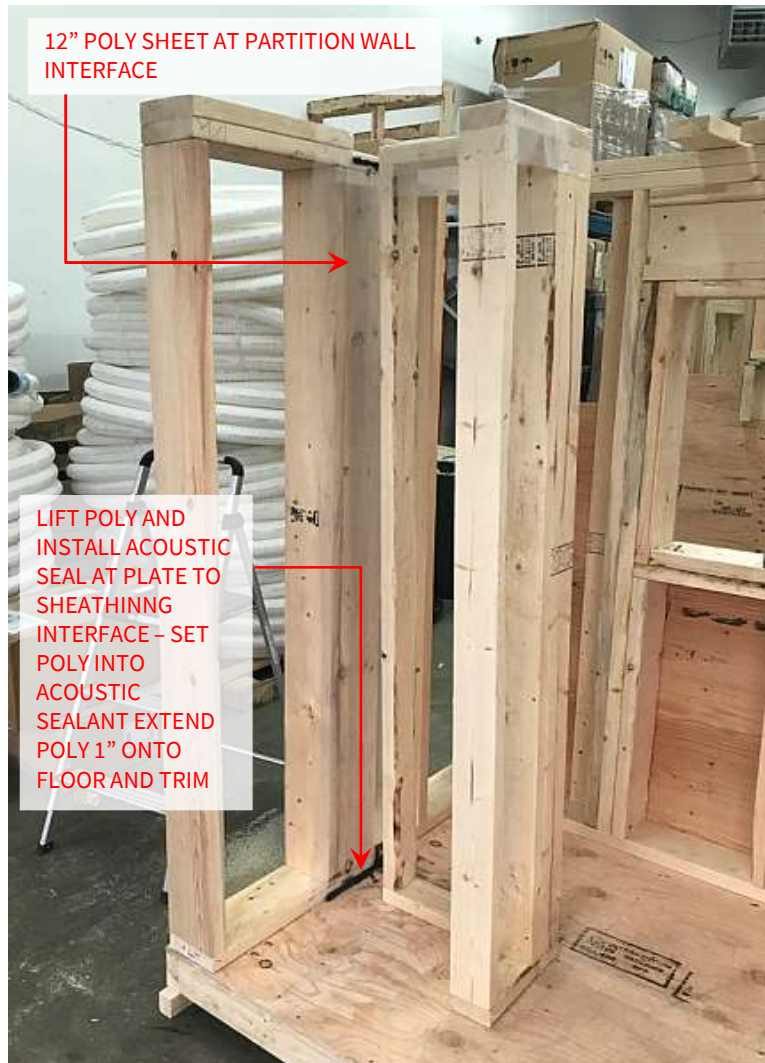


# Roof to Wall Airtightness: Step by Step

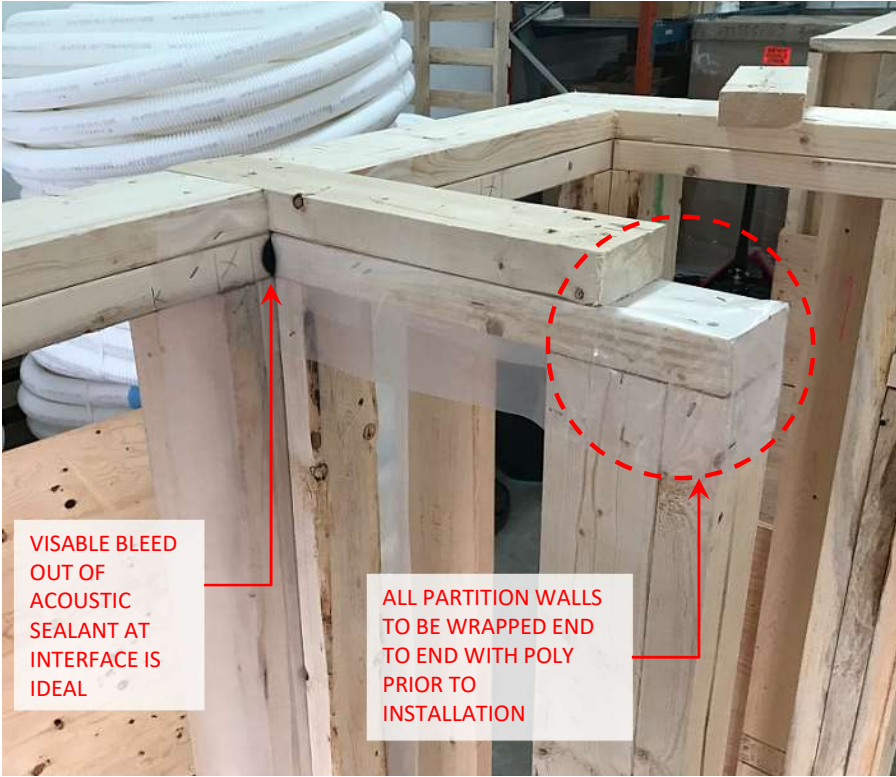
- Standard performance approach: Sealed pre-strip
- Higher-performance approach: Taped top plates



