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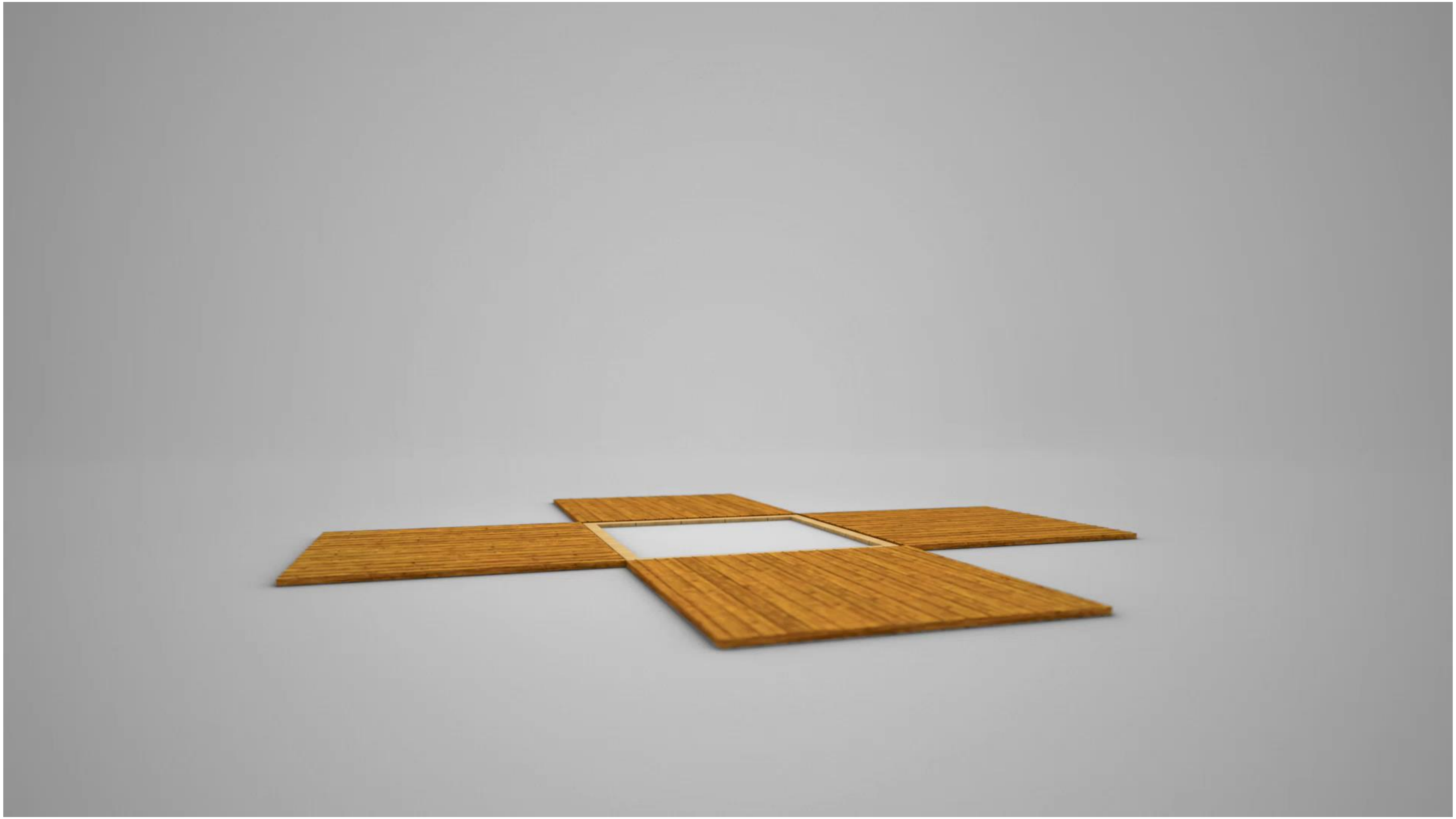
- The HERS Associate Course
- The High Performance Mechanical Systems course

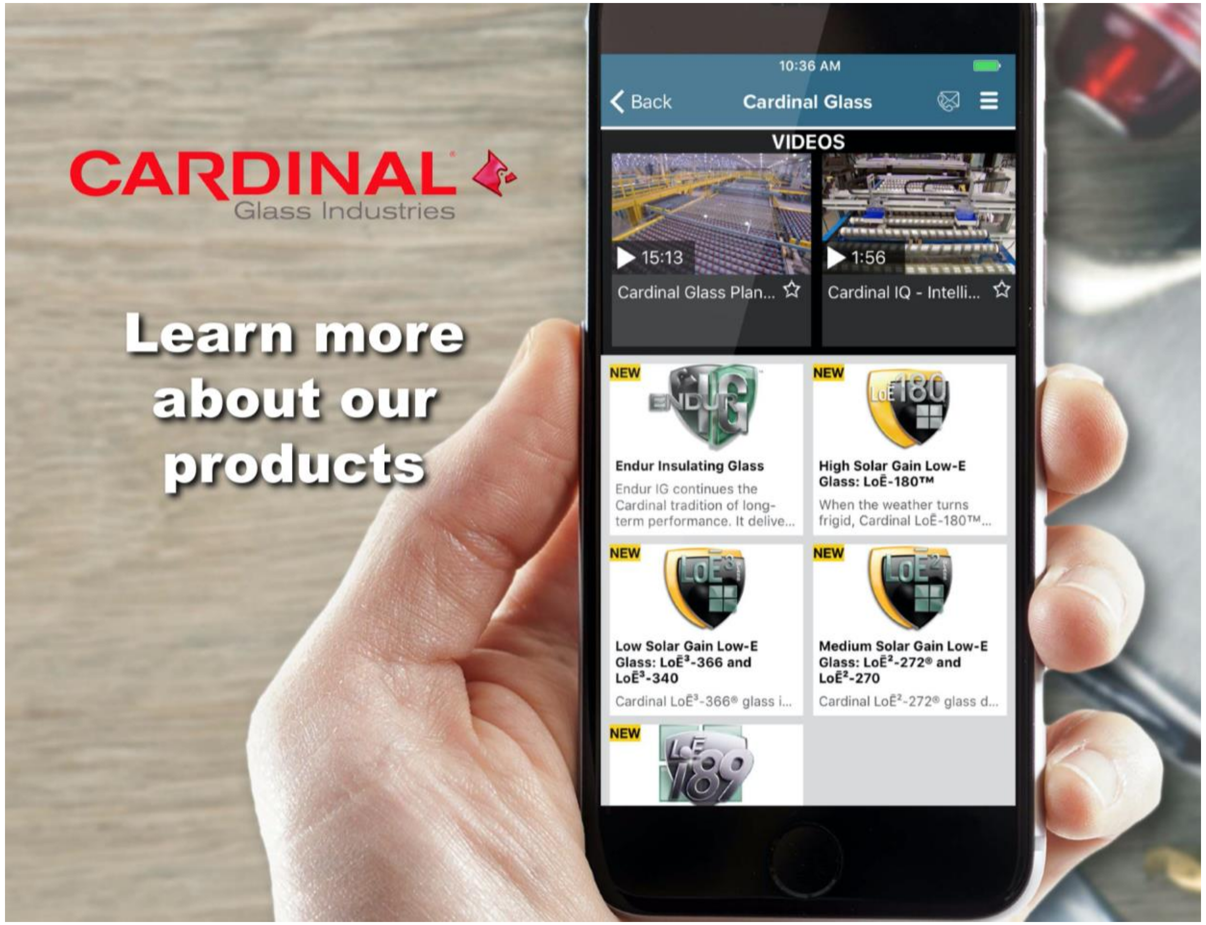


Welcome to:

&

Applied Building Science

App for FREE


CARDINAL
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15:13
Cardinal Glass Plan...
1:56
Cardinal IQ - Intelli...
NEW
Endur Insulating Glass
Endur IG continues the Cardinal tradition of long-term performance. It delive...
NEW
High Solar Gain Low-E Glass: LoĒ-180™
When the weather turns frigid, Cardinal LoĒ-180™...
NEW
Low Solar Gain Low-E Glass: LoĒ^3-366 and LoĒ^3-340
Cardinal LoĒ^3-366® glass i...
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Cardinal LoĒ^2-272® glass d...
NEW


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Andrew Oding Vice President | Director of Building Science

Partner, Construction Instruction Inc.

- Member, NBC SCEEHB Standing Committee Energy Efficiency in Houses & Buildings 2019 - present
- Chair, NBC Task Group “Unintended Consequences “ SCEEHB Standing Committee Energy Efficiency in Houses & Buildings 2019 – present
- Voting Member, ASHRAE 90.2 EE Standard for low Rise Buildings and homes
- Member, CSA TC424 Energy systems in buildings
- CACEA Canadian Association of Consulting Energy Advisors , BOD
- Chair-Past, CHBA Technical Research Committee
- Chair-Past, CHBA Net Zero Council
- Chair-Past, NRCan Energy Star for New homes TAC
- Chair-Past, CaGBC LEED for Homes TAC

Who's here and What would you like to talk about??

Module One

- Compelling Industry trends
- The Essential High Performance elements in a home
- Basic building science to effectively manage the flow of **Heat, Air and Moisture** in buildings

What is our goal?

"Create an enclosure that separates the indoors from the outdoors...and is safe and healthy for the people inside."

In addition to:

Creating a high performance home that is; energy efficient, durable, healthy, aesthetically pleasing, respectful to the environment and profitable…

in short, **HOUSES THAT WORK**

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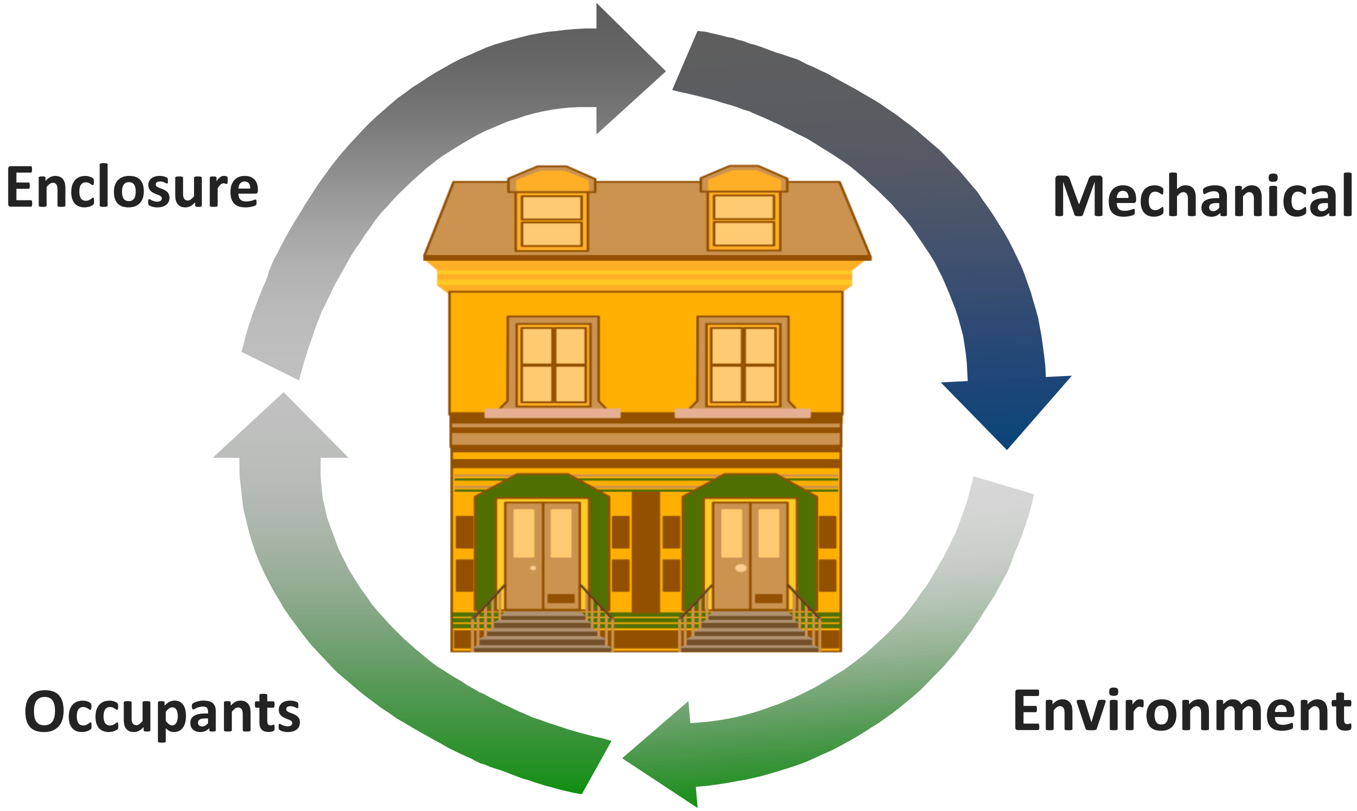
House Systems

What's Changed in homes in the last 35 years?
What impacts does that have?



What’s the decision tree?

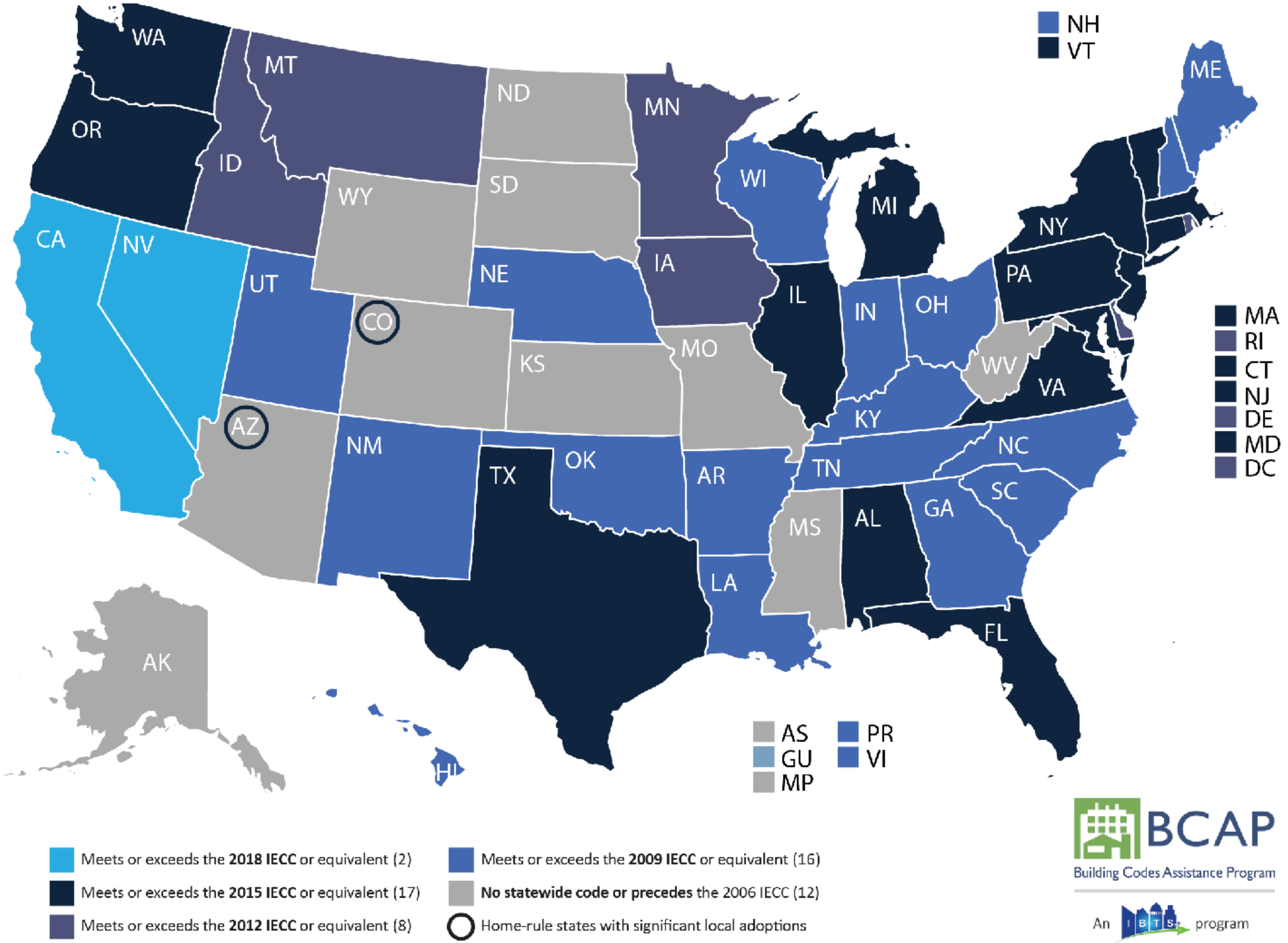
- Decisions made on price(First Cost vs TOTAL Cost)
- Decisions made on warranty/service issues
- Customers satisfaction/expectations
- Process/cycle times
- Supplier availability

