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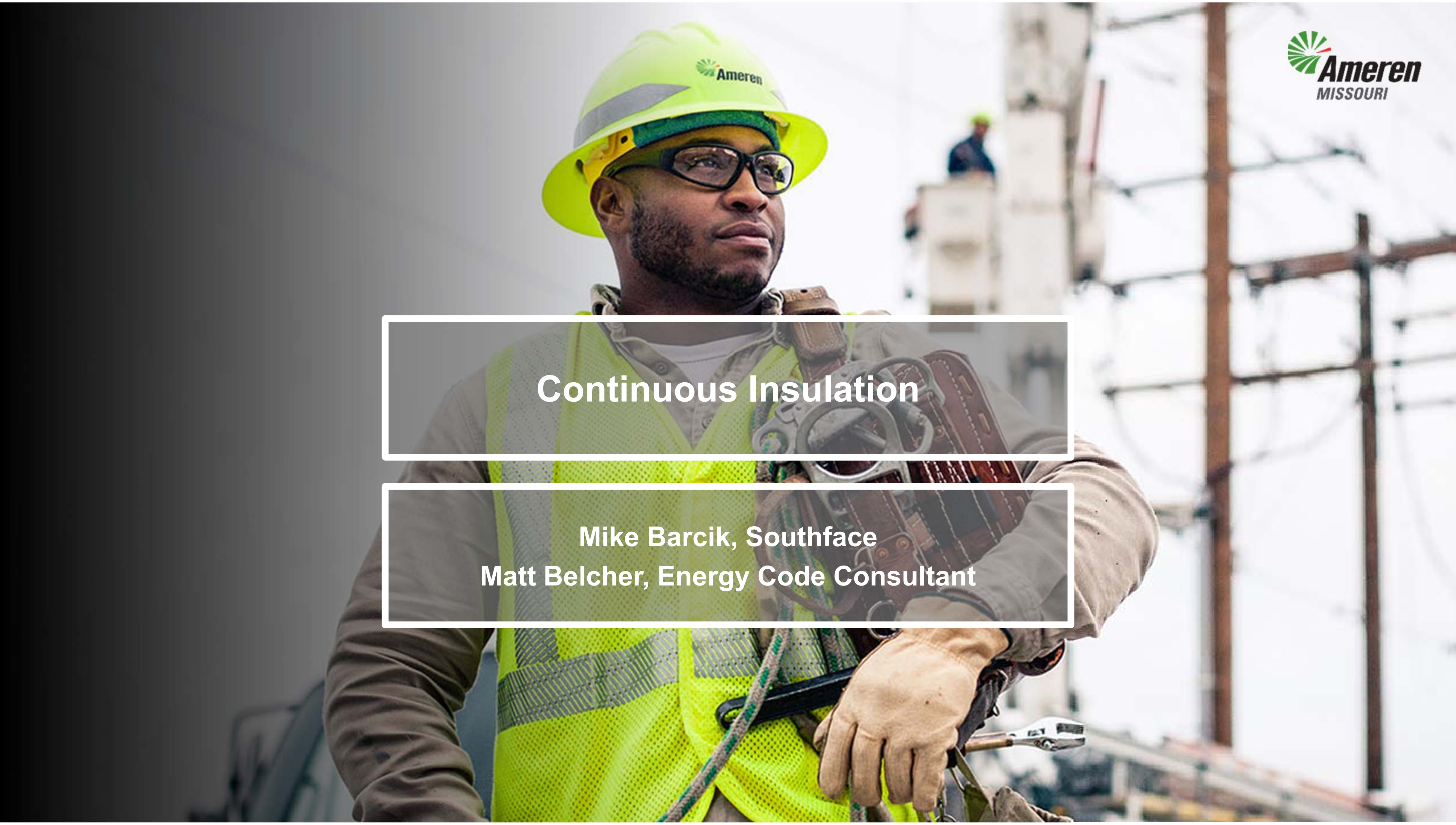

Continuous Insulation

Mike Barcik, Southface
Matt Belcher, Energy Code Consultant

Energy Code Resources

Technical assistance or training requests:

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314.749.4189

Energy Code Resources

Missouri Residential Building Energy Code Construction Practices Study:
https://energy.mo.gov/energy-codes/missouri-residential-building-codes-study
For additional information on other DOE Field Studies and participating states, please visit https://www.energycodes.gov/compliance/energy-code-field-studies.
Additional education resources are available at www.southfaceonlinetraining.org.

www.southface.org

mikeb@southface.org

About Southface

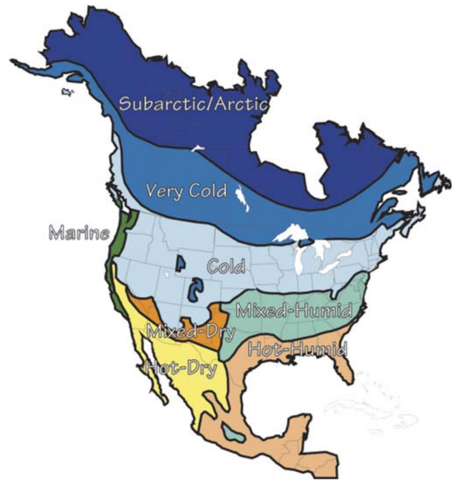
www.southface.org

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

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

Why building science?

- Employ scientific principles from a variety of fields that govern building performance
- Optimize building performance and understand, prevent and correct building failures
- Systems approach to houses
- Physics of
  - Heat
  - Air
  - Moisture



All efficiency measures should take occupants into account (e.g., air sealing & ventilation)

Who Are You?

- Weatherization
- HERS Raters
- Code official
- Designer
- Contractor / Trades
- Utility
- Manufacturers / Product Rep
- Policy / Government
- Building Managers
- Home Inspectors
- Other?