# Sealed Top Plate Pre-strip



# Sealed Top Plate Pre-strip



# Sealed Top Plate Pre-strip

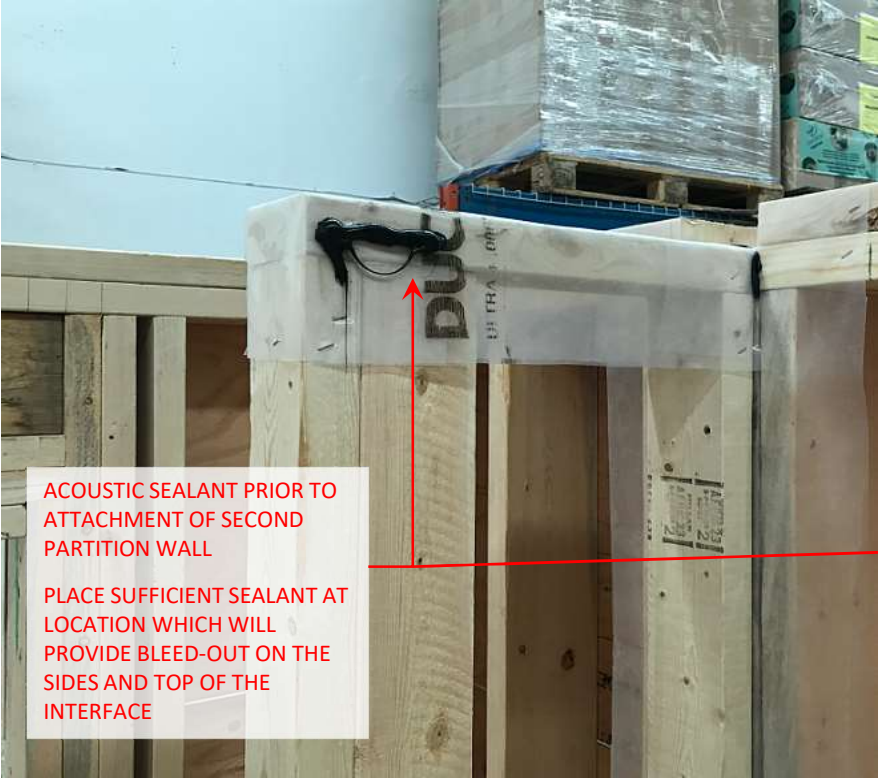