We are here to help reinforce your decision process

Codes Have Changed

Residential Code Adoption

as of March 2020



BCAP Building Codes Assistance Program

An IBTS program

There are Programs to Help

RESNET® HERS INDEX

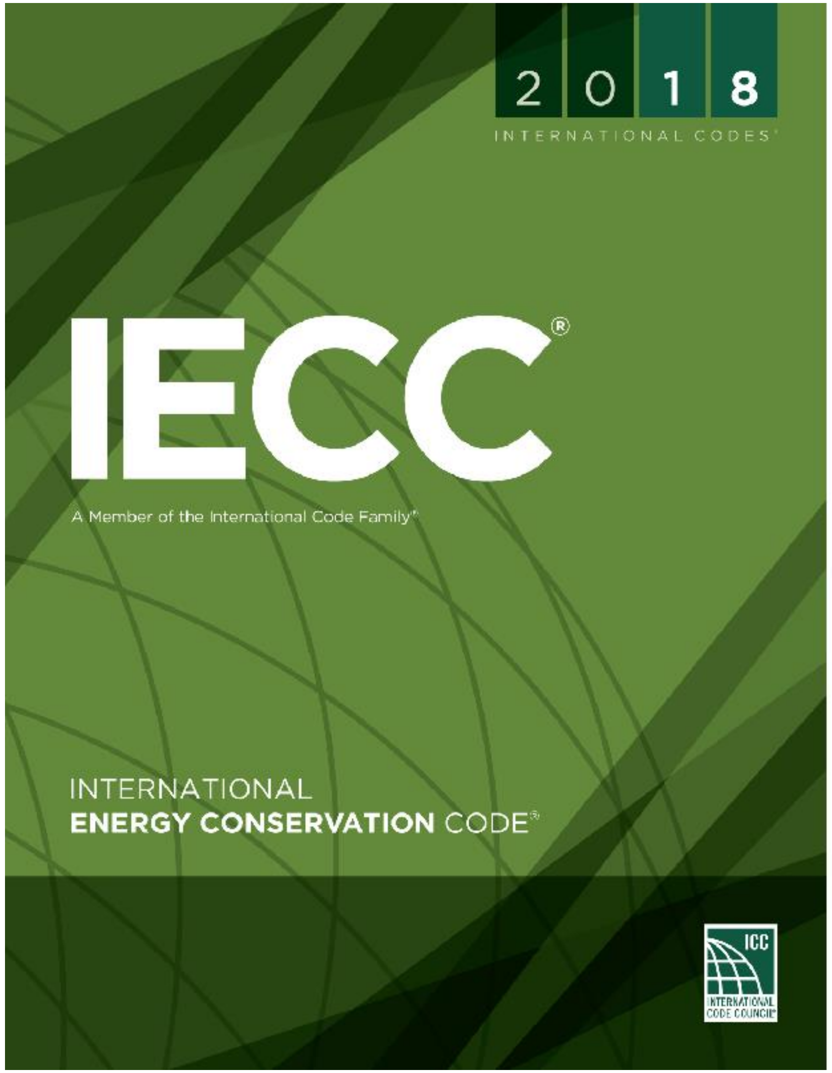
ENERGY STAR

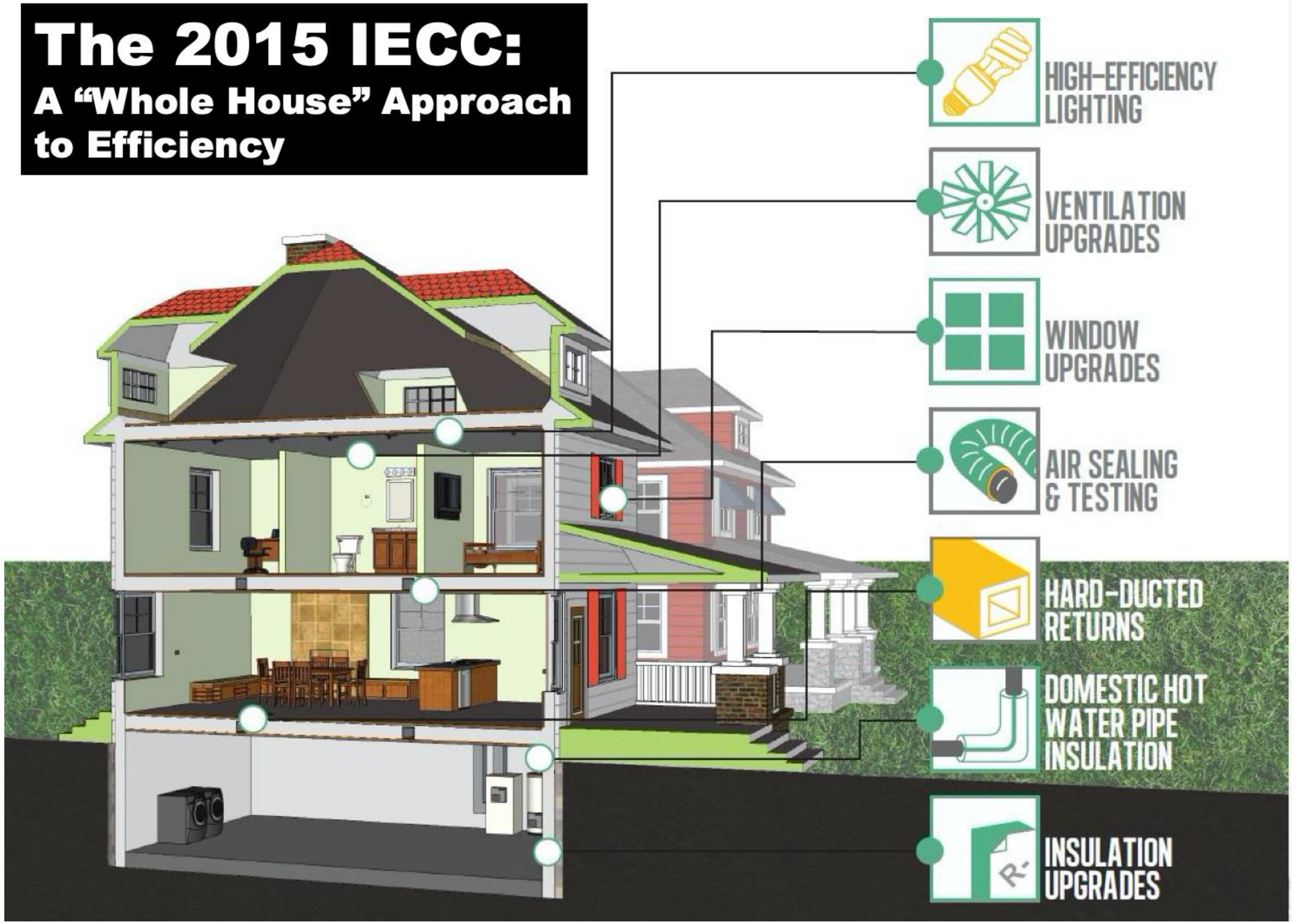
ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

PHIUS
Passive House Institute US

RESNET®
HERS
INDEX

Codes respecting the science





Codes will be more Performance Objectives

Climates	2015 IECC HERS Index Scores
Zone 1 — 2	52
Zone 3	51
Zone 4	54
Zone 5	55
Zone 6	54
Zone 7 — 8	53

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What's Changing quicker….
Codes or expectations of consumers?

- Comfort
- Quiet
- Lifestyle
- Investment quality
- Demographics
- Access to information
- Warranty

Defining High Performance Homes....

Tighter Construction

Improved Insulation Systems

Improved Insulation Systems

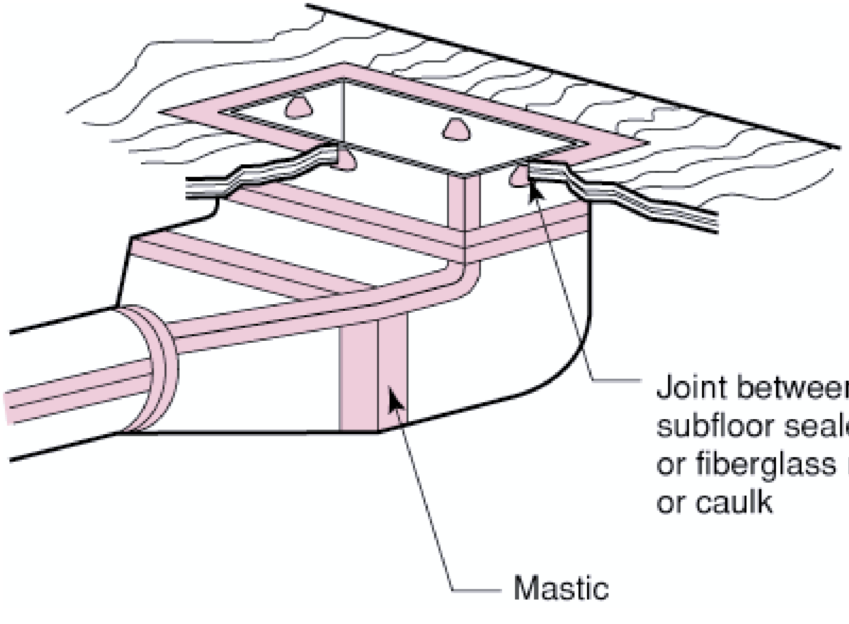
Improved Durability

High Performance Windows

ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P) 0.18	Solar Heat Gain Coefficient 0.22
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance 0.42	Air Leakage (U.S./I-P) 0.1
Condensation Resistance 70	

Efficient Heating and Cooling Equipment

Effective Distribution



Efficient Water Heating

Ventilation & IAQ Systems

Lighting-Energy Efficiency

Efficient Appliances

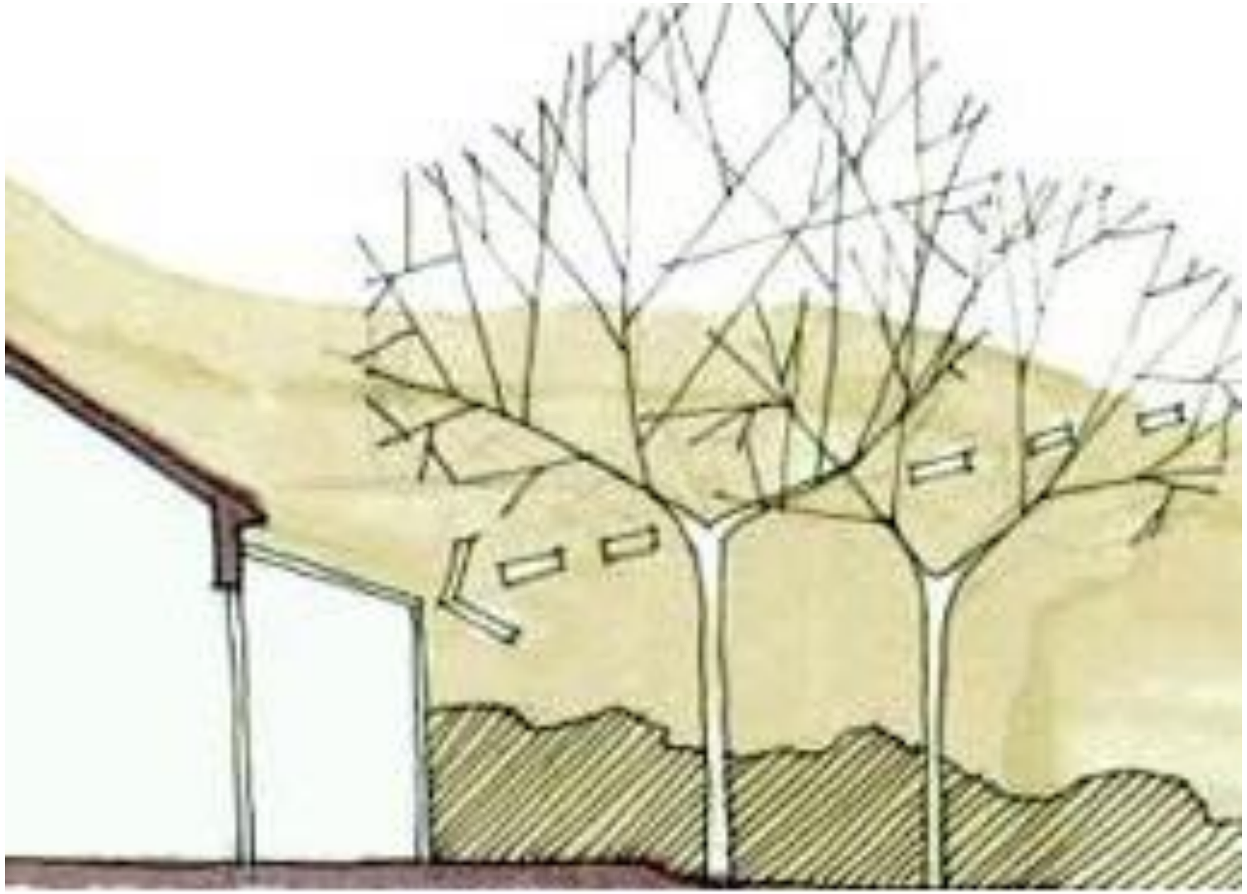
ENERGY STAR

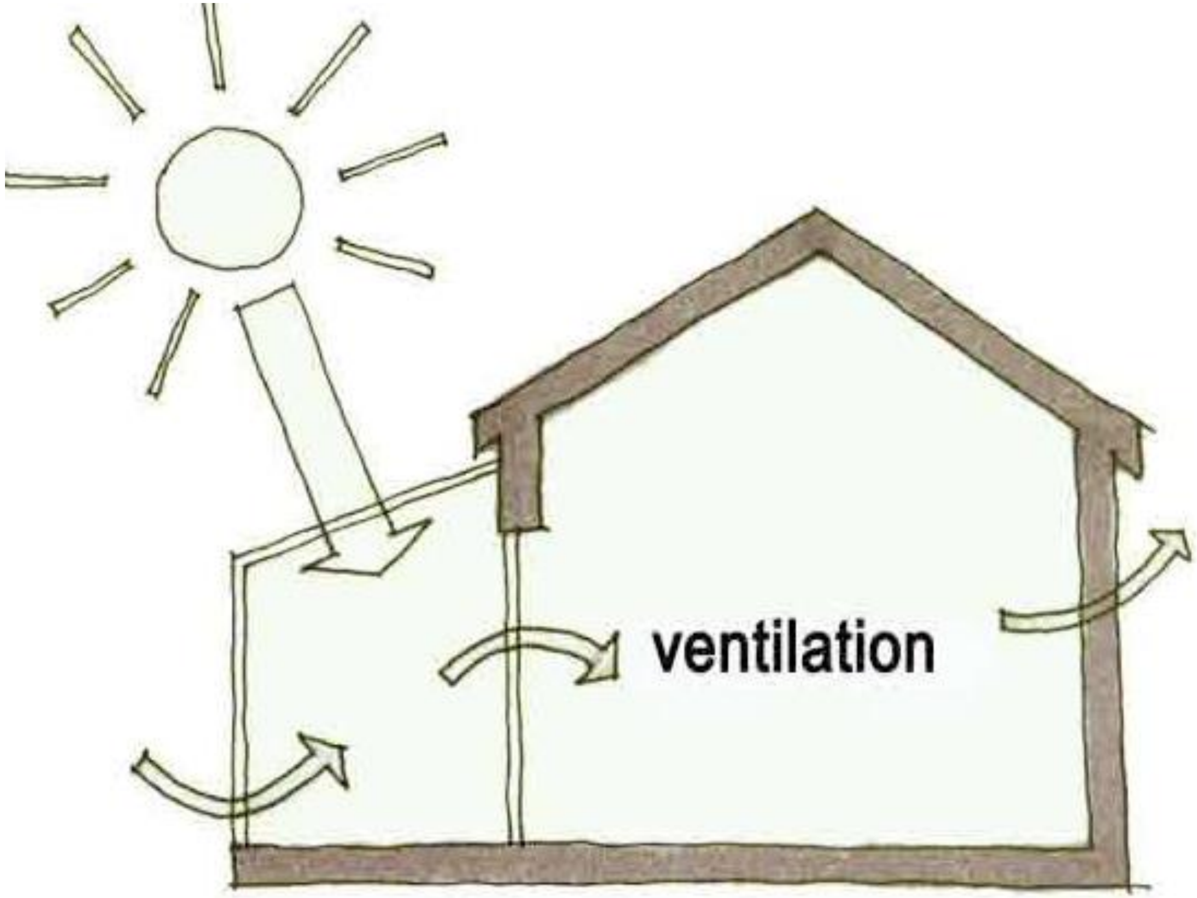
Water Efficiency

Smart Technology

Sustainable Materials

Site planning





Renewable Energy & Storage Systems

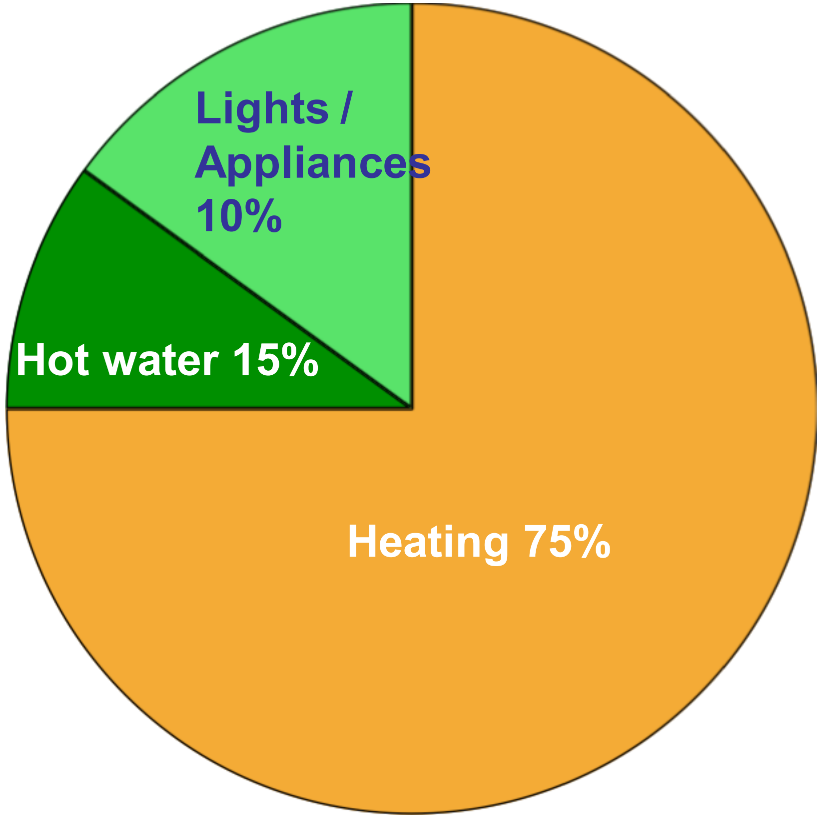
A Complicated Business

- Extensive collection of materials
- Uncontrolled building conditions
- Communication challenges
- Workforce training
- Changing codes
- Elevated consumer expectations

discussing a high performance heating system installation in field

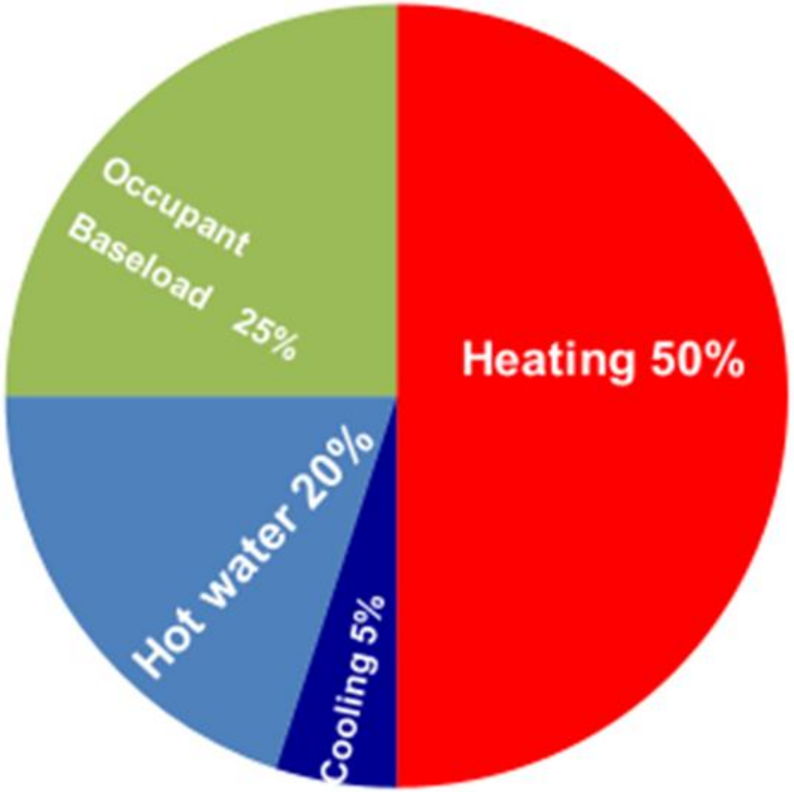
Let’s Proceed with Some Science

30 years ago….



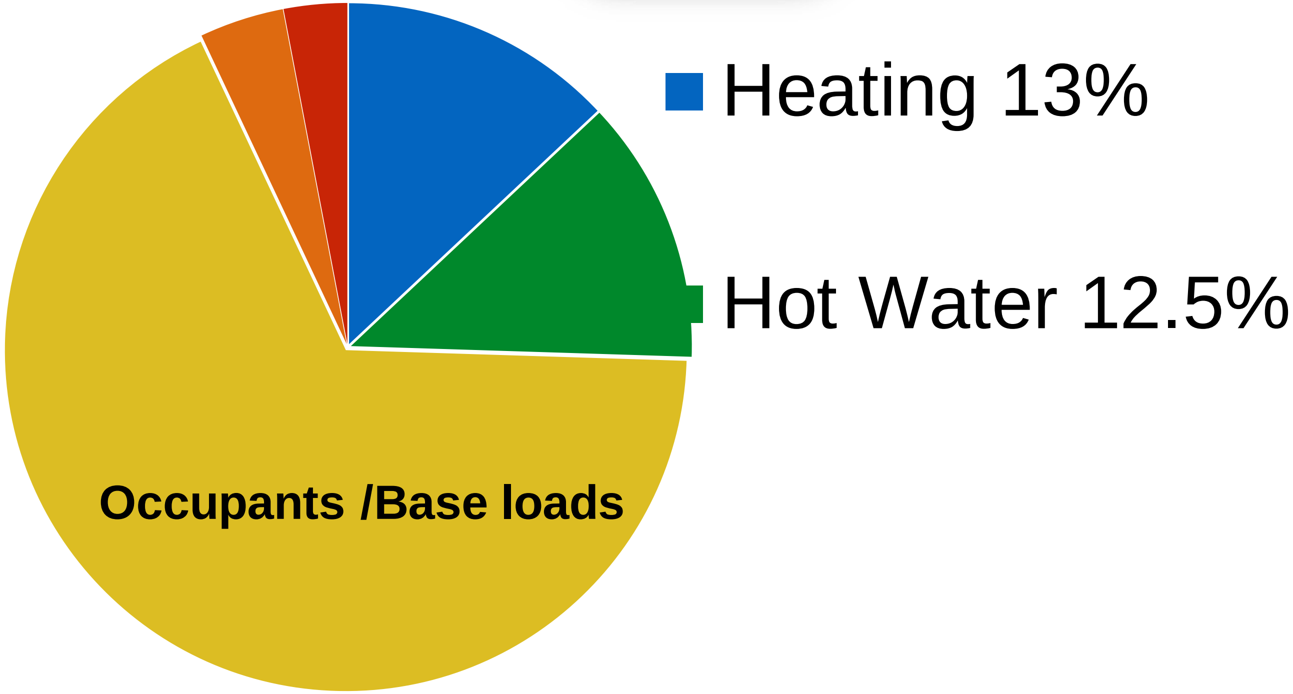
IECC 2015….

