Build a Better House

The Shell



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Thank you, program sponsors...























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The Goal

Energy and Cost Efficiency

Comfort

Healthy Indoor Environment

Futureproof



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“Shell”

Envelope or Enclosure

Components and assemblies that physically separate the interior environment from the exterior

Requires “structure” to perform



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Shell Components



For today…

Walls

Roofs

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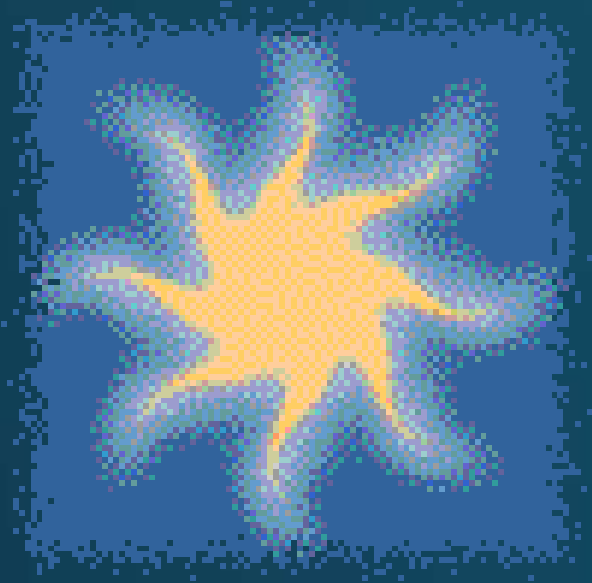
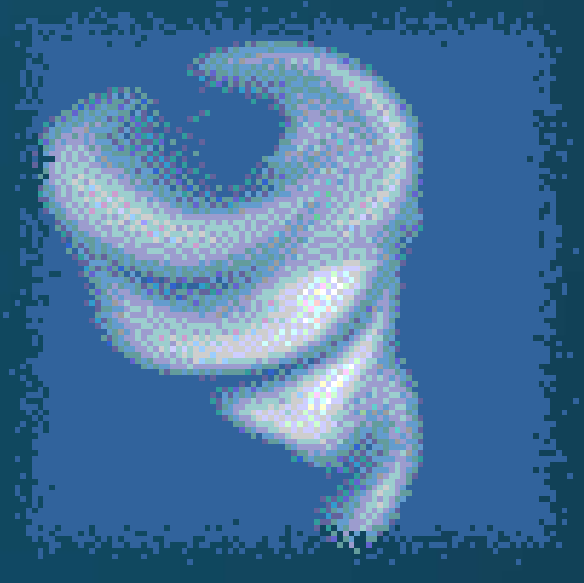
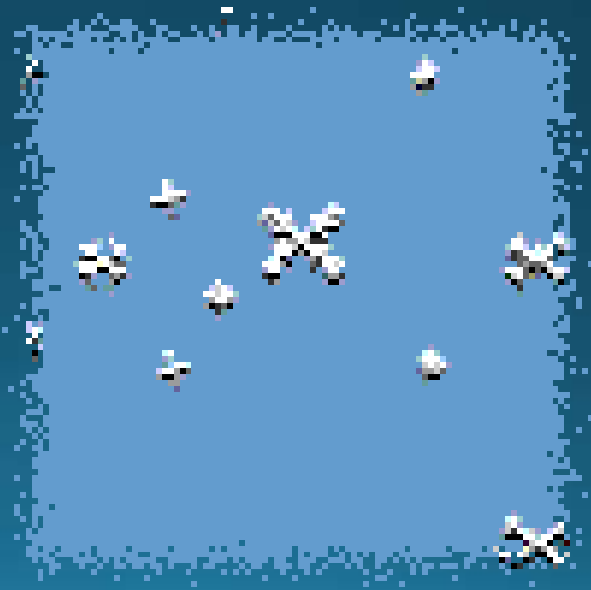




The Purpose of the Building Shell…
Protection from the elements







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An effective shell must…



Control water & moisture *(IRC)*
- Drainage plane, flashing, capillary break, VDR

Control air leakage *(IECC)*
- Continuous air barrier

Control heat loss *(IECC)*
- Continuous layer of insulation

Block pests and insects *(IRC)*
- Integrated Pest Management

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Futureproof means…

Prevent deterioration

Stimulate durability and adaptability

Extend service life, resilience

Fortify against extreme weather and shortages of energy and material

Local materials and labor

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Housing of Yesterday



Single component walls and roofs

Resisted moisture damage

Thermally inefficient

Unhealthy

Simple shapes

©2021

Housing of Today

Thermally efficient

Healthy

Multi-component walls and roofs

Must resist moisture damage

Complex shapes



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Walls are now multi-component…



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… as well as roofs



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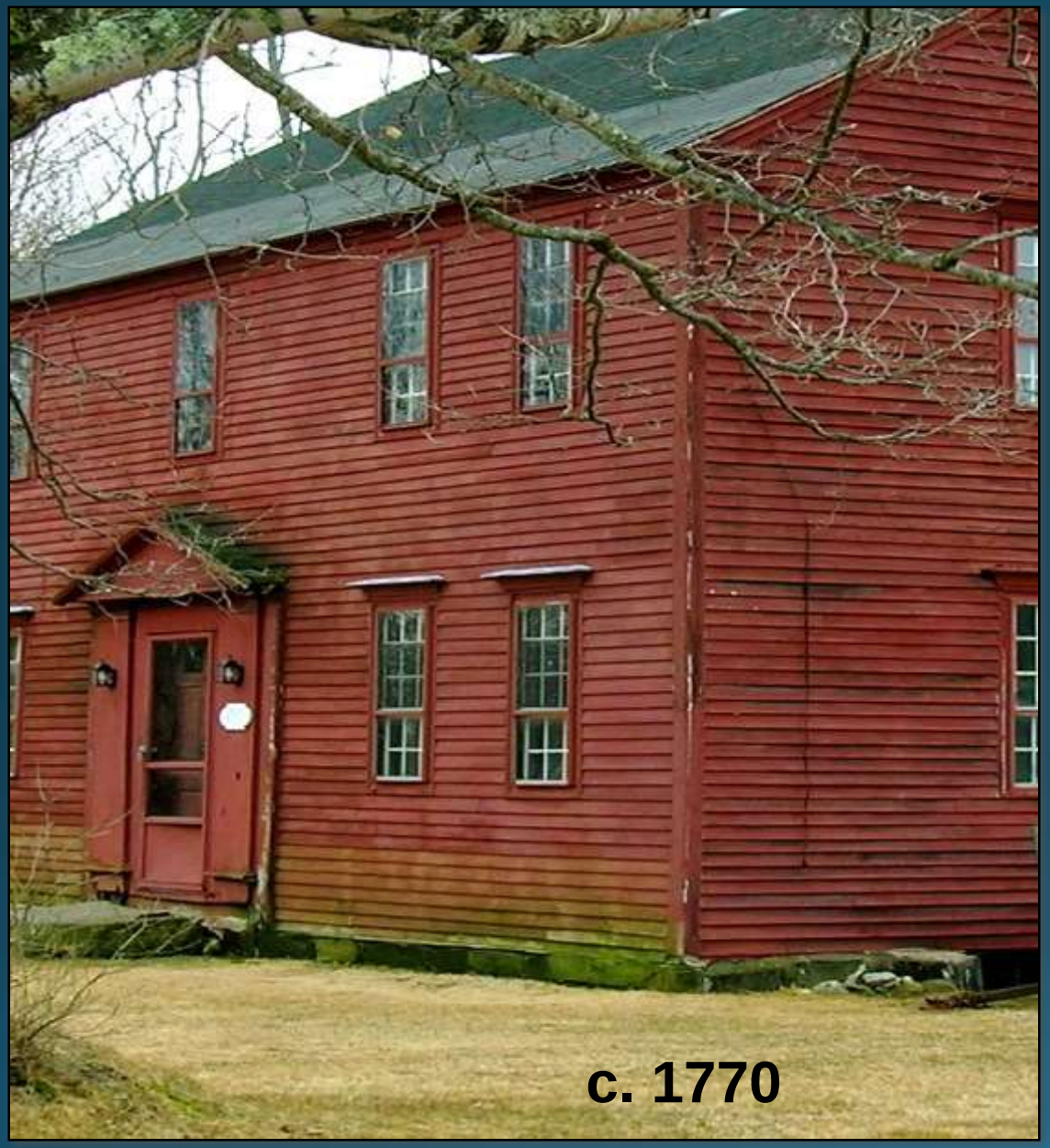

What changed?

Why?

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What…The ability to dry out

More complicated construction

More air tight and better insulated

Harder to get wet

Less energy transfer through the wall

More difficult to dry

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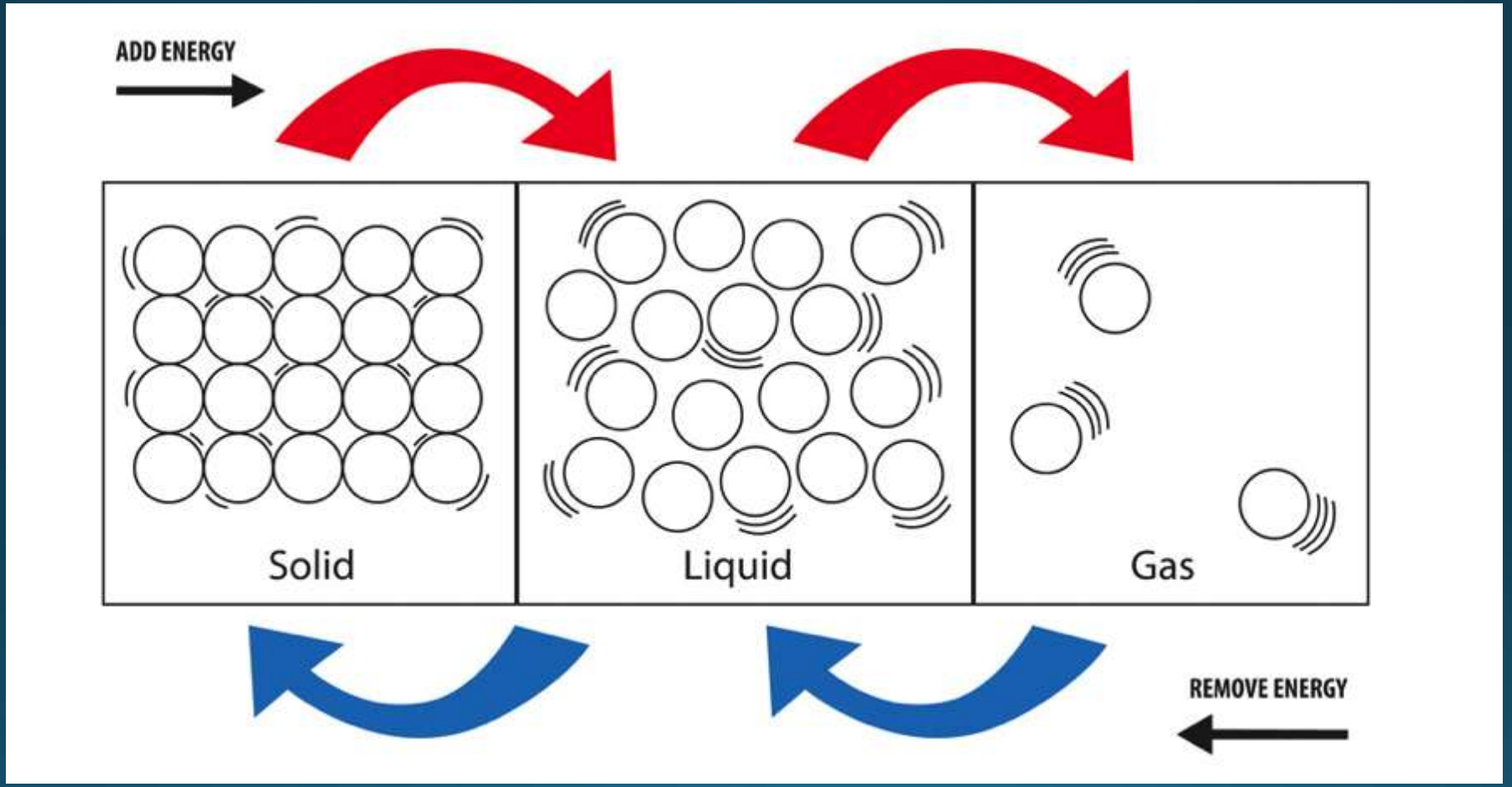
The Phases of Matter



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Surfaces





Shell components are joined together to form multi-surfaced structures

More surfaces equals more complication

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Building Science Basics

Bulk Water Management

Heat Flow Management

Air Flow Management

Vapor Management

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Bulk Water Management



Moisture flow is from warm to cold

Moisture moves from more to less

Air carries moisture from high pressure areas to low pressure areas

Gravity pulls water down
Water wicks up

The Rules of Moisture Movement

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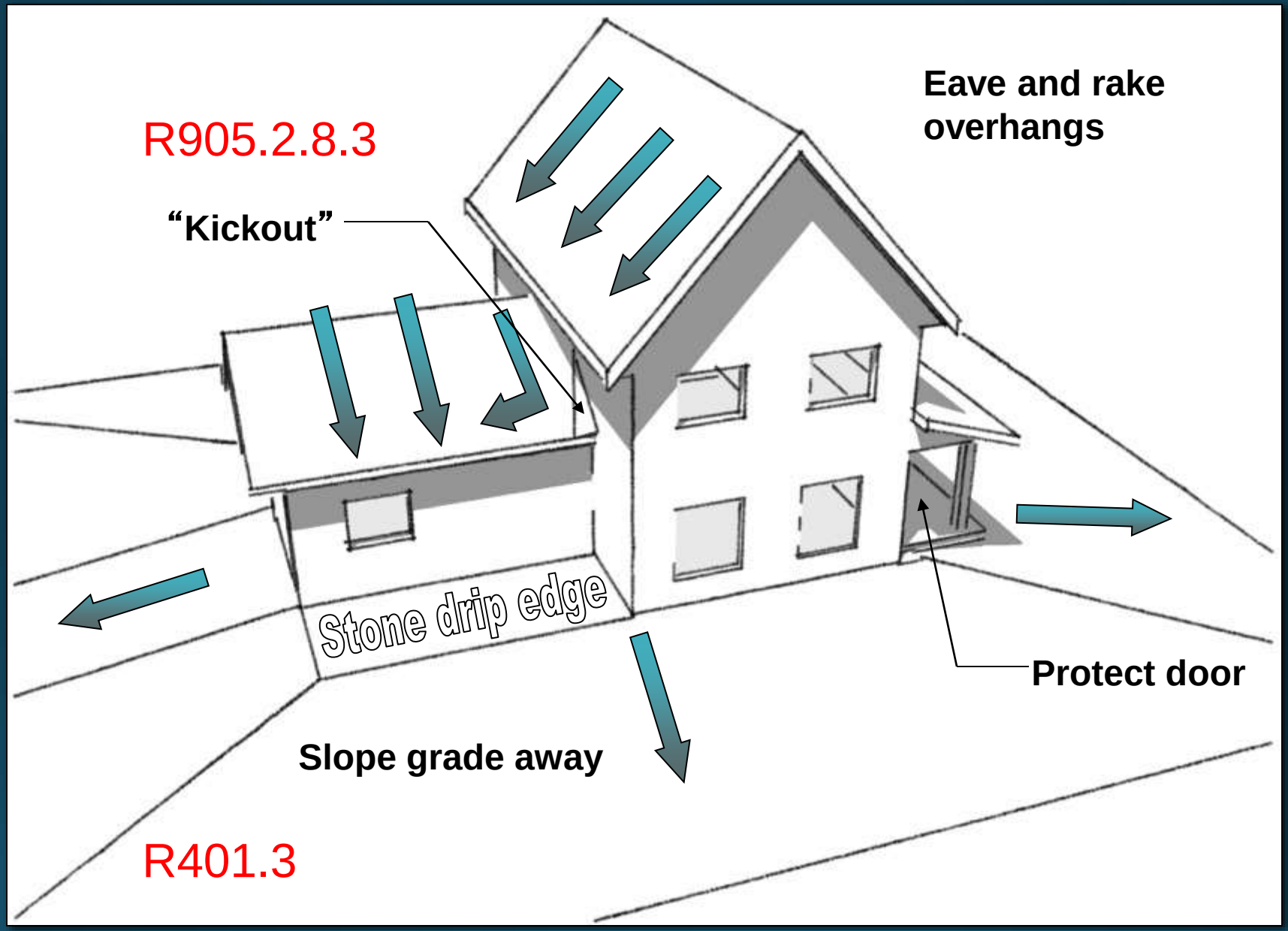
R905.2.8.3
Eave and rake overhangs
“Kickout”
Stone drip edge
Protect door
Slope grade away
R401.3

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Common situation...





Common problem

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Adding an overhang

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Keep Out …

Wind driven rain



Cold dry air in winter



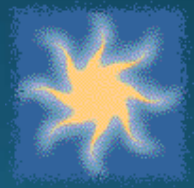
Humid air in summer



Retain…

Supplemental heat

Water vapor in winter



Solar gain when needed

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Some definitions

Cladding (or siding)… a protective layer attached to the exterior of a building enclosure

First, but not primary, line of defense

Wet zone… the section of a wall system that is intended to be exposed to short and long term effects of bulk water penetration

Moisture tolerant

Dry zone… the section of a wall system that is not intended to be exposed to bulk water

Low moisture tolerance and little storage capacity

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More definitions

Drainage plane… an element forming the dividing line between wet and dry zones

Water resistant and vapor permeable

Flashing… an element intended to collect and divert bulk water to the exterior of a building enclosure

Installed above any interruption to downward flow of water

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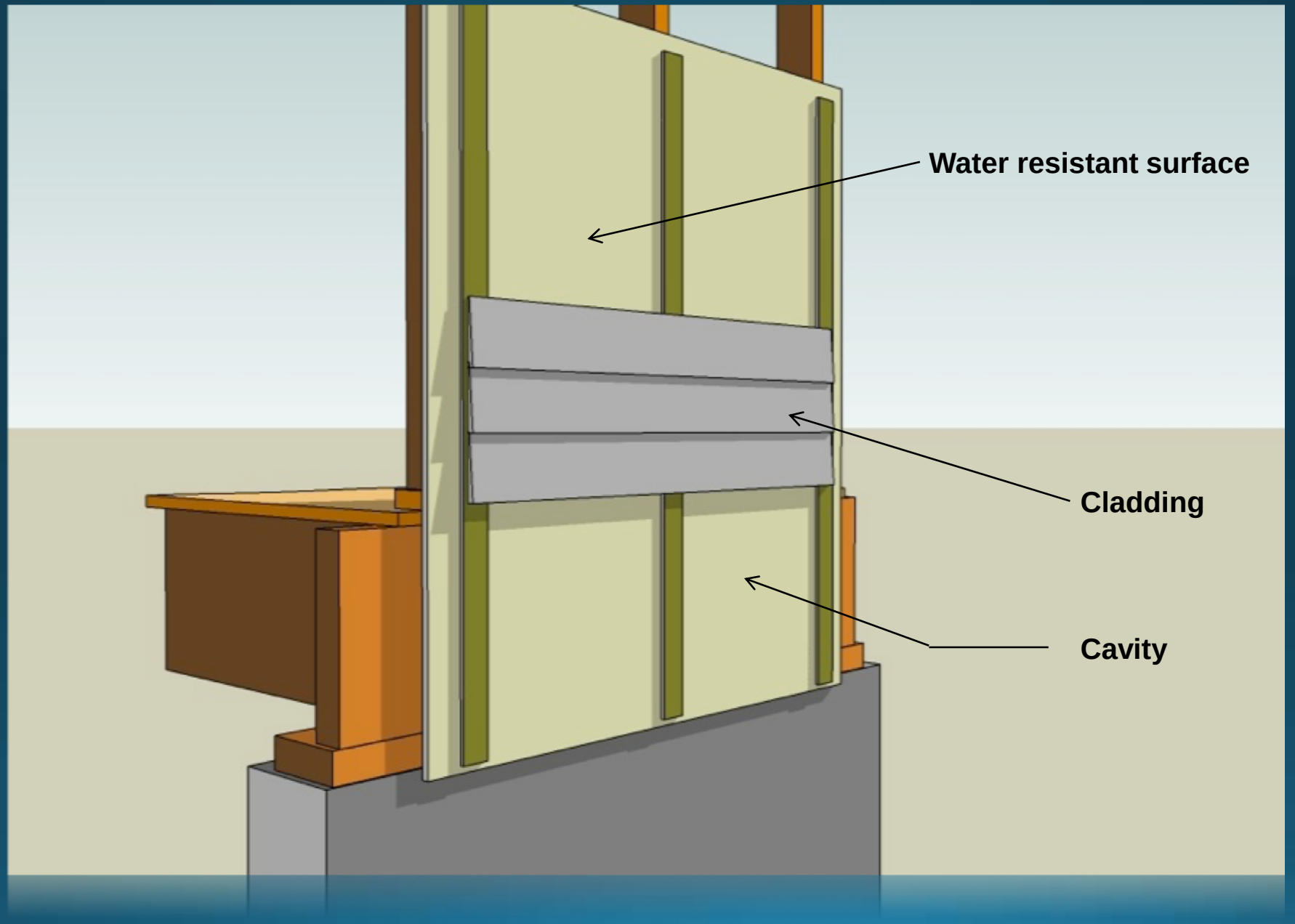
24

Cavity Wall



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Rain Screen Walls
Water Managed Assemblies

Exterior cladding
Clapboards, vinyl, cement board

Air cavity
1/8” min. to break capillary action

Drainage layer
Building wrap, felt paper

Sheathing
Water resistant, airtight, structural(?)