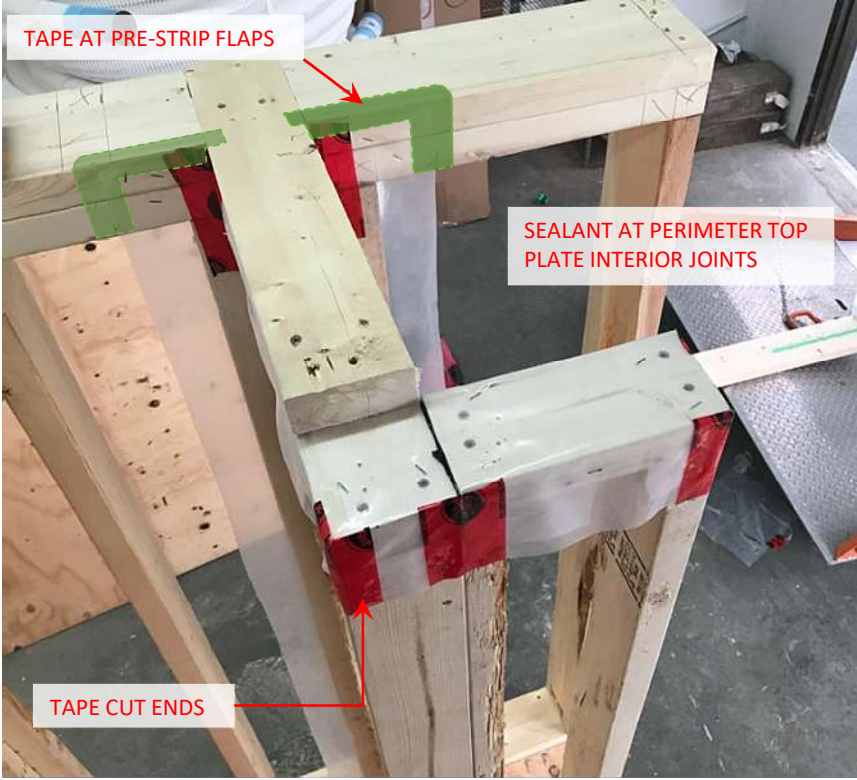
# Sealed Top Plate Pre-strip



# Sealed Top Plate Pre-strip

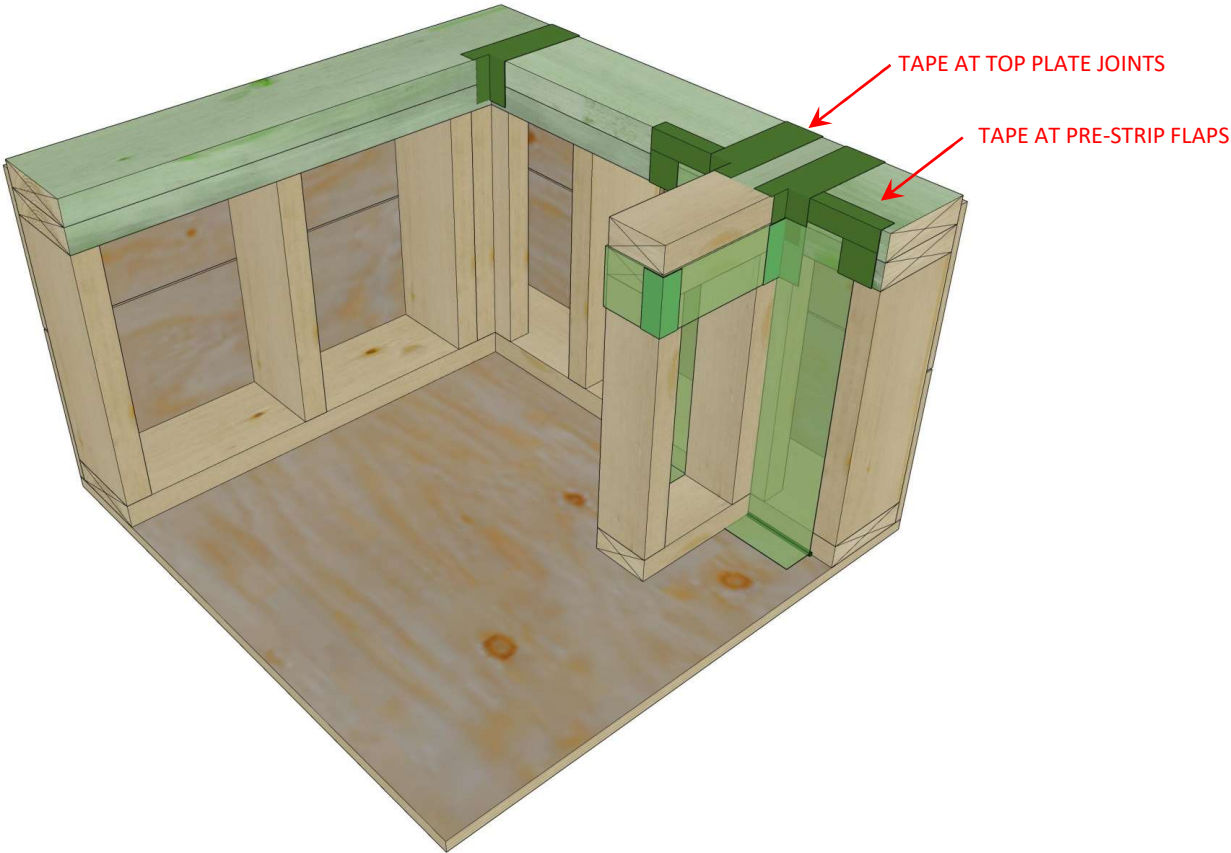