SMALLER TOTAL CIRCLE…
LOAD PROFILE HAS CHANGED



NET ZERO / ZERH….

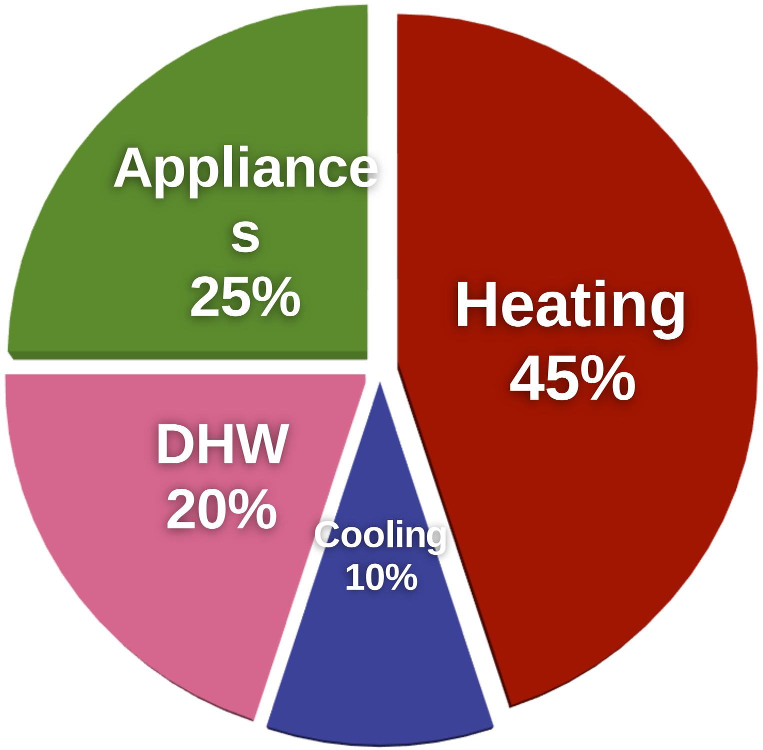
ZERO
ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY



Energy use in homes - Cold Climate

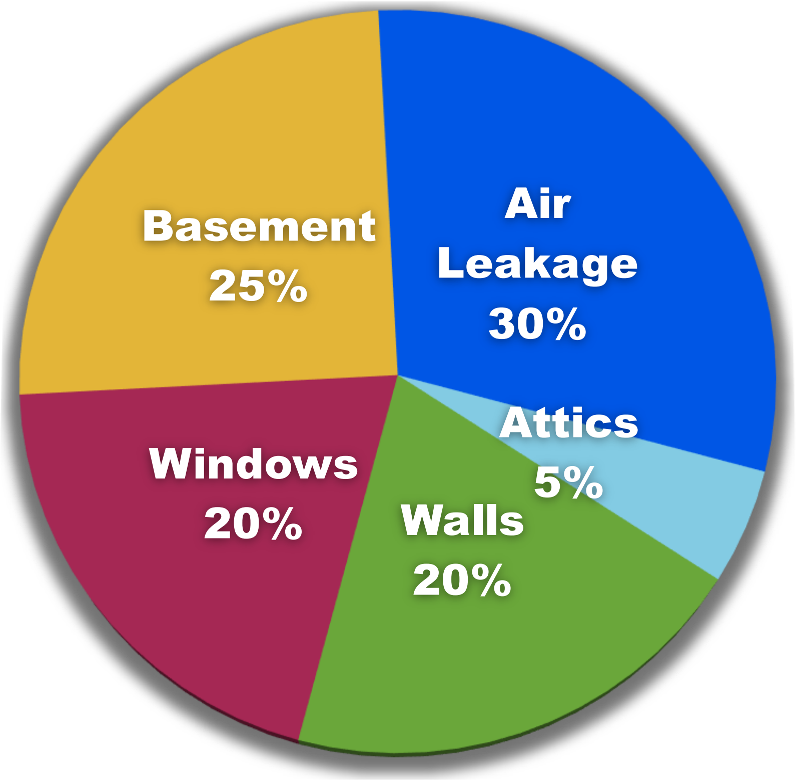
<u>Typical cold climate home</u>

- This is energy used - the costs of energy will vary
- What would you do first?
- Is usage going up or down?

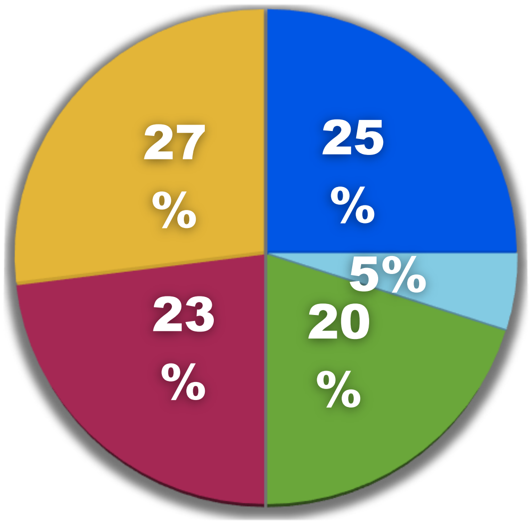


Components of Heat Loss Opportunities

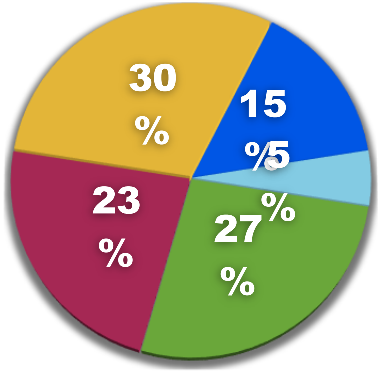
HERS Index 100



HERS Index 75

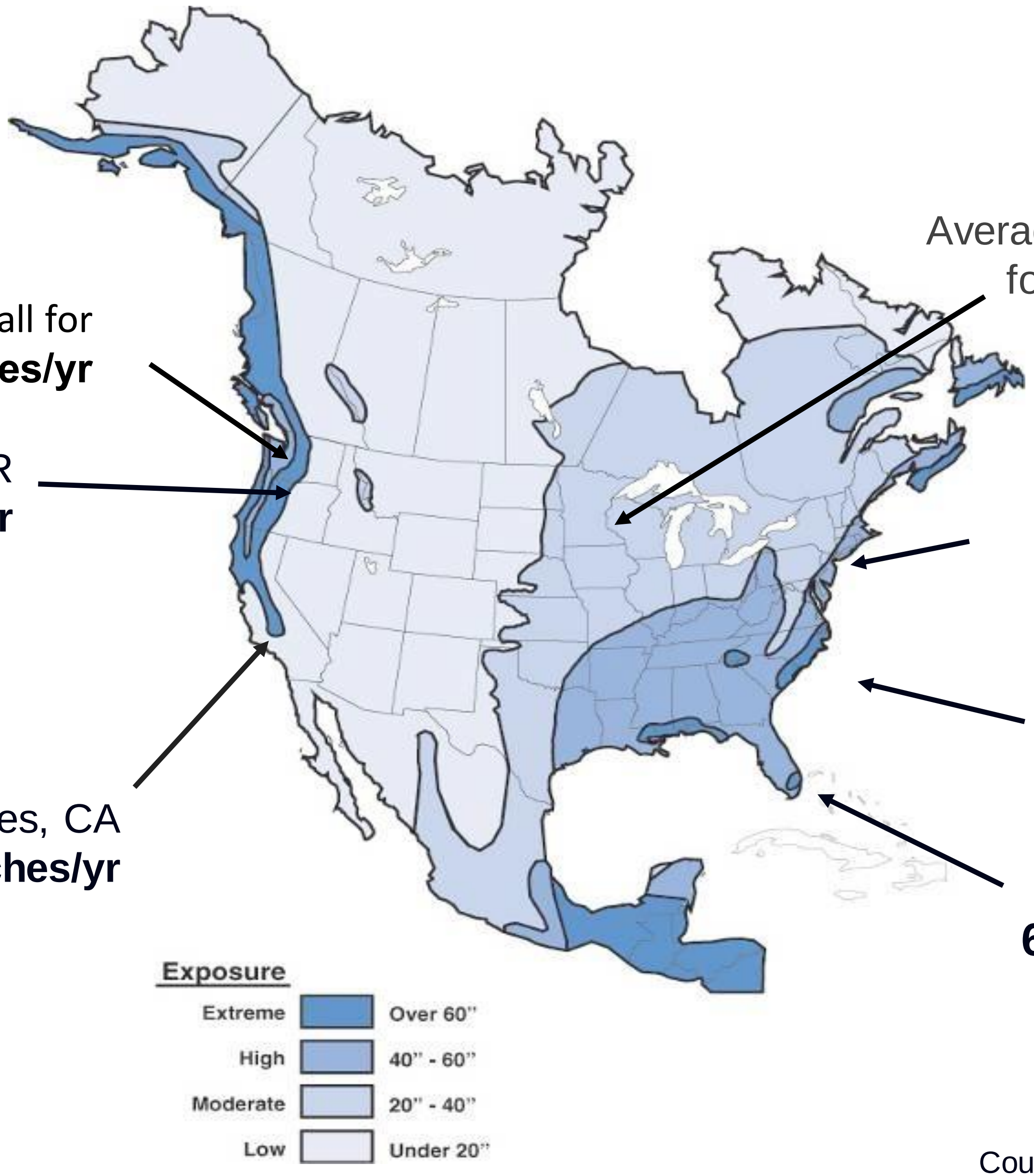


HERS Index 50



Walls become more important

Where we live affects performance.



Average Annual Rainfall for Seattle, WA - 38" **inches/yr**

Portland, OR
40 inches/yr

Los Angeles, CA
15 inches/yr

Average Annual Rainfall for Minneapolis, Mn
28 inches/yr

Philadelphia, PA
50 inches/yr

Columbia, SC - 49 "**inches/yr**

Miami, FL
60 inches/yr

Courtesy of Building Science Corp.

Minneapolis, MN
- design conditions

Condition	ASHRAE 99% / 1%
Winter, design dry bulb (F)	-15°F
Summer, design dry bulb (F)	91°F
Summer, design wet bulb (F)	71.6°F
Degree days-heating	7981
Degree days-cooling	682
Precipitation	28”
Solar incidence - South, July	90

Our investment in the structure is significant

We often under invest in managing moisture

The resulting damage can be extensive

What defines durability?

- Materials & Products
  - Are they installed properly?
  - Are they compatible with surrounding materials?
  - Are they replaceable?
- Will they be affected by:
  - Water
  - Heat
  - Radiation
  - Insects

Design Challenges?

Insects & Rodents

Each climate zone has insects that affect the building and their clients. Understanding their needs is the best deterrent.

Material Risk or Installation Challenge?

The Building Industry is Changing

"You must learn from the mistakes of others. You can't possibly live long enough to make them all yourself."

Sam Levenson


Humorist Sam Levenson, 1911-1980.

AS THE CODE ADVANCES SO DOES THE RISK

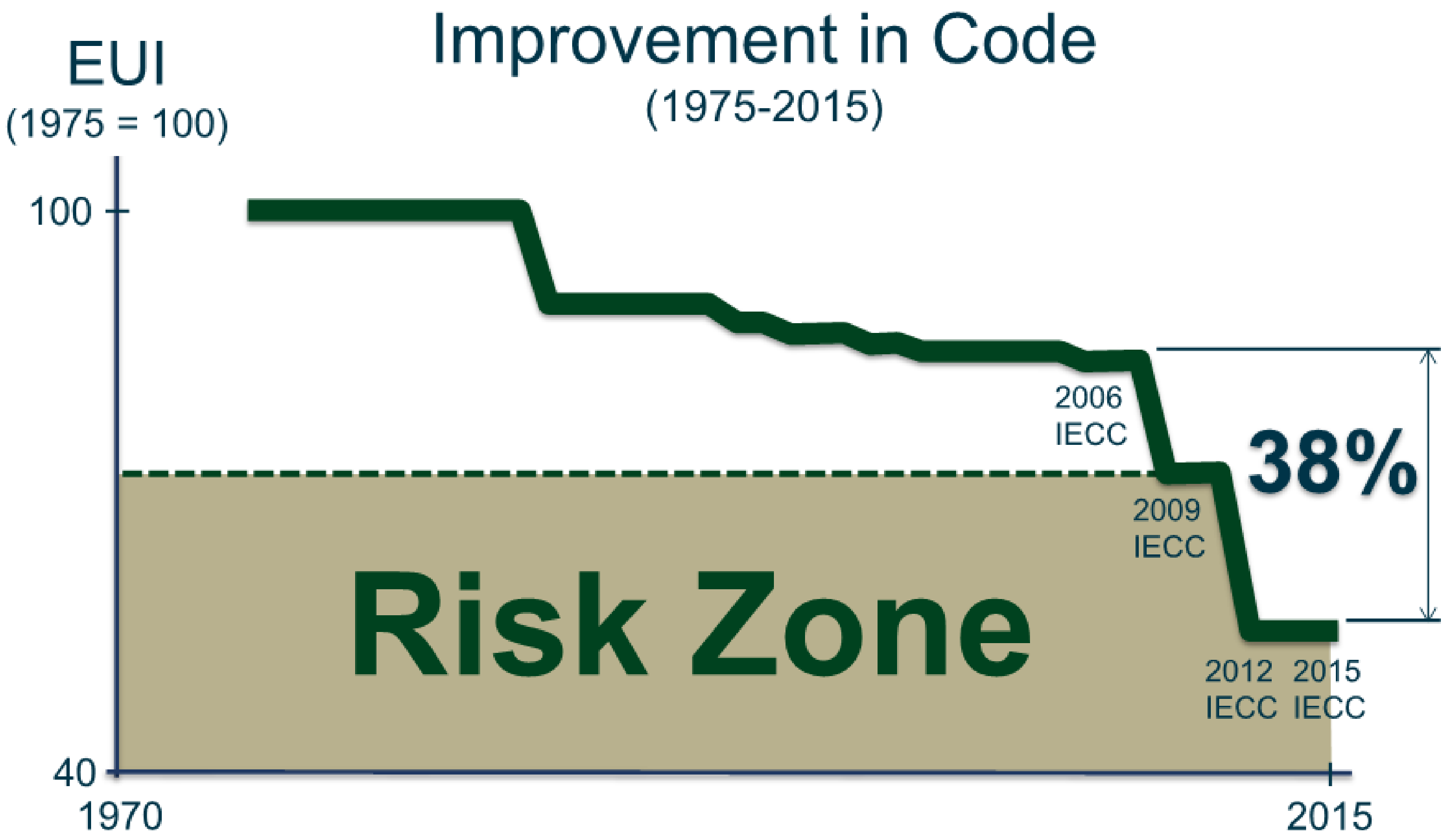


Image Basis: Building Energy Codes Program: National Benefits Assessment, 1992-2040, https://www.energycodes.gov/sites/default/files/documents/BenefitsReport_Final_March20142.pdf

THE BUILDING SCIENCE TIPPING POINT

ADVANCED ENCLOSURES

- More air tight
- Higher insulation levels
- Complete insulation systems
- Adv. Window

COMFORT RISKS

WETTING RISKS

INDOOR AIR QUALITY RISKS

“Building Science Tipping Point Analogy”

Courtesy of Sam Rashkin U.S DOE

Operational vs Embodied Carbon: Unintended Consequences?.....

ENDEAVOUR

innovative learning, building & living

Chris Magwood, MAsc

http://endeavourcentre.org/

The Trouble With Embodied Carbon….

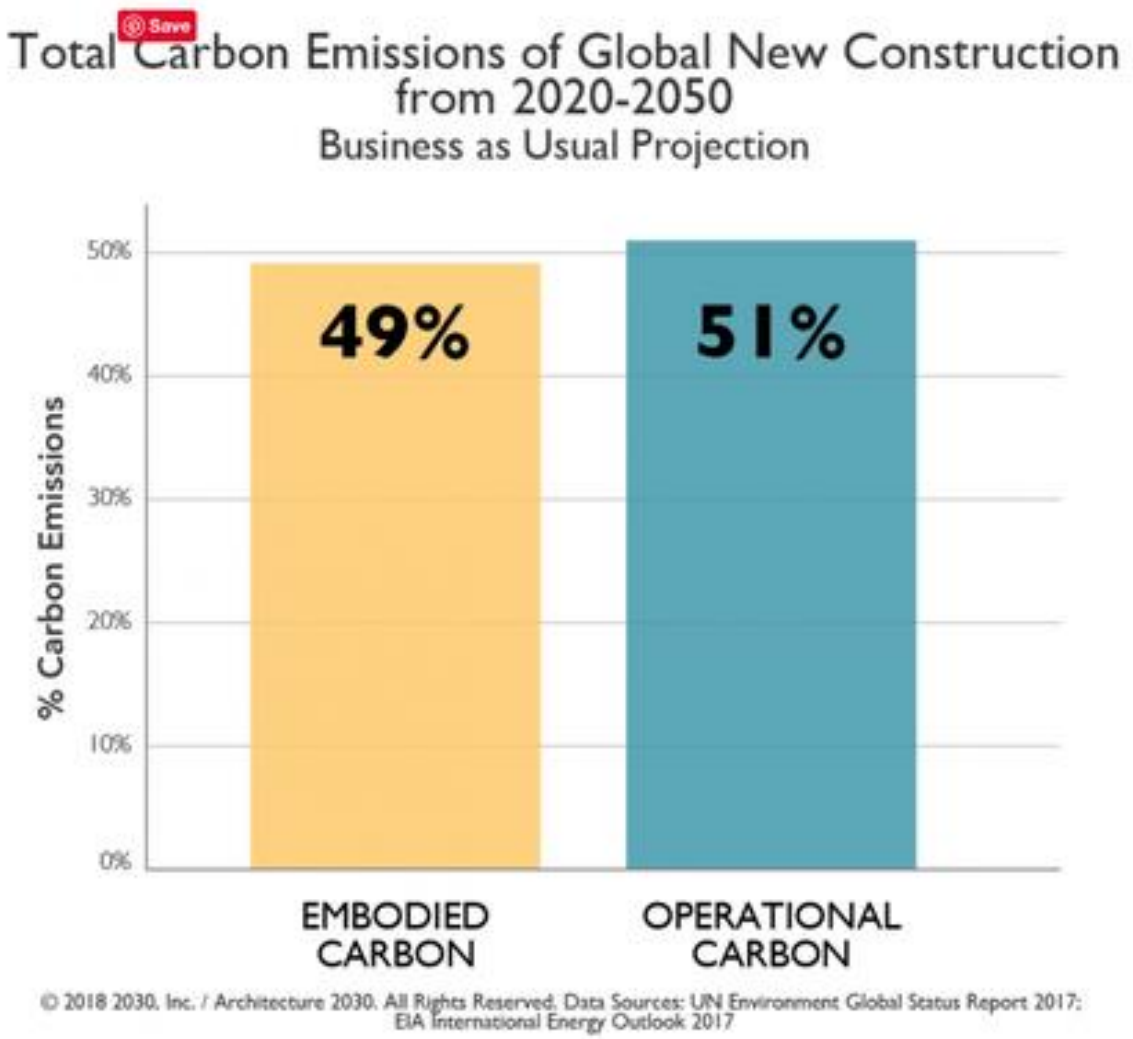
- Passive Homes/ Net Zero Energy homes, may need to operate for **400+ years to offset embodied energy**
- Organic Cotton bag may need to be **used 20,000 times** to be an improvement over a plastic, single use bag
- Stainless steel water bottles embodied carbon is **14x greater than single use plastic bottle**

Operational vs Embodied Carbon: Unintended Consequences?.....