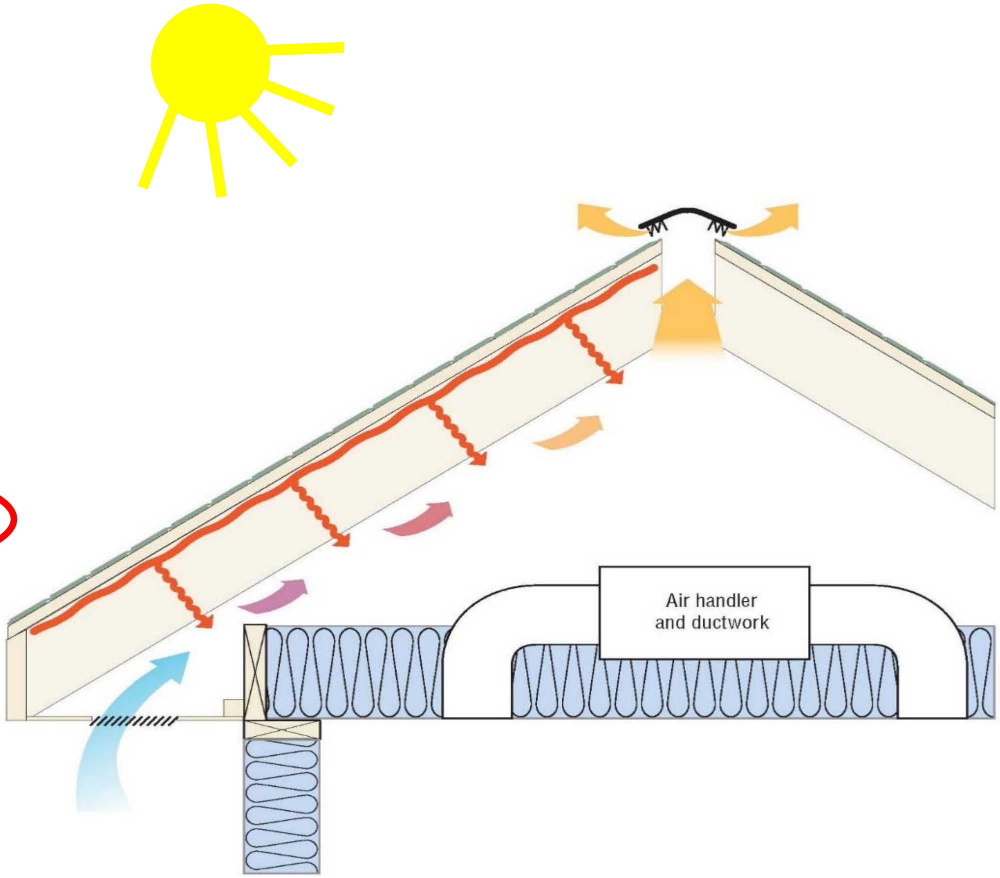
Learning Objectives

- A little math…making a case for why continuous insulation is worthwhile (assembly U-factors, coldest point)
- Energy flow through assemblies - exterior vs. interior continuous insulation
- Cold climates – understanding the minimum amount of exterior insulation needed
- Common continuous insulation products – EPS, XPS, Poly-iso
- Other continuous insulation products – fiberglass blankets, cellulose “boards”, rockwool, spray applied foams
- Hybrid sheathing products, nail-base, SIS, SIPs
- Retrofit case study
- Environmental concerns – GWP, flammability, etc.

Who loves acronyms?!

Building Science: Heat transfer

- Heat is a form of energy
- Heat moves from hot to cold
- 3 methods of heat transfer:
  - **Radiation:**
    Sun to shingles; underside of decking to other attic surfaces
  - **Conduction:**
    Through shingles and decking
  - **Convection:**
    Soffit vents through attic to ridge



Why is Continuous Insulation Worth It?

- **Conduction** is heat flowing through a solid material (insulation slows conduction)



Continuous Insulation - Math

Conduction Heat Flow

Heat transfer through a solid object: the formula for calculating conduction heat transfer is q = U x A x ΔT

q = heat flow (Btu/hr)

U = inverse of R-Value [U=1/R, R=1/U] (Btu/hr ft^2 °F)

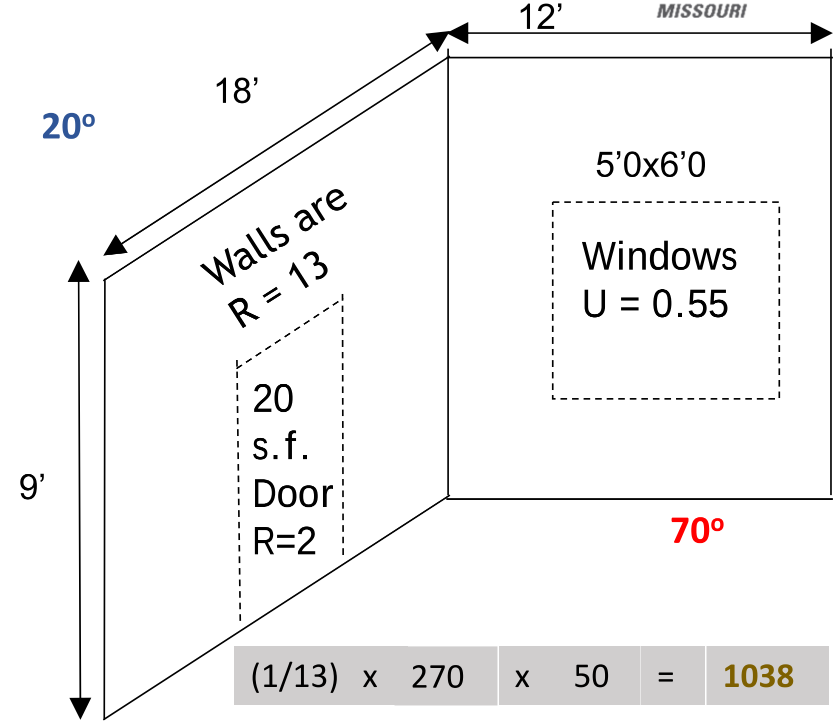
A = area (square feet)

ΔT = temperature difference across component (°F)

q = U x A x ΔT

Manual J: q = A x HTM

where HTM = UxΔT



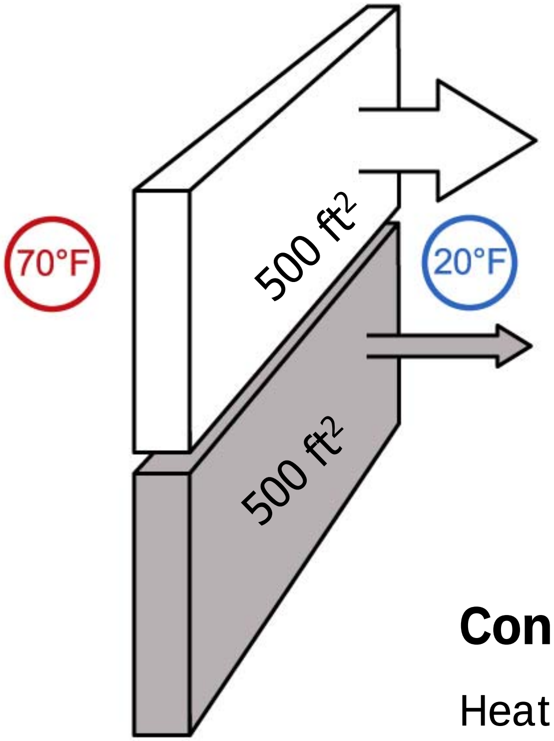
(1/13)	x	270	x	50	=	**1038**

R	U	Area	Delta T	q
13	1/13	220	50	846
2	½	20	50	500
-	0.55	30	50	825
				2171

Effect of U-factor (U = 1/R)

- Smaller is better
- Double the R-value, U-factor is halved and so is amount of heat transfer
- Weighted average U-factor of assembly includes thermal bridging effects of framing

Conduction



Low R-value (R-5)

(1/5) x 500 x (70-20) =
5,000 Btu/hr

High R-value (R-10)

(1/10) x 500 x (70-20) =
2,500 Btu/hr

Conduction Equation

Heat Transfer $= q = U \times A \times \Delta T = \frac{\text{Area} \times \Delta T}{\text{R-Value}}$