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Air Space

Drainage space or cavity to avoid capillary movement
- Home Slicker™ or air space
- Driwall™ Rainscreen 020-1
- Mortairvent™

Cavity *Air Pressure* forces water down and out

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Home Slicker™



Continuous airflow behind the cladding

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©2021

Creating an air space with strips ripped from 2x4 stock



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Cladding...the first line of defense

Most exterior claddings must have rain control plane behind them

Shingles
Clapboards
Vinyl Siding
Brick Veneer



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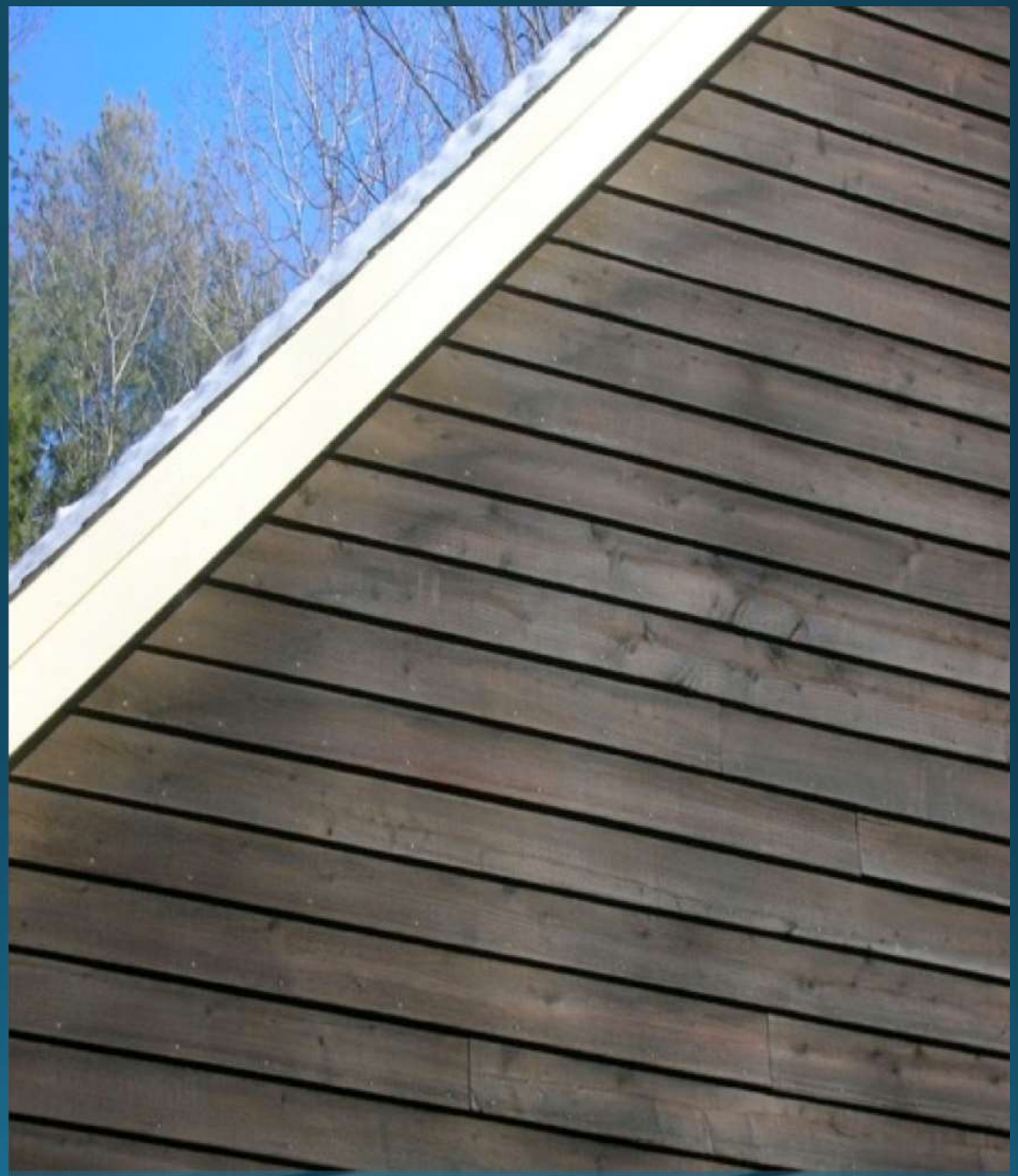
Clapboards

Minimal overlap

No sidelap

Wind driven rain issues



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Old Wood Clapboards



No drainage plane or rain screen

No insulation

Old growth wood

Note scarf joints

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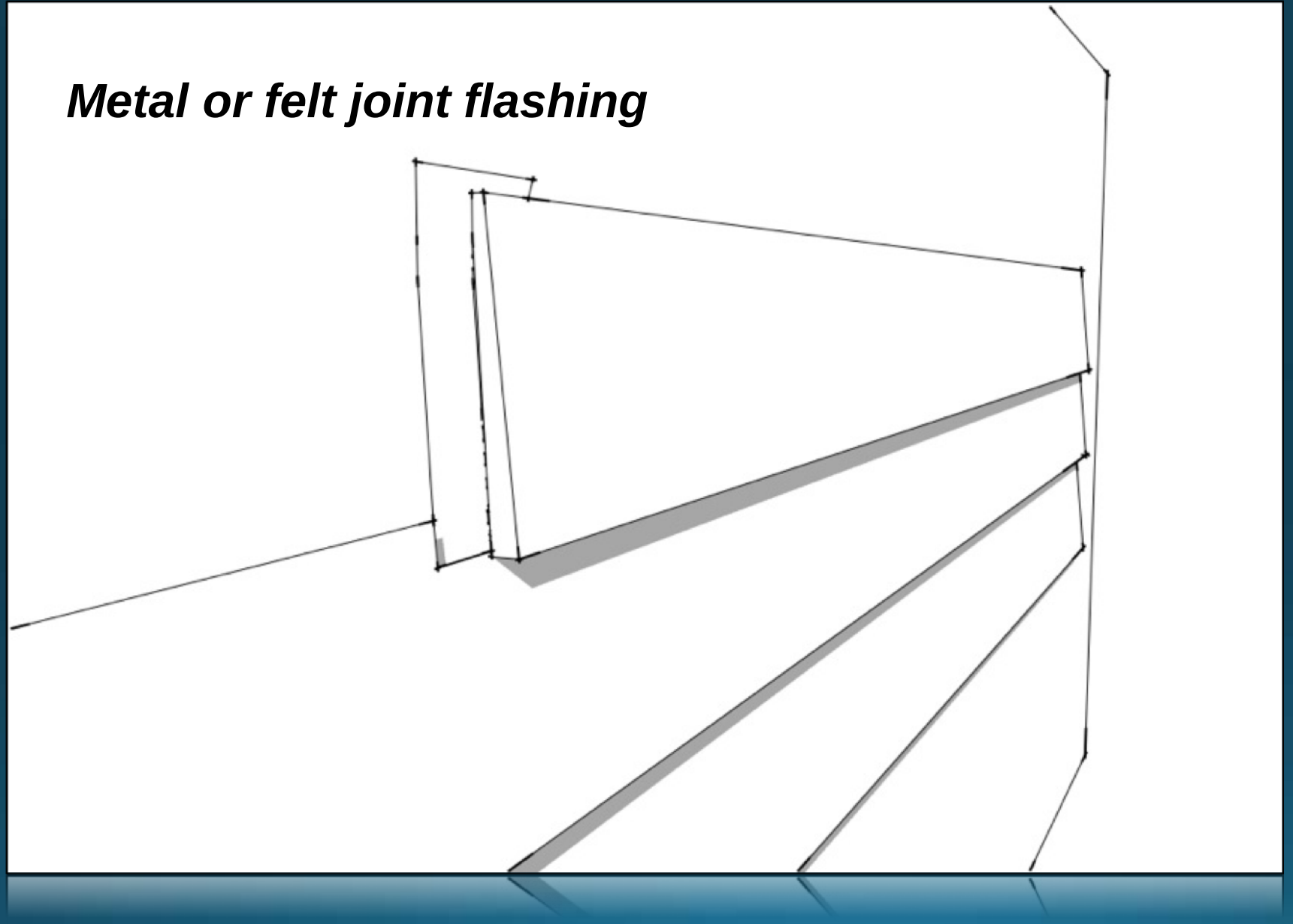
Metal or felt joint flashing



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Loose installation requires drainage plane



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Cement board siding

Concealed nailing

Longer lengths yield fewer butt joints

Good paint adhesion

Recommend rain screen and drainage plane



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First generation cement board siding

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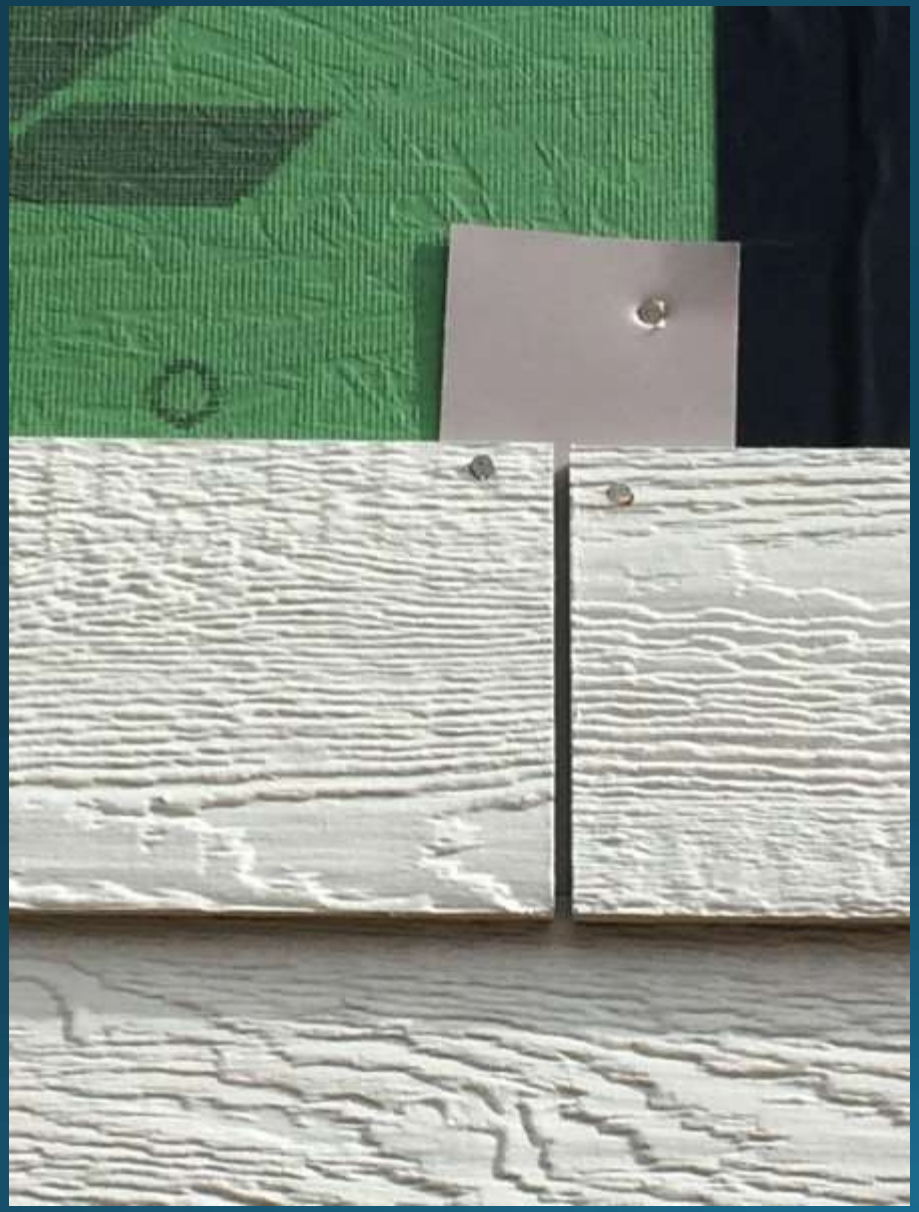

Louisiana Pacific SmartSide™ lap siding

OSB based

16' lengths

Correct installation critical

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Wood shingles



Concealed nailing

Triple coverage

Breathable

Long lasting

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Wall Sheathing



OSB, common and inexpensive

Susceptible to moisture

- Swells
- Flakes apart
- Supports mold growth

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CDX plywood



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CDX plywood vs. OSB

At 100% relative humidity…

OSB perm rating of 10

CDX perm rating of 30+

CDX dries three times faster than OSB!

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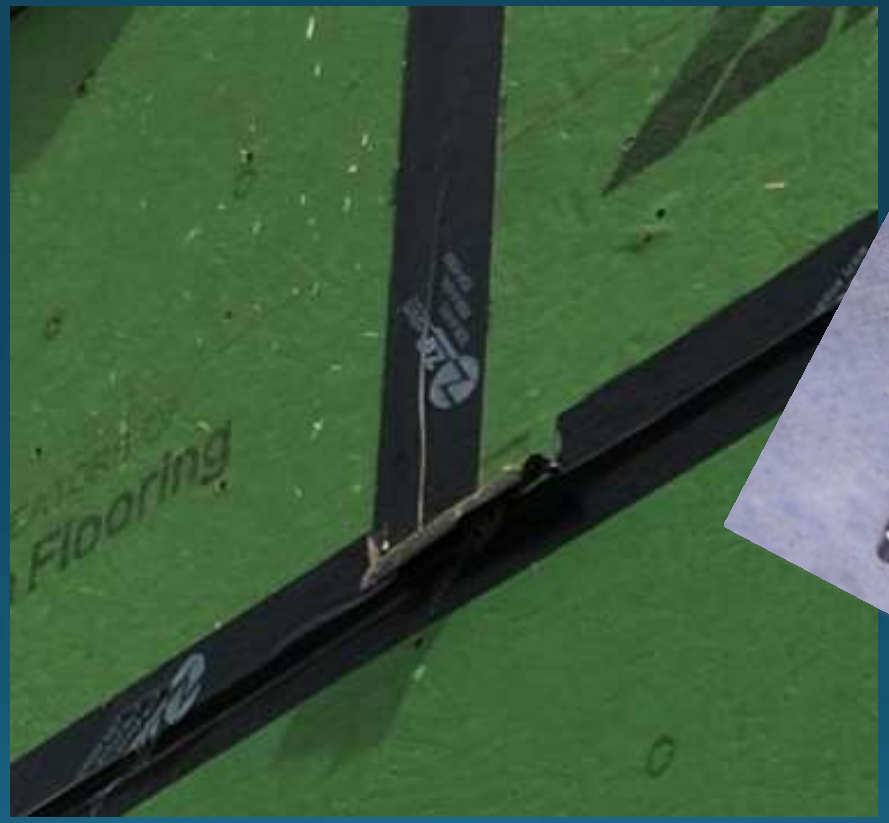
Zip™ wall sheathing



Courtesy Huber

Perm rating of 12-16





Burnish the tape!

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Exterior wind and water resistive barrier

Must be fastened properly

Joints must be overlapped and taped

Cover promptly



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Fastening housewrap





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Dupont™ Tyvek® DrainWrap™

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Self adhering Housewrap

Blueskin VP100™





Grace Vycor en V-S™

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Steve Konstantino

Performance Building Supply

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Roofing underlayment

W. R. Grace Ice & Water Shield® or Certainteed Winterguard®
Does it prevent ice dams?
Does it prevent damage from ice dams?

Felt

RoofTopGuard® and others







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Flashing

Redirects bulk water onto the exterior surface

Must flash all penetrations
to avoid wall wetting

Intentional holes should not be straight through wall,
water will follow air

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Flashing details

Window flashing



Deck flashing



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Incorrect flashing







Failure to properly weave step flashing into horizontal cladding

Board sheathing soaked and insect-ridden…

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End result

A very unhealthy situation

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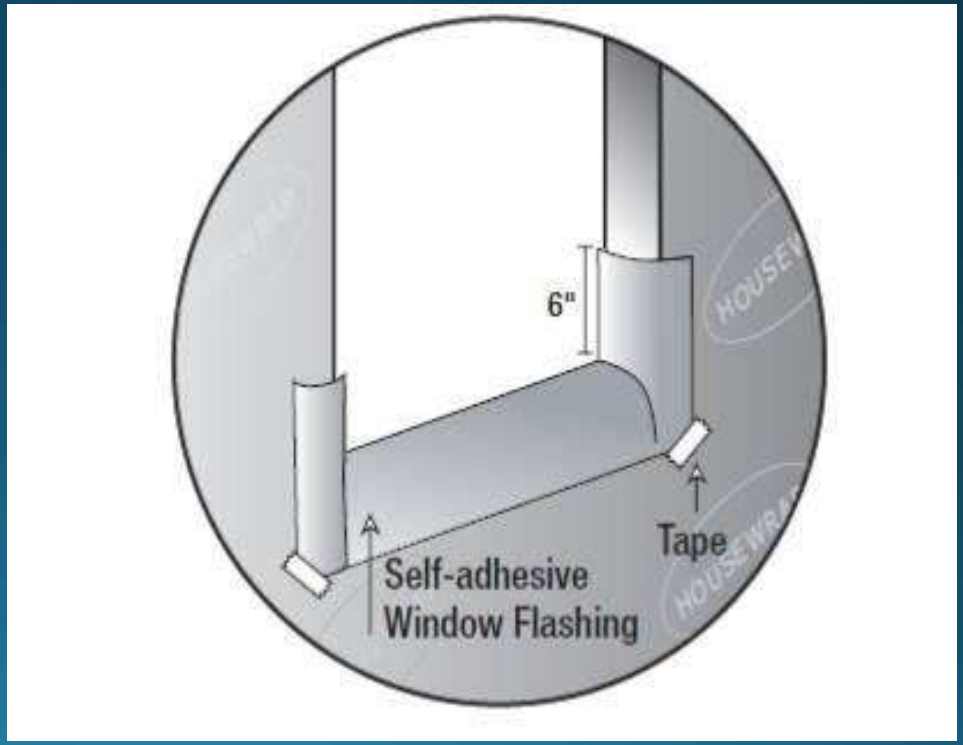
Water managed window installation



#1… "I" cut house wrap, cut head flap

#2… Install back dam, slope sill



From US Department of Energy

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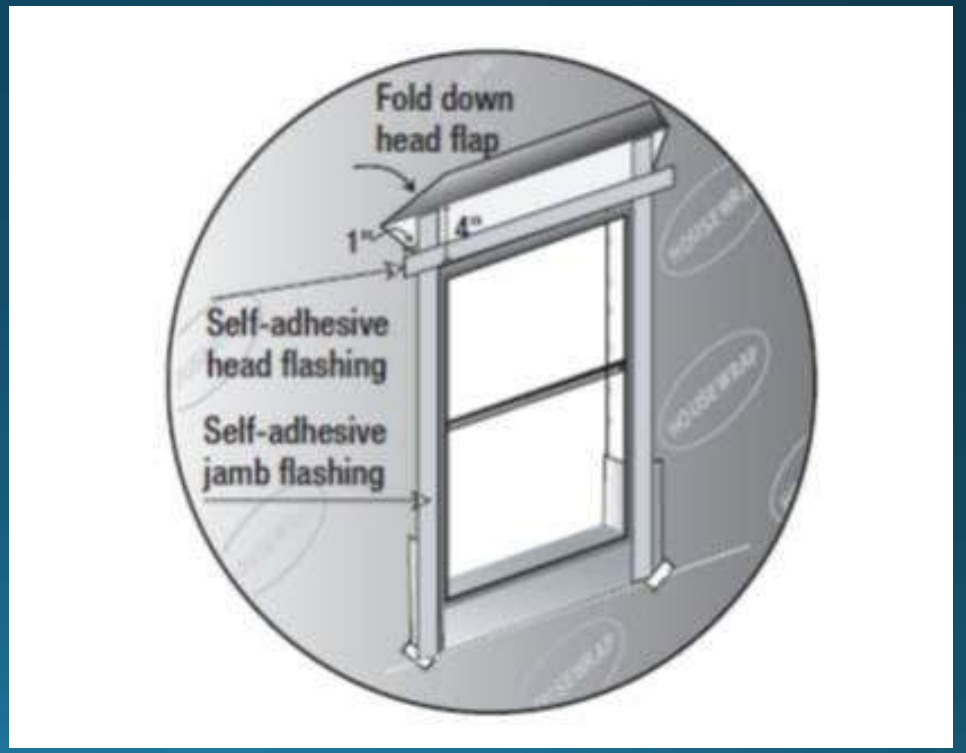
#3... caulk outside edges of head, side jambs

Install window plumb, level, square

#4... Install jamb and head flashing



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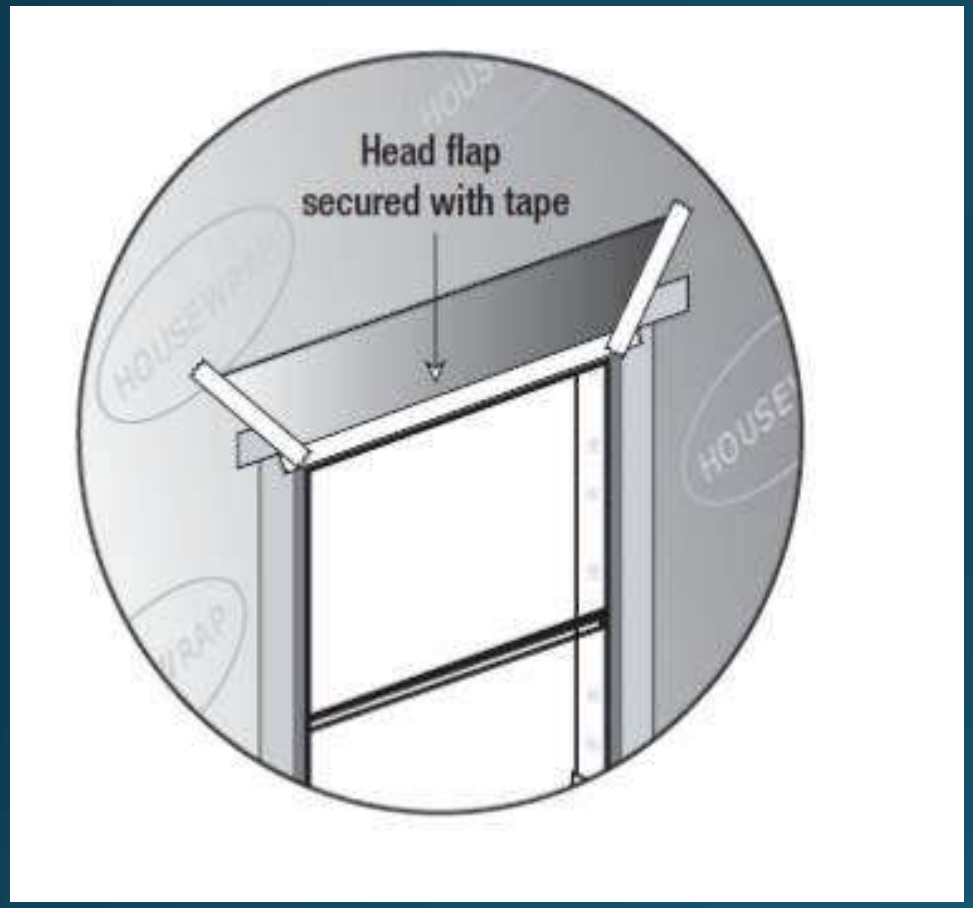
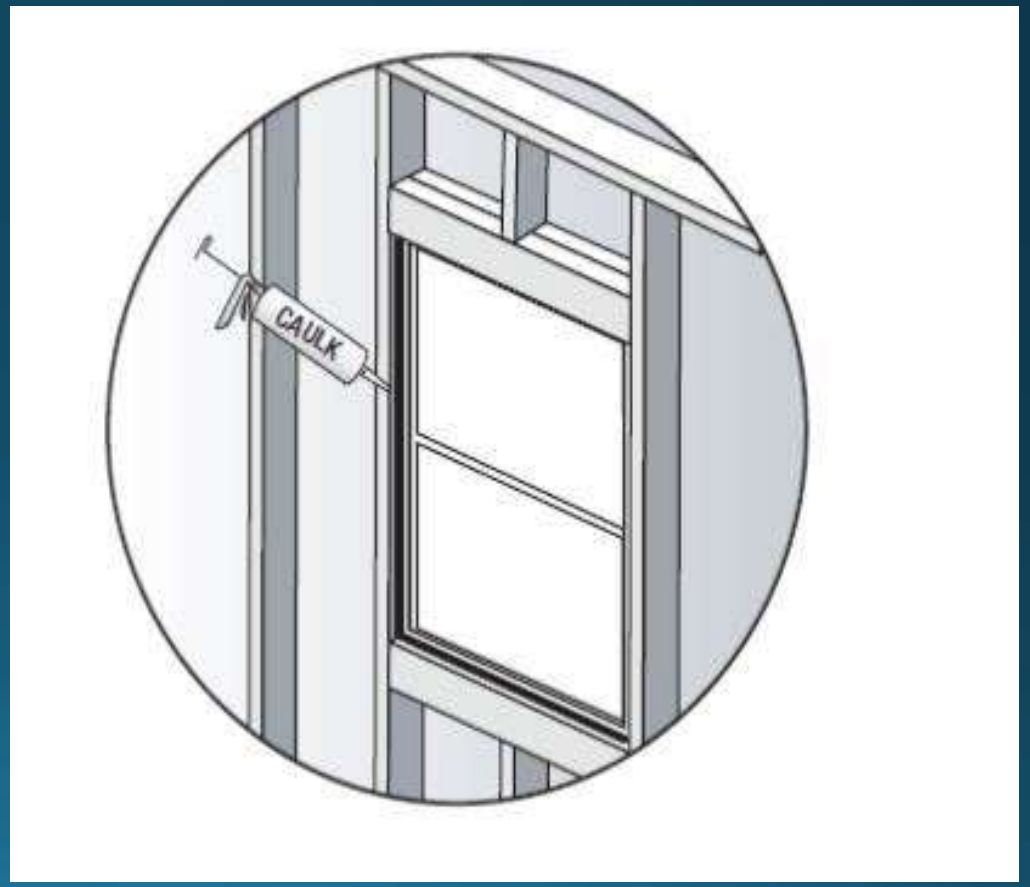