# Sealed Top Plate Pre-strip – Exterior Transfer





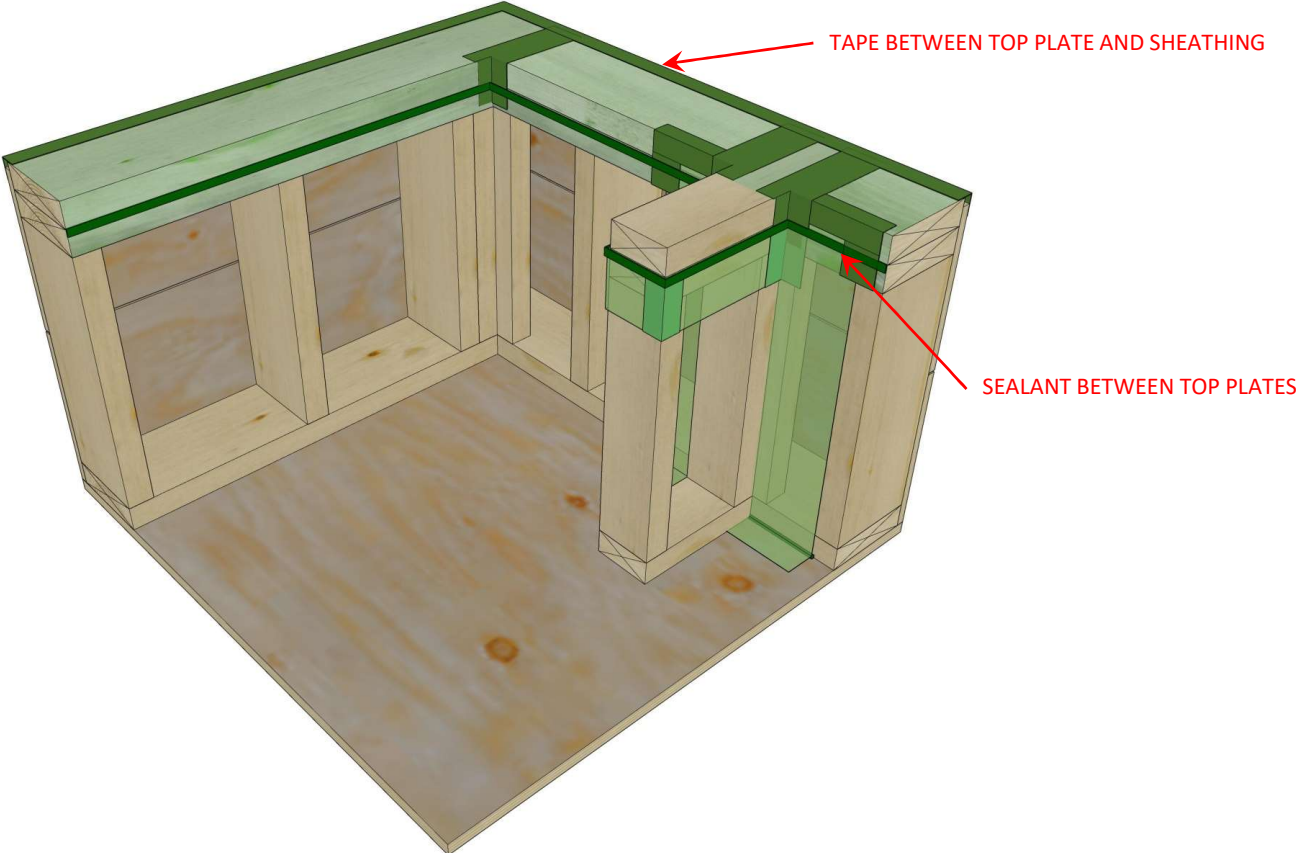
# Sealed Top Plate Pre-strip – Exterior Transfer