Embodied Carbon

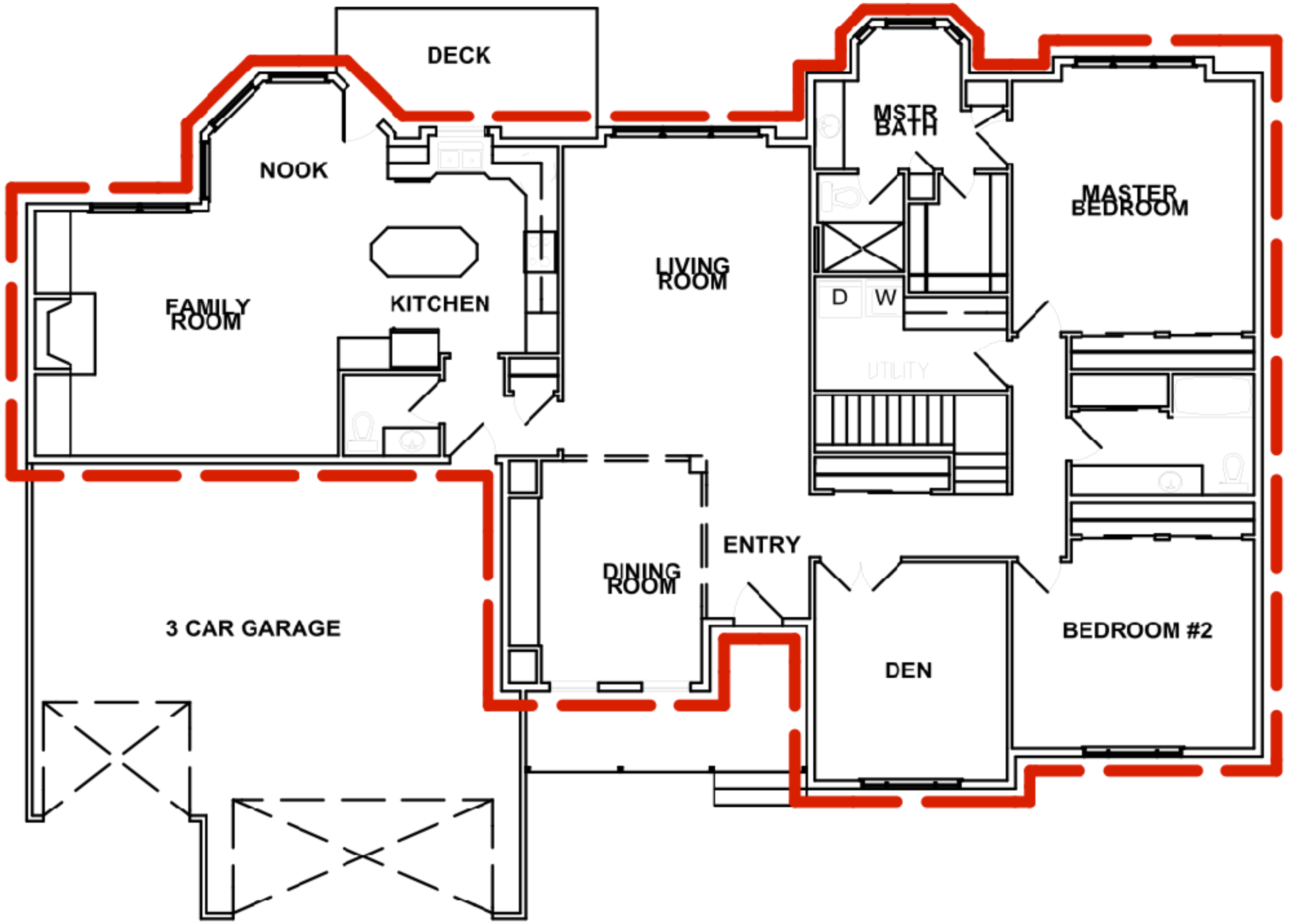
vs

Operational Carbon

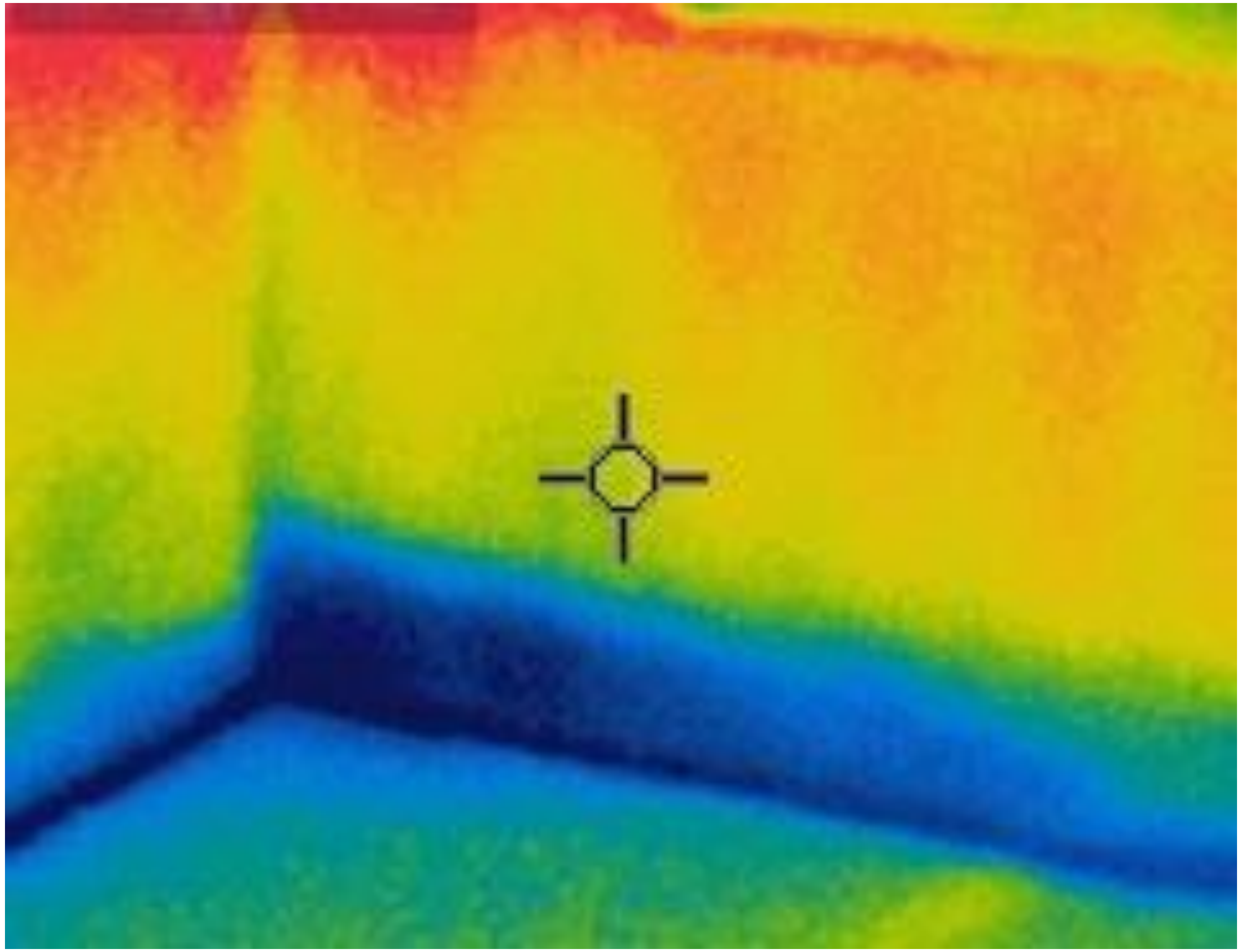


Take a Strategic Approach

Apply the science to the building enclosure



What rules must be followed?



Building Science Fundamentals

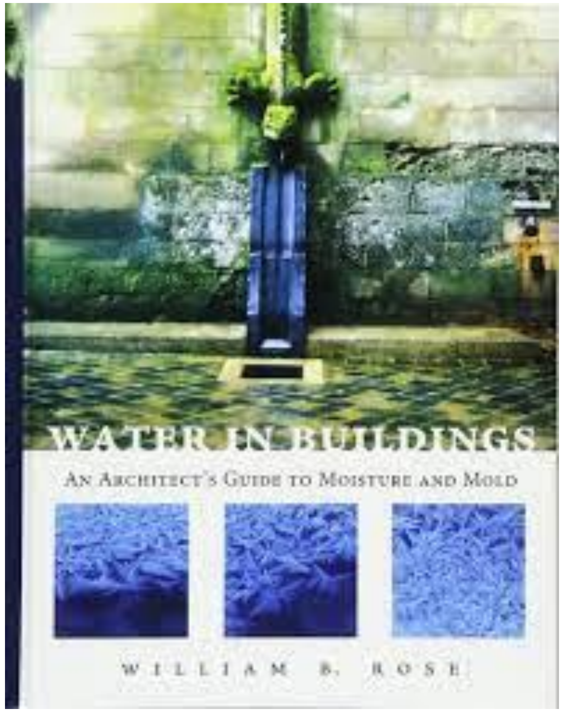
- Heat
- Air
- Moisture

The Physics of Buildings

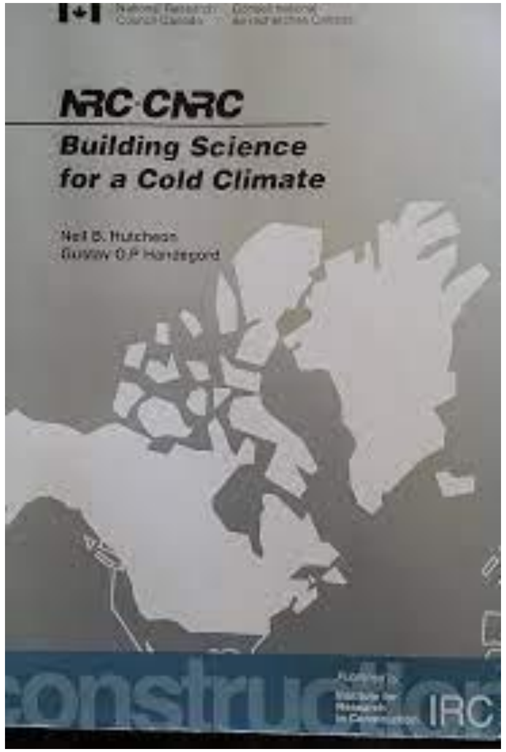
- Moisture moves from more to less
- Moisture moves from warm to cold
- Heat flows from warm to cold
- CFM (air) out equals CFM (air) in
- Heat, air & moisture are one
- Drain the rain
- Things always get wet - let them dry
- All the action happens at the surface

Great Reads !

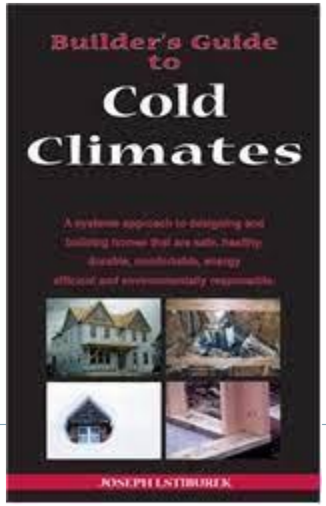
BUILDING SCIENCE FOR BUILDING ENCLOSURES: John Straube –Eric Burnett



WATER IN BUILDINGS: William Ross



Building Science for a Cold Climate: (The ORIGINAL) Canada NRC – Hutcheon & Handegorde



Builders Guide to Cold Climates: Joe Lstiburek- Building Science Corp

Building Science: The study of what goes wrong

Main damage functions of an enclosure, in order of magnitude:

1. **Water**

2. Heat

3. UV

Building Science and Technical challenges

Rate of Thermal Flow:

A well-insulated and air-sealed home, with good windows and doors, reduces the amount of energy needed to keep the home comfortable.

…Beware; The good old "Thermal Flow" also historically dried out walls, made windows and doors last longer and sometime even provided ventilation!

Good science = Sustainable homes

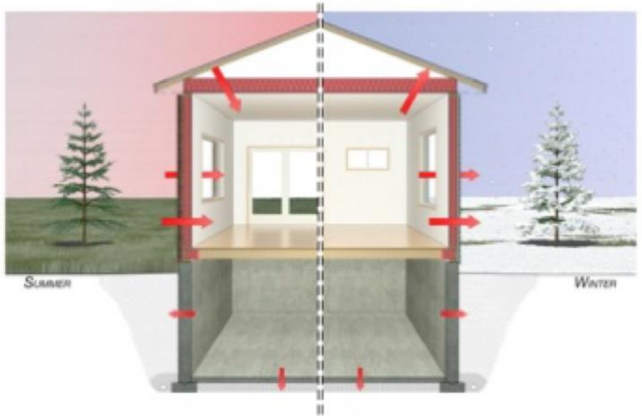
Physics dictates performance

The objective is:

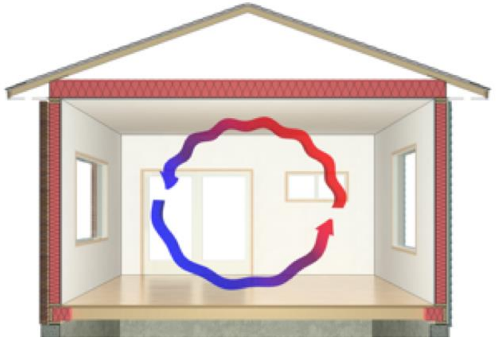
- Healthy
- Safe
- Durable
- Efficient
- Affordable
- Sustainable

Let’s start with Heat Flow

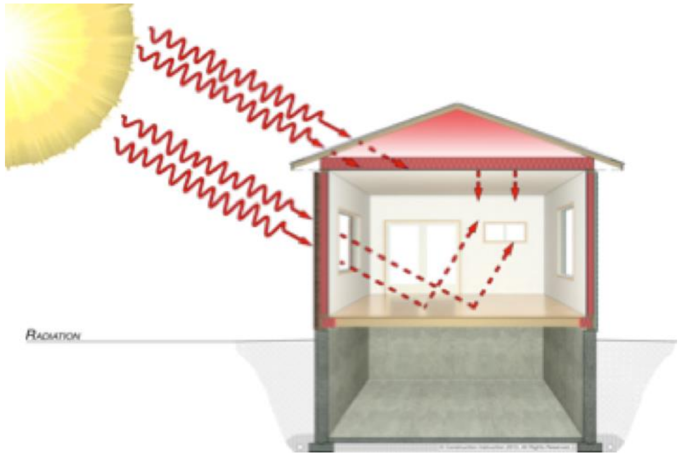
Methods of Heat Transfer



- Conduction



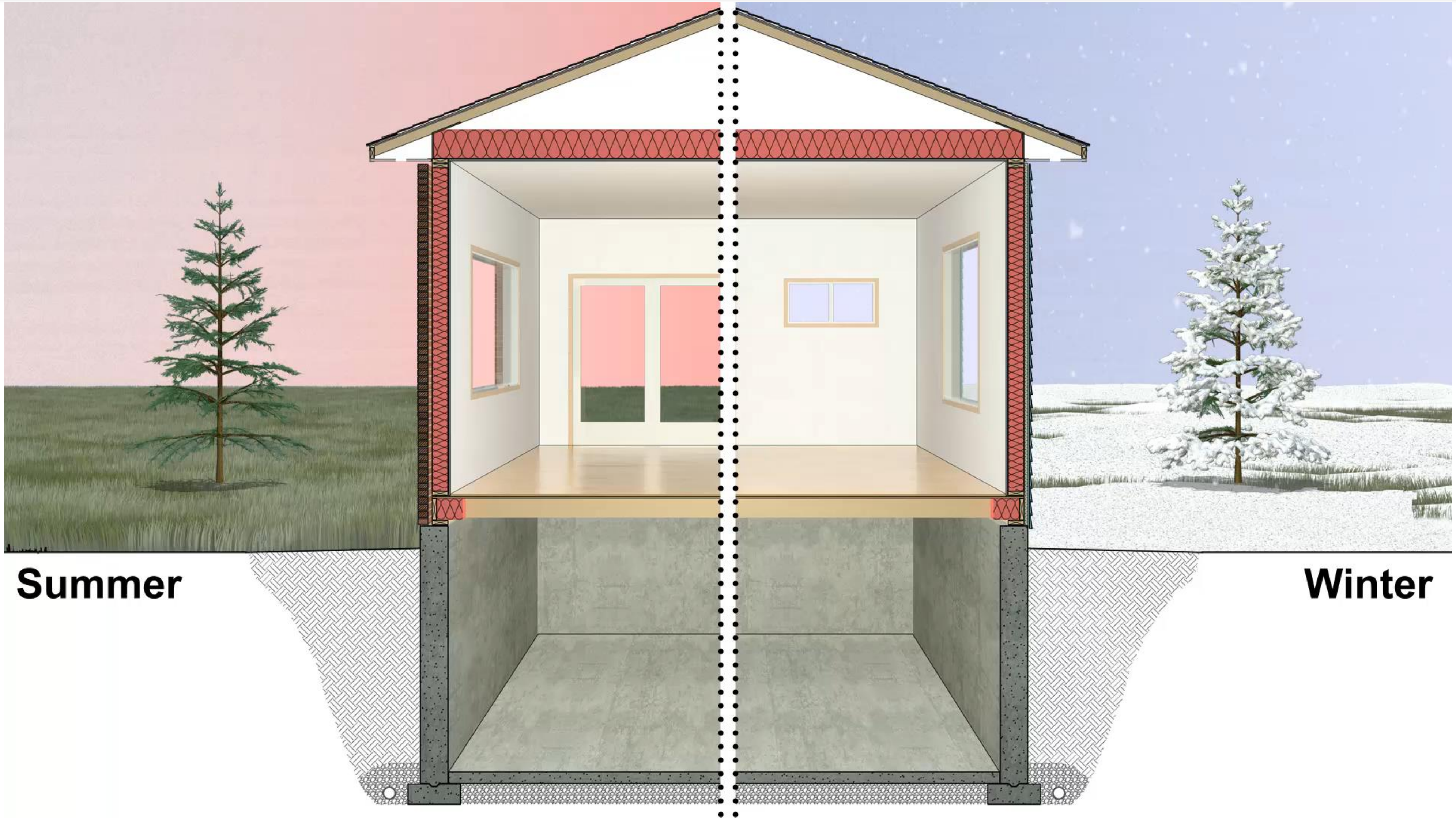
- Convection



- Radiation

Heat Transfer by Conduction

Primary mechanism through walls, floors, attics



Conduction Heat Loss/Gain

$$\textbf{Heat flow} = \frac{\text{Exposed Area} \times \text{Temp. Difference}}{\text{R-Value}}$$

Example: With R-30 insulation in the attic

Heat Loss through 1000 sq. ft of ceiling, 70 F inside, 10 F outside

$=1000 \times (70 - 10) / 30$ **= 2,000 BTUs/hr**

Conduction Heat Loss/Gain

$$\textbf{Heat flow} = \frac{\text{Exposed Area} \times \text{Temp. Difference}}{\text{R-Value}}$$