#5... Tape down house wrap head flap

#6... Air seal rough opening from inside



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Window Pan Flashing





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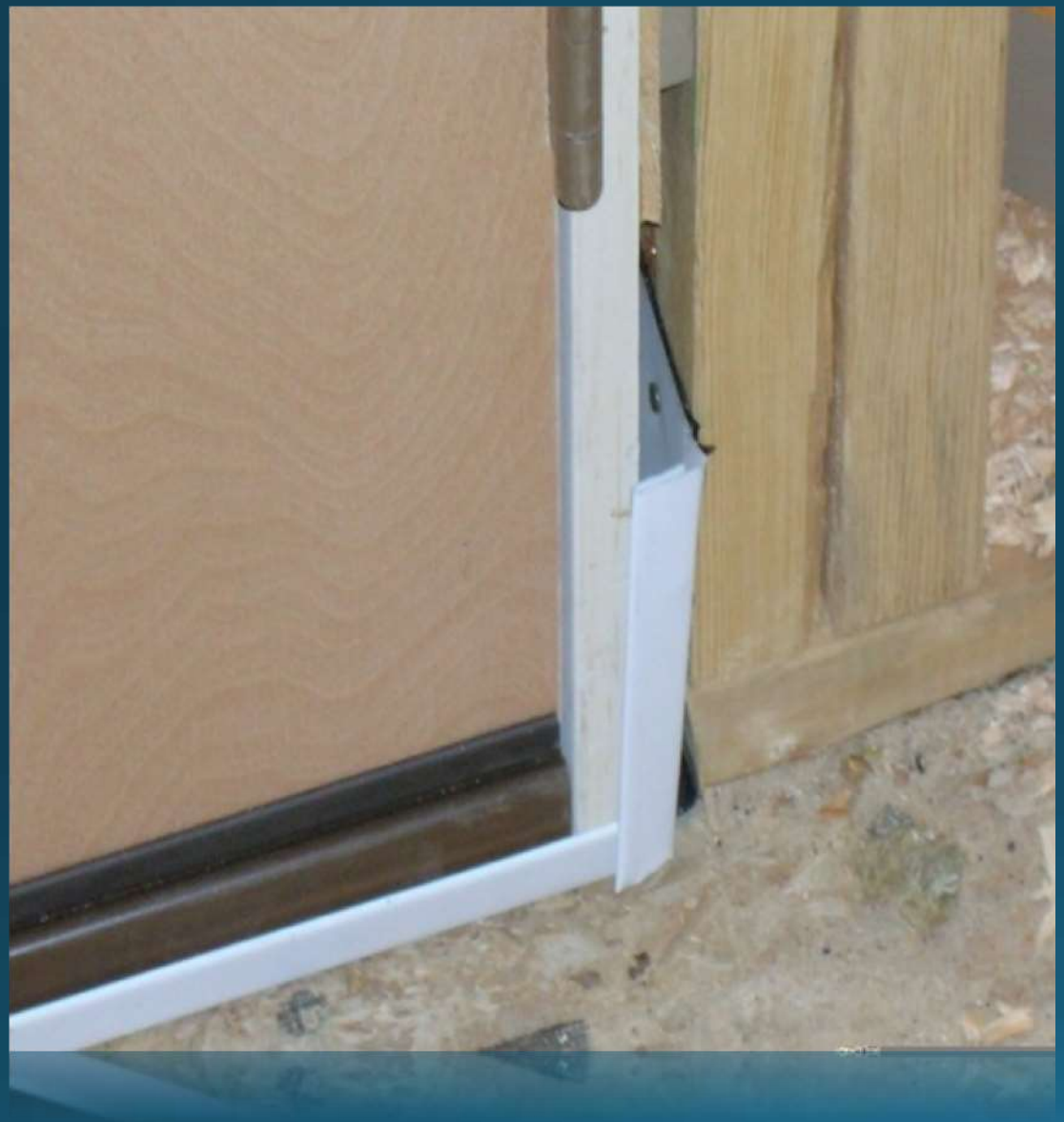

Door pan

Simple to bend on site

Invisible after trim and flooring installed

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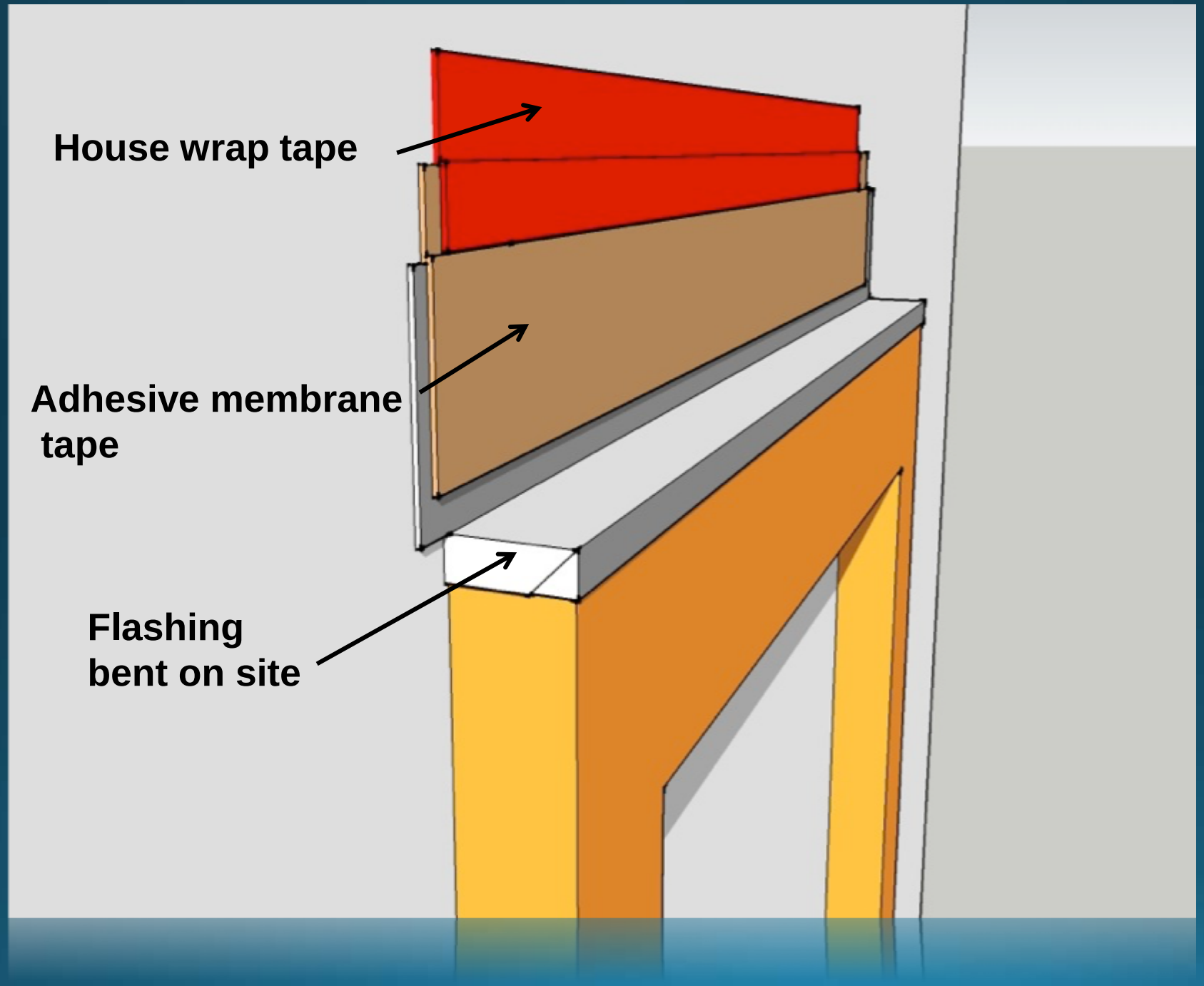
House wrap tape
Adhesive membrane tape
Flashing bent on site

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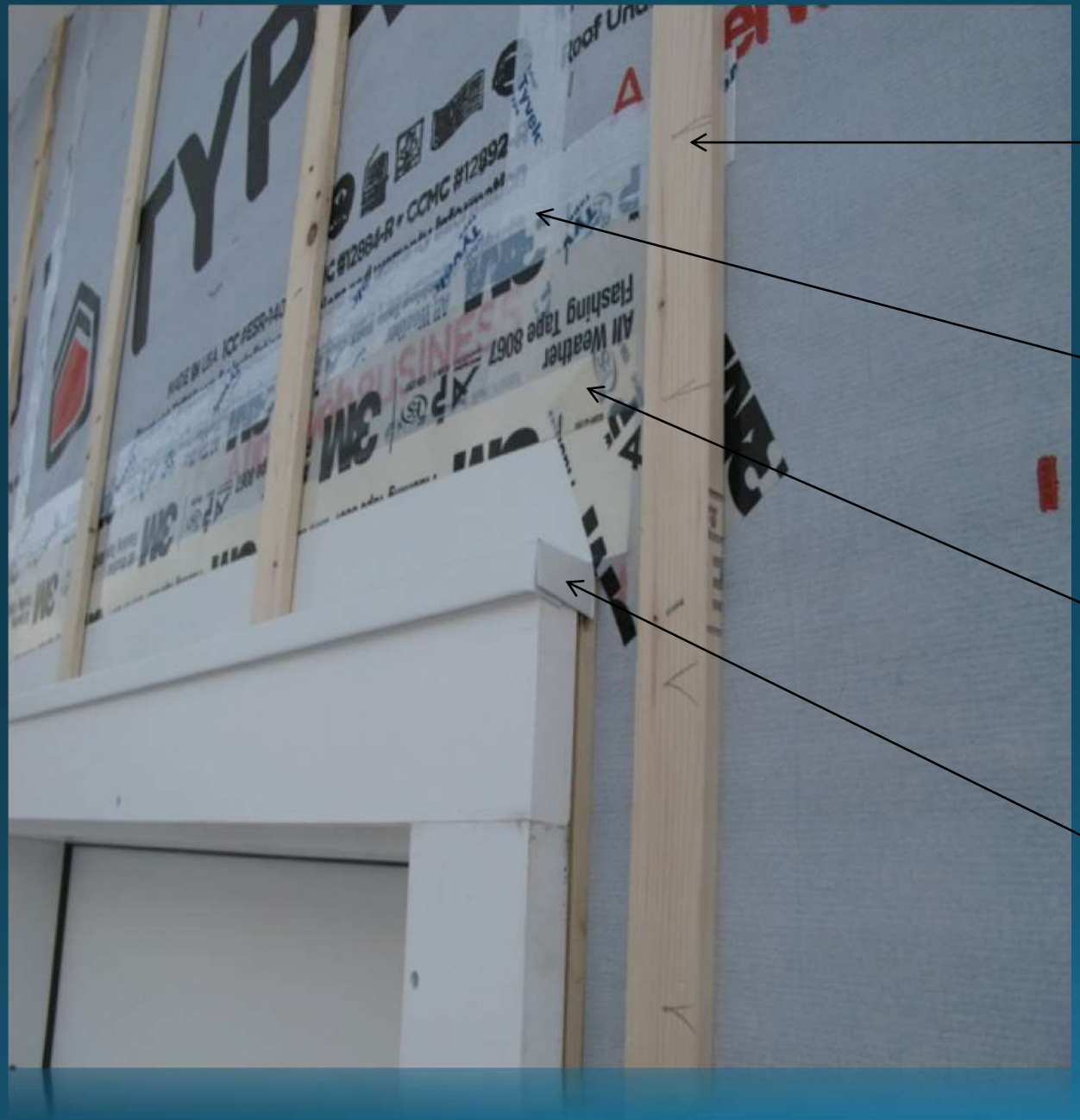

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Prefabricated exterior window casing

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Dealing with the previous situation





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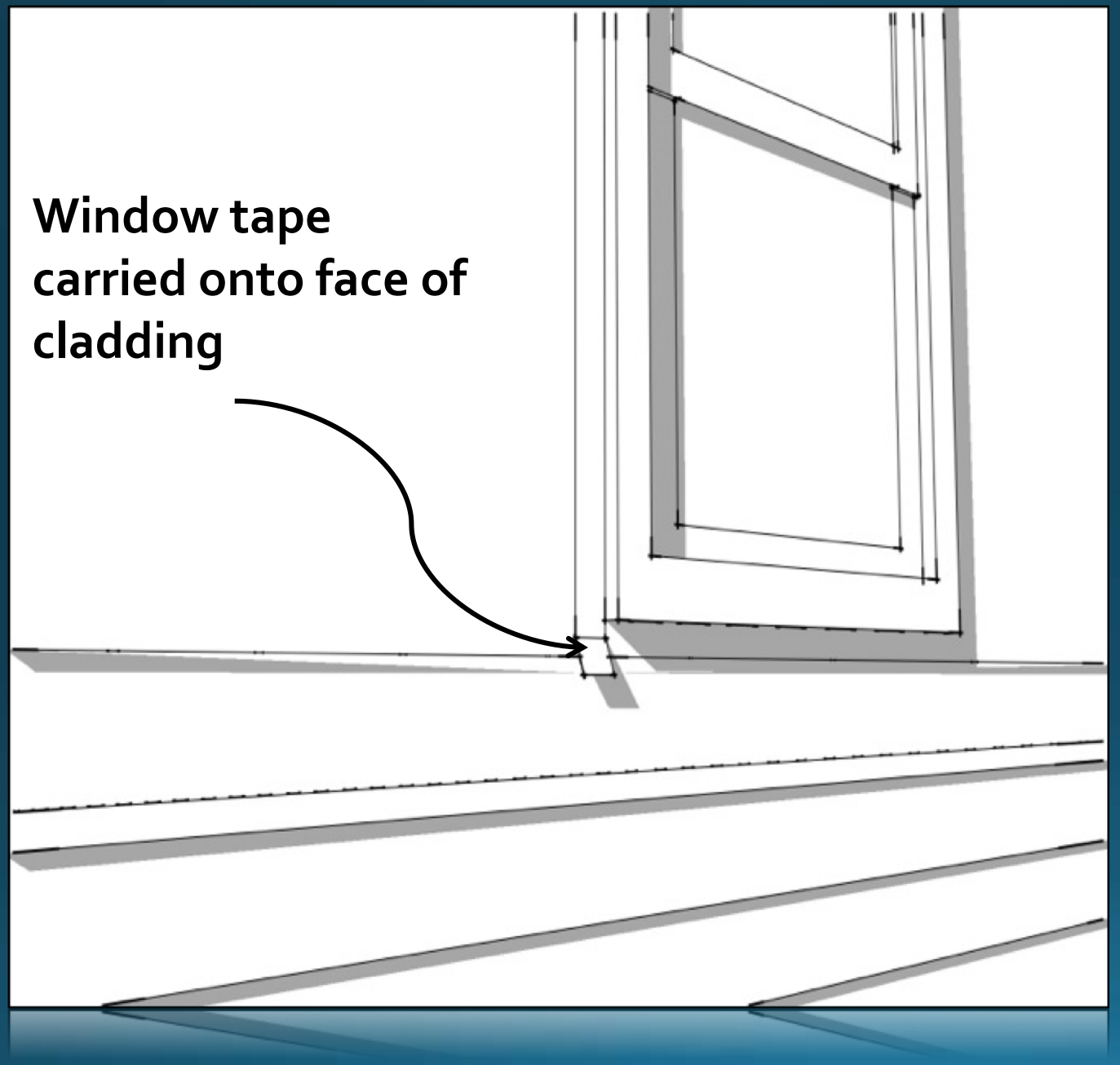

Lower window side flashing detail

Leave backing on lowermost tape until siding

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Roof Flashing





Copper valley flashing ("cricket" or "gusset") showing "vee" center bend and soldered joints

Note also gap between roofing and cladding

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Chimney pan flashing or
“through flashing”



Chimney flashing

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Metal roof





Two methods of chimney flashing

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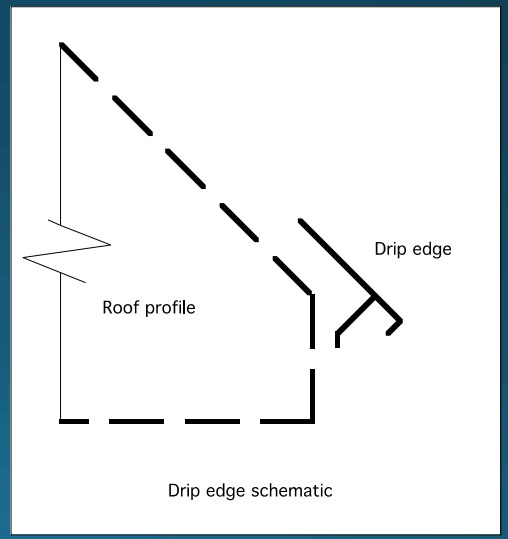
Drip Edge



Note the overhanging shingles and the additional bend in the metal edge



Drip edge schematic

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15 minute break

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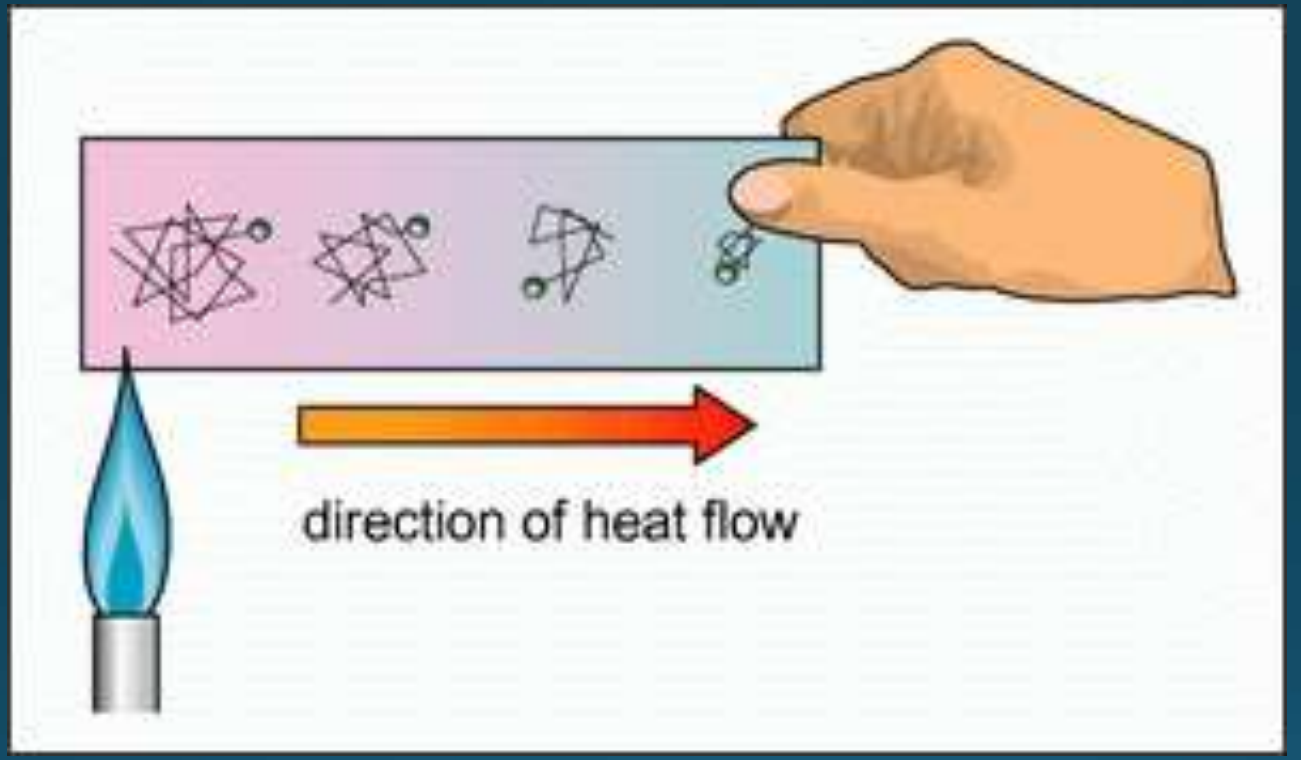
Heat Flow Management



Heat will always flow from warmer to cooler, or more to less

With no external energy, molecular vibrations slow down until equilibrium is reached

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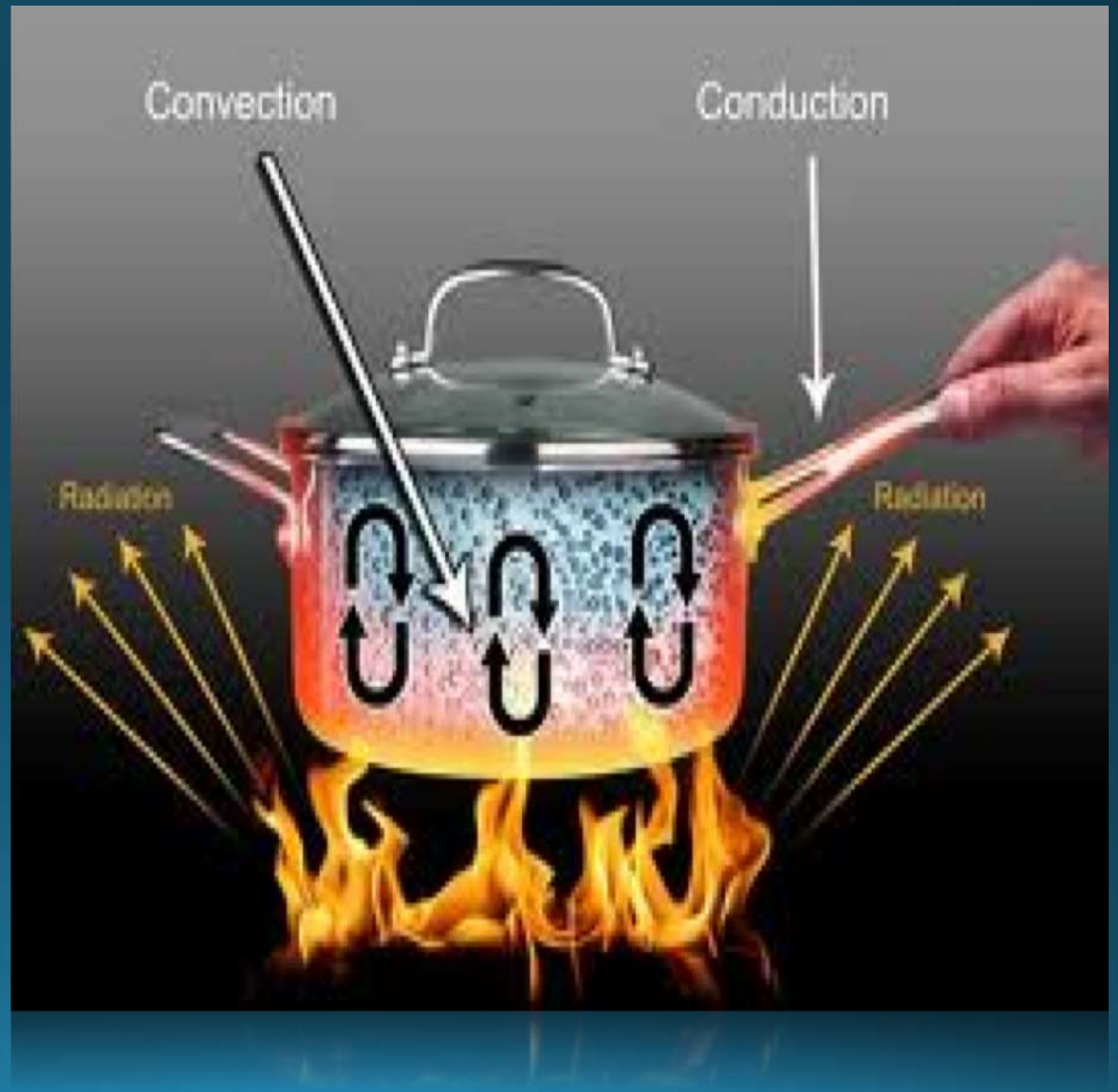
Heat transfer mechanisms

Conduction… molecular excitation without molecular movement

Convection… fluid movement of excited molecules

Radiation… electromagnetic motion of charged particles



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Heat Flow Management

Reduce conductive losses by placing resistive material
in the path of heat flow

Disrupt thermal contact

"Thermal Break"

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Wall systems

Wall systems must...