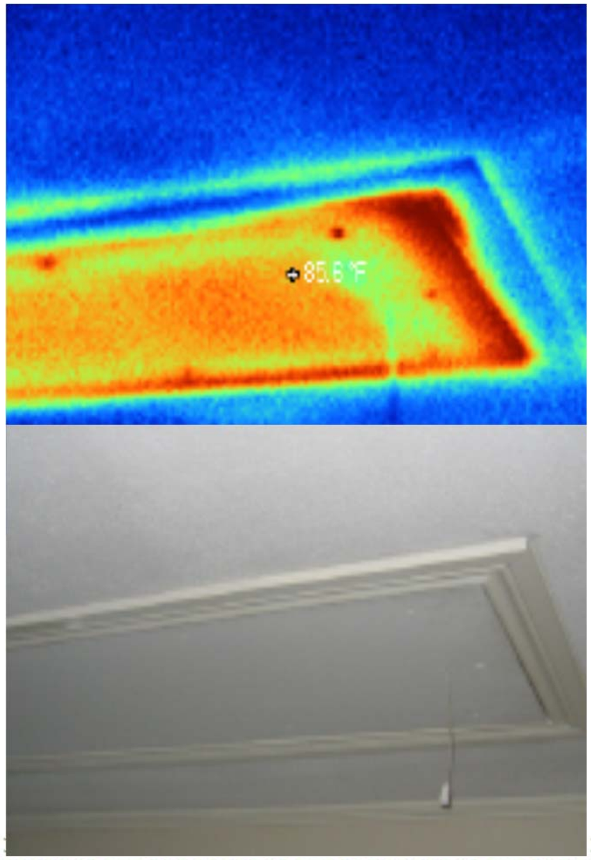
Insulation Coverage is key!

- If 990 s.f. of R-38 is installed with 10 s.f. of uninsulated attic access (R-1), it effectively yields the same heat transfer as R-28!

$$U_{avg} = \frac{U_1 \times A_1 + U_2 \times A_2 + U_3 \times A_3}{A_{total}}$$

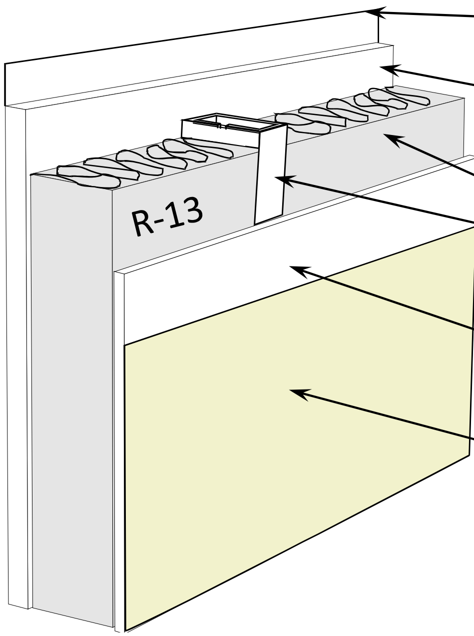
$$U_{avg} = \frac{0.026 \times 990 + 1 \times 10}{1000}$$

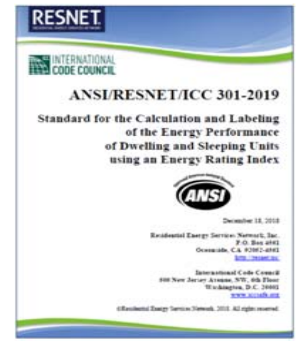
$$U_{avg} = \mathbf{0.036} \qquad \mathbf{R} = \mathbf{27.7}$$



U-factors / R-values of Insulated Assemblies

- **Grade I** - Effective R-value of wall with cavities and studs





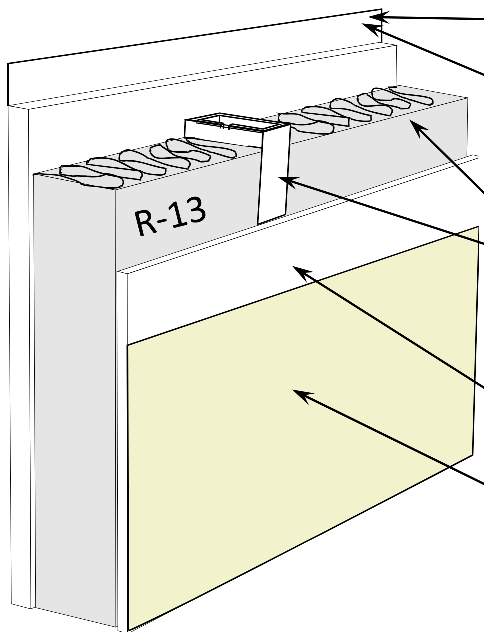
		cavity | stud
Outside air film*	=	**0.17 | 0.17**
Cladding + Ext. sheathing	=	**1.0 | 1.0**
Cavity / Stud R-values	=	**13.0 | 4.4**
Gypsum Board	=	**0.45 | 0.45**
Inside Air Film*	=	**0.68 | 0.68**
TOTAL R-values	=	**15.3 | 6.7**

If 23% of the wall is wood (77% cavity), the weighted average U-factor is:
Uavg = 0.77 x (1/15.3) + 0.23 x (1/6.7) = 0.08466

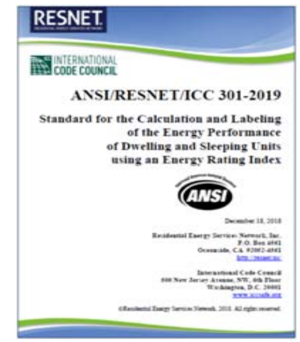
Ravg = 1/U = 11.8

U-factors / R-values of Insulated Assemblies

- **Grade III** - Effective R-value of wall with cavities, studs and voids



	cavity	stud	voids
Outside air film* =	**0.17**	**0.17**	**0.17**
Cladding + Ext. sheathing =	**1.0**	**1.0**	**1.0**
Cavity / Stud Voids R-values =	**13.0**	**4.4**	**1.0**
Gypsum Board =	**0.45**	**0.45**	**0.45**
Inside Air Film* =	**0.68**	**0.68**	**0.68**
TOTAL R-values =	**15.3**	**6.7**	**3.3**


RESNET

INTERNATIONAL CODE COUNCIL

ANSI/RESNET/ICC 301-2019

Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index

ANSI

If 23% of the wall is wood, 72% is cavity (& 5% is voids), the weighted average U-factor is:

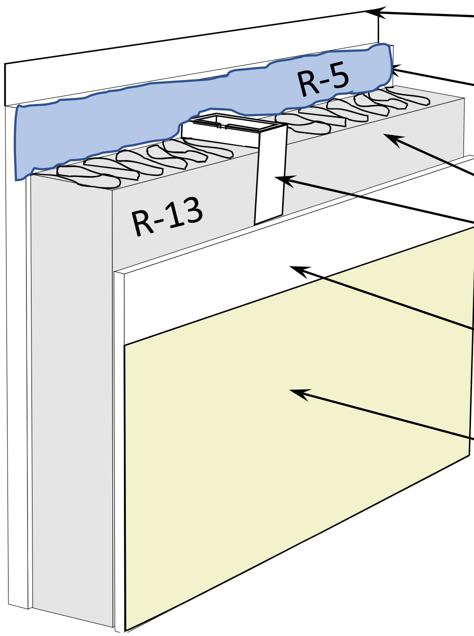
Uavg = 0.72 x (1/15.3) + 0.23 x (1/6.7) + 0.05 x (1/3.3) = .09654