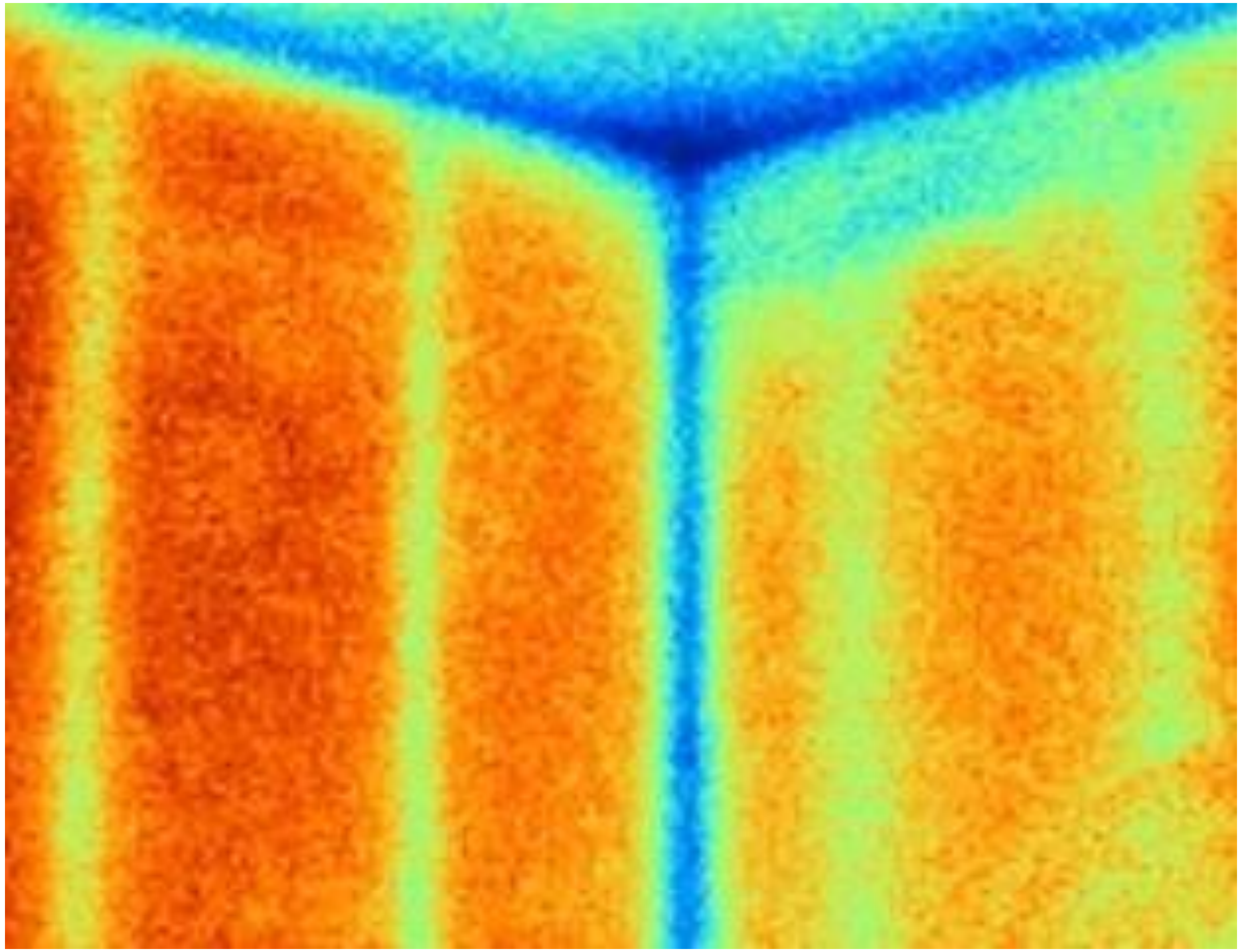
Example: With R-30 insulation in the attic

Heat gain through 1000 sq. ft of ceiling, 135 F in the attic, 75 F in the house

$=1000 \times (135 - 75) / 30$ **= 2,000 BTUs/hr**

$=1000 \times (135 - 75) / 60$ **= 1,000 BTUs/hr**

Thermal bridges

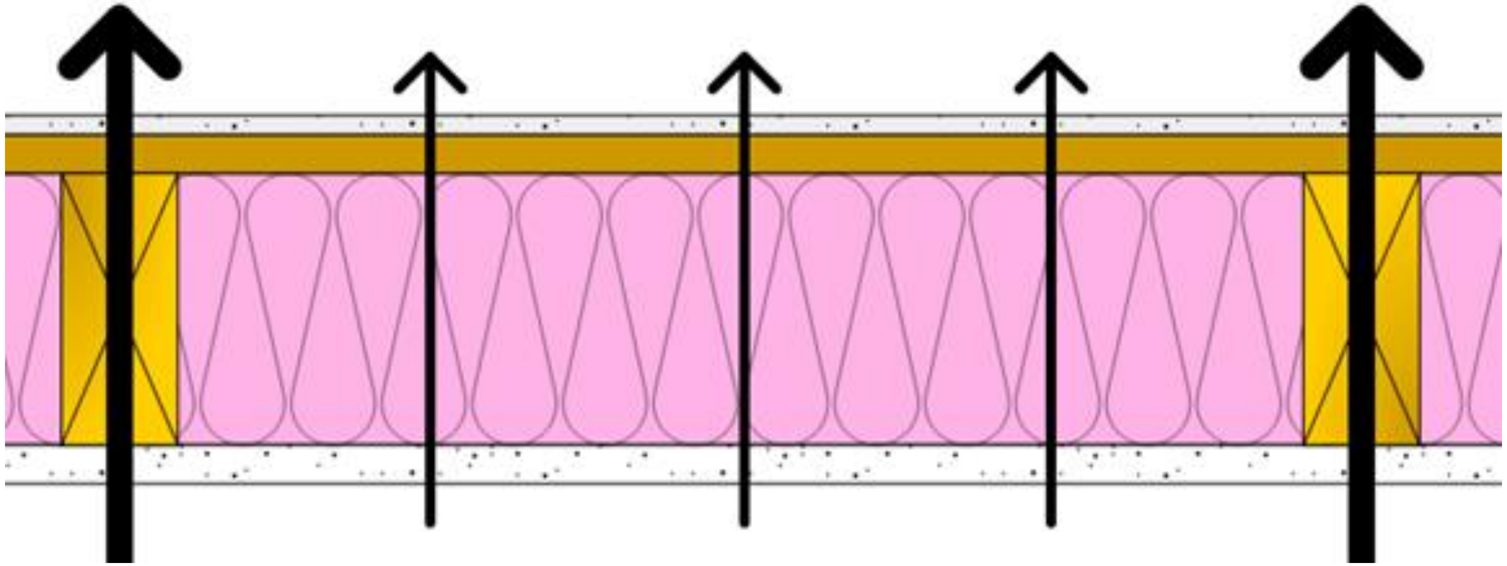


Thermal Bridging- Problem

Heat flows more easily through wood studs = Conduction

2” x 4” stud = R-3.5

Insulation cavity = R-13+

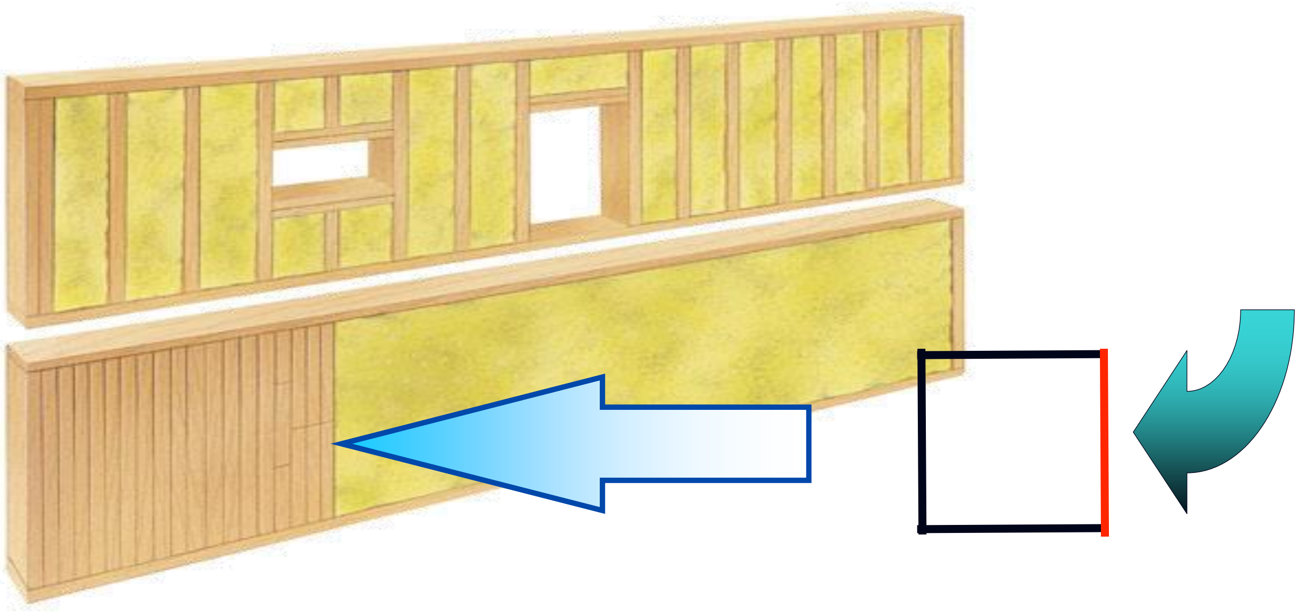


What about...double, triple studs, rim joists, headers and partition wall intersections?

Thermal Bridging - Stud Loss

- Without insulated sheathing, a quarter of your walls are not insulated!
- On a square house, it's the equivalent of one whole wall!

25% of the surface Area is wood!



Effective R-value of 2 x 4 wall- no windows or doors

23% framing-no windows	R-Value	
	Cavity	Studs
Outside air film	0.17	0.17
½" OSB	0.62	0.62
2 x 4 stud-wood	n/a	3.71
cavity insulation*	13	n/a
½" gypsum	0.45	0.45
Interior air film	0.68	0.68
Totals	14.92	5.63
Total wall	9.92	

* denotes "perfect" insulation installation

Remember this number

EEBA

There are 3 ways to reduce conduction flow

Increase cavity insulation

Reduce thermal bridges

- reduce framing

Add continuous insulation

Effective R-value of 2 x 6 wall- no windows or doors

23% framing-no windows	R-Value	
	Cavity	Studs
Outside air film	0.17	0.17
½" OSB	0.62	0.62
2 x 6 stud-wood	n/a	5.83
cavity insulation*	21	n/a
½" gypsum	0.45	0.45
Interior air film	0.68	0.68
Totals	22.92	7.75
Total wall	15.26	

* denotes "perfect" insulation installation

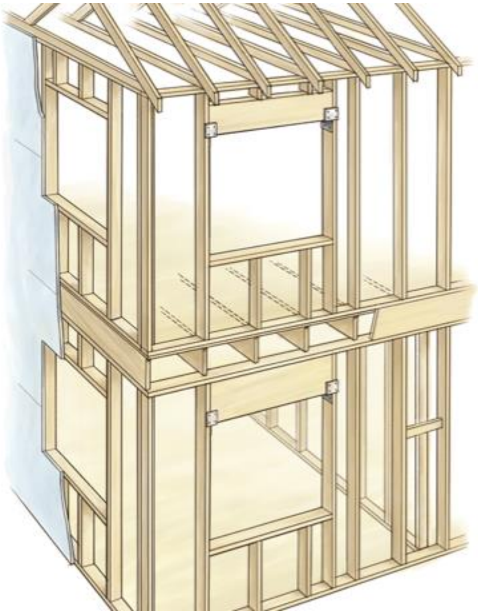
Remember this number

2 x 6 Wall Total Effective R-Value with HD Foam

Framing Percentage	R-Value	
23%	Cavity	Studs
Outside air film	0.17	0.17
Exterior insulation	**0**	0
7/16" OSB	0.62	0.62
Cladding/Siding	0.62	0.62
Framing - 2 x 6	n/a	5.83
cavity insulation	**35**	n/a
½" gypsum	0.45	0.45
Interior air film	0.68	0.68
Sub-Totals	37.54	8.37
Total Wall R- Value	18.81	

3 Ways to improve Effective R-values

- More cavity insulation
- **Advanced / Optimized framing**
- Continuous insulation

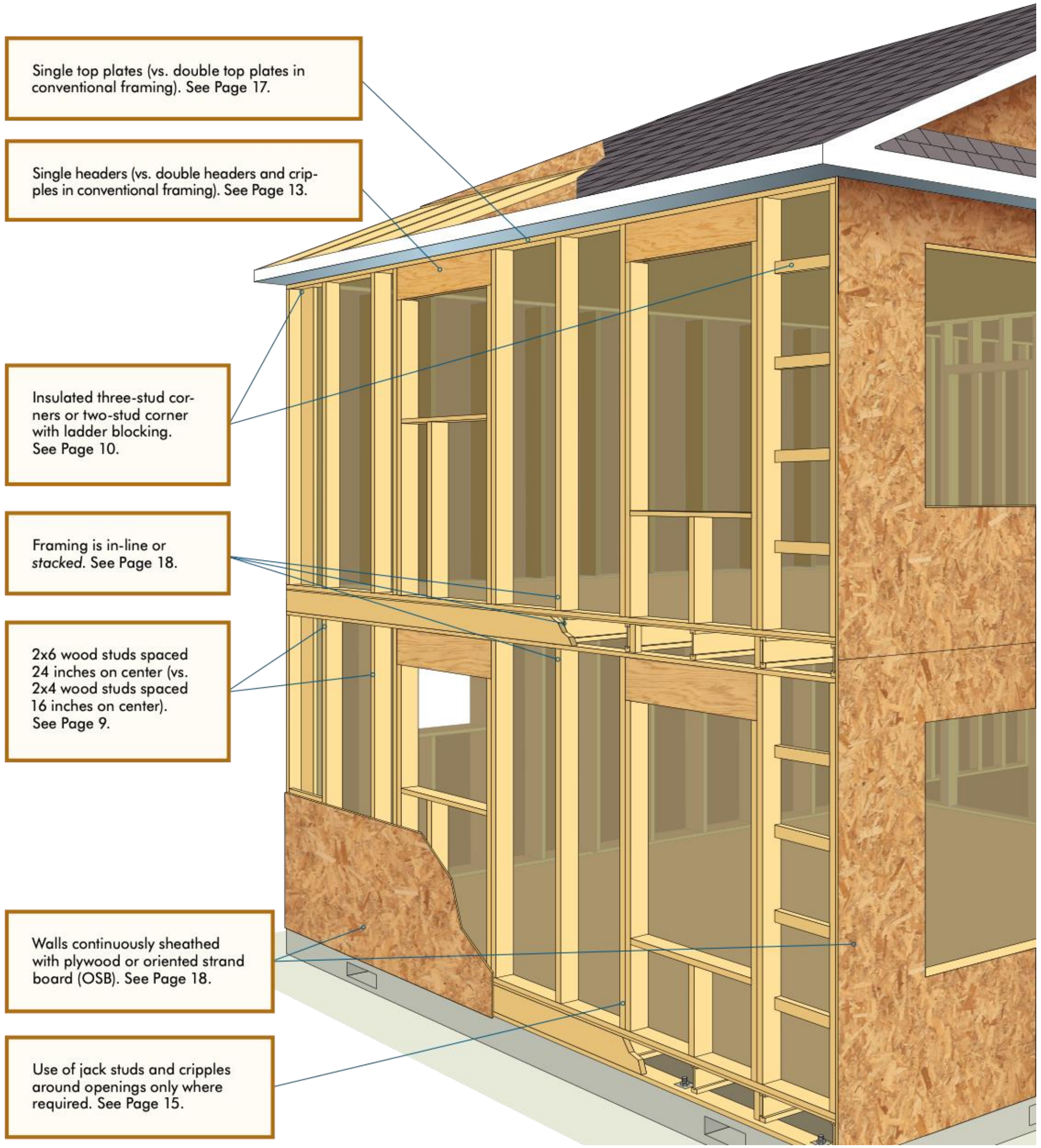


Elements

- Two stud corners
- Ladder framing
- Wider stud spacings
- Properly sized headers
- Single top plates

COMPONENTS OF ADVANCED FRAMING

Houses constructed with advanced framing techniques may include some or all of the following details:

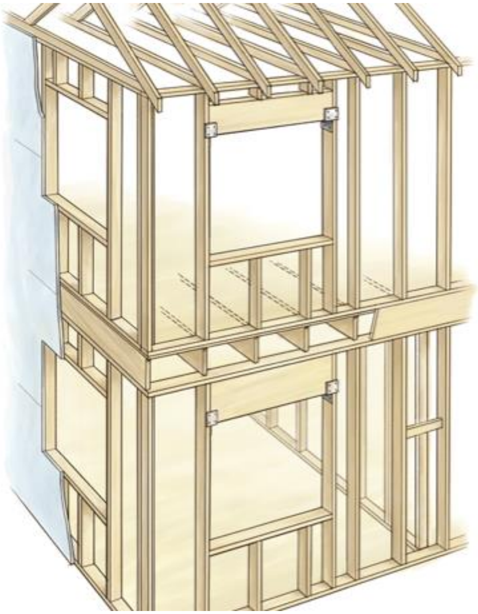


2 x 6 Wall Total Effective R-Value

Framing Percentage	R-Value	
19%	Cavity	Studs
Outside air film	0.17	0.17
Exterior insulation	**0**	0
7/16” OSB	0.62	0.62
Cladding/Siding	0.62	0.62
Framing - 2 x 6	n/a	5.83
cavity insulation	**20**	n/a
½” gypsum	0.45	0.45
Interior air film	0.68	0.68
Sub-Totals	22.54	8.37
Total Wall R- Value	**16.22**	

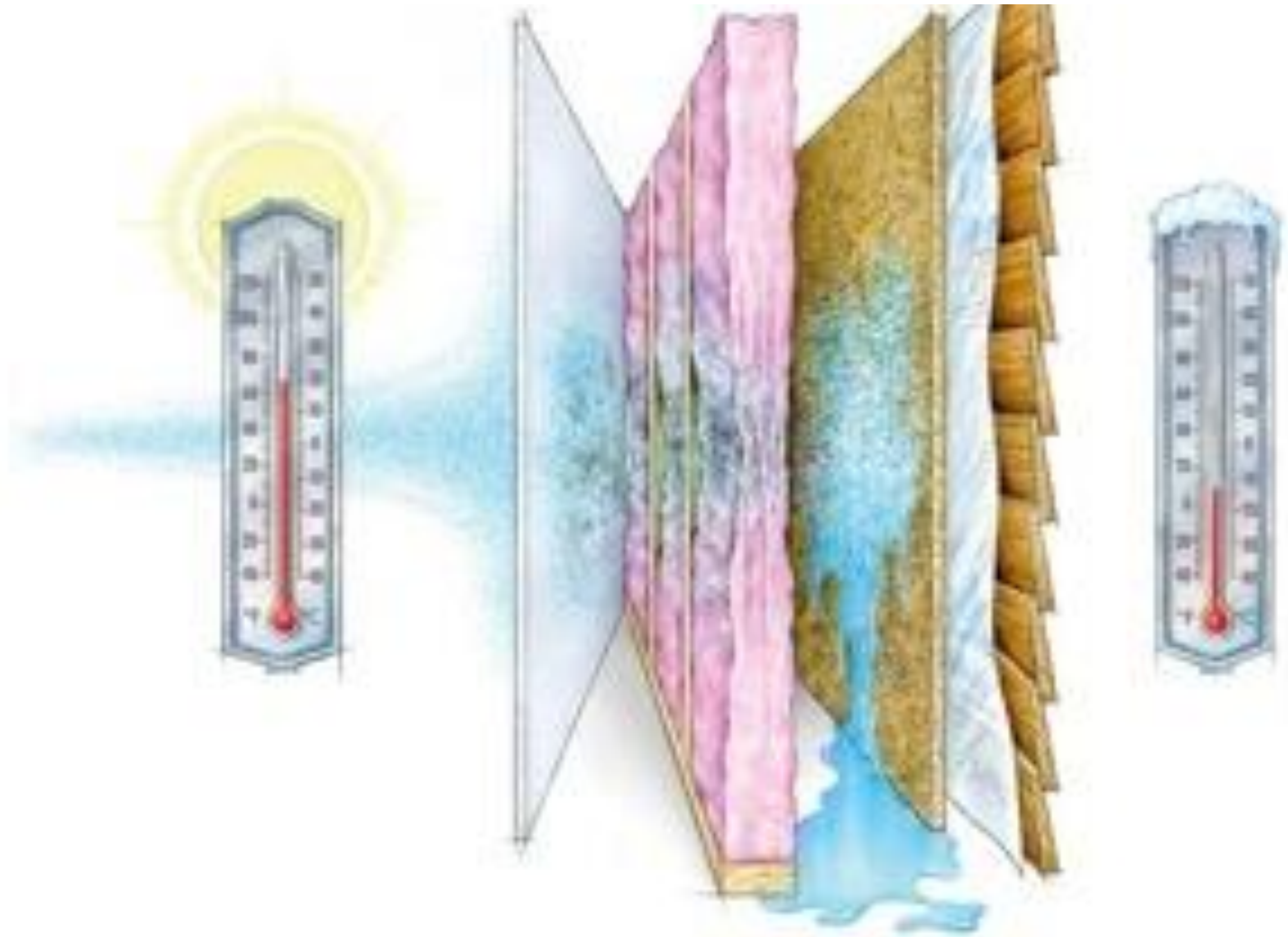
3 Ways to improve Effective R-values

- More cavity insulation
- Advanced / Optimized framing
- **Continuous insulation**