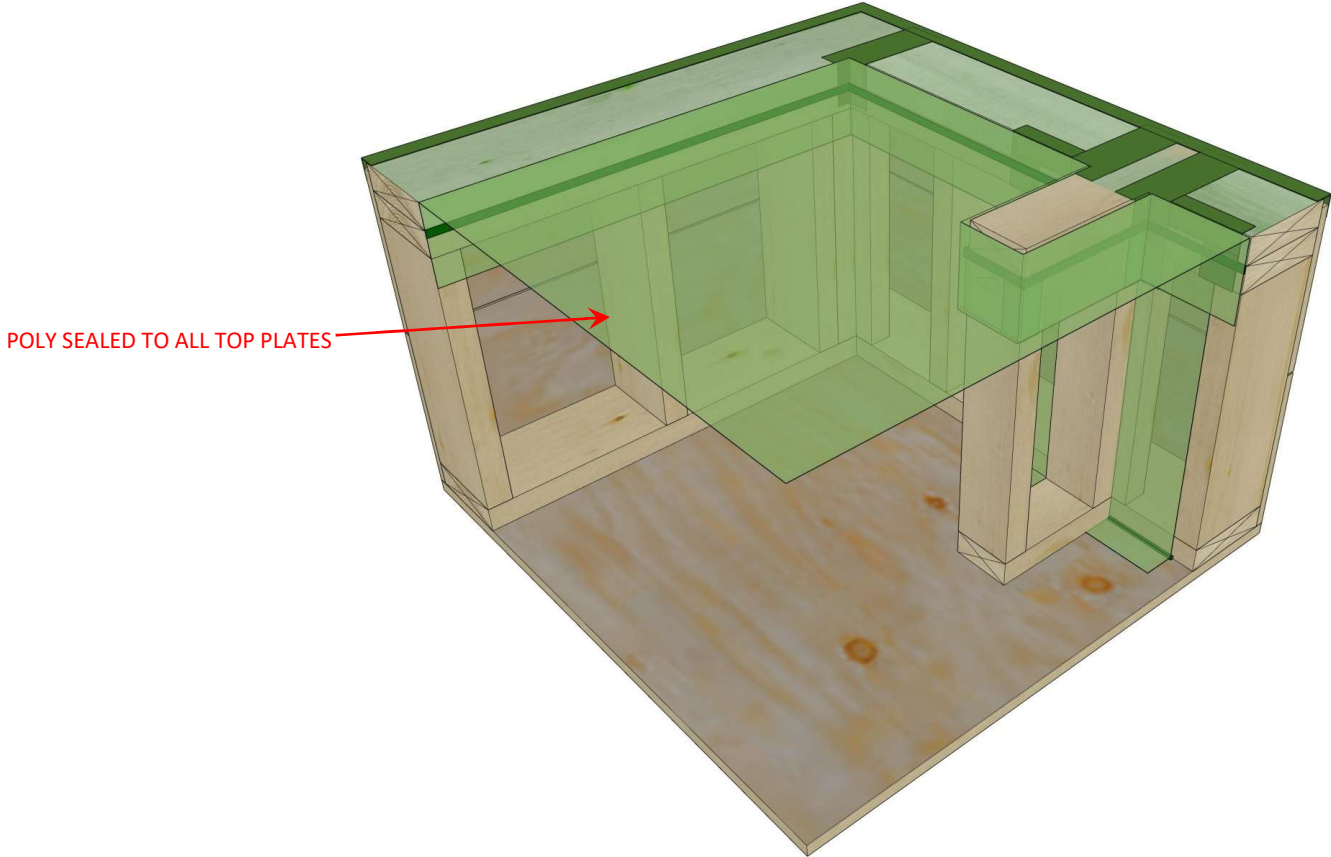
# Sealed Top Plate Pre-strip – Exterior Transfer