Transfer gravity loads to the foundation

Resist wracking from high winds

Minimize heat loss and water penetration

Be penetrated by windows and doors

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Redundancy?

No Stud Variants

Structural Insulated Panels

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No Stud Variation

Insulating
Concrete Forms

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No Stud House 2008

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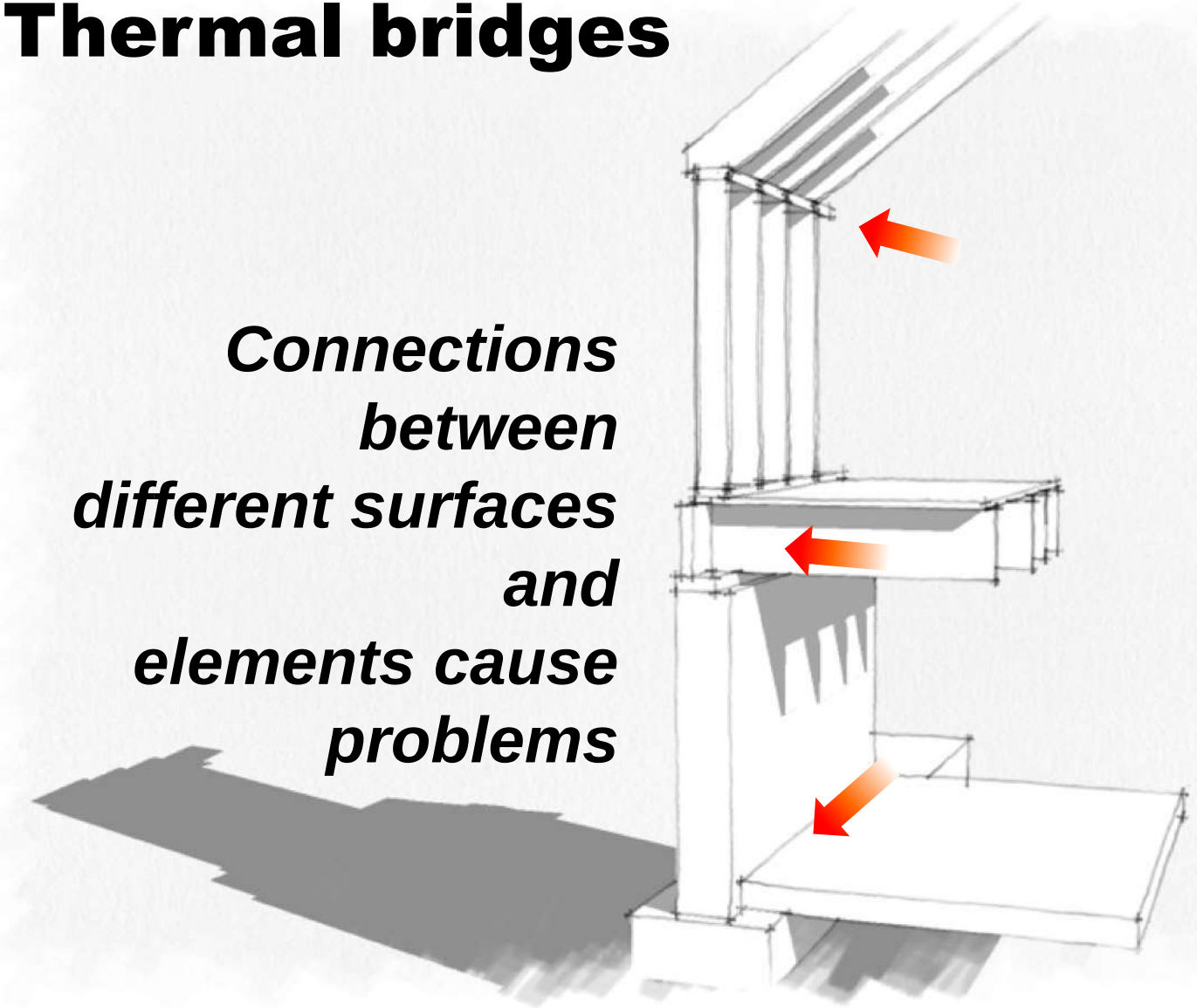
Thermal bridges

Connections between different surfaces and elements cause problems



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Single stud variations



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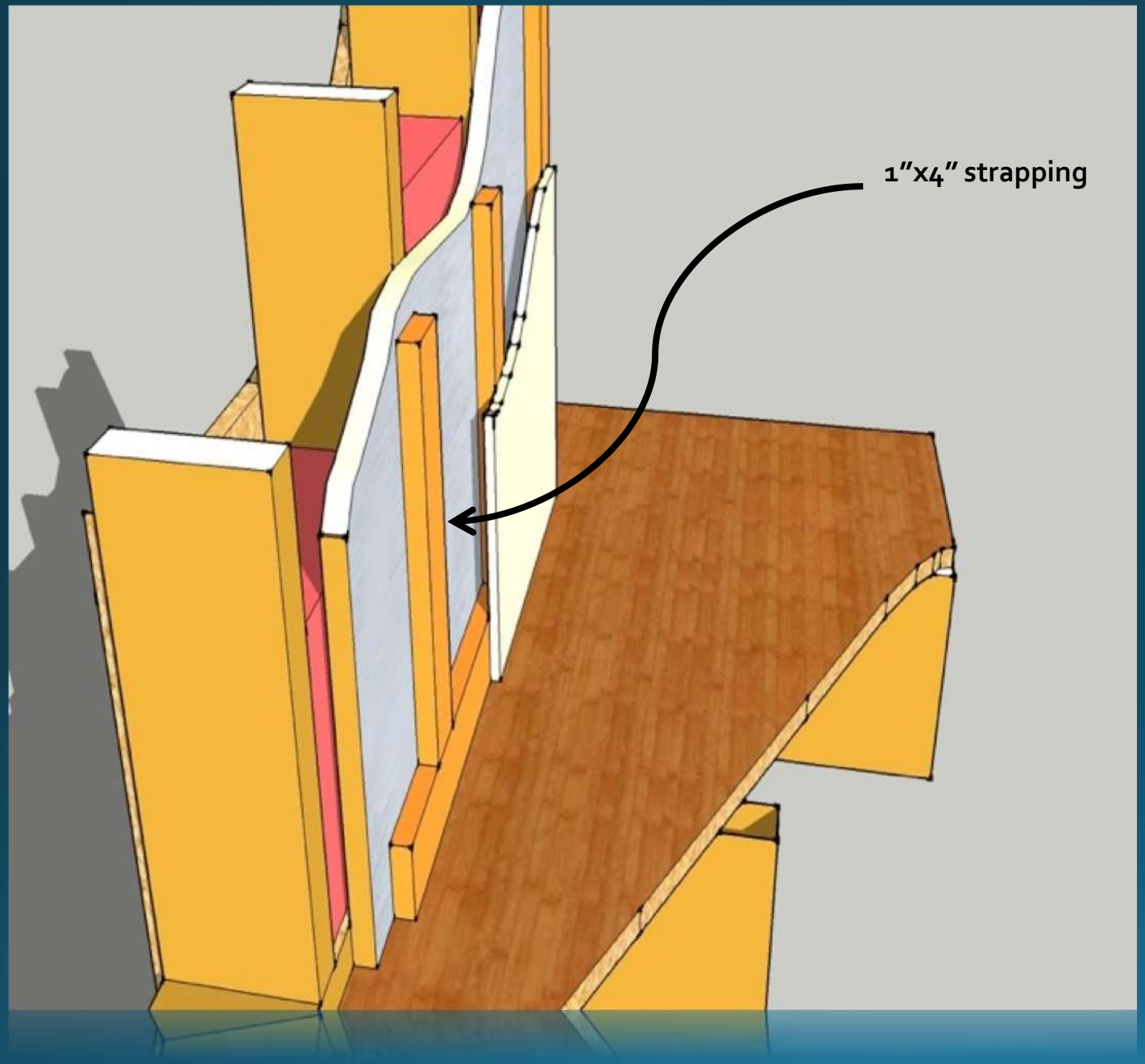

Modified Wall

Little thermal bridging

Interior isocyanurate with air space

Cold framing/sheathing

Radiant "bounce"

Outlet difficulty

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XPS Insulation



Interior or exterior

Controls conductive and convective losses

Miscuts can be foamed

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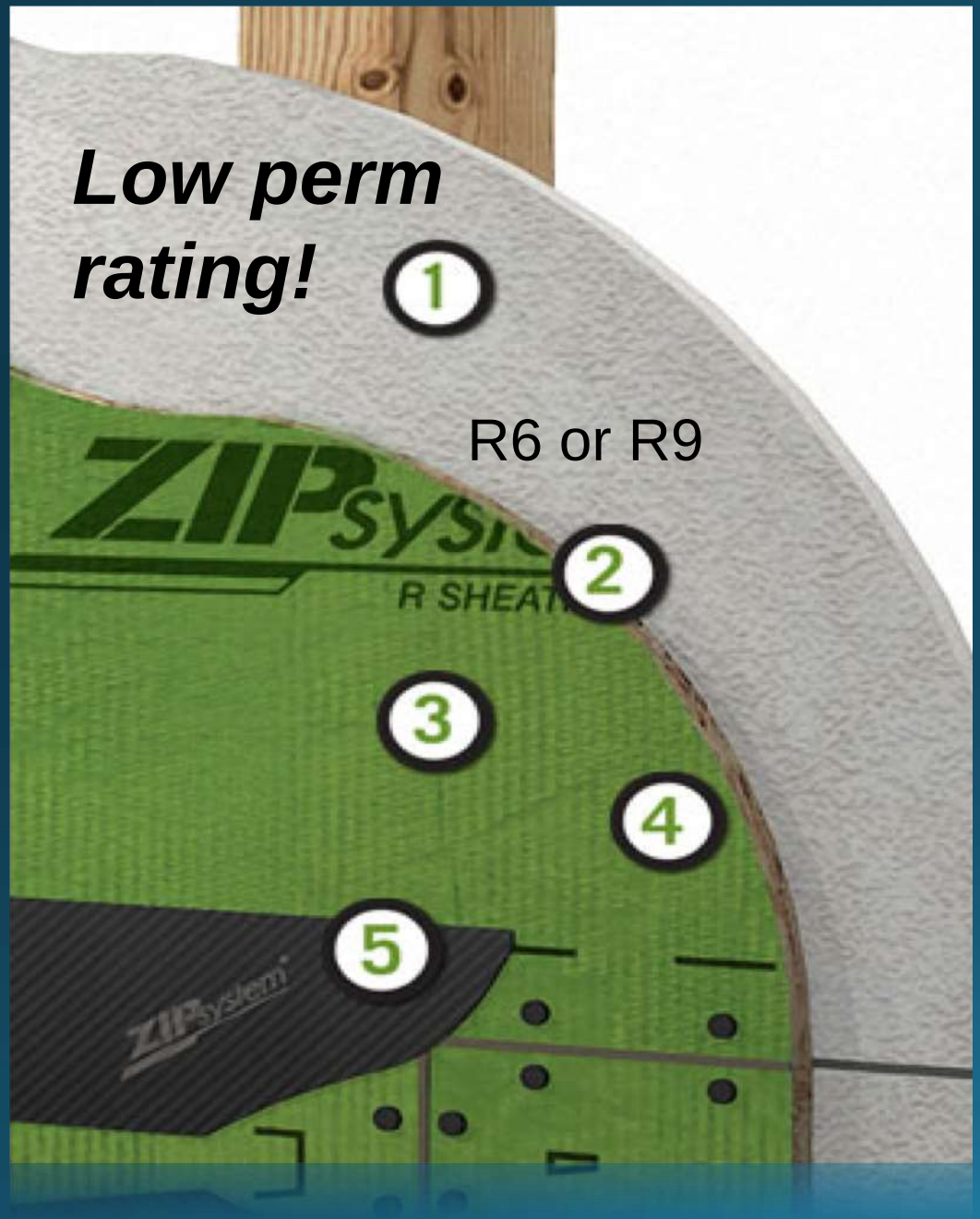

Insulated sheathing

1. *Continuous foam insulation*

1. *Engineered wood*

2. *Water resistive barrier*

3. *Continuous air barrier*

4. *Zip™ system tape*

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1.5" insulated sheathing on 2x6 studs

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Climate zone	Minimum R-value for exterior foam installed on an existing 2x4 wall	Minimum R-value for exterior foam installed on an existing 2x6 wall
Marine 4	2.5	3.75
5	5	7.5
6	7.5	11.25
7 and 8	10	15

Courtesy BuildingGreen, Inc

Minimum True R-values for exterior foam applications

IRC R702.7.1

w/Class III VDR

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Modified Wall

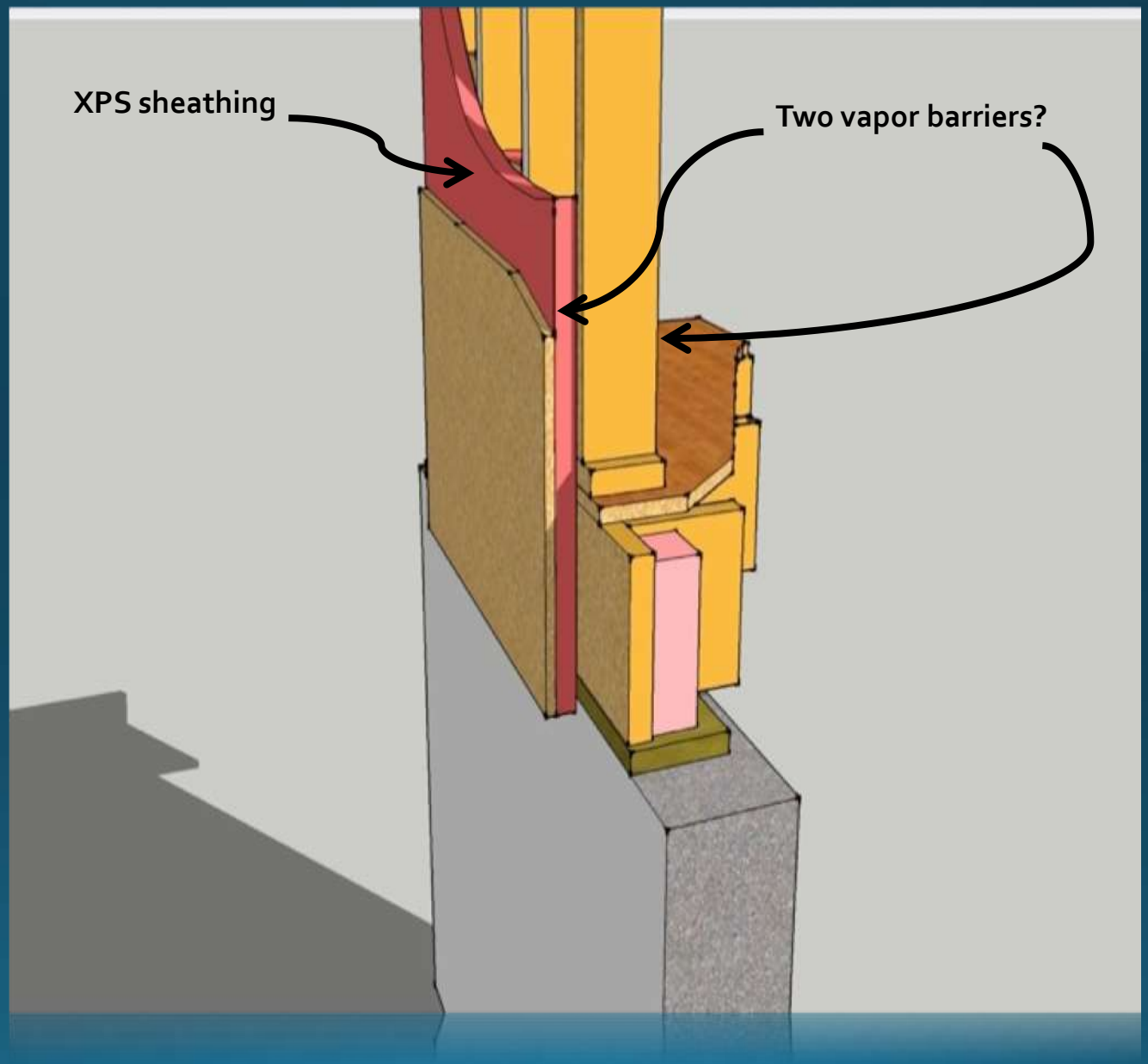
No thermal bridging

Dew point concerns

Warm framing

Cold sheathing

No outlet problem



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Single Stud House 2009

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Double Stud Wall

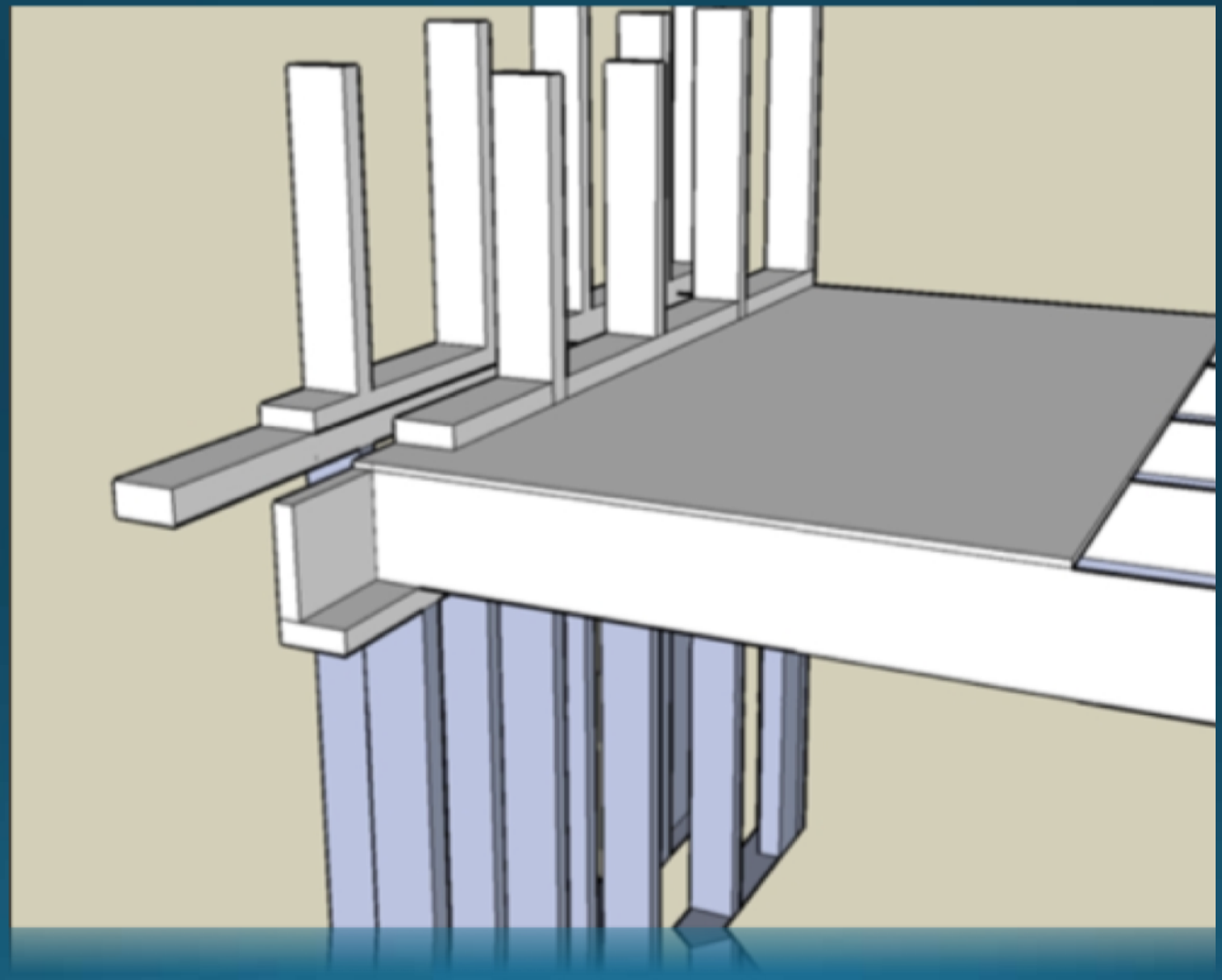
Two 2x4 walls, 3" space between

VB applied to outer face of inner wall

Outer 2/3 dense pack

Inner 1/3 HD batts

Minimal thermal bridging



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Double Stud Wall



Sheathing omitted for ease of joist band installation



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Tremco™ acoustical sealant, 22 years old



Double wall VB after 22 years

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Connecting walls together at the second floor

Truss mending plates
@ 48" centers

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Double Stud House 1982

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"Wrap and Strap"



Dense Pack Cellulose and Roxul Batts
R-30

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Acoustical sealant
at overlaps and
at penetration repairs



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Avoid aligning horizontal elements

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Block for outlets, cabinets

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Wrap and Strap House 2018

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Larsen™ Truss for major wall retrofit



Roof Systems

A roof system is a wall system laid on its side, except…

Stack effect more pronounced

Snow loads must be considered

It is subjected to harsher sun and more persistent rain

Has far fewer penetrations

Maintenance is more difficult due to its greater height

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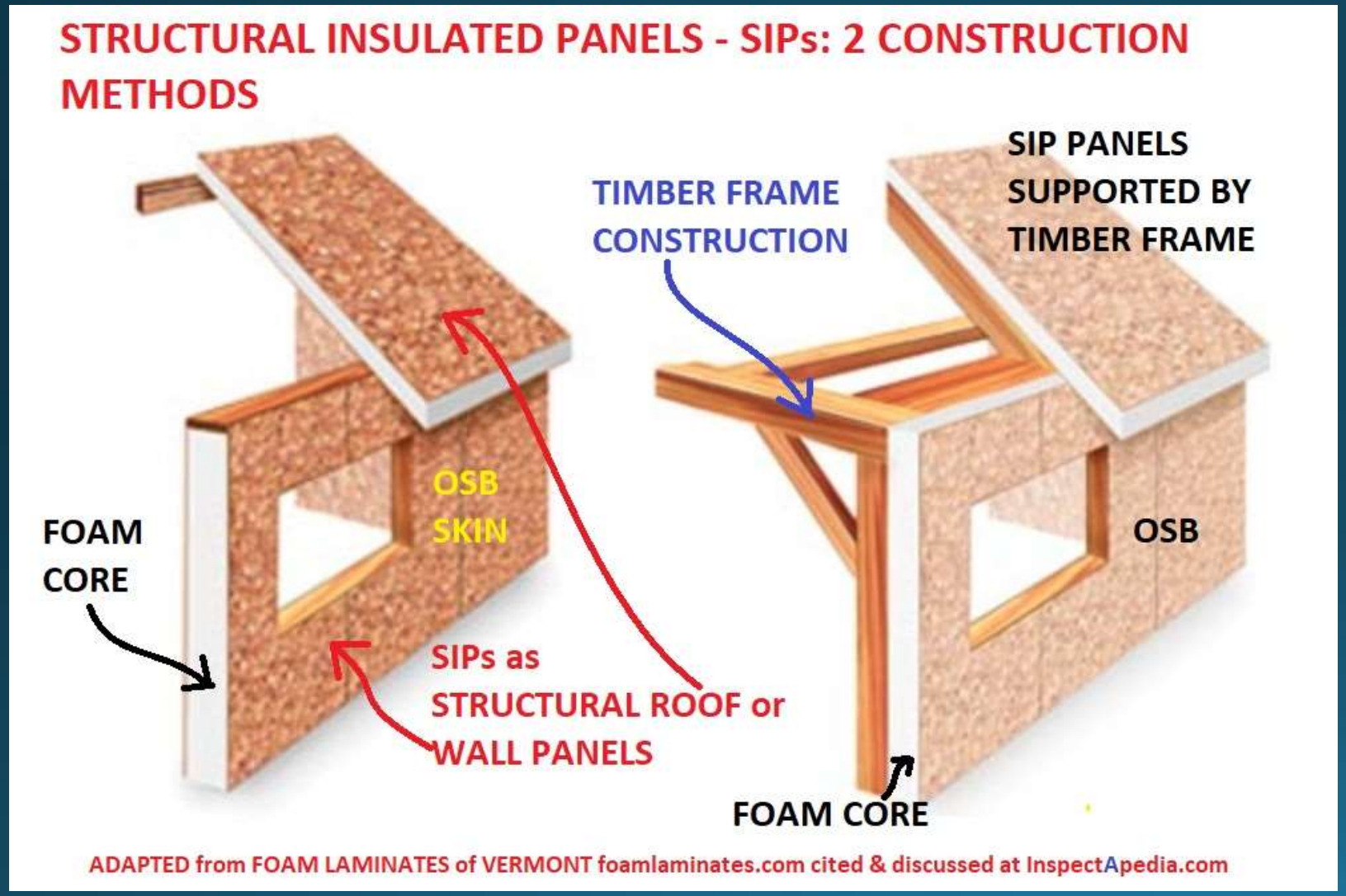
Zero Rafter Roof



Redundancy?