2 x 4 Wall + R5 Total Effective R-Value

Framing Percentage	R-Value	
25%	Cavity	Studs
Outside air film	0.17	0.17
Exterior insulation	**5**	5
7/16” OSB	0.62	0.62
Cladding/Siding	0.62	0.62
Framing - 2 x 4	n/a	3.71
cavity insulation	**13**	n/a
½” gypsum	0.45	0.45
Interior air film	0.68	0.68
Sub-Totals	20.54	11.25
Total Wall R- Value	**15.54**	



The dew point discussion

Construction Instruction®

Building Science for Everyone, Everywhere

Condensation

The more insulation, the greater the risk

Moisture flows with air leakage

Seal air leaks to stop moist air from getting into cold cavities

Canada Mortgage and Housing Corporation

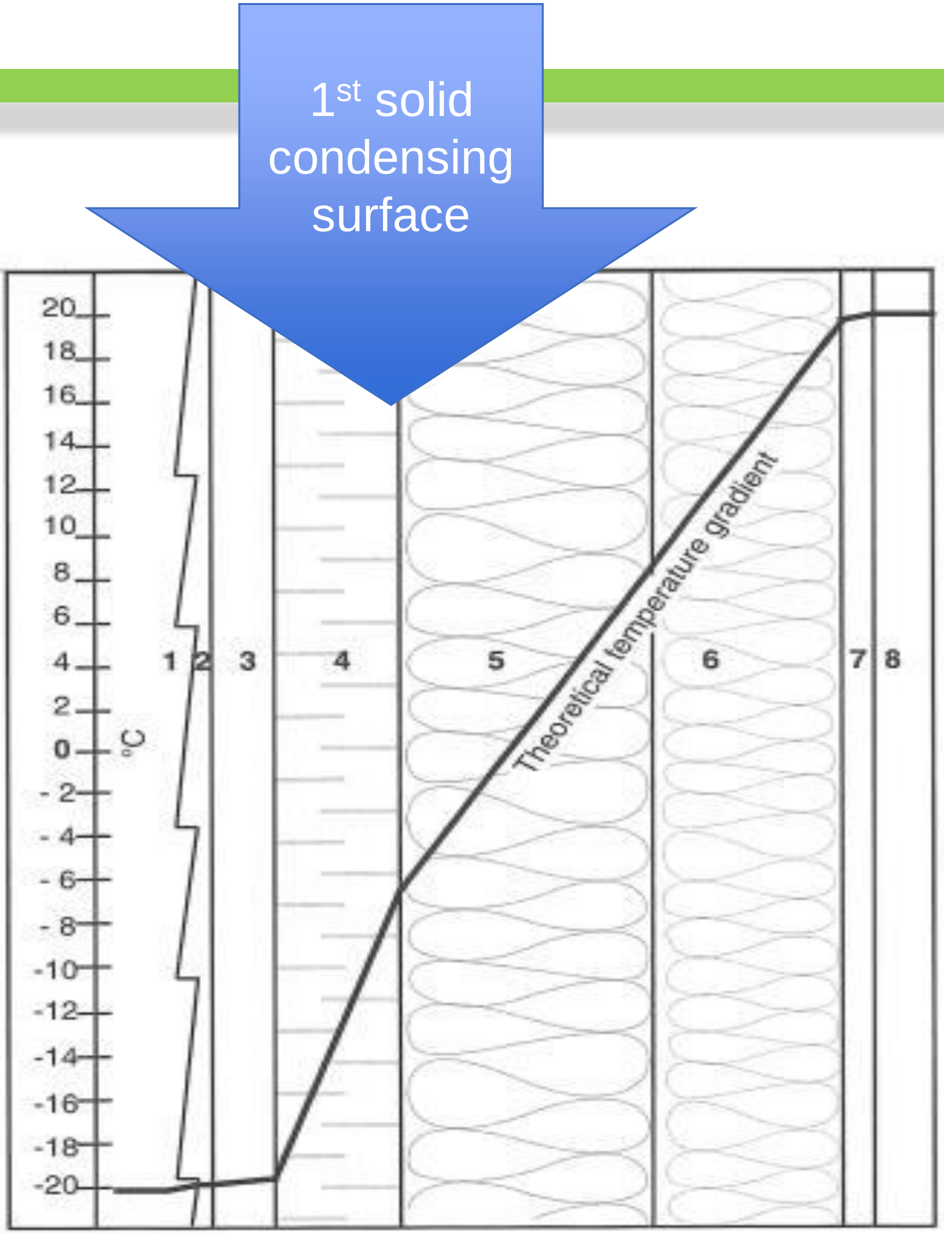
A typical temperature gradient through a wall.

Where is the 1st, solid condensing surface (where all the ACTION happens)?

	Wall Component	RSI	ΔT across component ($RSI/RSI_t \times \Delta T_t$)
1	Exterior air film	0.0053	0.039
2	Metal siding	0.0211	0.157
3	Air space with strapping	0.0300	0.224
4	50 mm (2") extruded polystyrene	1.761 (R10)	13.125
5	38 x 89 mm (2 x 4") studs with batt insulation	2.113 (R12)	15.749
6	38 x 64 mm (2 x 3") horizontal strapping with batt insulation	1.409 (R8)	10.502
7	Gypsum wall board	0.0062	0.046
8	Interior air film	0.0211	0.1572
	Totals	RSI_t 5.3667	ΔT_t 40°C

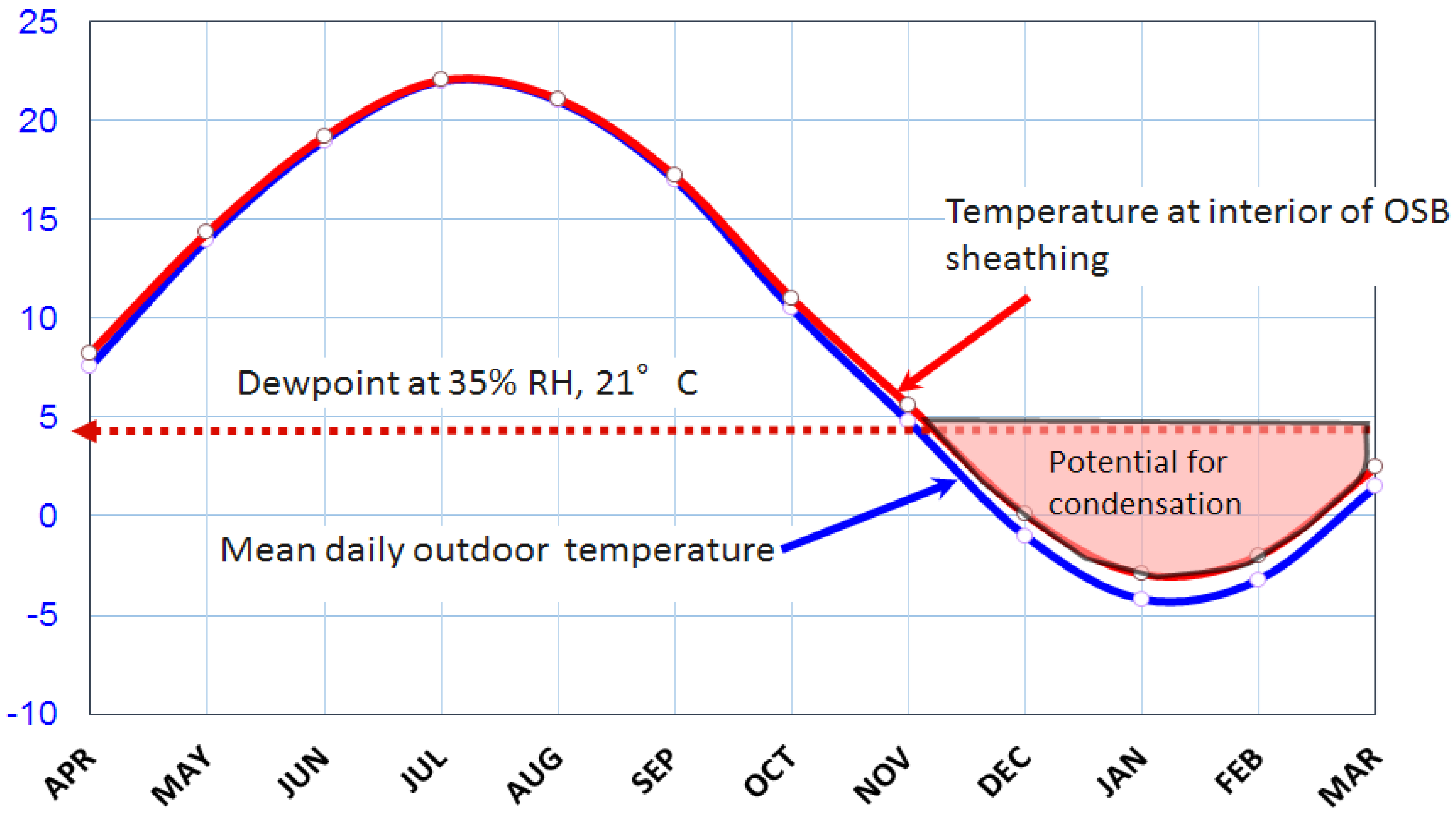
Winter conditions

Inside temperature		+20°C
Outside temperature		-20°C
ΔT_t across wall assembly		40°C



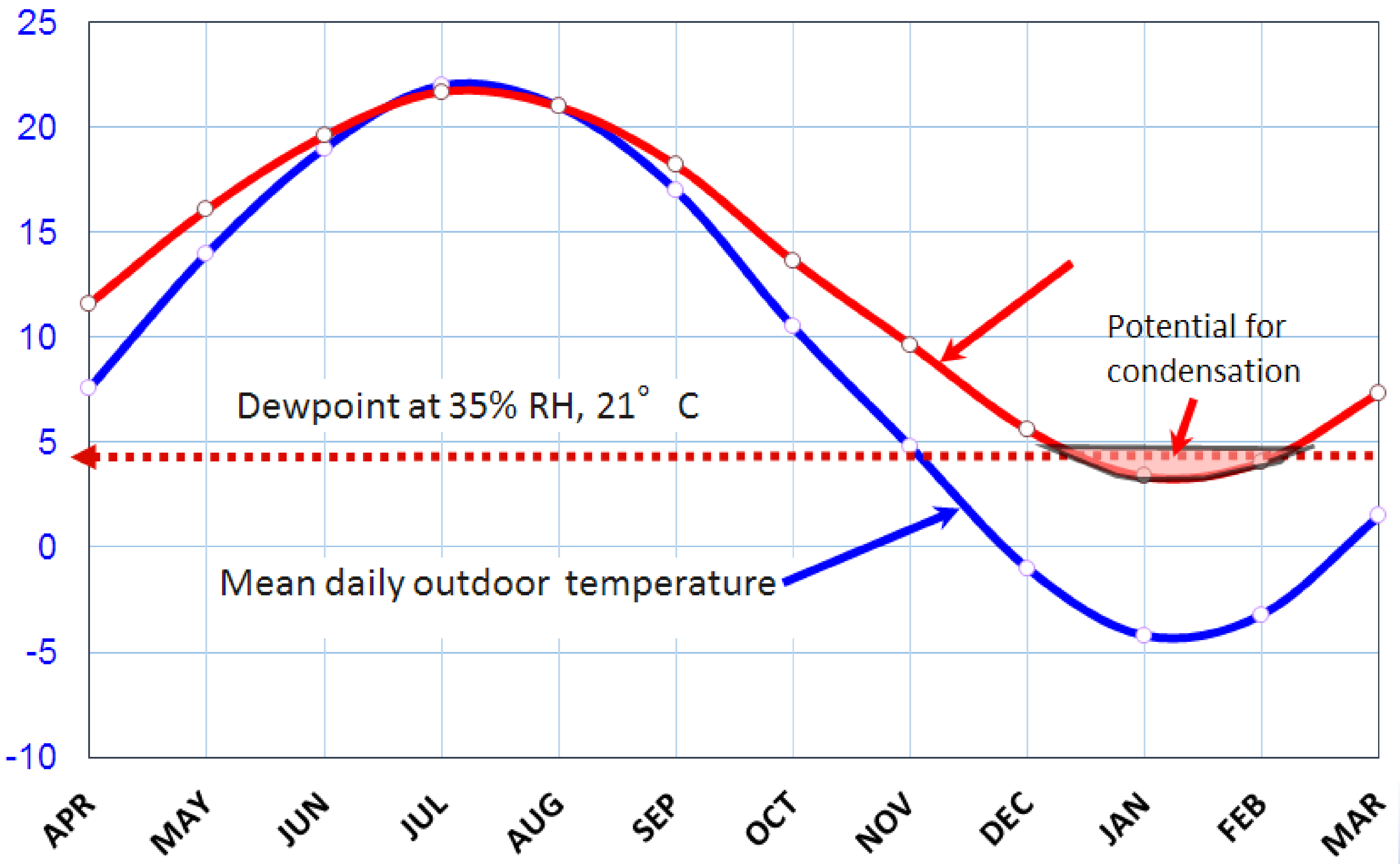
The more important factor: Dew point

Condensation potential in walls
Zone 5, 2x6 - R20 wall, OSB sheathing



The more important factor: Dew point

Reduced condensation potential in wall
Zone 5, 2x6 - R20 + R5 sheathing



EEBA

Vapor Permeance of Materials

Material	Imperial Permeance
6 Mil polyethylene Drywall Building paper	0.06 Perms 20 - 60 5-10
Structural Sheathing Wood Plywood OSB	 2 - 8 0.75 - 3.5 0.75 - 2
Insulated Sheathing Foil Faced Poly Iso - 1” XPS - 1” EPS - 1” EPS with foil face - 1”	 0 to 0.01 0.75 - 1.5 2 - 4 0.5 - 1.5
WRBs Spun bonded Polyolefin Coated Wraps	 20 - 50 6 - 14

Class III Vapor retarders (semi-permeable) are permitted if:

Permeance of < 10 or >1.0

Climate Zone	Minimum Cont. Insulation R-Value	
	2 x 4 walls	2 x 6 walls
Marine & Zone 4	R-2.5	R-3.75
Zone 5	R-5	R-7.5
Zone 6	R-7.5	R-11.25
Zones 7 & 8	R-10	R-15

Foam is an excellent thermal barrier

Insulated Sheathing will be Normal

It doesn't have to be foam

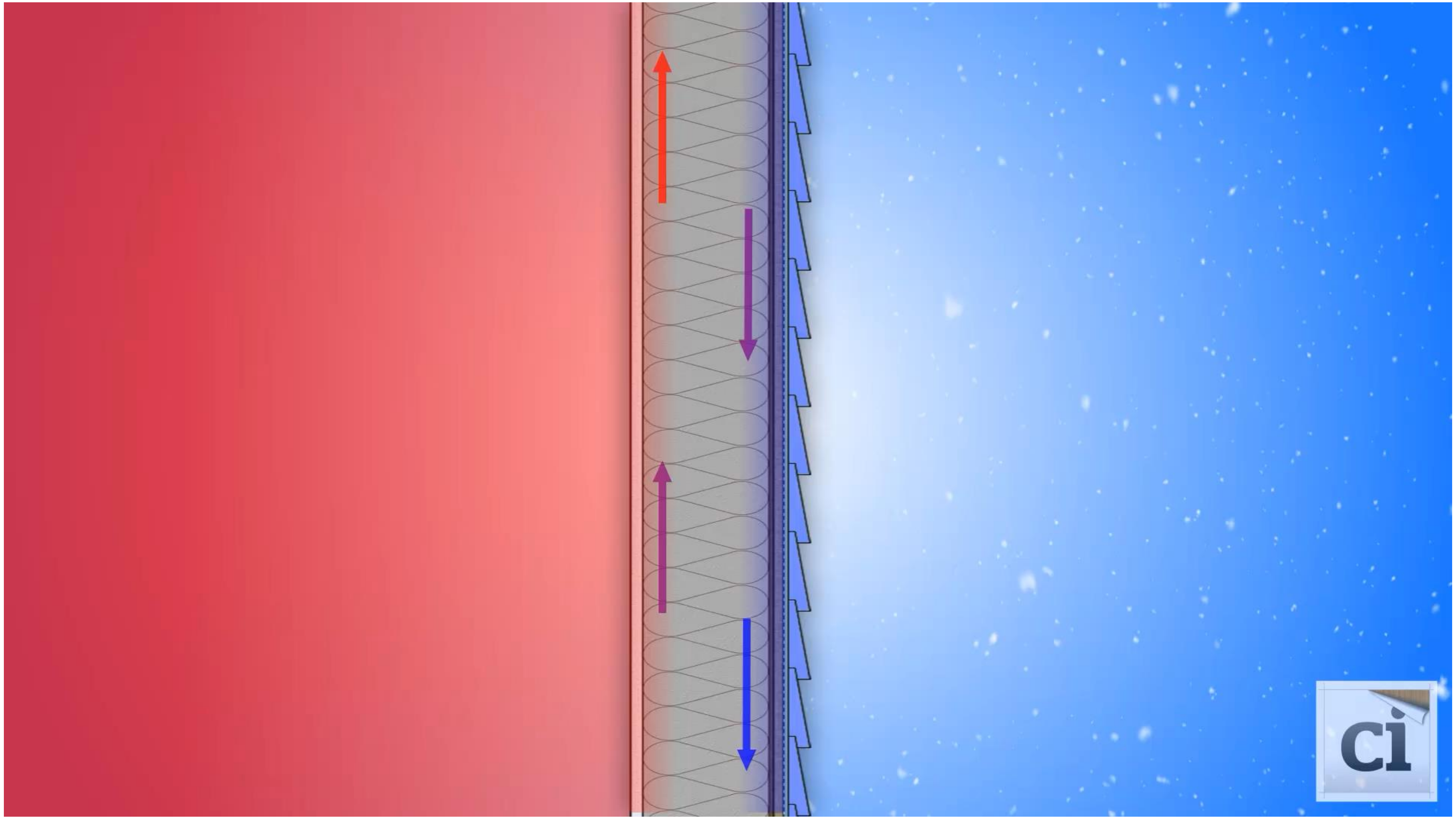

SOPREMA

Effective R-Value of framed walls

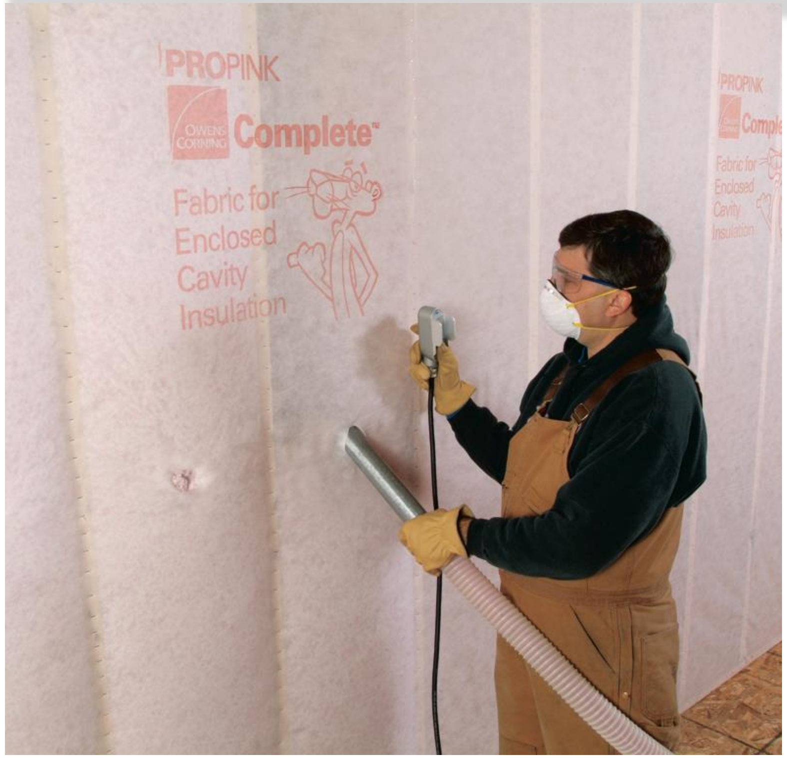
Wall Options	Total Effective R-Value
Traditional 2 x 6 with R20 Batt insulation	15
Zero Energy Ready Wall for "Mild Climates":	
2" x 4" w/ R-15 Cavity + R-10 cont. ext. Insulation	21
Zero Energy Ready Wall for "Cold Climates":	
2" x 6" w/ R-23 cavity + R-10 cont. ext. insulation	27