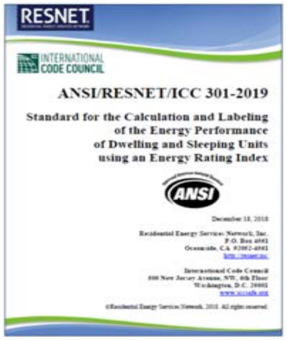
Ravg = 1/U = 10.4

Compare to R-11.8

U-factors / R-values of **Continuously Insulated** Assemblies

- **Grade I** – R-5 continuous insulation installed





	cavity	stud
Outside air film* =	**0.17**	**0.17**
R-5 Cont. Insul. =	**5.0**	**5.0**
+ Cladding & Ext. Sheathing =	**1.0**	**1.0**
Cavity / Stud R-values =	**13.0**	**4.4**
Gypsum Board =	**0.45**	**0.45**
Inside Air Film* =	**0.68**	**0.68**
TOTAL R-values =	**20.3**	**11.7**

If 23% of the wall is wood (77% cavity), the weighted average U-factor is:
Uavg = 0.77 x (1/20.3) + 0.23 x (1/11.7) = 0.05759

Ravg = 1/U = 17.4

Compare to R-11.8

Question: Which is preferred?

R-20 Cavity

U-0.059

R-13 Cavity + R-5

U-0.057

The R-13+R5 is better since it has a lower U-factor!

U-factors from RESCheck (www.energycodes.gov)

Can you have too little exterior insulation?

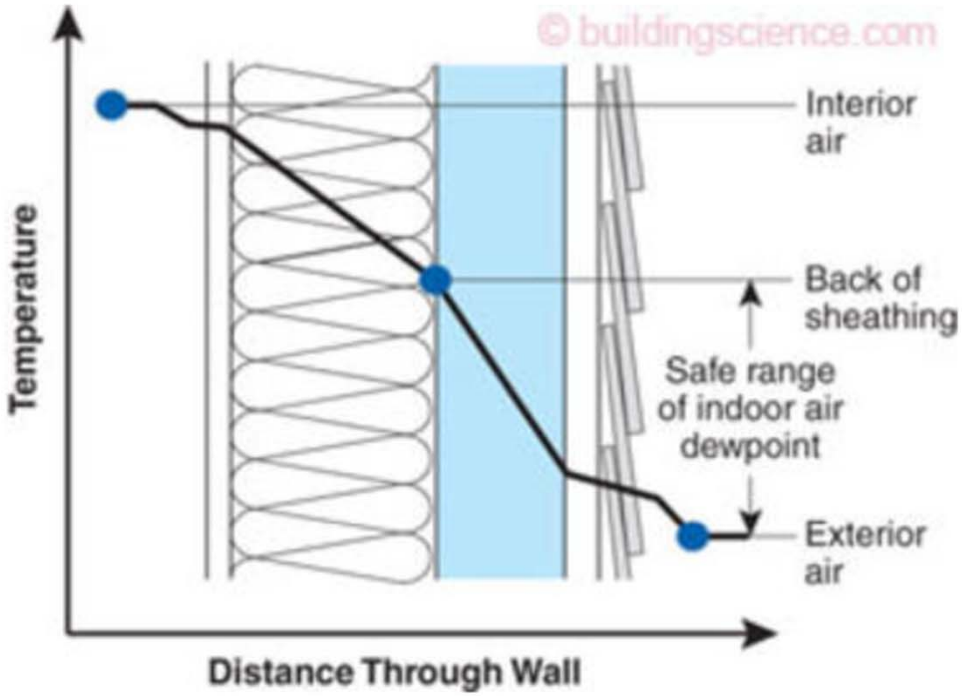


Figure 1: Insulating sheathing reducing air leakage condensation

Building Science Corporation

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BSD-163: Controlling Cold-Weather Condensation Using Insulation

John Straube

Continuous Insulation - Products

Continuous Insulation – Rigid foam

- A desirable insulation installation is one that will stay in place, be resilient in case of moisture issues, and low cost

EPS Foam, ~R-4/inch

XPS Foam, ~R-5/inch

Poly-iso Foam, ~R-6+/inch

Continuous Insulation – Spray

Open Cell Foam,
~R-3.7/inch

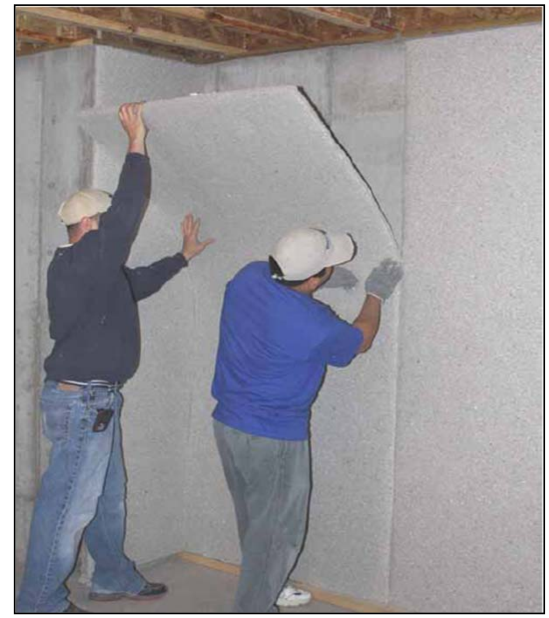
Cellulose,
~R-3.7/inch

Closed Cell Foam,
~R-6+/inch

Continuous Insulation – Other Products

Rock Wool, ~R-3.7/inch

Rigid Fiberglass board, ~R-3.5/inch



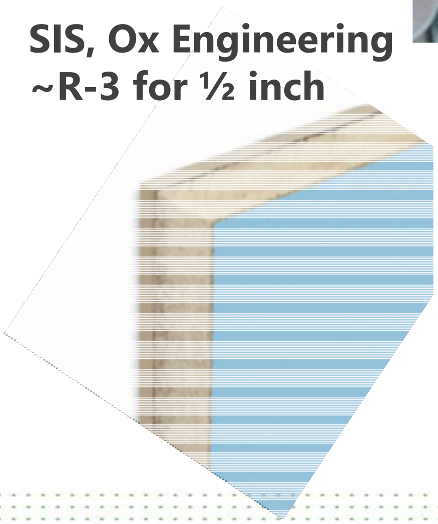
Cellulose “blanket”, ~R-3.7/inch

Fiberglass blanket, ~R-3.5+/inch

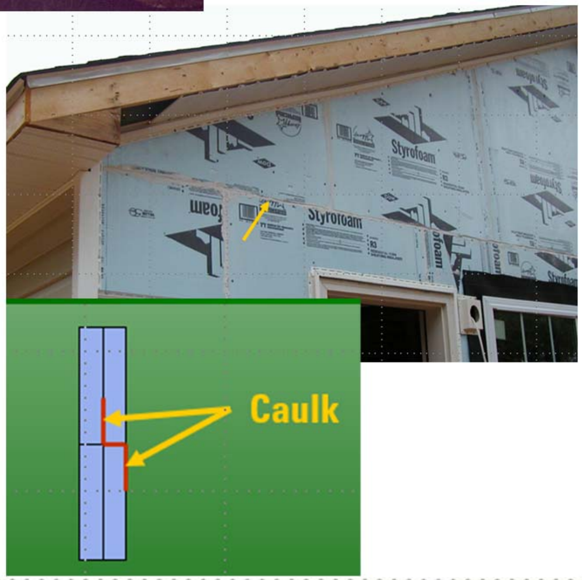
Continuous Insulation – Hybrid/Sheathing Products