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Single Rafter Roof



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Double Rafter Roof





Supertruss™...22" depth

1982

©2021

“Supertruss” 2021



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Site built “scissor trusses”

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Another approach

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Dealing with the problem ar

2 part spray foam must be properly applied

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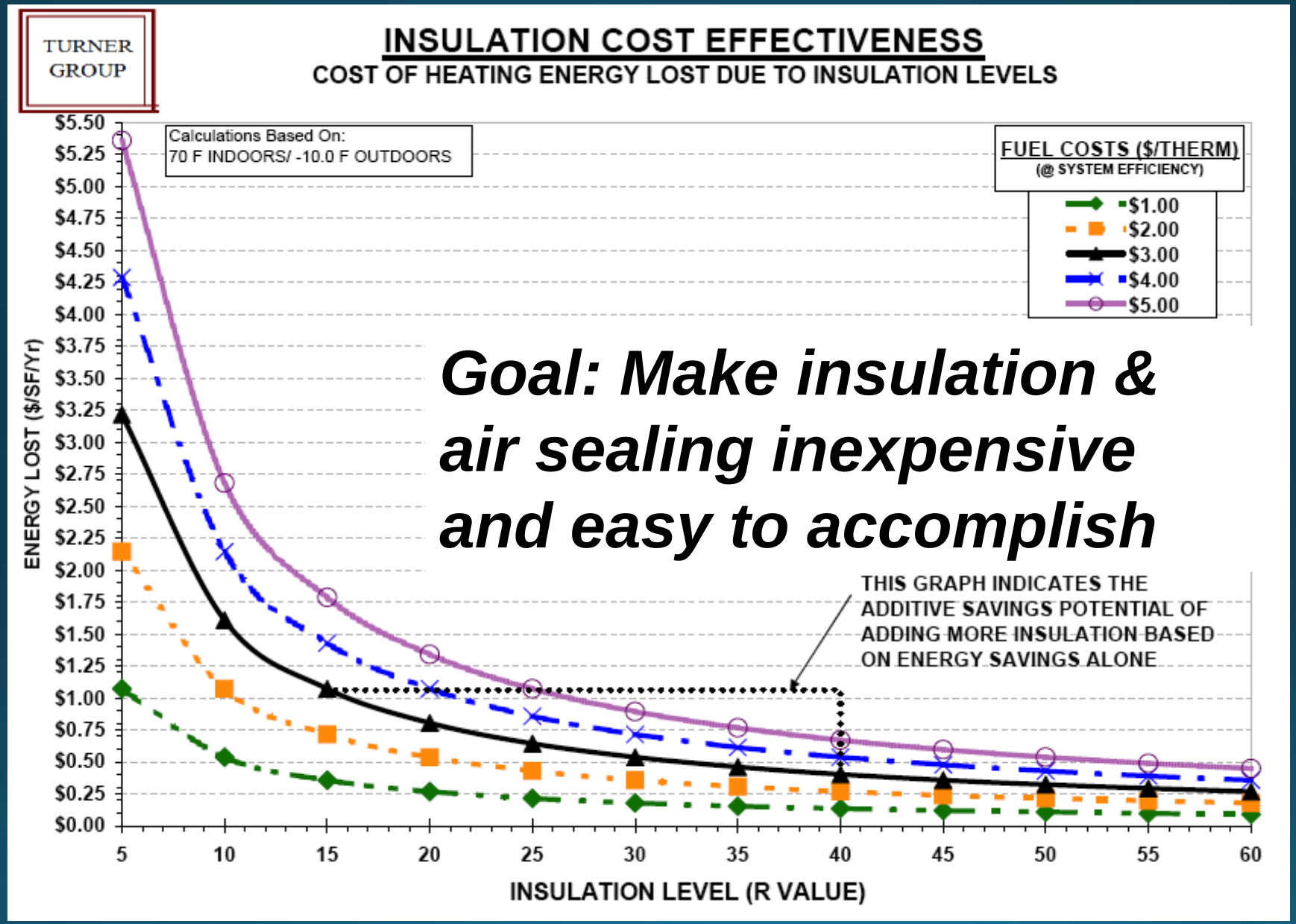

Goal: Make insulation & air sealing inexpensive and easy to accomplish

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“R” values per inch

Material	Resistivity
Concrete…	0.08
Softwood…	1.41
Fiberglass…	3.5
DP cellulose...	4.0
XPS…	5.0
HCFC…	7.5
Dead air…	5.6
Water…	0.24
Vacuum…	40.0

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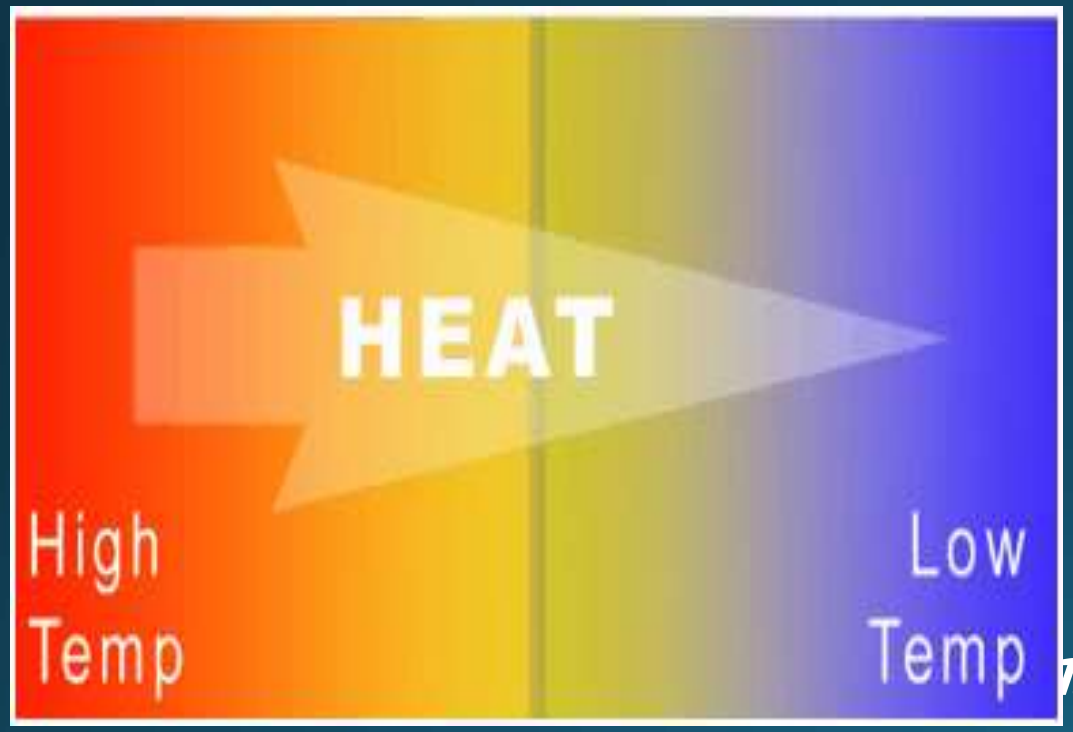
Heat Loss Calculation



Surface Heat Loss =AΔT/R

A = Surface Area
ΔT = Temperature Difference
R = Resistance

One can change one or all three of these
eters

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Fiberglass Insulation

Controls conductive losses

Air sealing necessary





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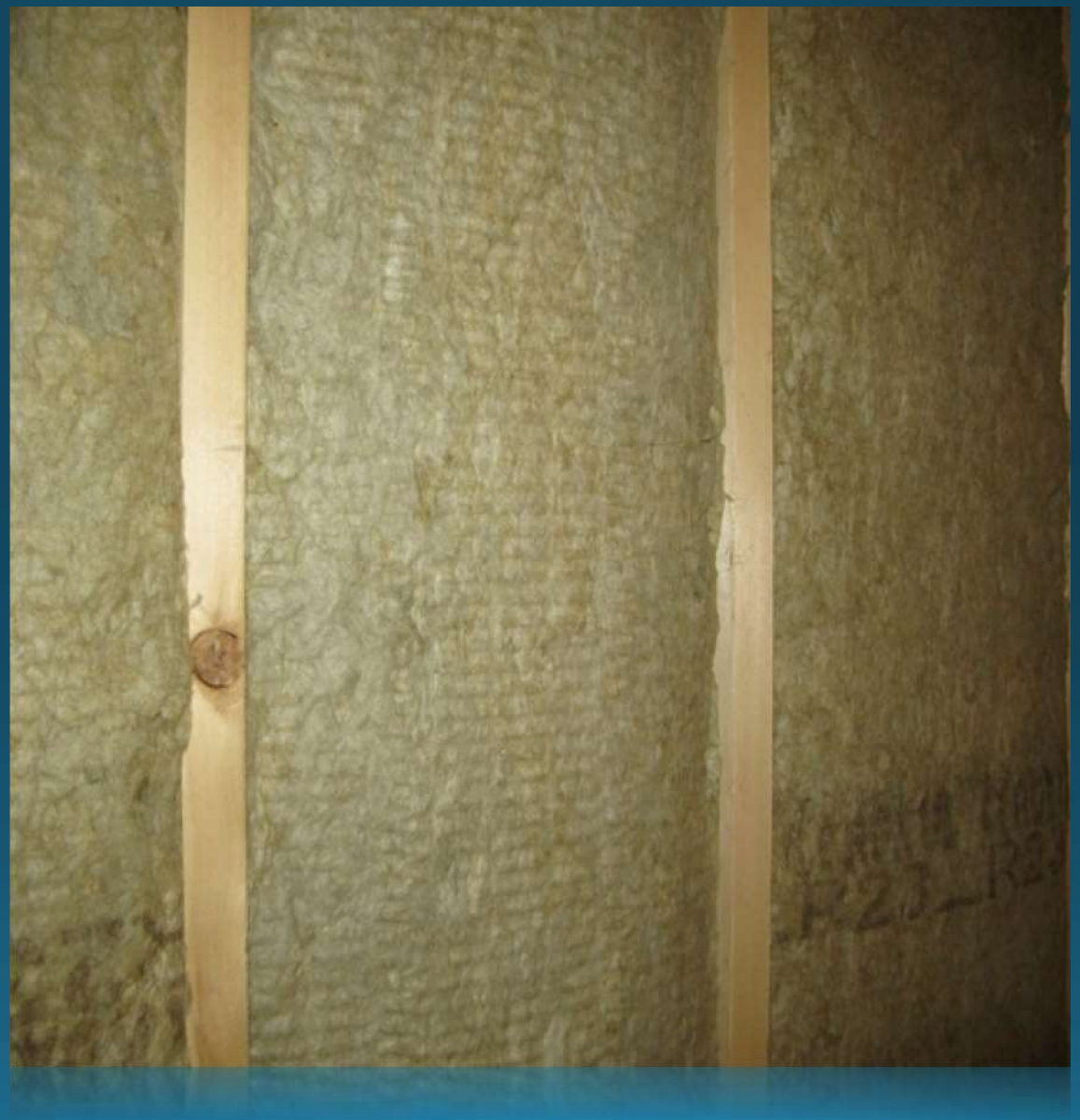
Roxul™ Mineral Wool Insulation

Tight friction fit

Controls conduction and convection



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Cellulose





Controls conductive and convective losses

Proper installation reduces settling

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Dense packed cellulose

R-3.35/in

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Rigid foil faced insulation



Controls conductive, convective, and radiant losses

Requires careful installation with taped seams, foamed penetrations



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Insulation with air sealing and VB



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Spray Foam Insulation



Courtesy Corbond

No convection

Dense, almost structural
Aerosol “Gorilla Glue”

VDR not needed?

“Green” ?

Messy if uncontrolled

Proper installation critical

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Heat Flow Management

Radiation

Dealing with MRT

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Managing Radiant Energy



Planned winter gain



Planned summer shading

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The importance of Mean Radiant Temperature (MRT)

Operative temperature is what humans experience thermally in space

$$T_o = (T_{mr} + T_{db})/2$$

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MRT is a
building enclosure performance element

Poorly designed buildings have
low MRT's in winter
and
high MRT's in summer

For instance, excessive fenestration

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Radiant Floor Heat does not heat our bodies...

It reduces the temperature difference between
our bodies
and the interior surfaces

Metabolic heat is retained

Remember the rules of heat movement

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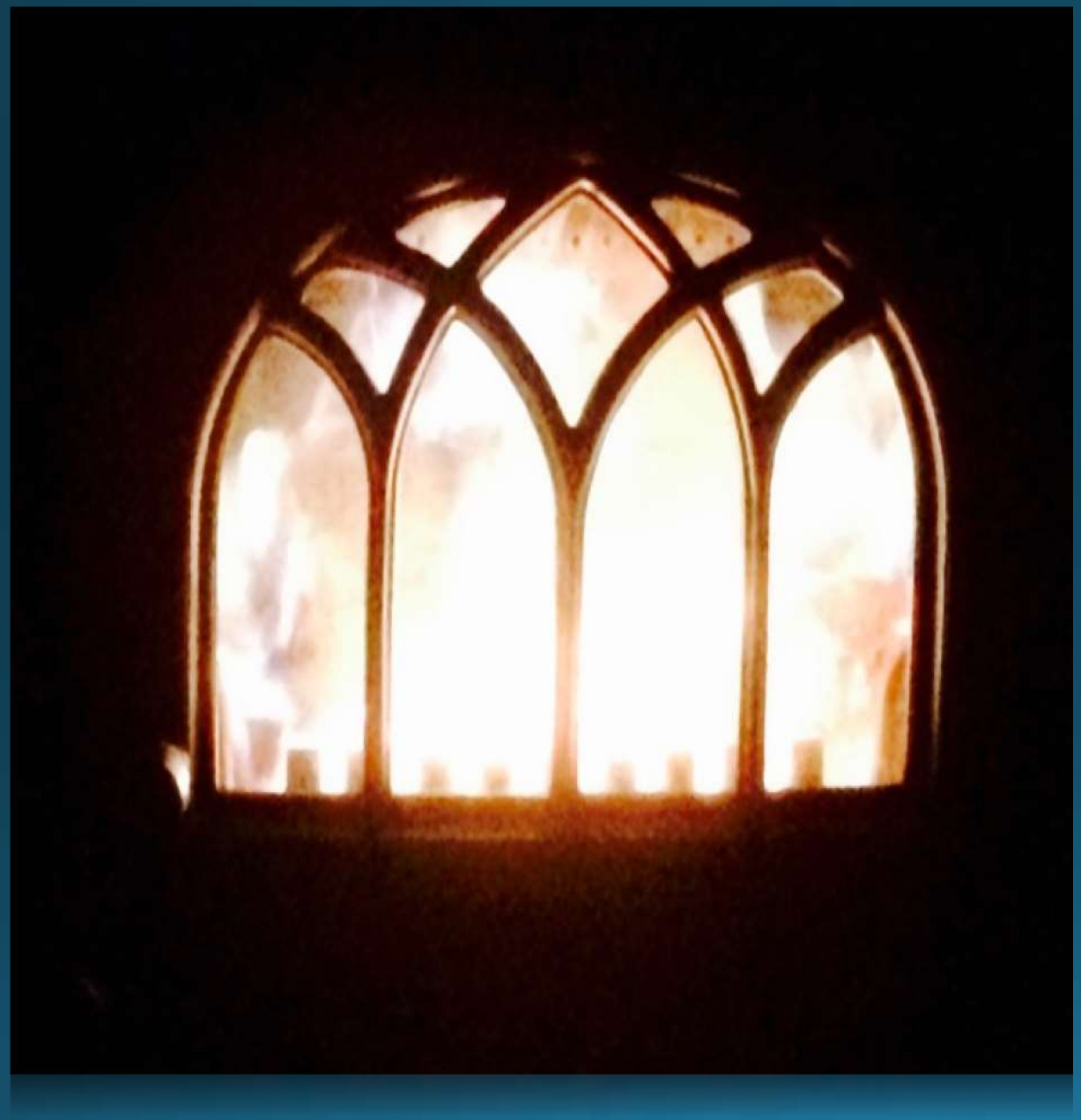

This radiation
heats
our bodies

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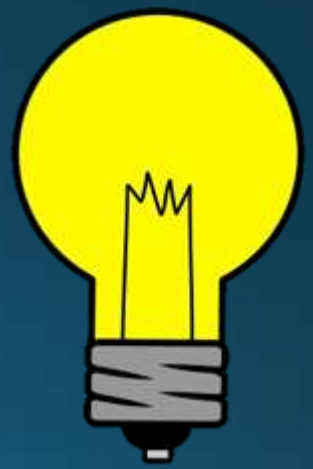
Relationship between warm human body and cold wall

For every ΔT° , the human body radiates 9 additional watts of heat energy

With a ΔT° of 10° , radiated energy is equal to 90 watts

A ΔT° of 30° raises that radiated energy to 270 watts



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End of Session One

Up next...

Steve Konstantino

Performance Building Supply

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Build a Better House

The Shell Part Two



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Thank you, program sponsors...



















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Heat Flow Management

Reduce convective loss by disrupting fluid

motion of molecules between a heated object

and the surrounding environment

"Air Seal"

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Air Flow Management



The Rules of Air Movement

Air always moves from high pressure to low pressure

"Stack Effect" Mechanical fans Wind

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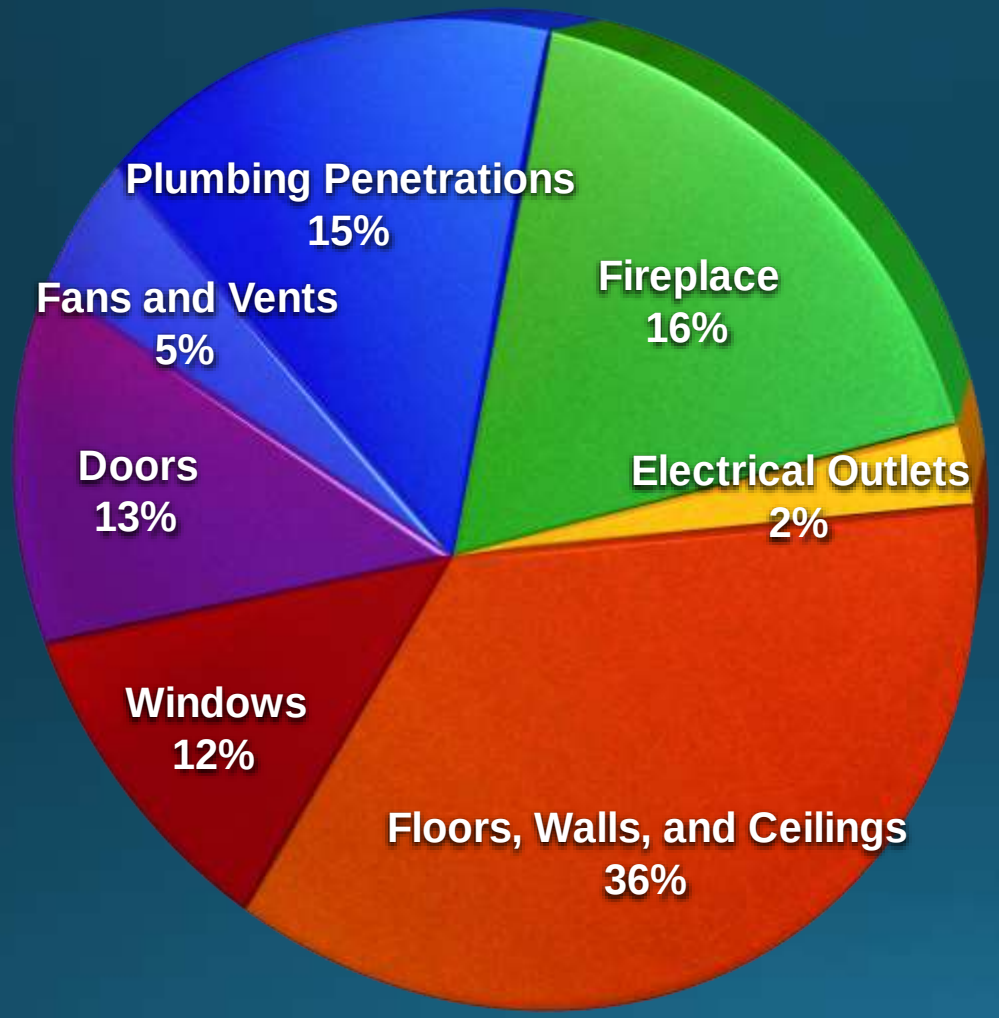

Where does the air leak most?