Heat Transfer by Convection

Convection loops occur in air gaps

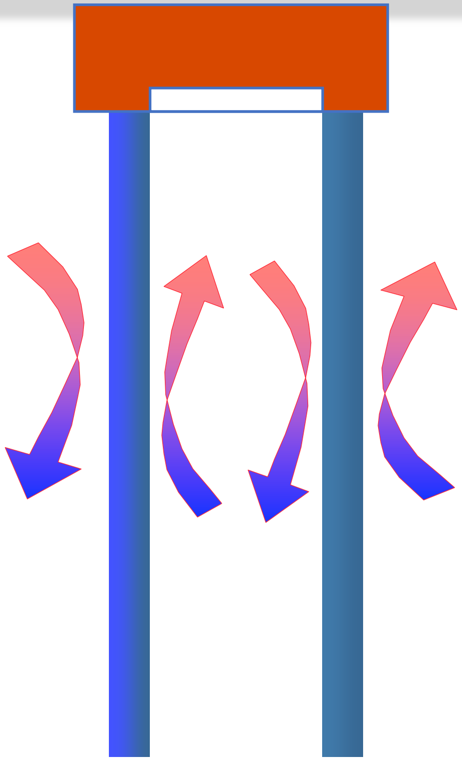


There are 3 ways to reduce convection flow



No gaps or voids

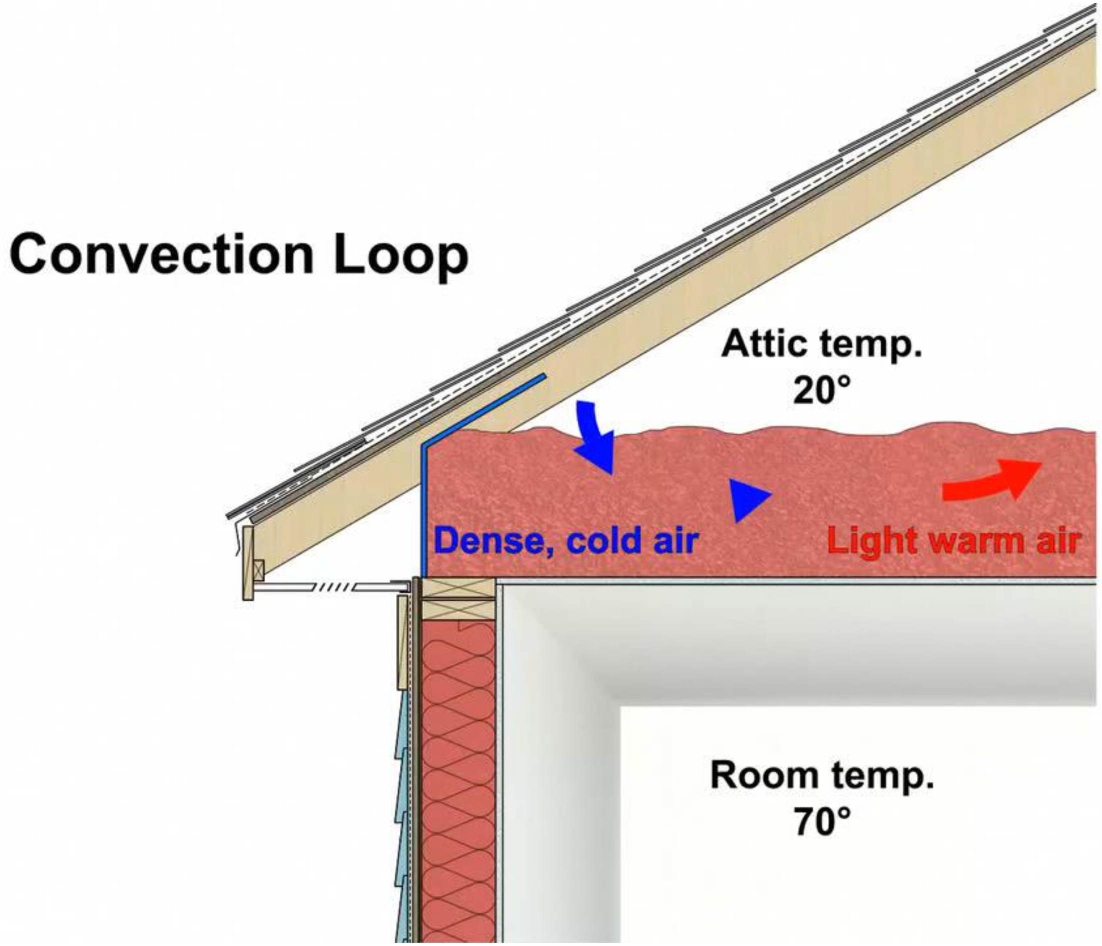
Seal the holes



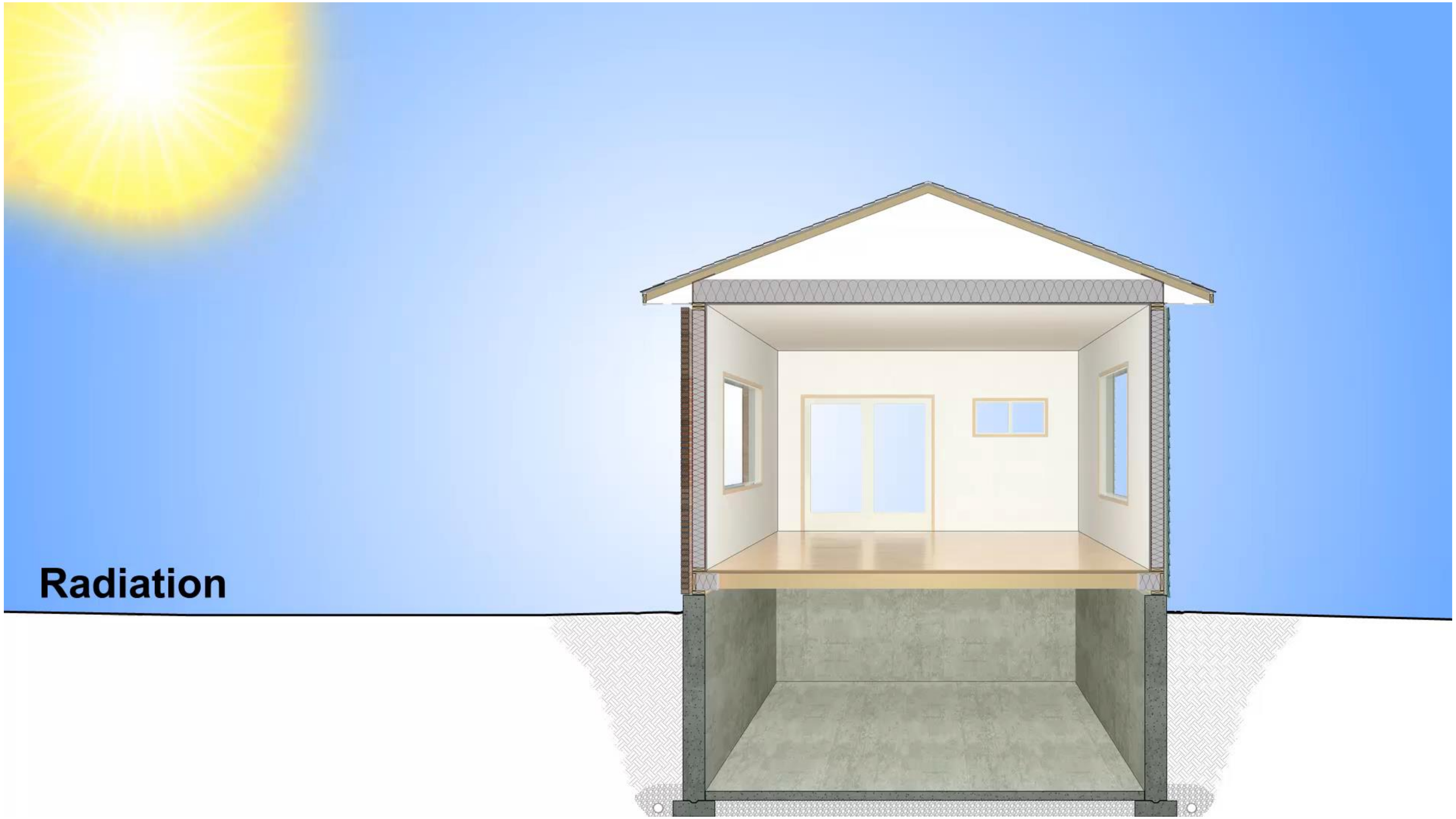
Use inert gases - windows

Convective loop in attic insulation

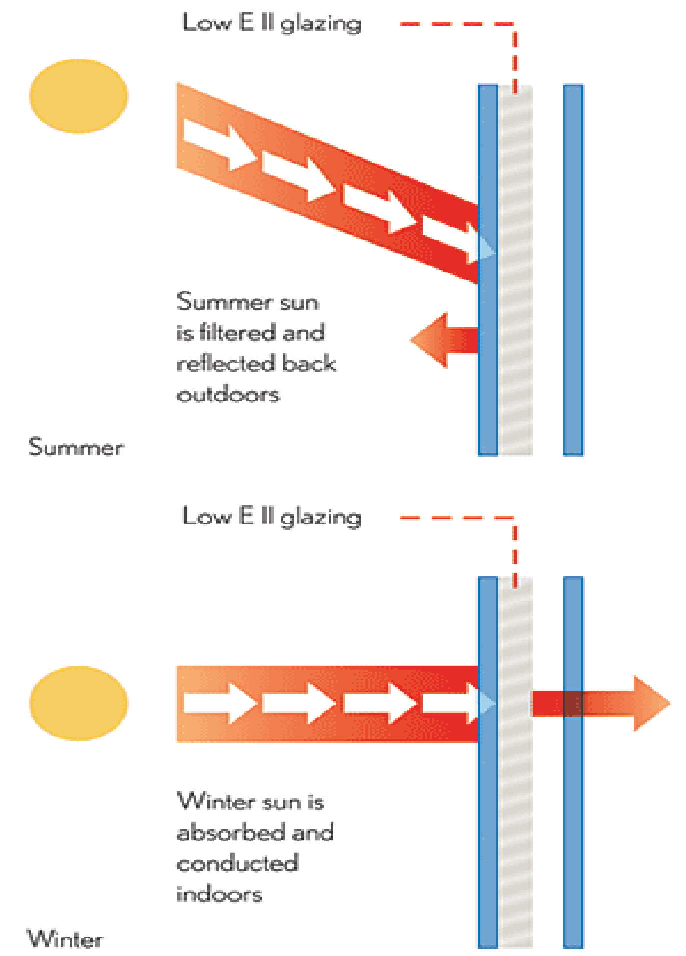
- Mitigated by adding more insulation
- Avoid wind washing of insulation



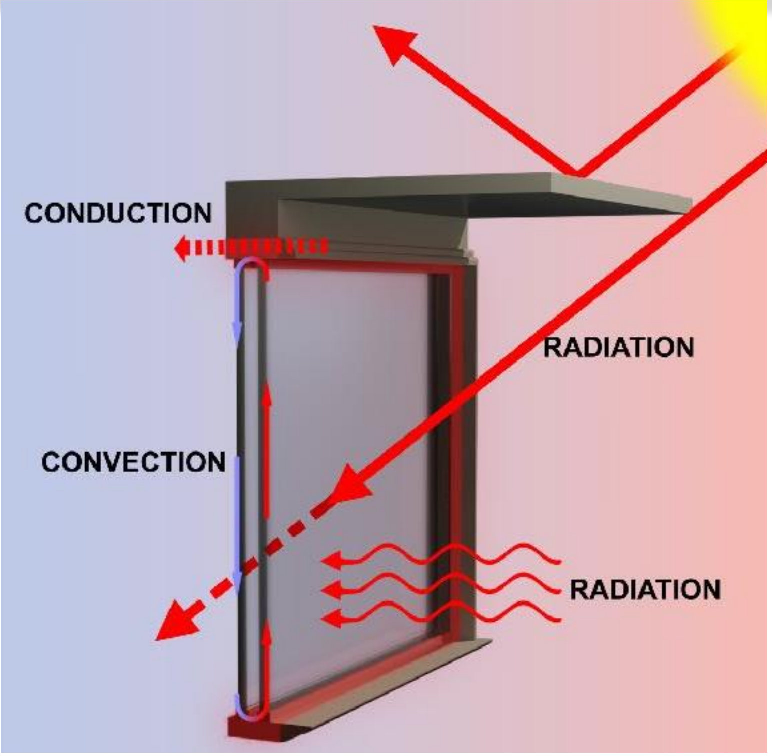
Heat transfer by Radiation - surface to surface



There are 3 ways to optimize radiation flow



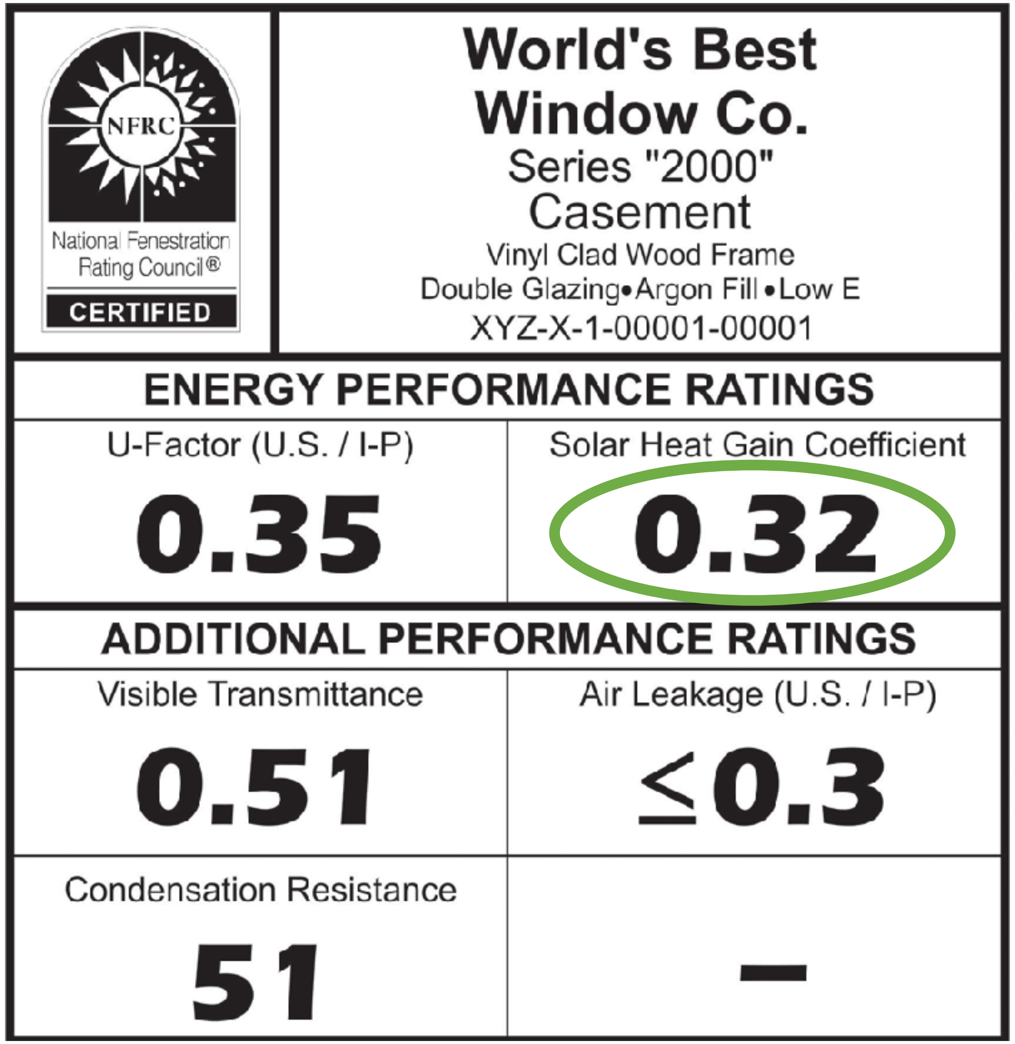
Selective Low E coatings

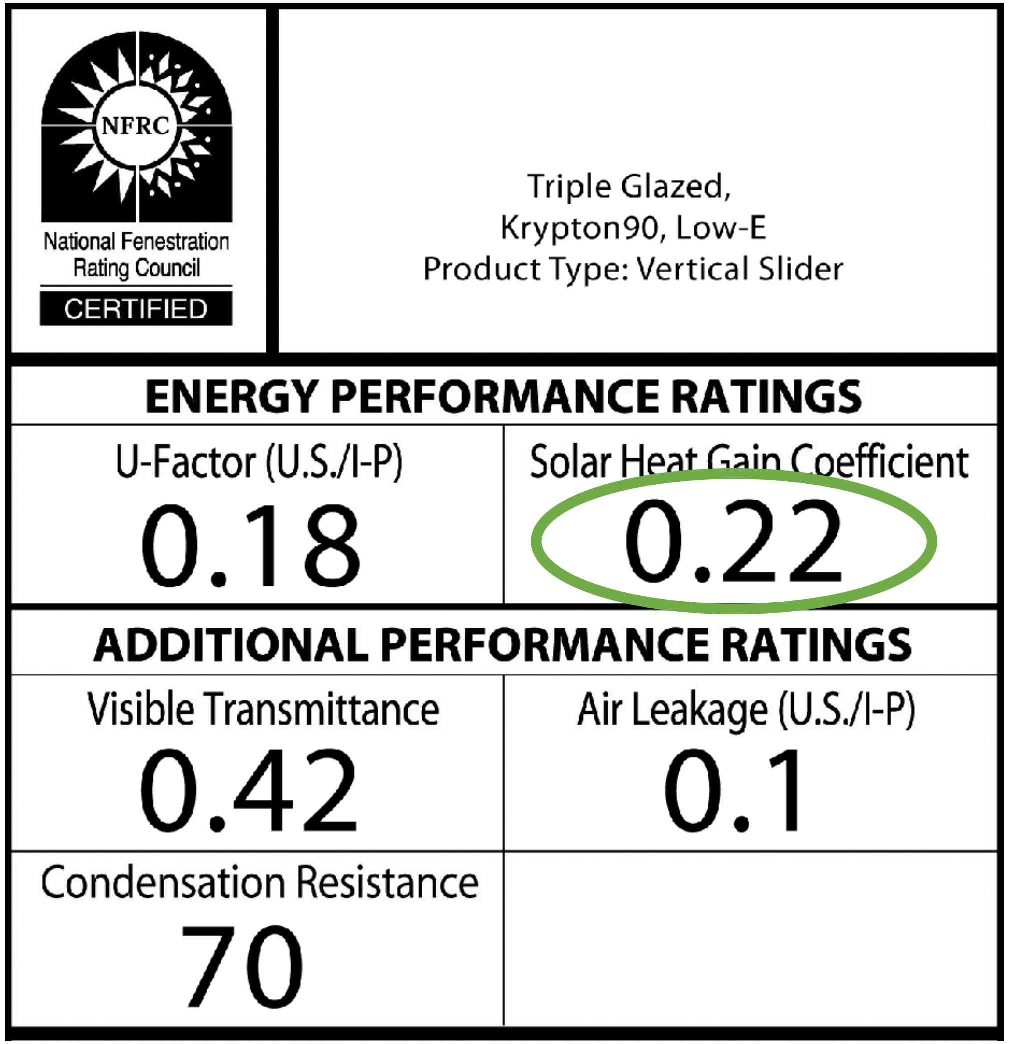


Proper shading

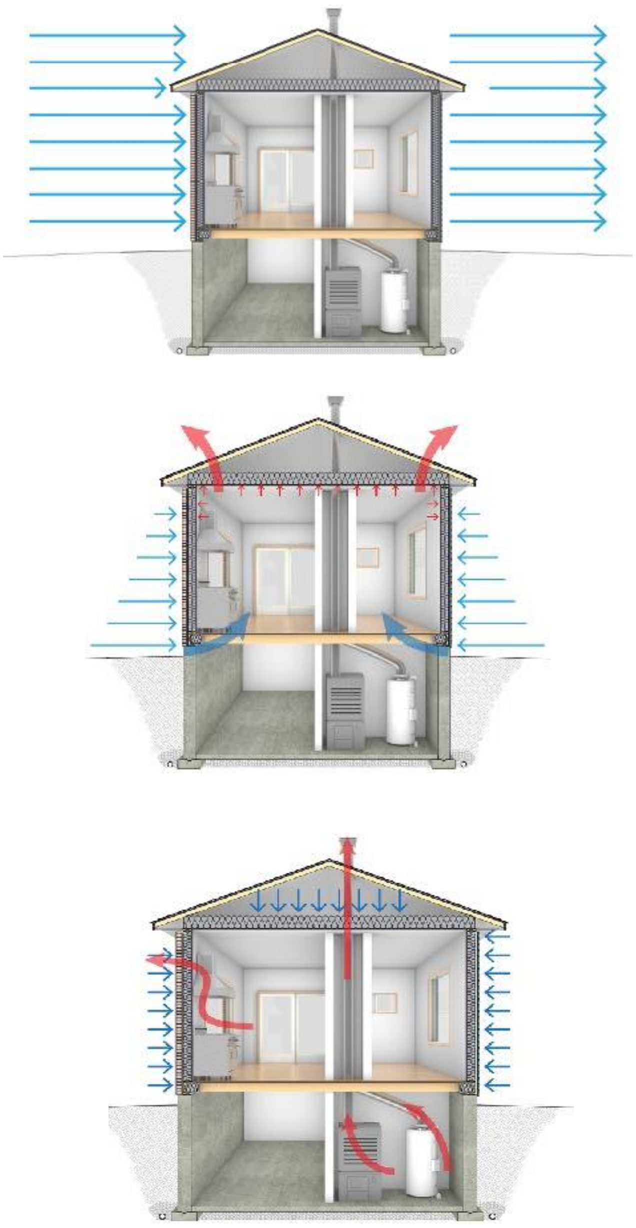
Radiant barriers

Choose appropriate windows for your climate





Now consider Air Flow



Methods of Air Flow

- Wind
- Stack (Predominant impact in cz 3-7
- Mechanical

Reasons we want houses to be tight

- Most cost effective energy saving measure - 20% - 30% savings
- Makes homes quieter and cleaner
- Makes homes more “comfortable”
- Reduces water entry - homes last longer
- Makes homes healthier - controlled air quality
- Environmental benefits because we are not wasting energy