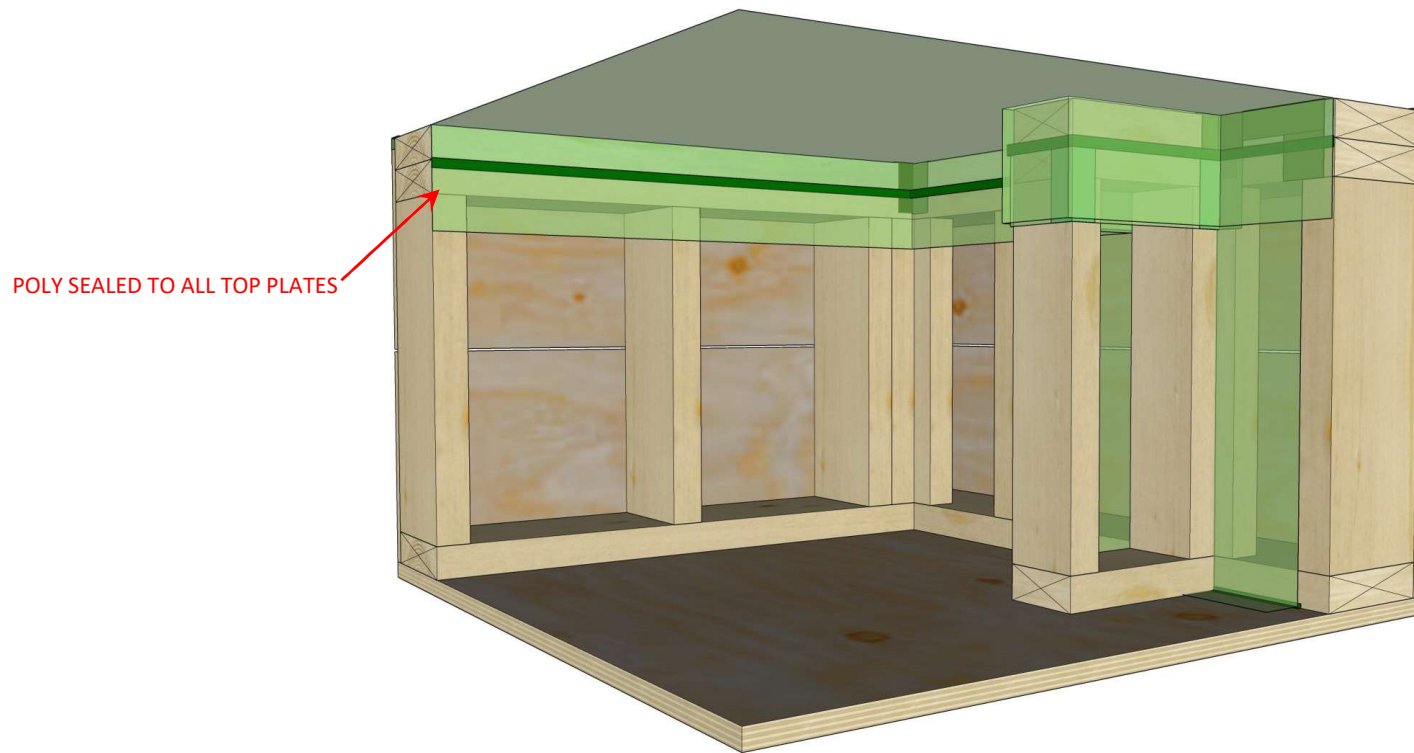
# Sealed Top Plate Pre-strip – Exterior Transfer