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Insulation

Continuous layer of insulation
- Avoid thermal bridges
  - Ideally separate *structure* from exterior
  - Avoid surface/interstitial condensation

Don't let air flow through insulation
- *Air sealing required*

Detail to prevent pest infestation



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Poor Insulation Performance

Airflow within assemblies

Convective loops around and through batt insulation caused by gaps and large temperature difference

Convective loops in batts or loose fill with one side open to cold air in attics

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Prevent “Windwashing”



Need air tightness outside the insulation

- Sealed housewrap
- Flashed corners
- Sheathing sealed with tape
- Attic baffles/blocking
- High density cavity insulation
  - foam, dense cellulose

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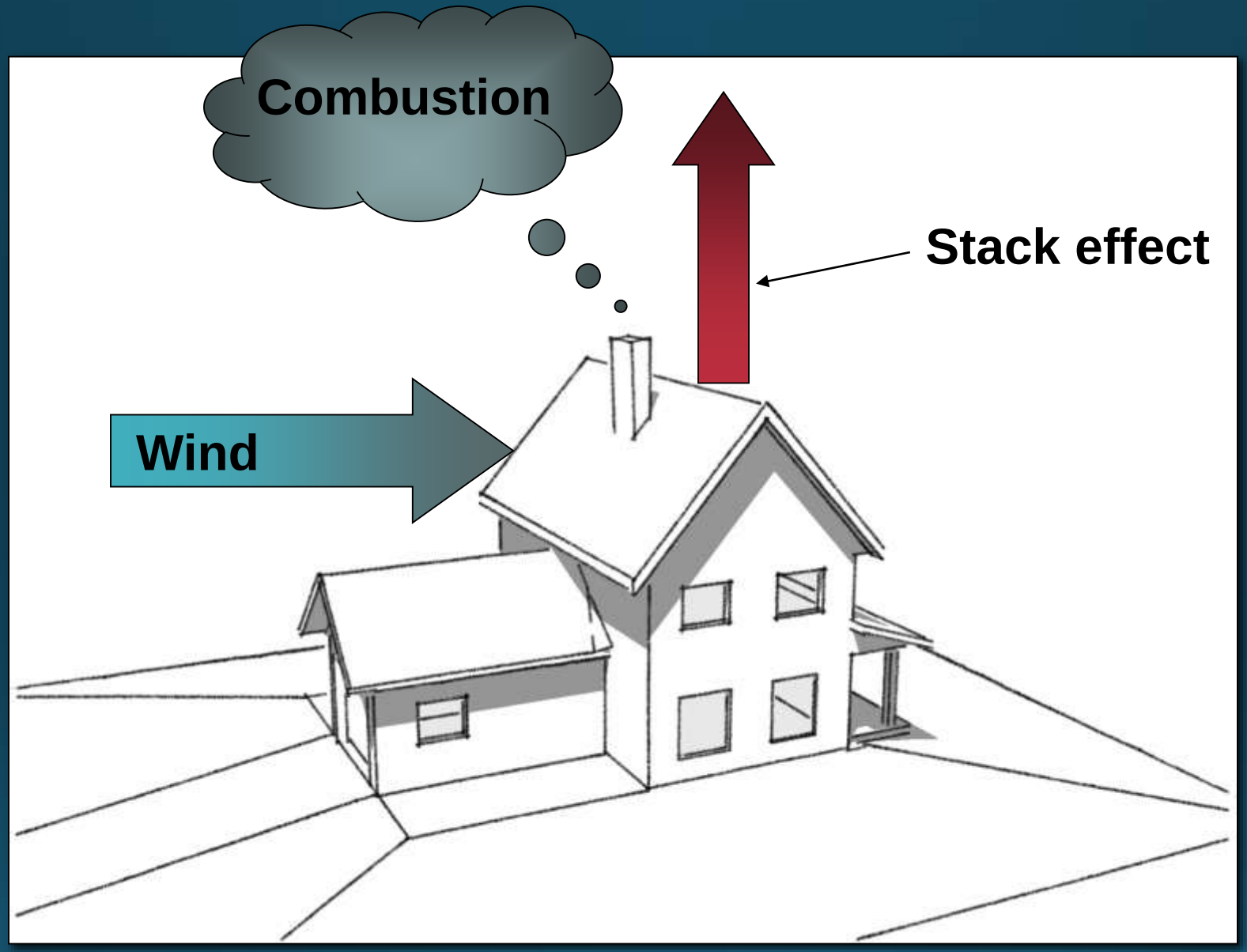
ZIPsystem
ZIP system
ZIP system
ZIP system



Control Airflow

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Dust and dirt around the switch



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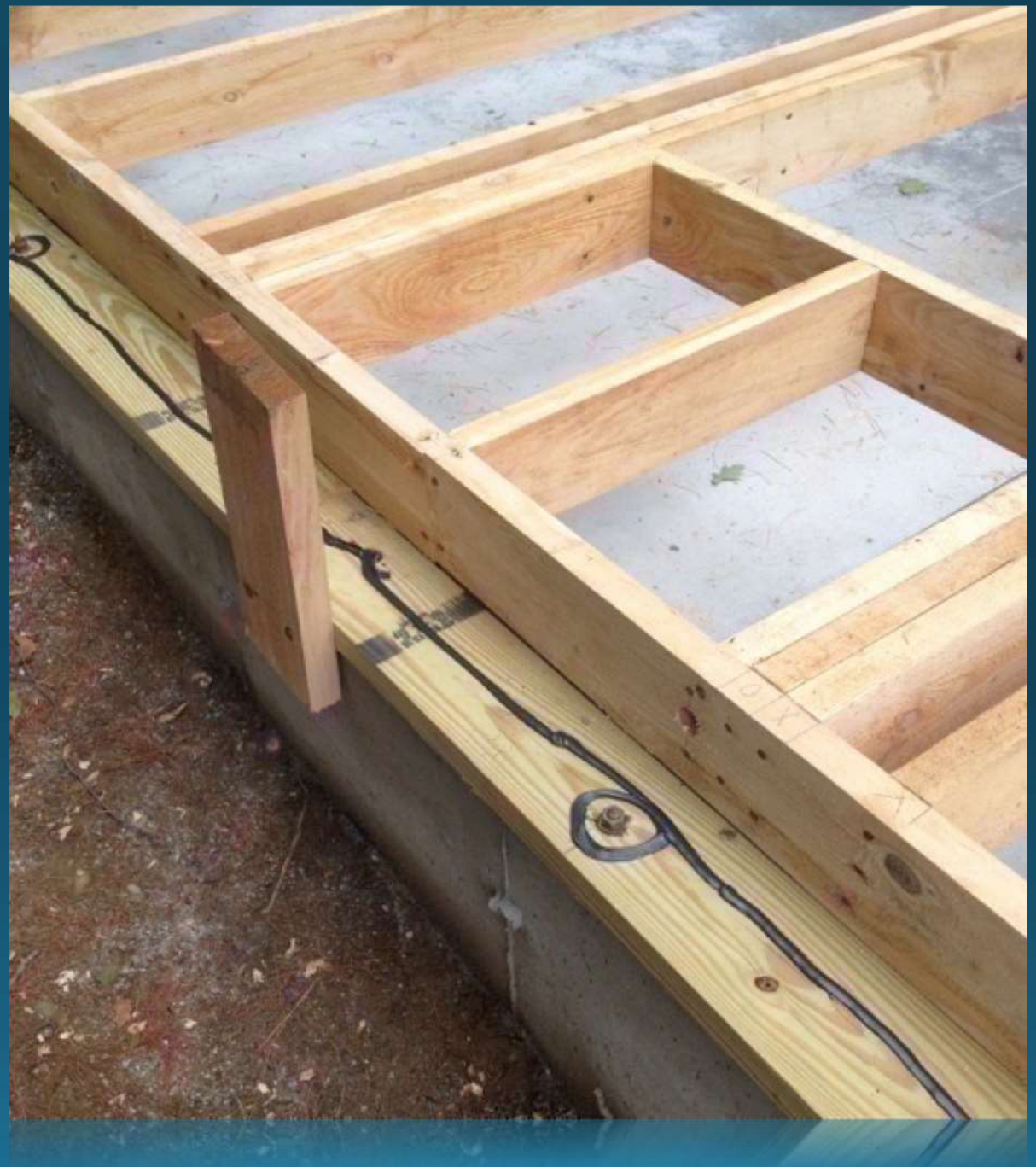
Sealed Floor Plate



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Fiberglass Air Filter

Air sealing is critical

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AIR LEAKS
PLUMBING STACK VENT
BATHROOM FAN VENT
RECESSED LIGHTS
ATTIC HATCH
RECESSED LIGHTS
CHASE
KITCHEN FAN VENT
ELECTRICAL OUTLET
DRYER VENT
CRAWL SPACE
OUTDOOR FAUCET
Air leaking into the house
Air leaking out of the house

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Air Leakage



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Air Leakage Evaluation

ACH @ cfm50
- < 7 is not particularly tight
- < 3 achievable is a good job
- < 1 really good job!
- Passivhaus .6ACH @ cfm50

MSH Green minimum standard
- 0.25 cfm/SF @ 50 PA

IECC 402.4.2.1…less than 3 ACH



©2021

©2021

Use Air Barriers

Inside... air tight drywall

Interstitial... smart membrane

Outside... taped sheathing

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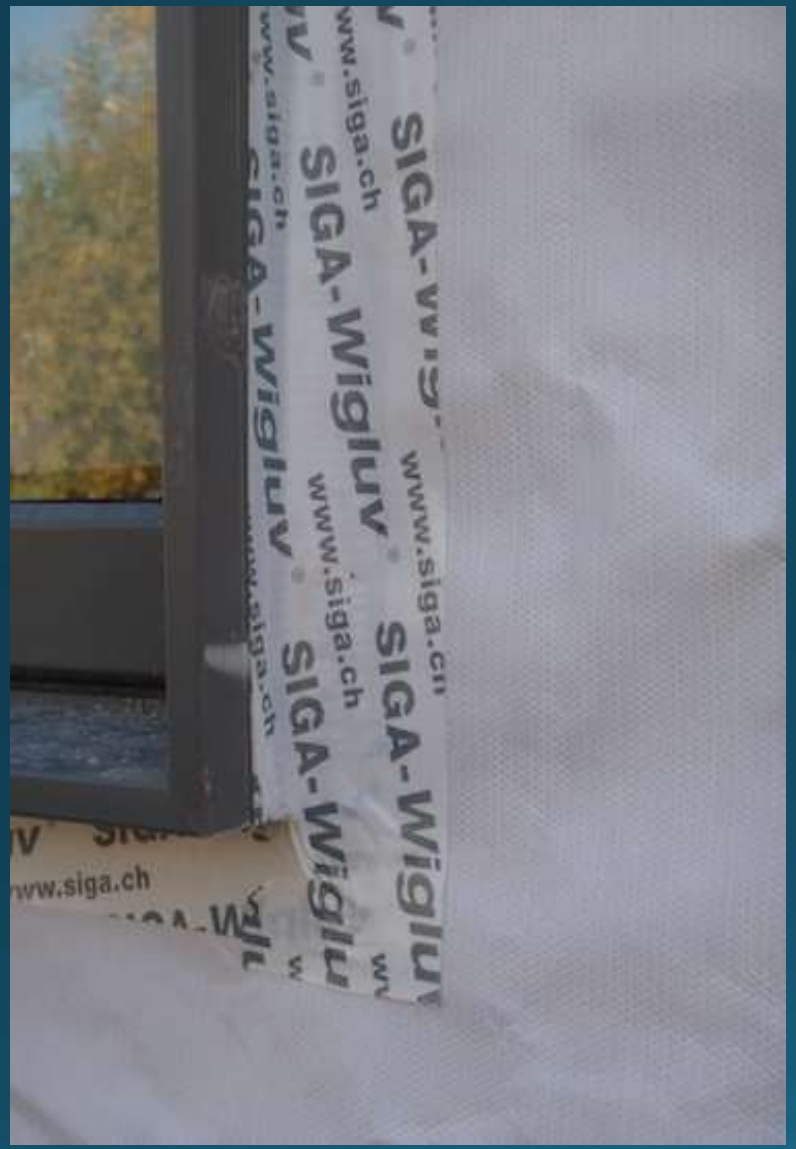



Courtesy Yandow Green Builders, LLC

Tape for Air Sealing Windows

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Shawn Spear

Dupont Building Envelope specialist

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The Rules of Vapor Transport

Water vapor will always move from areas of higher concentration to areas of lower concentration

Drivers include…

Vapor pressure differential

Permeability of membrane

Air movement

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Dew Point

Temperature at which water vapor condenses into liquid water

High relative humidity values indicate the dew point temperature is close to the current air temperature

Dew point at 100%RH equals ambient temperature

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Dew Point: What Happens Outdoors…





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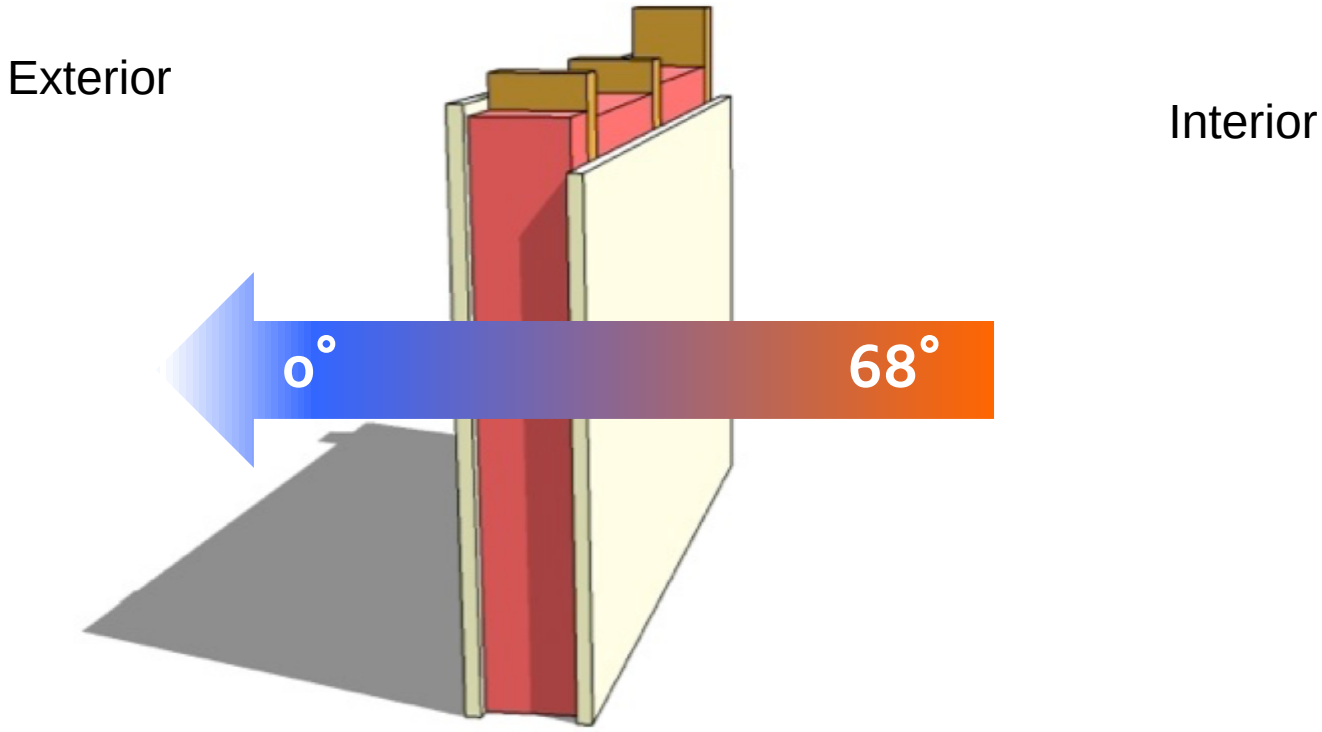
Where is the dew point?



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Exterior XPS with insufficient thickness

Interior RH too high

Dew point reached

Exterior sheathing rotted in 5 years

Structural elements too!

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Maine Uniform Building & Energy Code

IRC…Int'l Residential Code 2015

IBC…Int'l Building Code 2015

IECC…Int'l Energy Conservation Code 2015 or…

ASHRAE 90.1

IEBC…Int'l Existing Building Code

ASHRAE 62.1 and ASHRAE 62.2

ASTM E-1465



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Consider Climate Impact of Insulation Materials

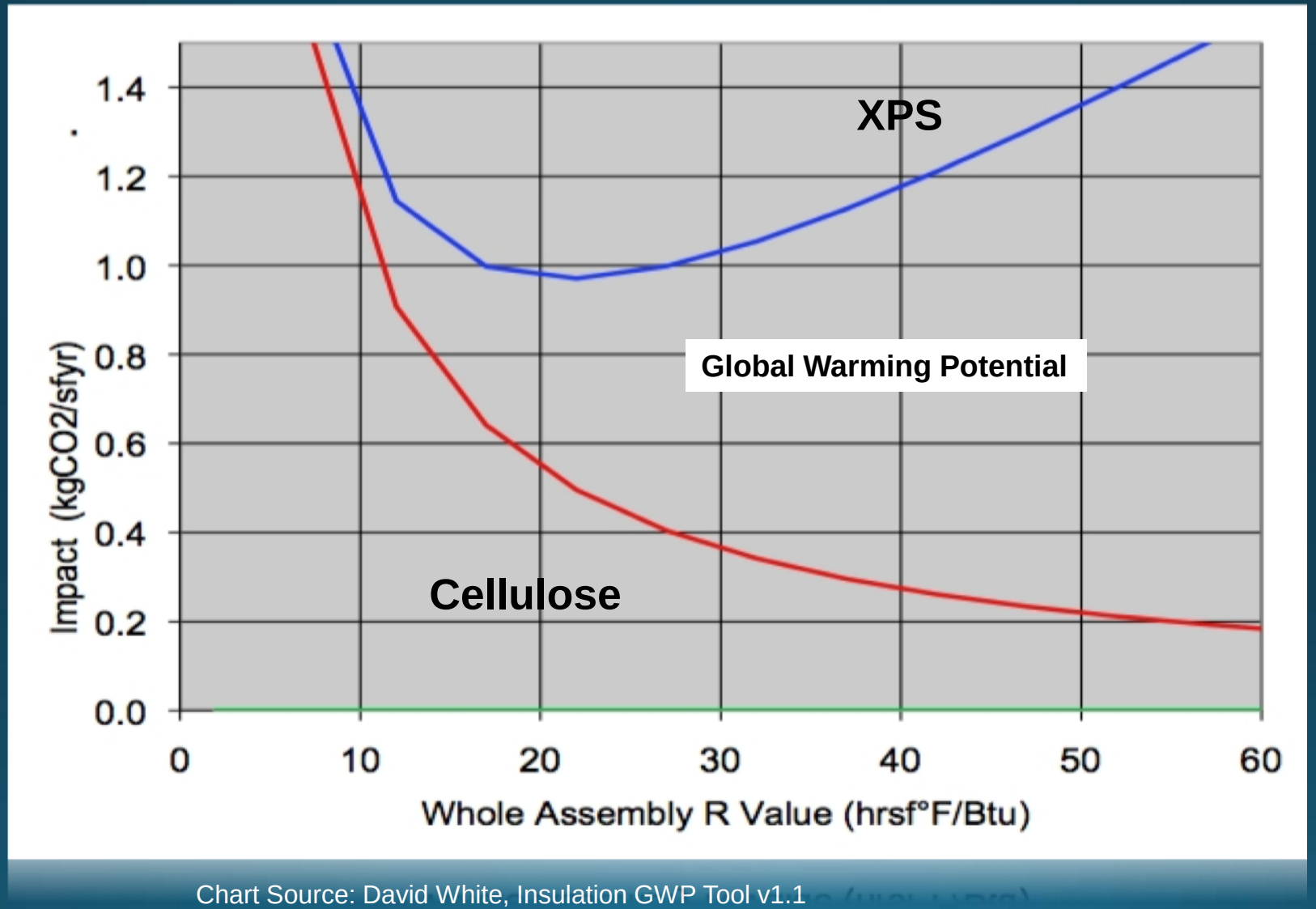
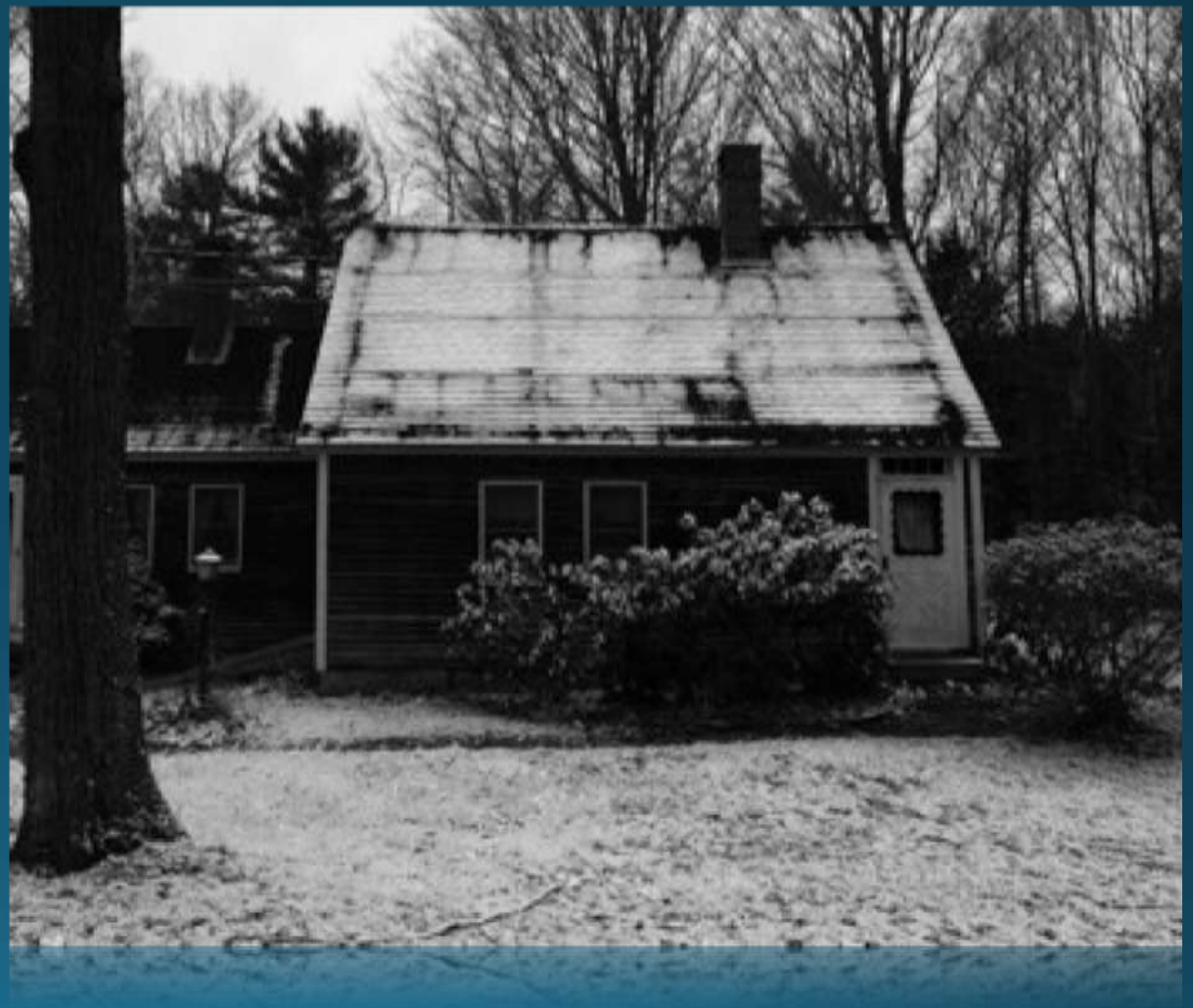


Chart Source: David White, Insulation GWP Tool v1.1

© TBS&D LLC, DJ&Co, 2014

Avoid thermal bypasses

Solid wood member bad
Uninsulated concrete worse
Uninsulated glass worse still
Through wall metal worst
Acts as a thermal radiator attempting to heat the outdoors
50% loss in system R value