Zip with R-value, ~R-3.6/inch

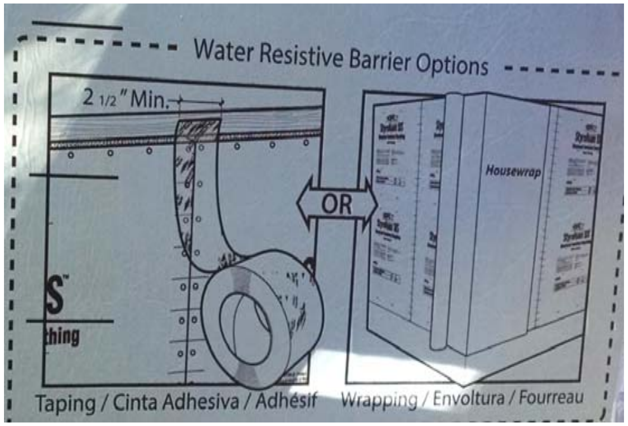
SIS, Ox Engineering ~R-3 for ½ inch

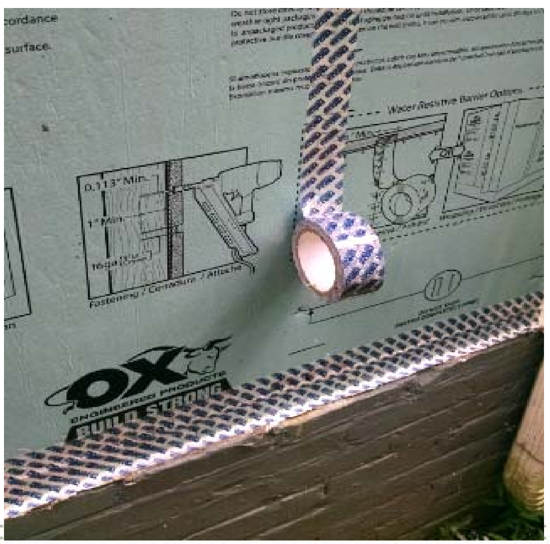


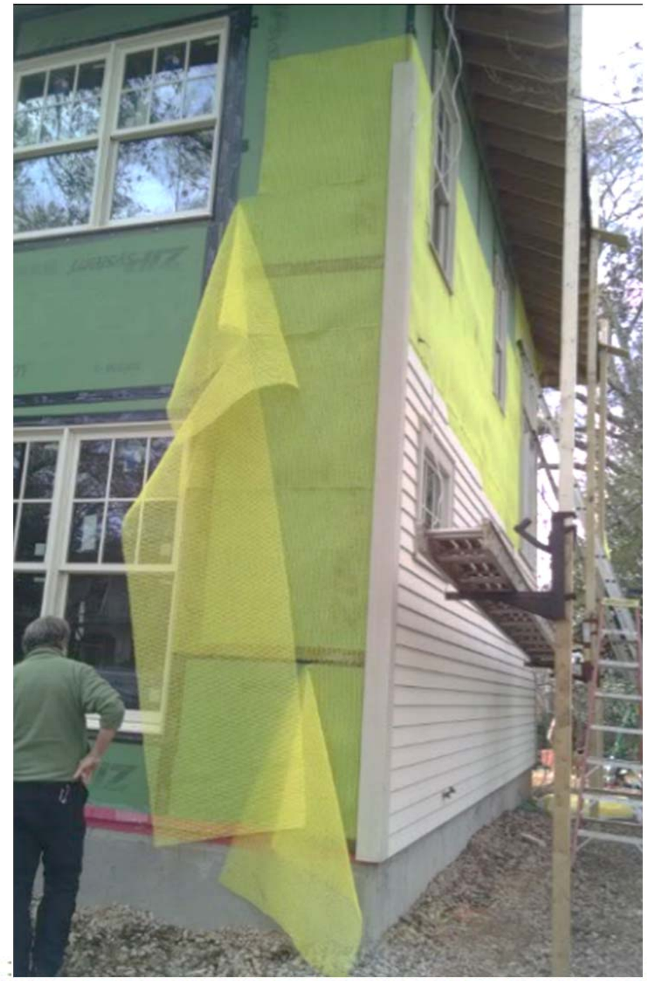
Oversheathing & Let-in bracing, ~R-3.7/inch



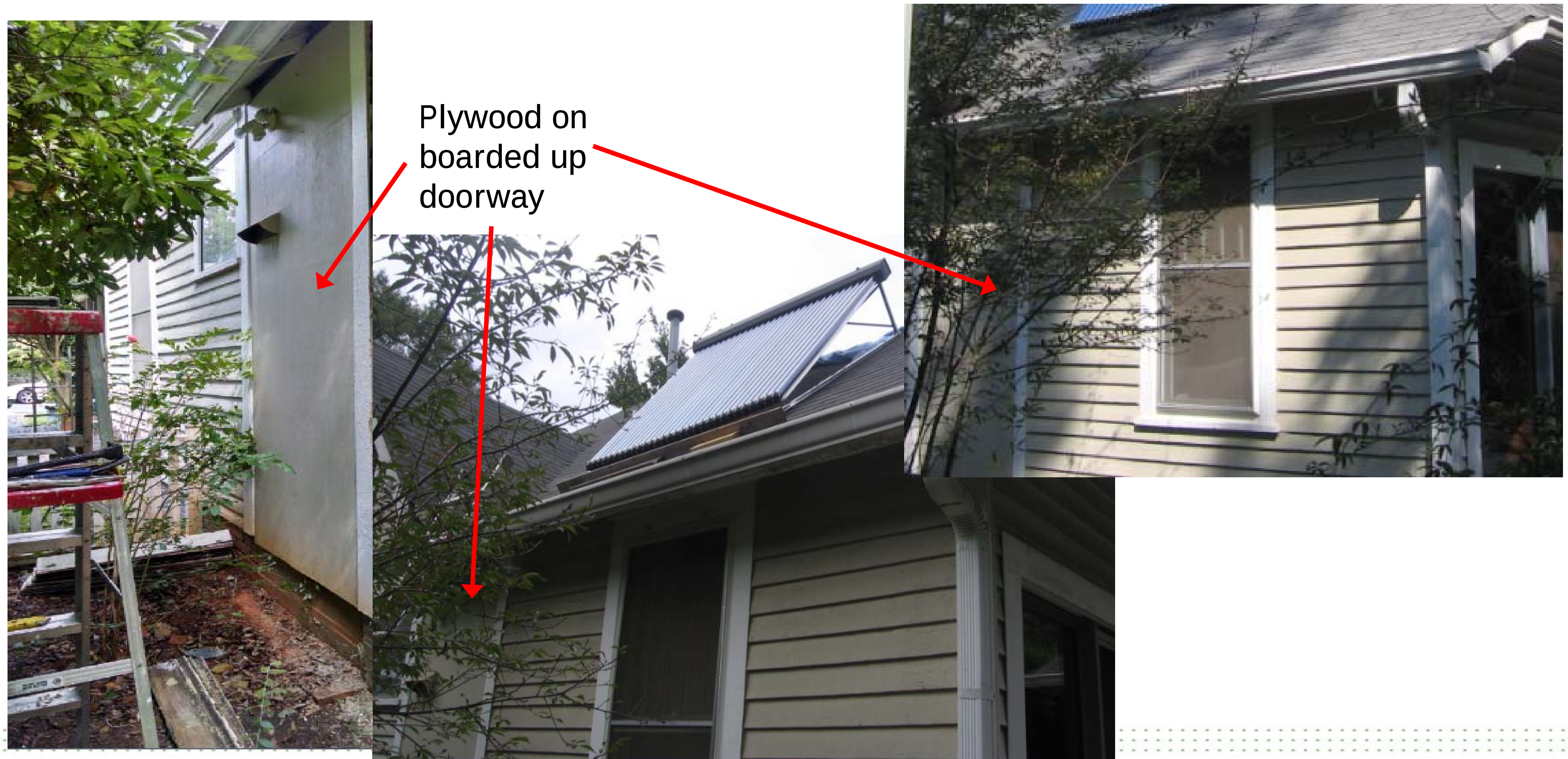
Continuous Insulation – Hybrid/Sheathing as WRB