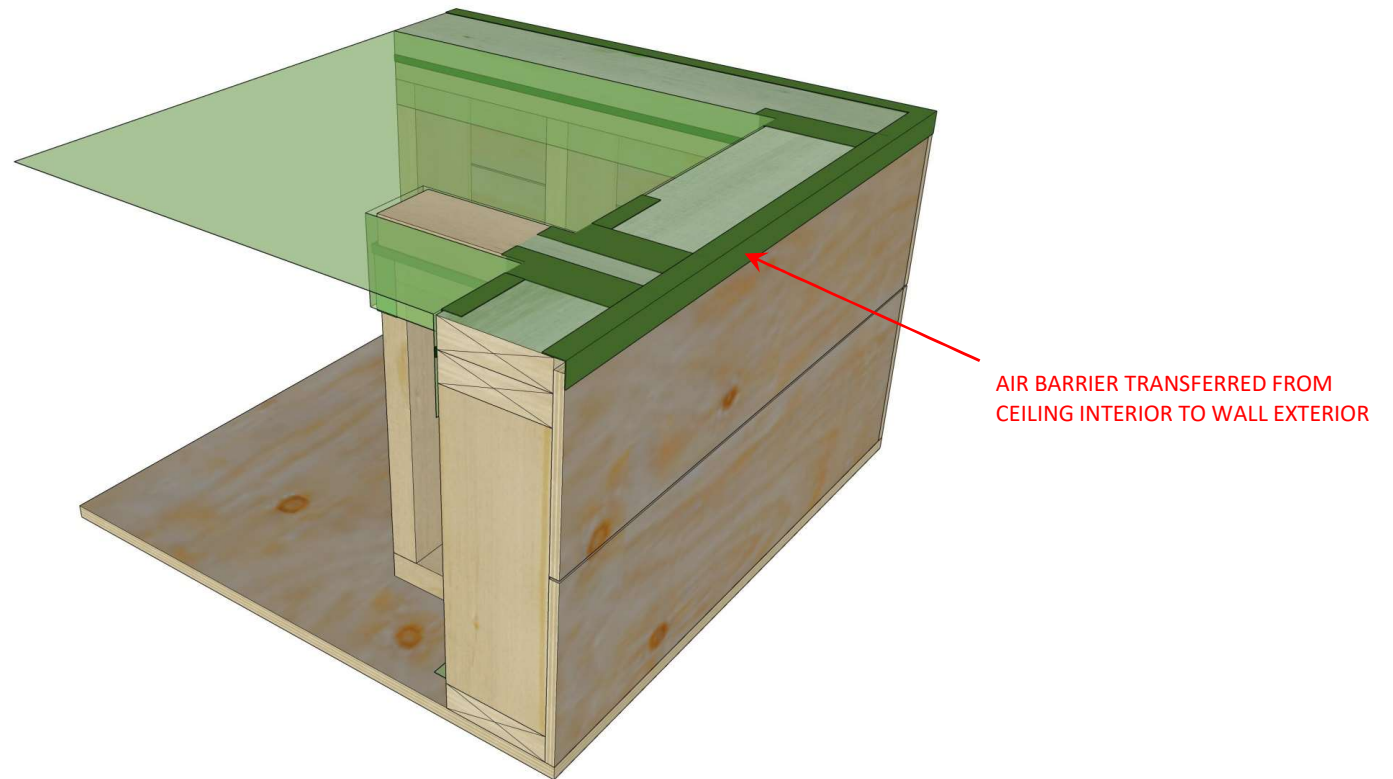
# Sealed Top Plate Pre-strip – Exterior Transfer



# Sealed Top Plate Pre-strip – Exterior Transfer



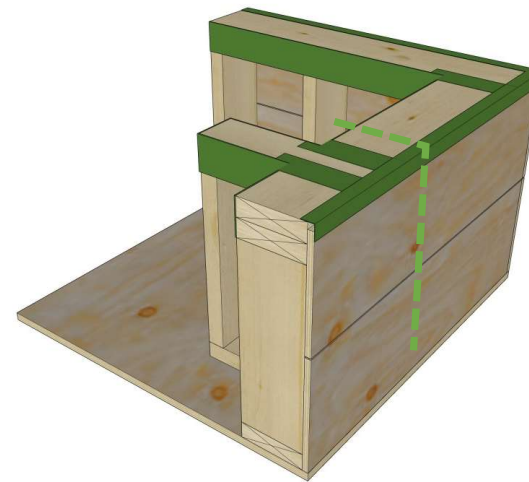
## Sealed Top Plate Pre-strip – Exterior Transfer





# Taped Top Plate Transition

- Taped top plates use high-performance tapes to make the top plates part of the air barrier.