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IRC R702.7

Class I or II vapor diffusion retarder required on the interior of frame walls

Class III permitted in special circumstances

Vented cladding

Class I...Polyethylene or foil

Class II... Kraft faced batts

Class III... Paint

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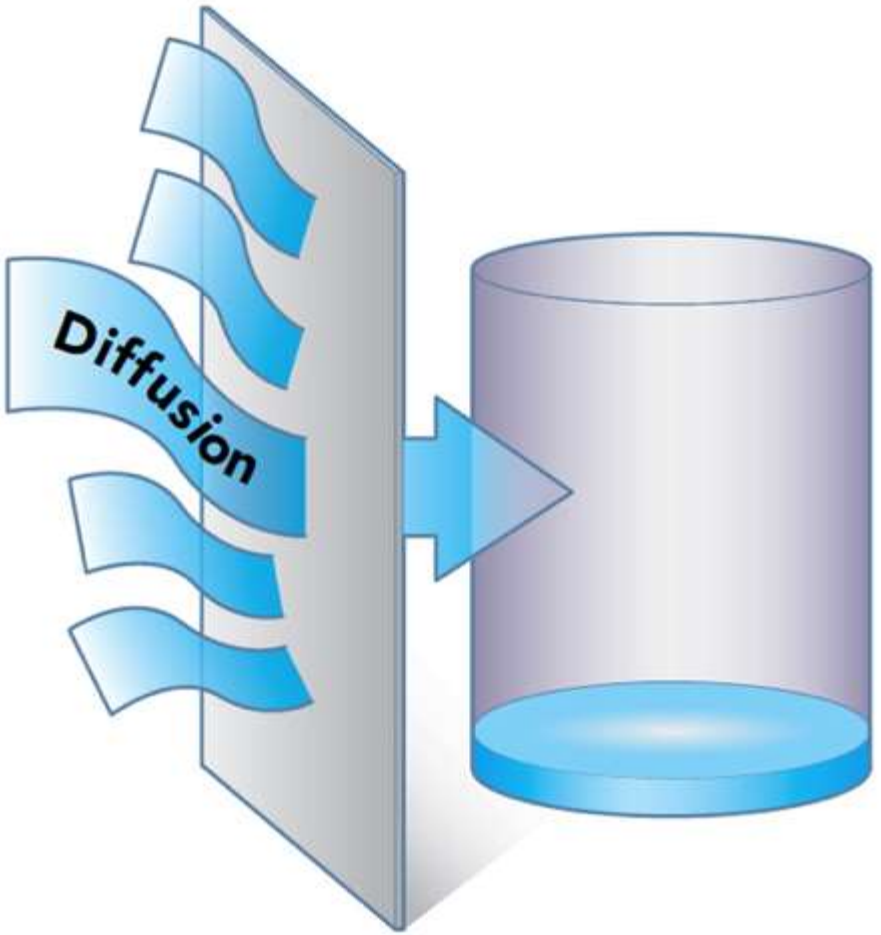
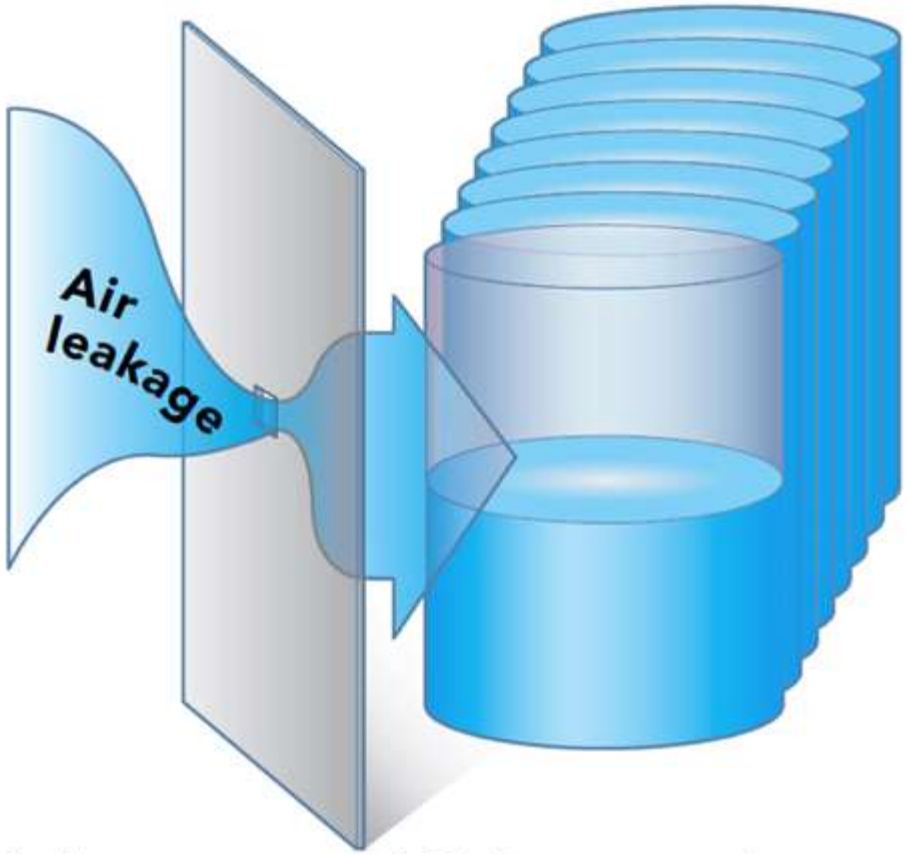


A small amount of water can pass through solid drywall via vapor diffusion.



Much more water—100 times as much—can pass through a 1-in. by 1-in. hole in drywall.

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VB vs. VDR

There really is a difference between the two

Remember, diffusion is weak
VB is overkill

VDR deals with diffusion easily
Allows accidental moisture to escape

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Vapor Management

Reduce *vapor diffusion* into assembly

Prevent *air leakage* into assembly

Plan on some moisture penetration into assembly

Allow for drying pathway

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Water Proof and Vapor Permeable



Courtesy dupont.com/products

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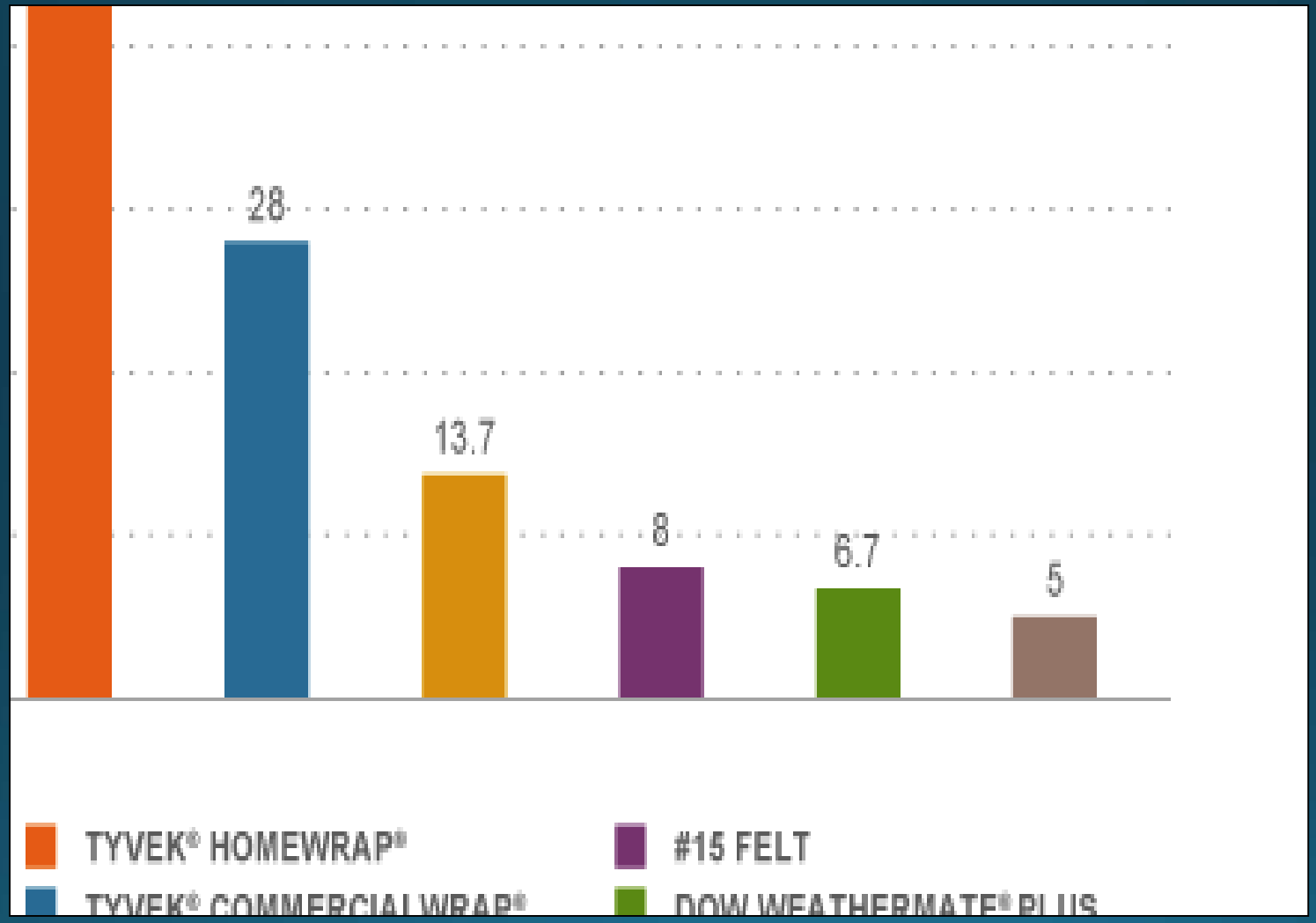
Water Proof and Vapor Permeable



Courtesy dupont.com/products

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Product permeability

Perm Rating	Product	Use
40	Vinyl siding	VP
40	Brick veneer	VP
30	Building felt paper	VP
10?	CDX plywood	VSP
5	Housewrap	VSP
2	OSB sheathing	VSP
>1	EPS (Beadboard)	VSP
1	XPS (1” - thickness)	VSP
0.1 - 1	XPS (1” + thickness)	VSP
<0.1	Faced XPS	VI (Barrier)
<0.1	Foil or poly facing	VI (Barrier)

Courtesy Building Science Corporation

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CDX plywood vs. OSB

"Wood layers versus Wood McNuggets



Building Science Corp

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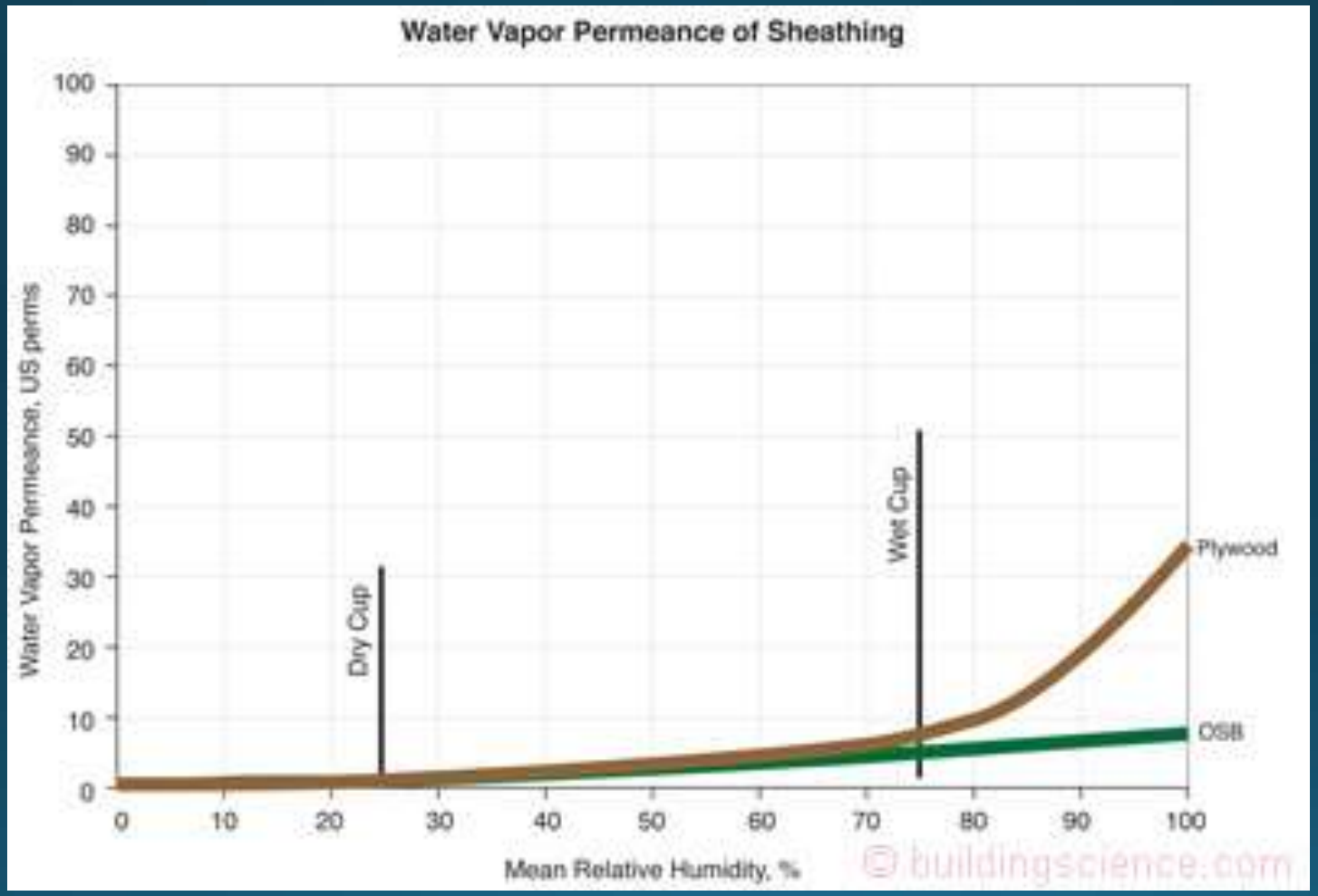
Vapor Diffusion Plywood vs OSB



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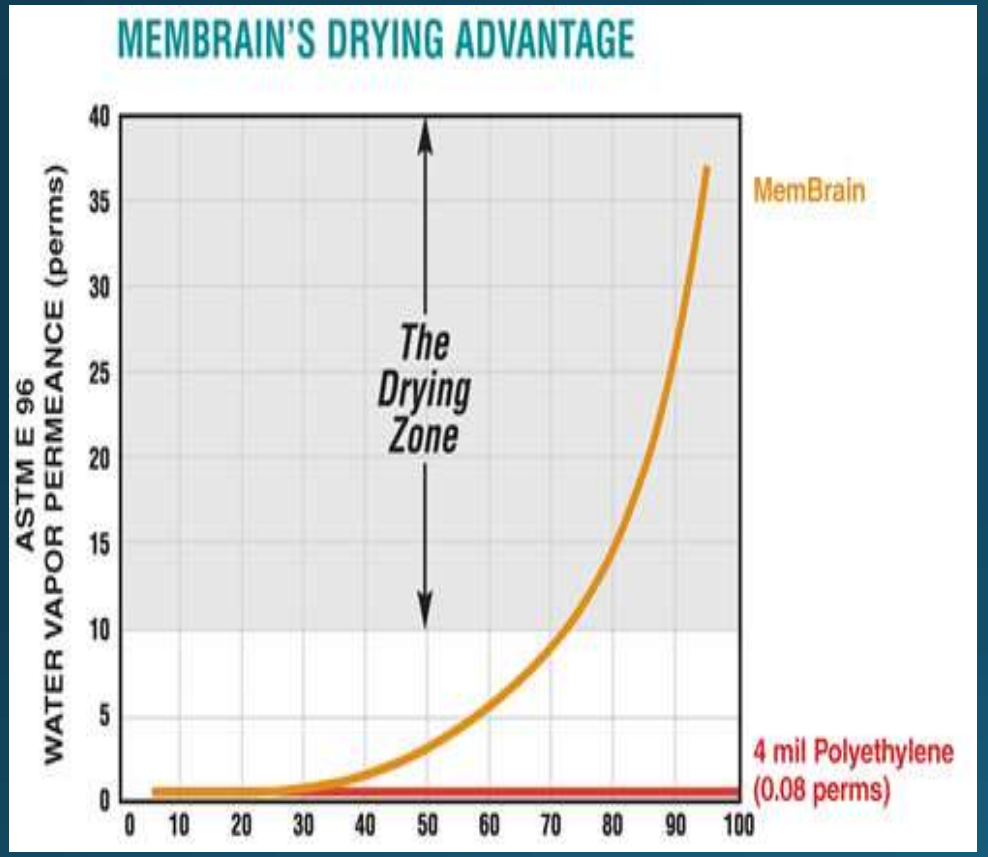
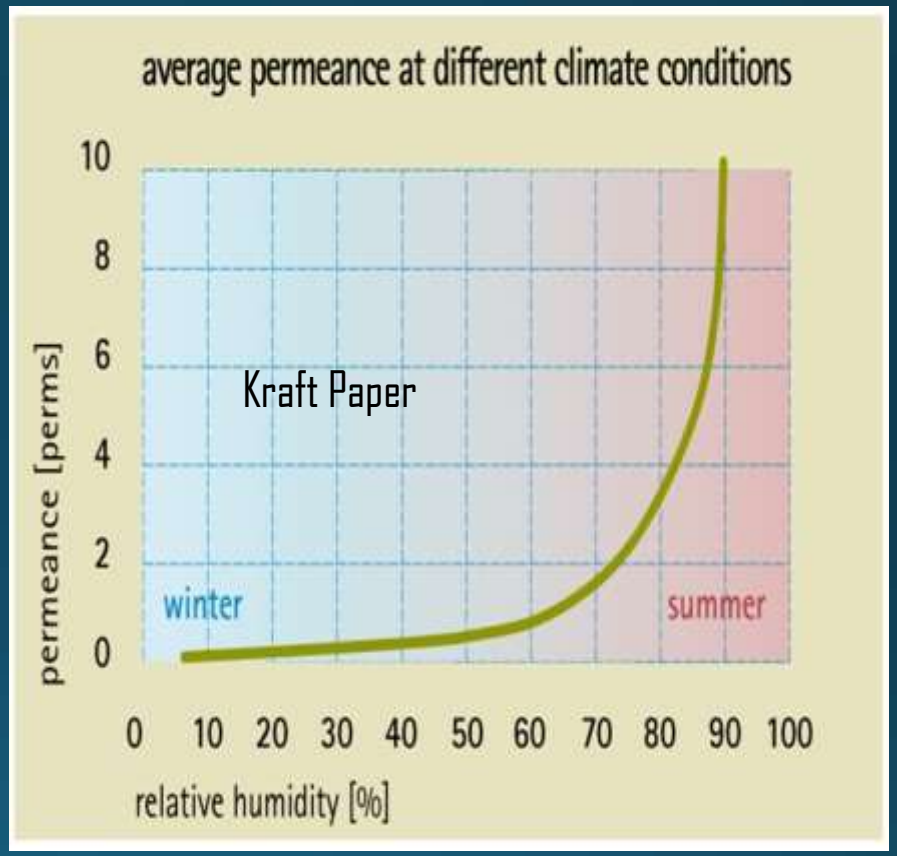
Smart vapor diffusion retarders



Courtesy naturalspacesdomes.com



Courtesy foursevenfive.com

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Damaging condensation occurs…

When humid exfiltrating air cools down

Diffusing water vapor hits cold surface

Air leakage is critical

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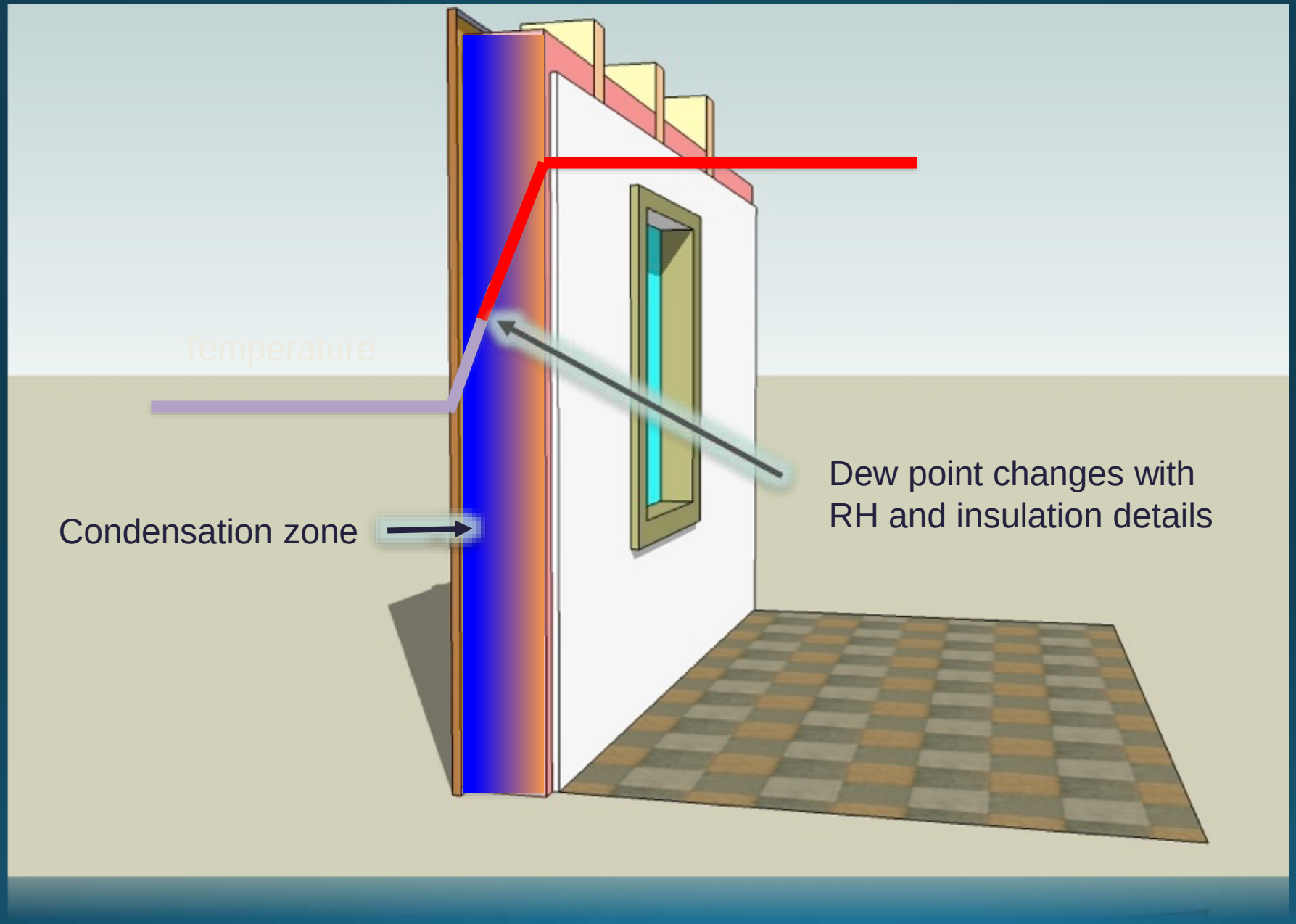
Temperature
Condensation zone
Dew point changes with
RH and insulation details

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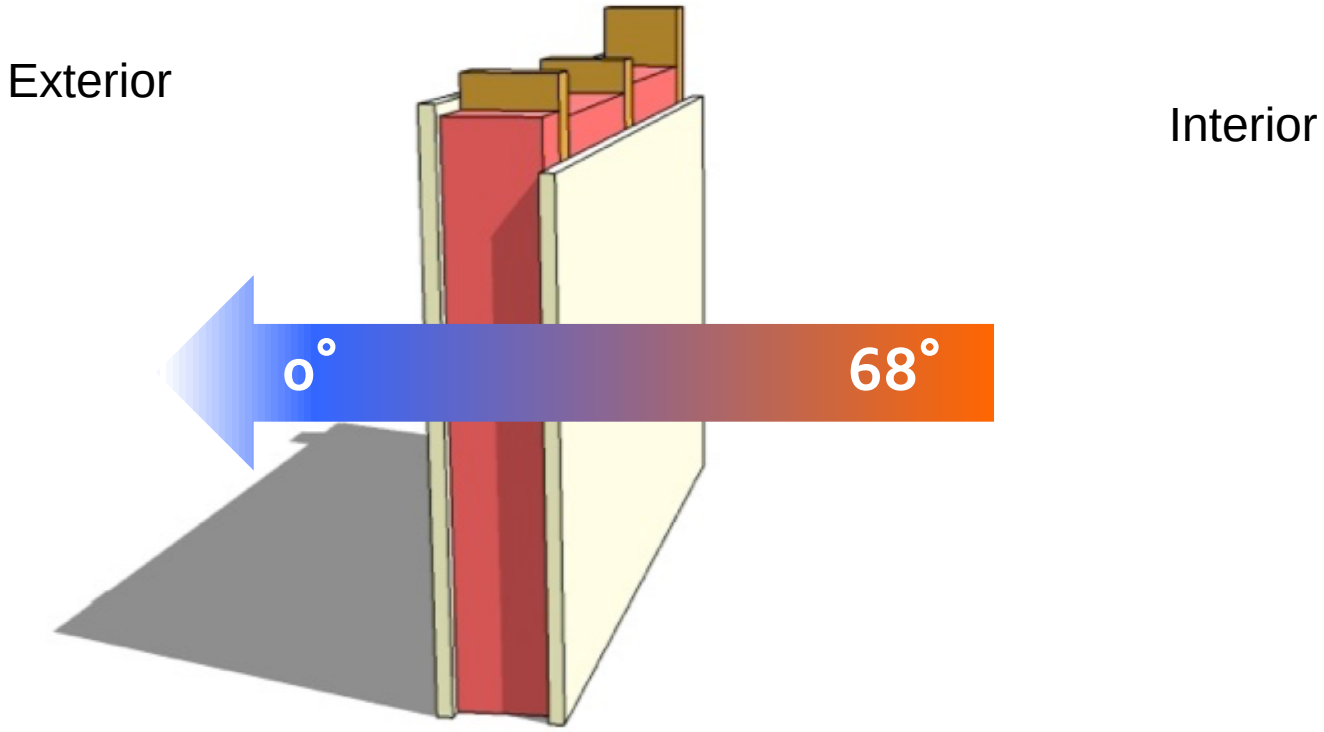
Where is the dew point? heating