Retrofit Case Study:
Lap Siding nailed directly to studs

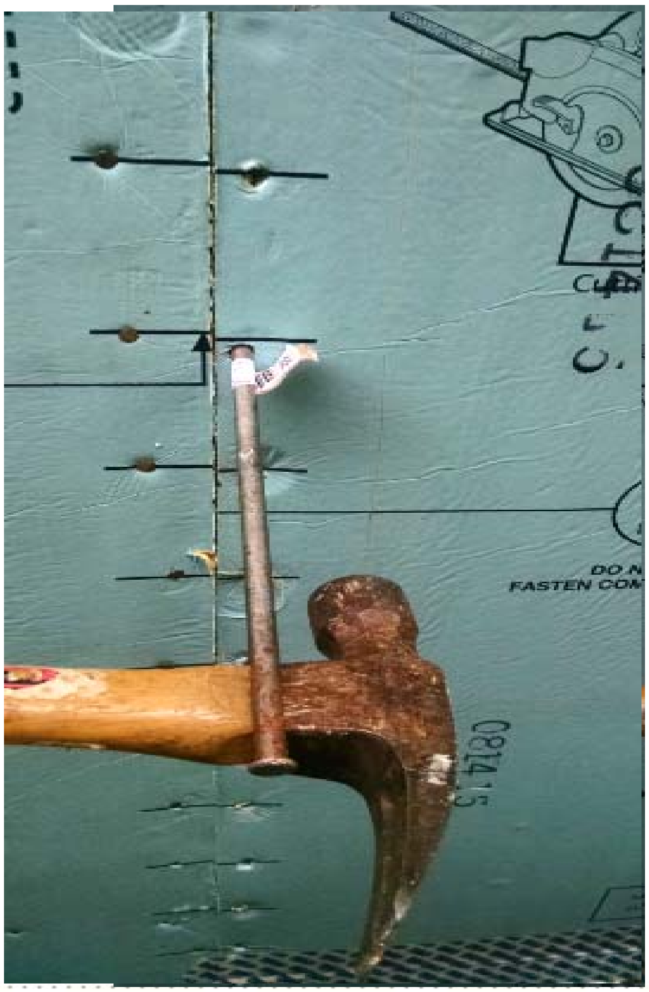


Siding Drainage Plane Retrofit

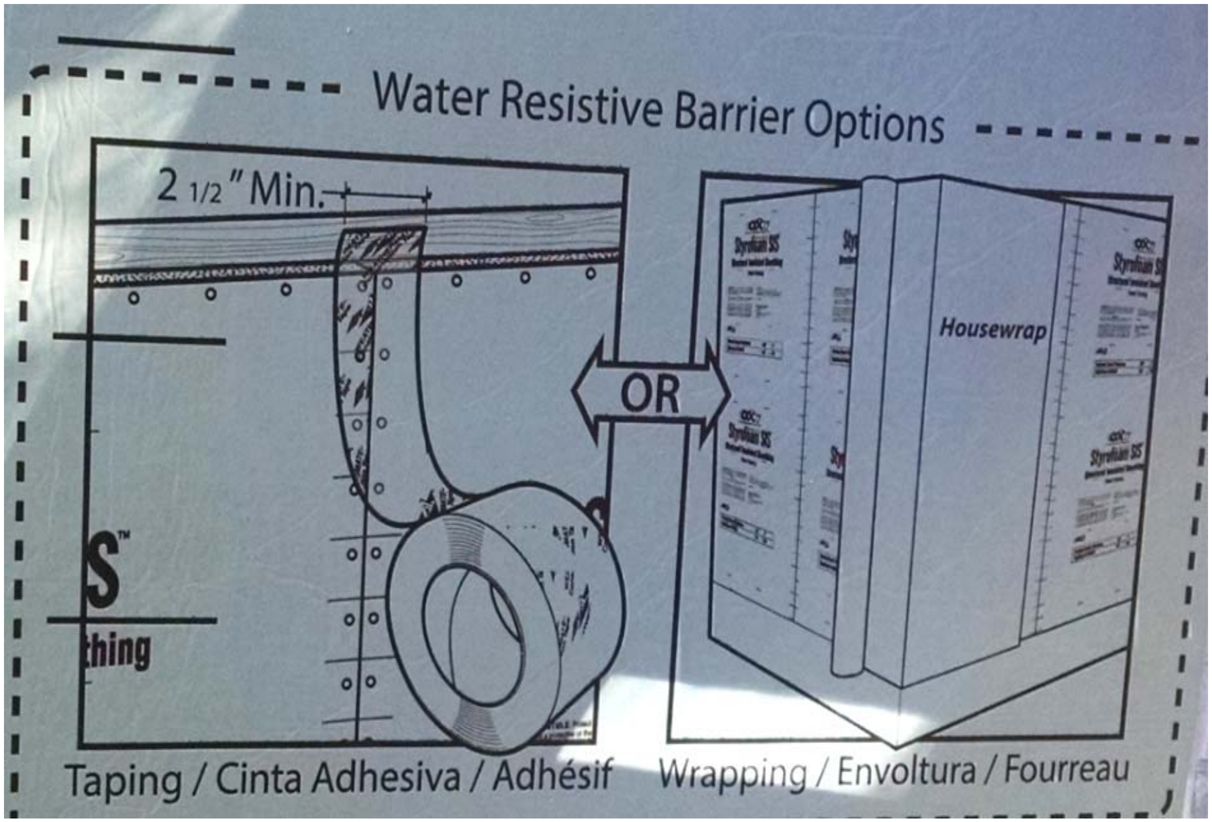
Siding Drainage Plane Retrofit

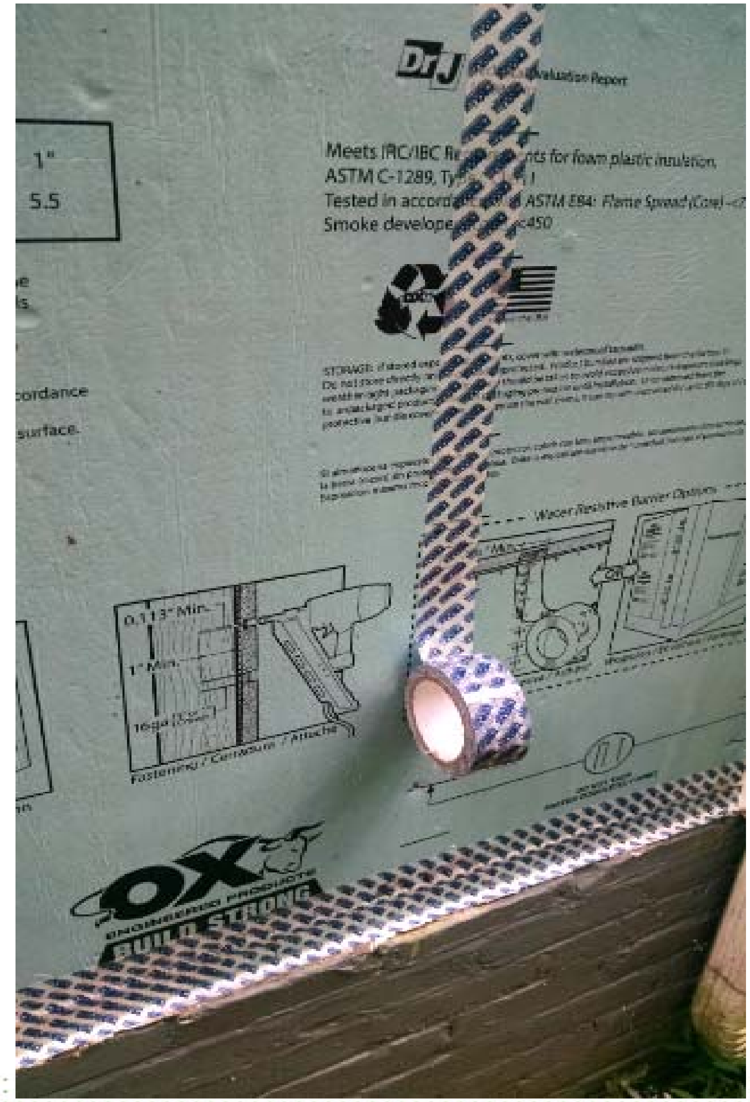
Install Structural Insulated Sheathing (SIS)