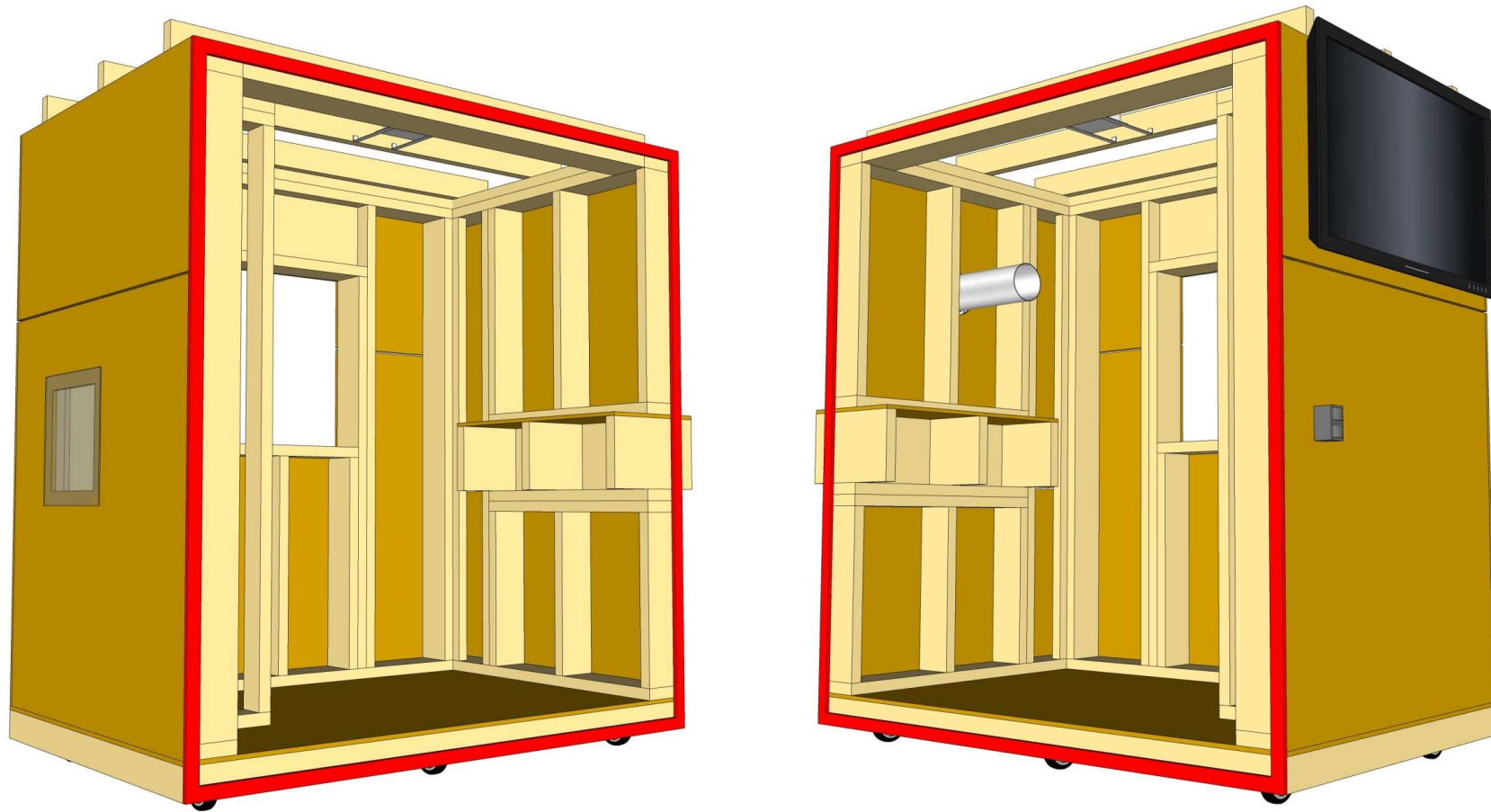








# Hands-On Demonstration



# Discussion & Questions