Temperature difference across a wall

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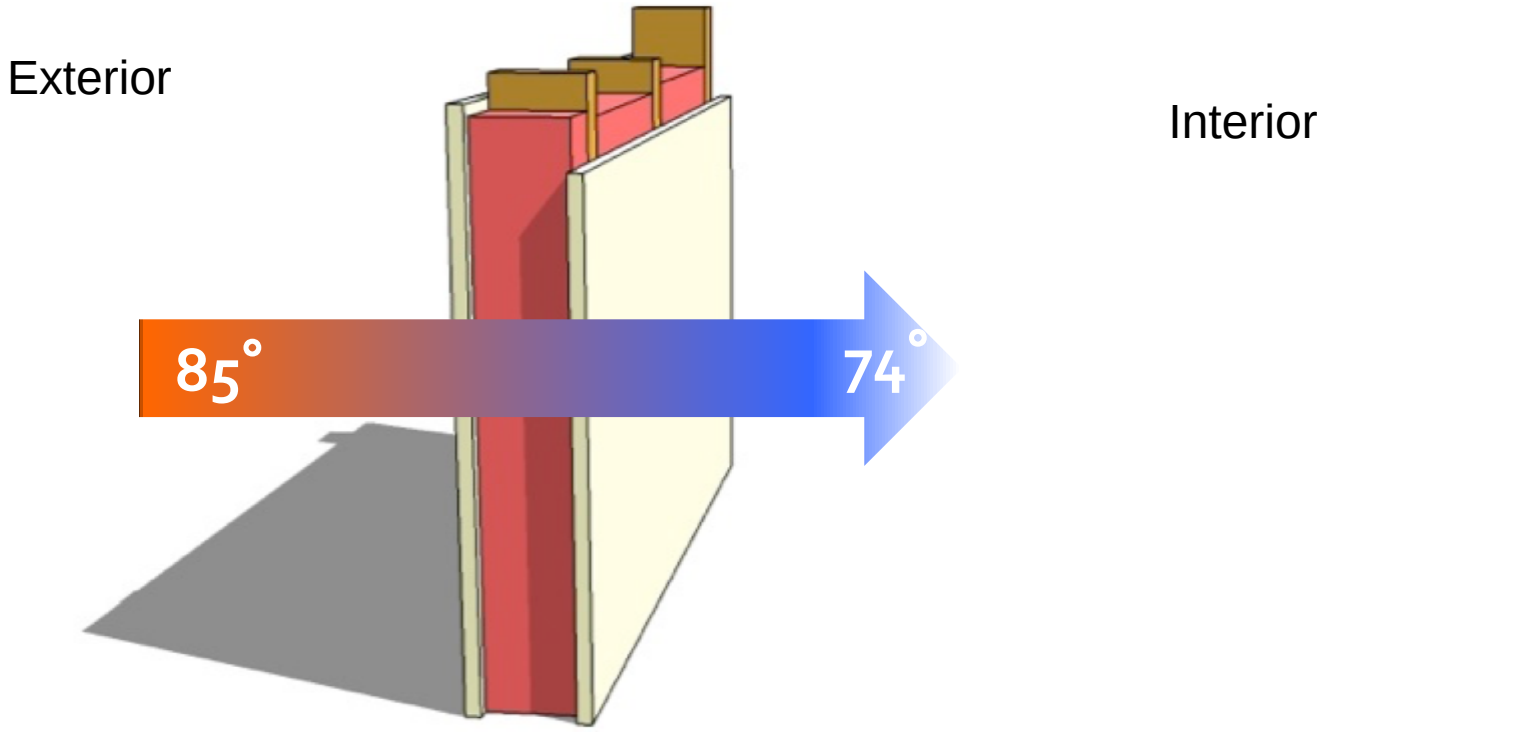
Where is the dew point? cooling



Temperature difference across a wall

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Temperature Calculation
within the wall

1. Determine total R-value

2. Determine ΔT across the wall

3. Starting from outside… $T_{interface} = T_{outside} + (\%\ of\ total\ R\ value \times \Delta T)$

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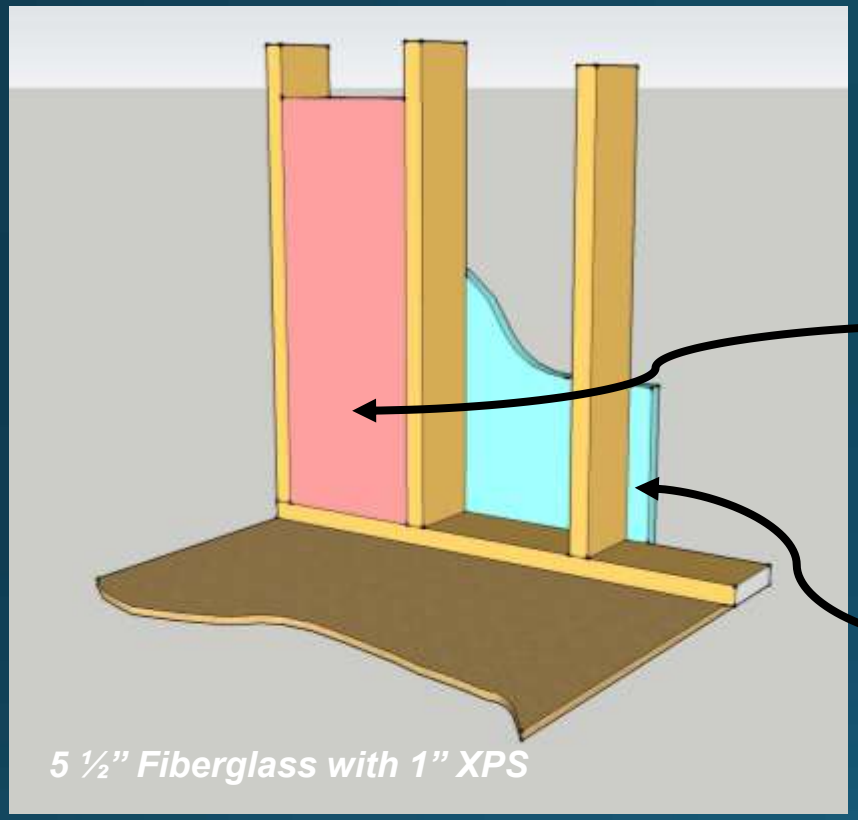

Exterior Foam Sheathing System

What temperature here?

What temperature here?

Calculating interface temperatures

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Total R value = R19 + R5 = R24

ΔT = 68º (68º interior, 0° exterior)

Step One

XPS R-value % = 20.8%

.208 x 68° = 14.14º

0º + 14.14° = 14.14º

Step Two

Fiberglass R-value % = 79.2%

.792 x 68° = 53.86º

0º + 14.14° + 53.86º = 68º

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Dew-Point Temperature (°F)															
Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

Adapted from ASHRAE Psychrometric Chart, 1993 ASHRAE Handbook—Fundamentals.

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Total R value = R19 + R10 = R29

ΔT = 68º (68º interior, 0° exterior)

Step One

XPS R-value % = 34.5%

.345 x 68° = 23.46º

0º + 23.46° = 23.46º

Step Two

Fiberglass R-value % = 65.5%

.655 x 68° = 44.54º

0º + 23.46° + 44.54º = 68º

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Dew-Point Temperature (°F)															
Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

Adapted from ASHRAE Psychrometric Chart, 1993 ASHRAE Handbook—Fundamentals.

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Climate zone	Minimum R-value for exterior foam installed on an existing 2x4 wall	Minimum R-value for exterior foam installed on an existing 2x6 wall
Marine 4	2.5	3.75
5	5	7.5
6	7.5	11.25
7 and 8	10	15

Courtesy BuildingGreen, Inc

Minimum R-values for exterior foam applications

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What temperature here?

Total R value = R11 + R7

ΔT = 68°

Step One

CCF R-value % = 38.9%

.389 x 68° = 26.45°

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Dew-Point Temperature (°F)															
Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

Adapted from ASHRAE Psychrometric Chart, 1993 ASHRAE Handbook—Fundamentals.

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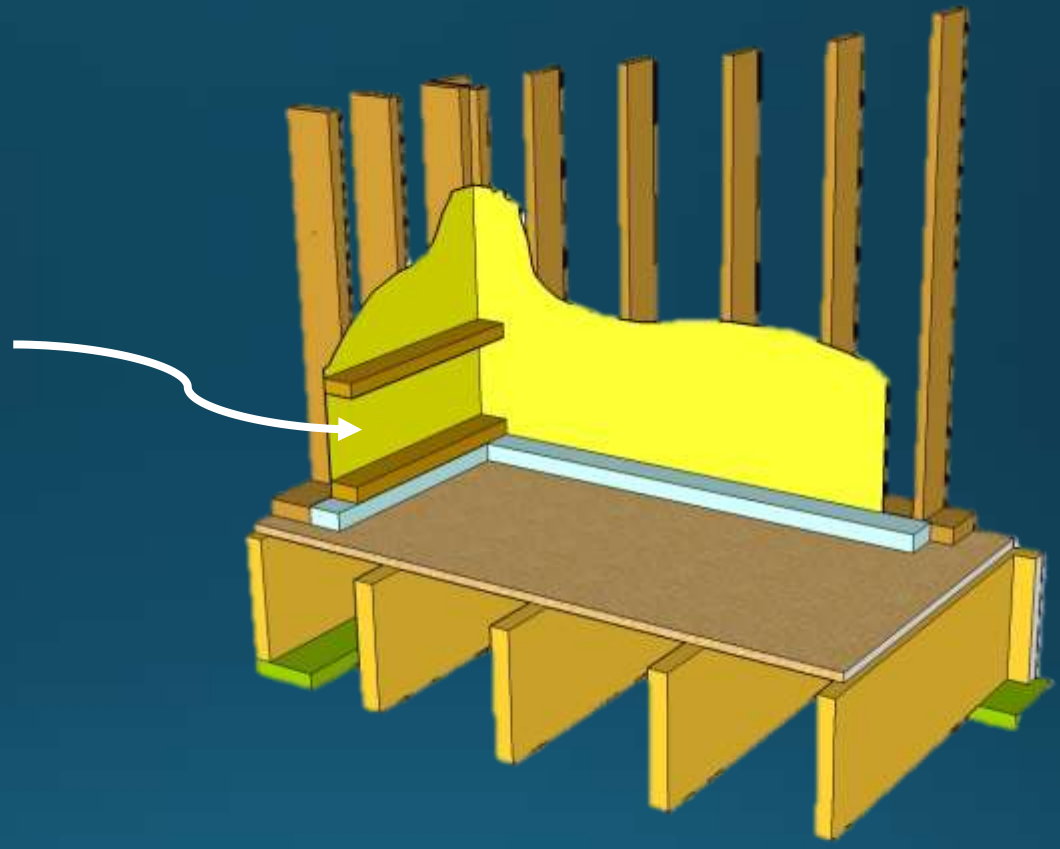
“Wrap and Strap” System

What temperature here?



Dense packed cellulose both cavities

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Total R value = R22 + R14 = R36

ΔT = 68º (68º interior, 0° exterior)

Step One

Ext. cavity R-value % = 61.1%

.611 x 68° = 41.55º

0º + 41.55° = 41.55º

Step Two

Int. cavity R-value % = 38.9%

.389 x 68° = 26.45º

0º + 41.55° + 26.45º = 68º

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Dew-Point Temperature (°F)															
Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

Adapted from ASHRAE Psychrometric Chart, 1993 ASHRAE Handbook—Fundamentals.

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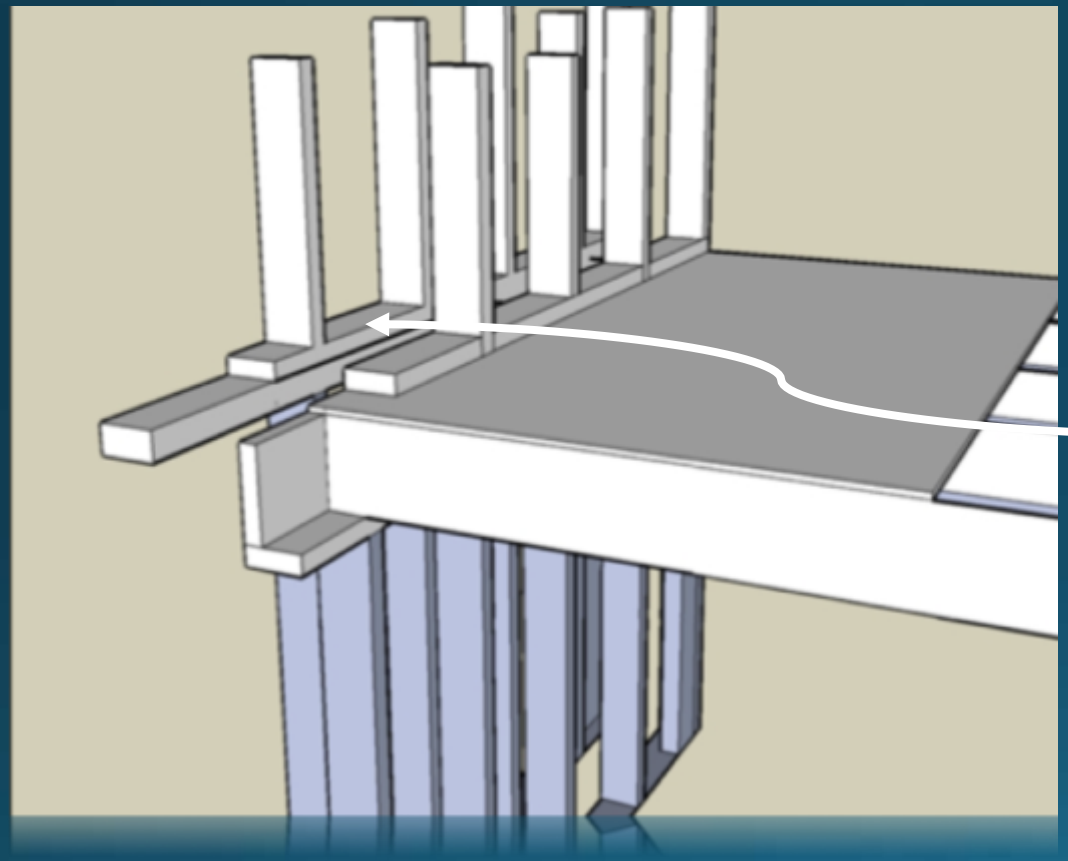

Double Wall System

What temperature here?

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Total R value = R26 + R11 = R37

ΔT = 68º (68º interior, 0° exterior)

Step One

Ext. cavity R-value % = 70.3%

.703 x 68° = 47.8º

0º + 47.8° = 47.8º

Step Two

Int. cavity R-value % = 29.7%

.297 x 68° = 20.2º

0º + 47.8° + 20.2º = 68º

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Dew-Point Temperature (°F)															
Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

Adapted from ASHRAE Psychrometric Chart, 1993 ASHRAE Handbook—Fundamentals.

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Assess Assembly

Permeability of each component
Least vapor permeable component
Extent and direction of vapor drive
Moisture storage and potential drying

Class I Vapor Retarder (vapor barrier): less than or equal to 0.1 perms

Class II Vapor Retarder: less than or equal to 1 perm and greater than 0.1 perms

Vapor III Vapor Retarder: greater than 1 perm but less than 10 perms

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Building Thermal Envelope

Section R402.4.1 – Air Leakage

Requires BOTH:

- ✓Whole-house pressure test
- ✓Field verification of items listed in Table R402.5.1.1

Air Leakage Rate	Climate Zone	Test Pressure
≤ 5 ACH	1-2	50 Pascals
≤ 3 ACH	3-8	50 Pascals

Testing occurs after all building envelope penetrations

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Air leakage site



Kraft paper face is a VDR

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Ice Dams

Air leakage from below

Rare in a properly sealed well insulated home



©2021





Courtesy Building Science Corporation

Air leakage problems

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Air Leakage From Occupied Space Into Attic





Courtesy Camroden Associates.

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Recessed Lights Are Holes in the VDR
air & vapor movement



Courtesy greenbuildingadvisor

Assess Assembly:

1. Permeability of each component
2. Least vapor permeable component
3. Extent and direction of vapor drive
4. Moisture storage and potential drying

Class I Vapor Retarder (vapor barrier): less than or equal to 0.1 perms

Class II Vapor Retarder: less than or equal to 1 perm and greater than 0.1 perms

Vapor III Vapor Retarder: greater than 1 perm but less than 10 perms

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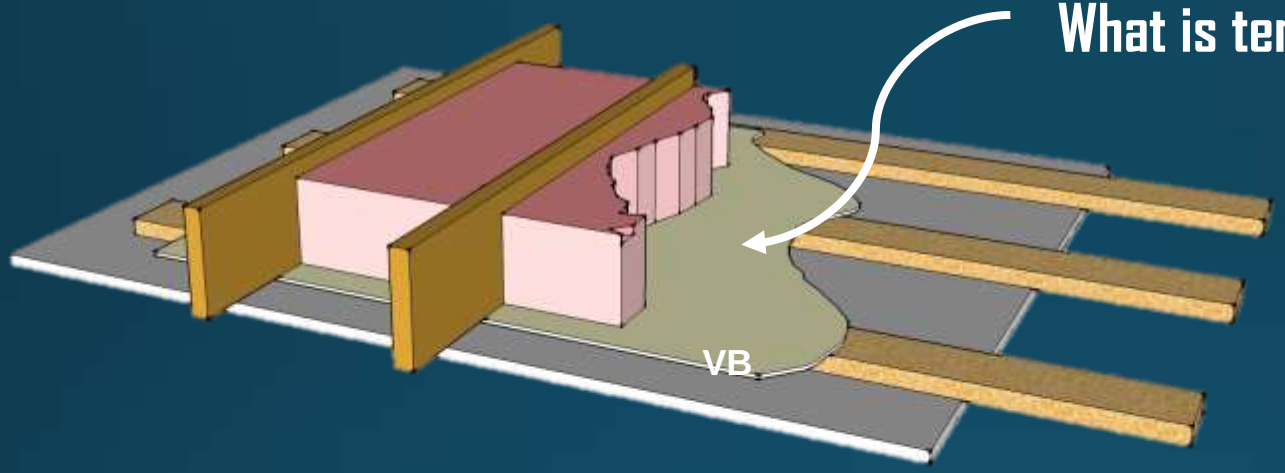
Attic insulation of the 1970's



Gypsum ceiling = R .45

Air space = R 4.2

Fiberglass = R 19

Total R value = 23.65

Why old time builders avoided vapor barriers at ceiling

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Total R value = 23.65

∆T = 68º (68º interior, 0˚ exterior)

Temperature of membrane at joist bay	*Temperature at joist*
Fiberglass R value = 19/23.65 x 100 = 80.33%	7.5/12.15 x 100 = 61.7%
.803 x 68˚ = 54.6º	.617 x 68 = 41.9˚

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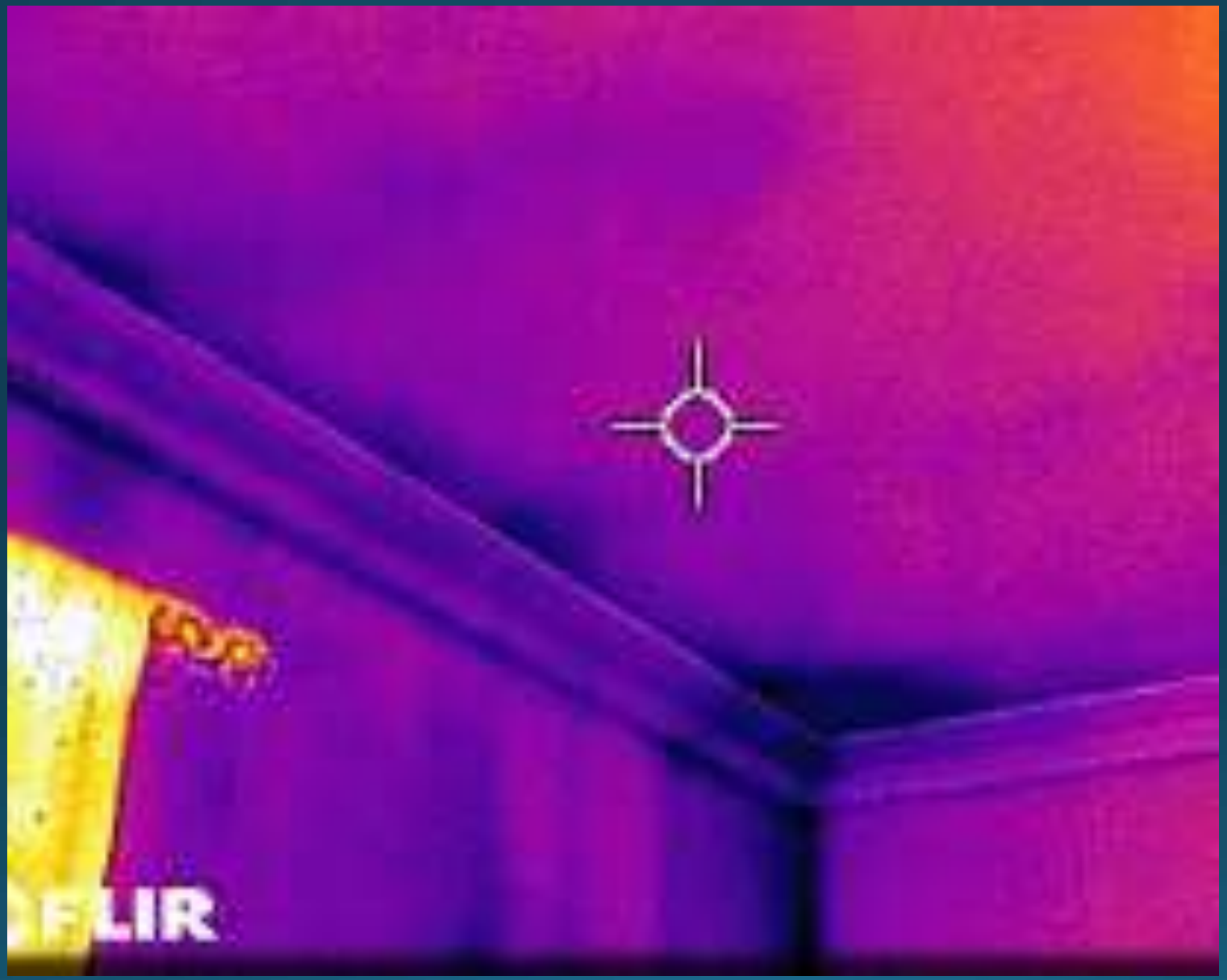

Myers Inspection

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Unvented roof



Mechanical systems located in attic

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Hot roof and shingles

Check with shingle supplier regarding warranty

Certainteed and GAF will honor warranties, with restrictions

Strict adherence to local codes required

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Roof retrofit



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Deep snow accumulation



In snowy areas, unvented roofs can fail

- Added insulation value of snow layer brings roof surface to melting temperature

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Building tight, moisture resistant shells is one part of the equation...

Proper ventilation and a warm, dry basement are also important

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Up next...

Mark Toth

RST Thermal/Renewaire

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