Set Nails in SIS



Seal Seams of SIS





Prep for Furring Strips

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3” Insect Screen Before Furring

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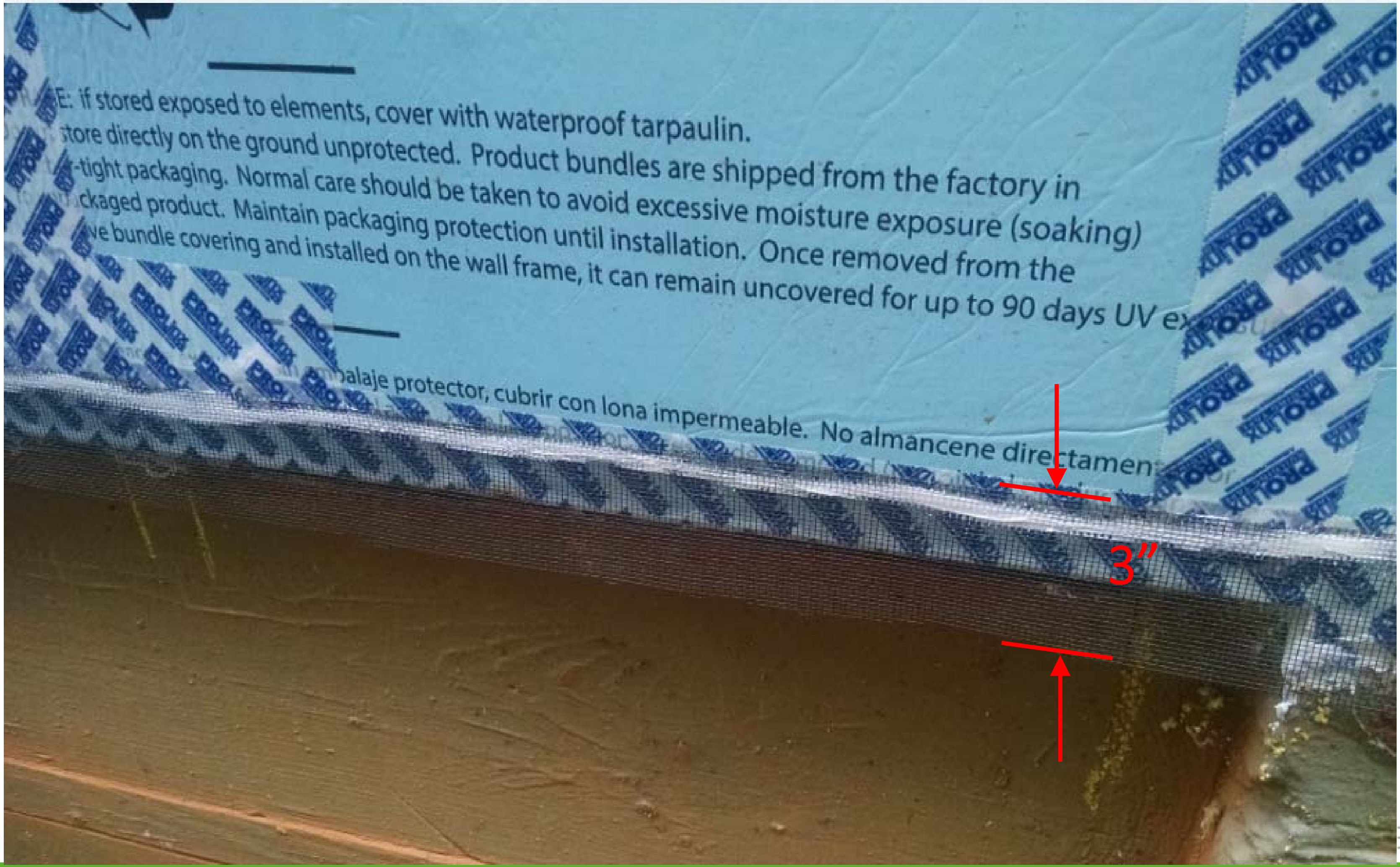
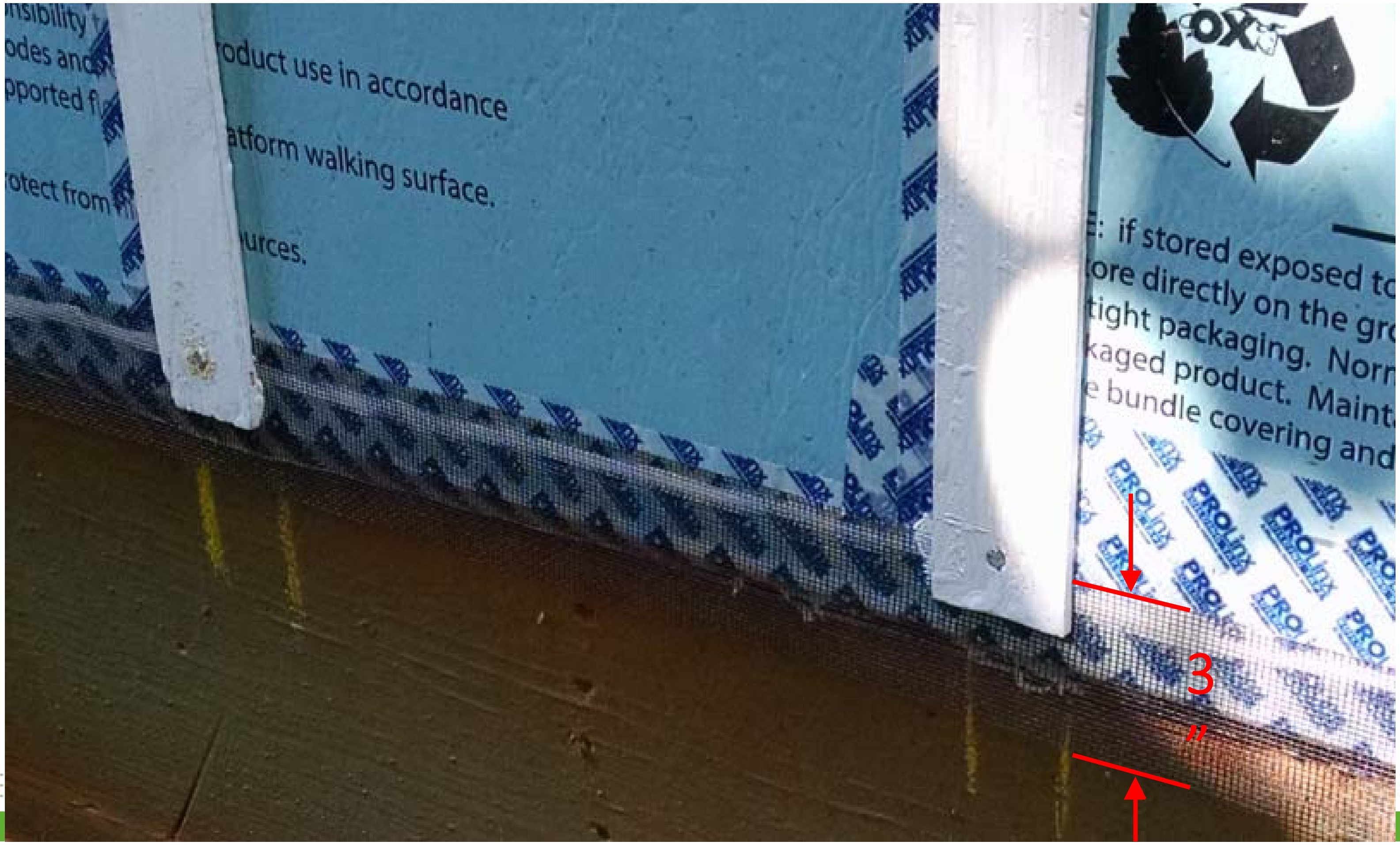


3/16" PT Furring Strips (with lower end primed)

Aligns with Wall Studs and Covers Top Half of Insect Screen



Bottom of Pest Screen Folded Up & Stapled
(also serves as deterrent for ember entry during a wildfire)

Ready for Siding …

Siding Caulked At Edge, Not At Butt Joints

Floating Butt Joint With Flashing

3/16" Gap Between Siding & WRB

Siding Installation

Siding Drainage Plane Retrofit

Siding Drainage Plane Retrofit

Kitchen hood exhaust penetration

Siding Drainage Plane Retrofit

Cont. Insulated Roofs/Ceilings – SIPS, nail base

Environmental Impacts

Environmental Impacts of Insulation Products

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Carbon Impact of various insulation types

Material	Example manufacturers / products	GHG Impact[2]	Notes
Wood fiber	Steico, Gutex	Lowest / Best	Boardstock, batts
Cellulose	Cleanfiber, GreenFiber	Lowest / Best	Densepack, loosefill
Fiberglass	CertainTeed Sustainable, Knauf EcoBatt	Low	Batts, boardstock, loosefill/densepack
Polyisocyanurate	DuPont Thermax	Low	Boardstock; Blowing agent: pentane
EPS* (expanded polystyrene)	Atlas, BASF Neopor	Low	Boardstock; Blowing agent: pentane
Open cell spray foam	Demilec APX, Lapolla Foam-Lok 450	Low	Site-blown; Blowing agent: water
Phenolic foam	Kingspan Kooltherm	Low	Boardstock; Blowing agent: pentane
Cellular glass	Glavel, Foamglas	Low	Aggregate, boardstock
Mineral wool	Rockwool, Owens Corning	Medium	Batts, boardstock
Closed cell spray foam, HFO	Demilec Heatlok HFO Pro, Lapolla ProSeal HFO	Medium	Site-blown; Blowing agent: HFOs
Next gen. XPS*, HFO/HFC	Owens Corning NGX series, DuPont XPS-ST-100 series	Medium / High	Boardstock; Blowing agent: HFO/HFC blend
Closed cell spray foam, HFC	Demilec Heatlok XT, Dow Froth-Pak	Highest / Worst	Site-blown; Blowing agent: HFCs
XPS*	Dow Styrofoam (blueboard), Owens Corning (pinkboard)	Highest / Worst	Boardstock; Blowing agent: HFCs

- Worst offenders are XPS and cc SPF (HFC)

Carbon Impact & other environmental features

- Worst offenders are XPS and cc SPF (HFC)

Material	GHG impact[a]	Recycled content[b]	Toxic emissions[c]	Notes[d]
Wood fiber	Lowest / best			
Cellulose	Lowest / best			
Fiberglass	Low			Avoid formaldehyde binders
Polyisocyanurate	Low			Chlorinated flame retardant (otherwise fairly inert) Toxic manufacturing process
EPS (expanded polystyrene)	Low			Brominated flame retardant
Open cell spray foam	Low			Off-gassing under investigation by EPA Chlorinated flame retardant Highly toxic when applied
Phenolic foam	Low		See note	Phenol formaldehyde content, but low emissions
Mineral wool	Medium		See note	Choose low-emitting products
Closed-cell spray foam, HFO	Medium			Off-gassing under investigation by EPA Chlorinated flame retardant Highly toxic when applied

Material	GHG impact[a]	Recycled content[b]	Toxic emissions[c]	Notes[d]
Closed-cell spray foam, HFC	Highest / worst			Off-gassing under investigation by EPA Chlorinated flame retardant Highly toxic when applied
XPS (extruded polystyrene)	Highest / worst			Brominated flame retardant (otherwise fairly inert) Toxic manufacturing process

Recycled content and toxic emissions potential of insulation materials. Source: Efficiency Vermont analysis and BuildingGreen Guide to Insulation.

Thank you!

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Please Unmute or use the Zoom Chat function to submit any questions or comments

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