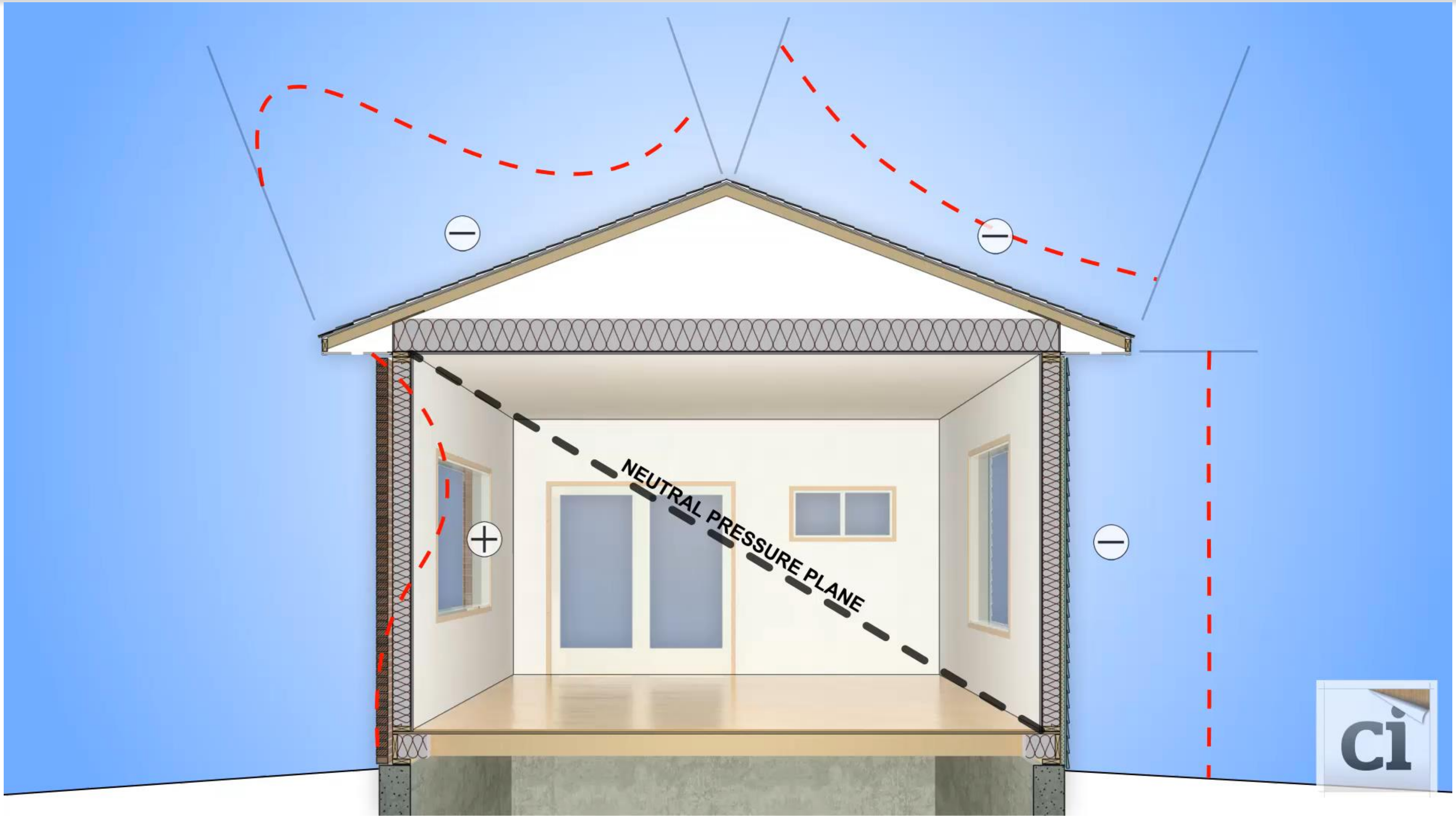
Are there any concerns of Houses Being “Too Tight”?

From an Energy Perspective we would like houses to be very tight

What are possible concerns about house being tight?

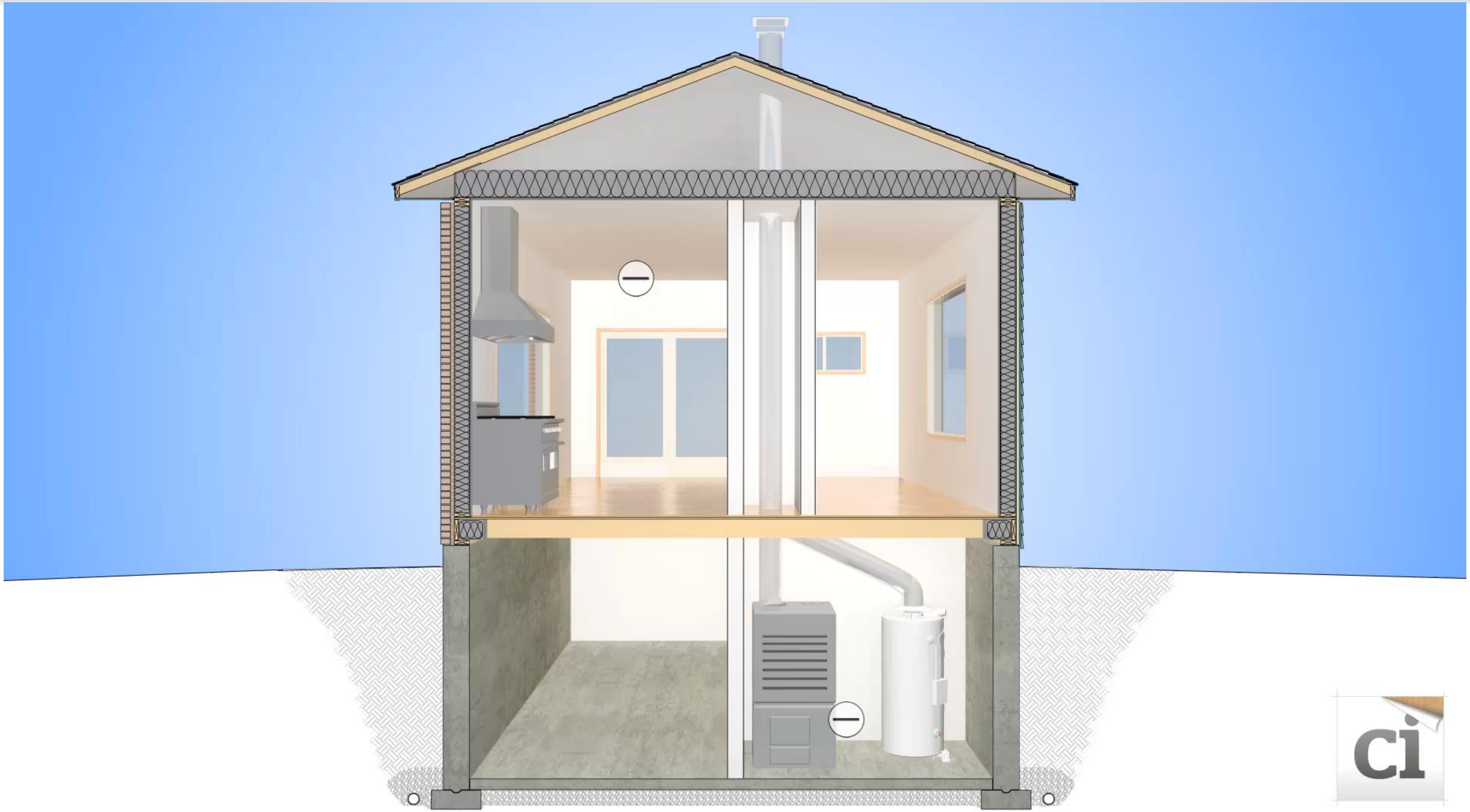
- Indoor Air Quality
  - Moisture problems
  - Chemical pollutants
- Combustion Safety
- “The walls have to breathe”

Wind effects are highly variable



Stack effect
- pressures created by air temp. differences

Mechanical systems may adversely affect performance

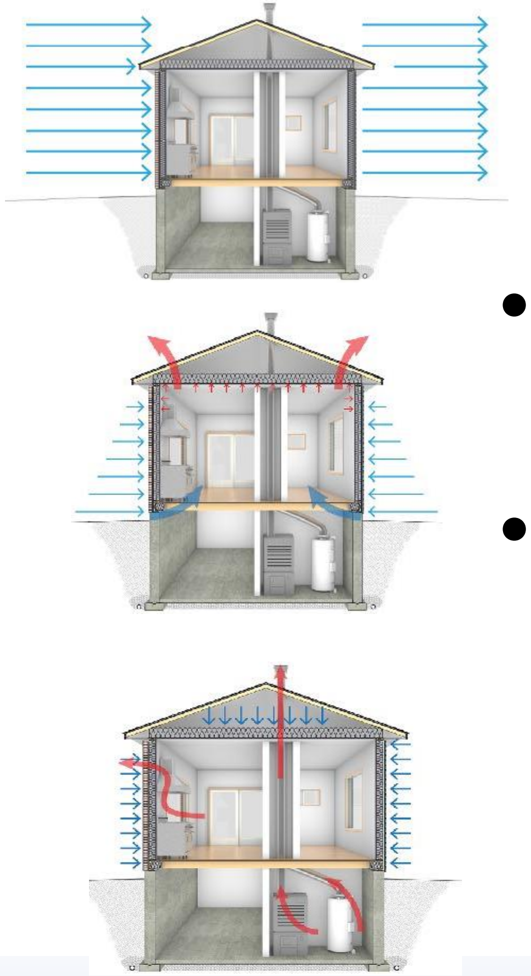


Neutral pressure plane of building

- The neutral pressure plane will change
- Wind, stack & mechanical effects
- Its locations determines which holes leak and in which direction

Moisture laden air flow can create problems

Managing Air Flow



- Its difficult to manage the varying pressures
- Its most cost effective to make buildings tighter - seal the holes

Finally… Moisture Flow

A very complex subject

Forms of Moisture

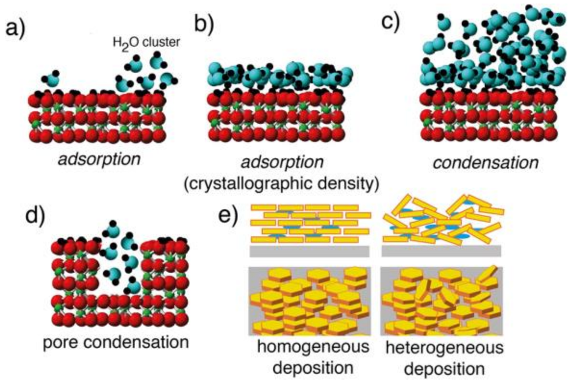
- Solid

- Liquid

- Vapor

Water in liquid form is the most concerning

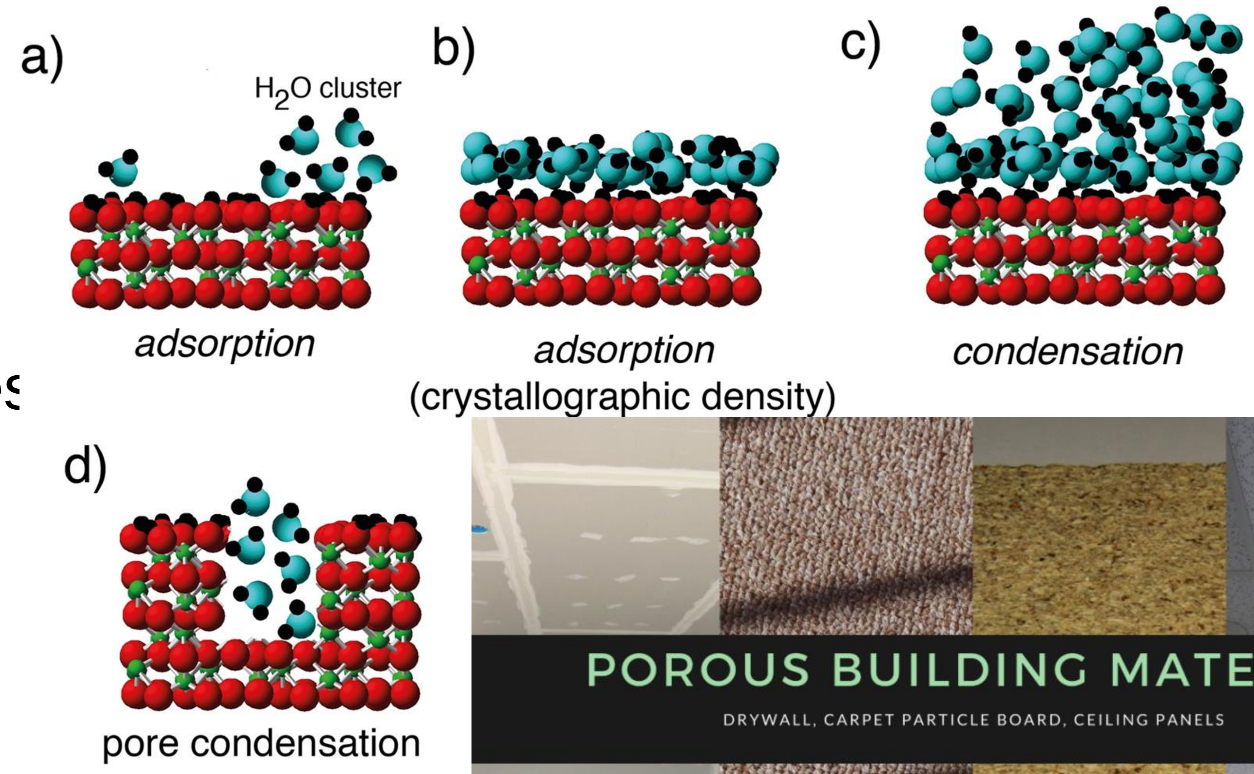
- Adsorbed ?



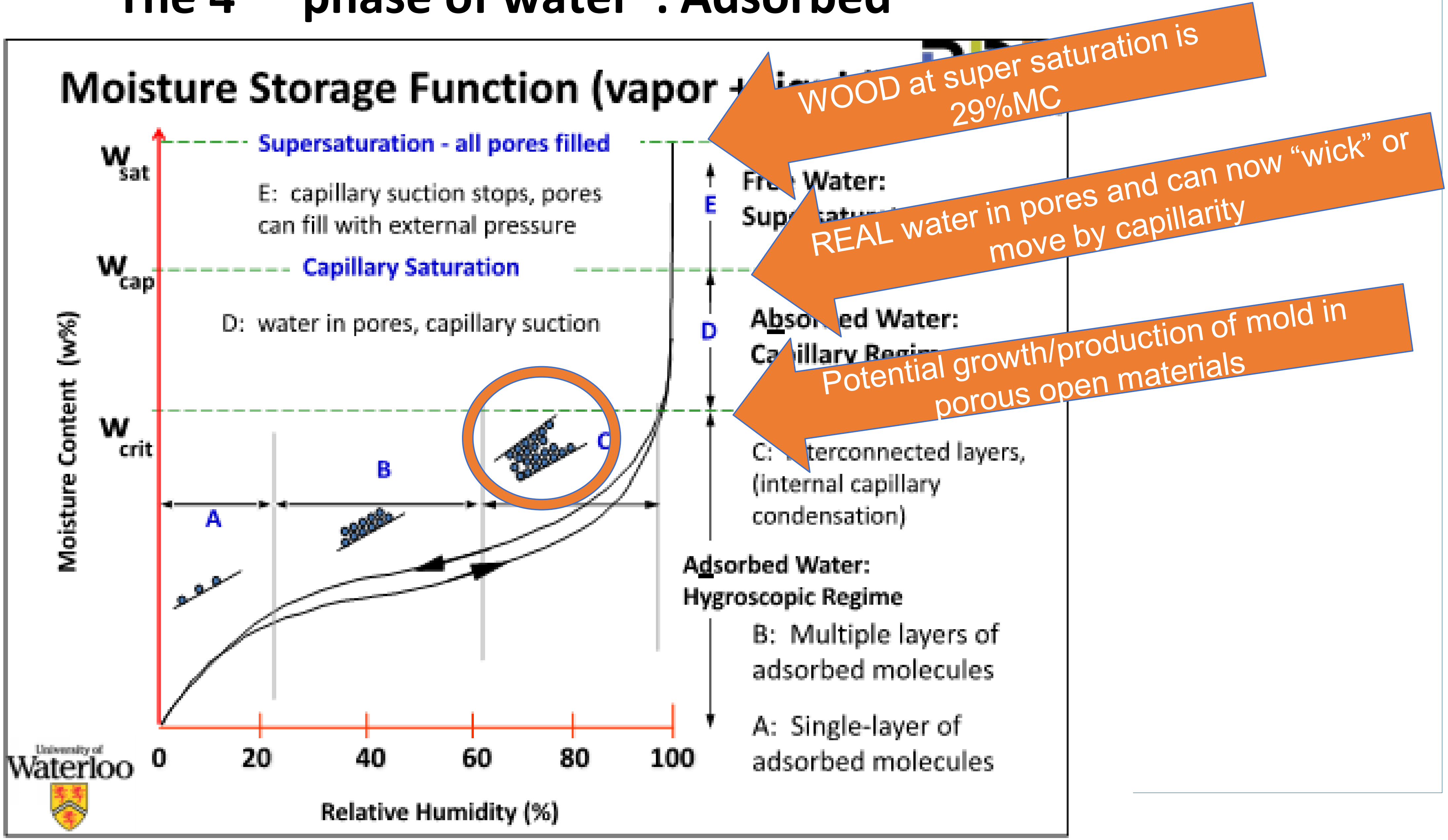
Managing water is critical to sustainability

The 4th “phase? of water”: Adsorbed

- Invisible, singular water molecules “stick” to surfaces (remember surface tension?)
- Layers of water molecules on surfaces increase as RH increases
- Porous surfaces are the most susceptible as the “RH” in the “pore” can increase to 100%



The 4th "phase of water": Adsorbed



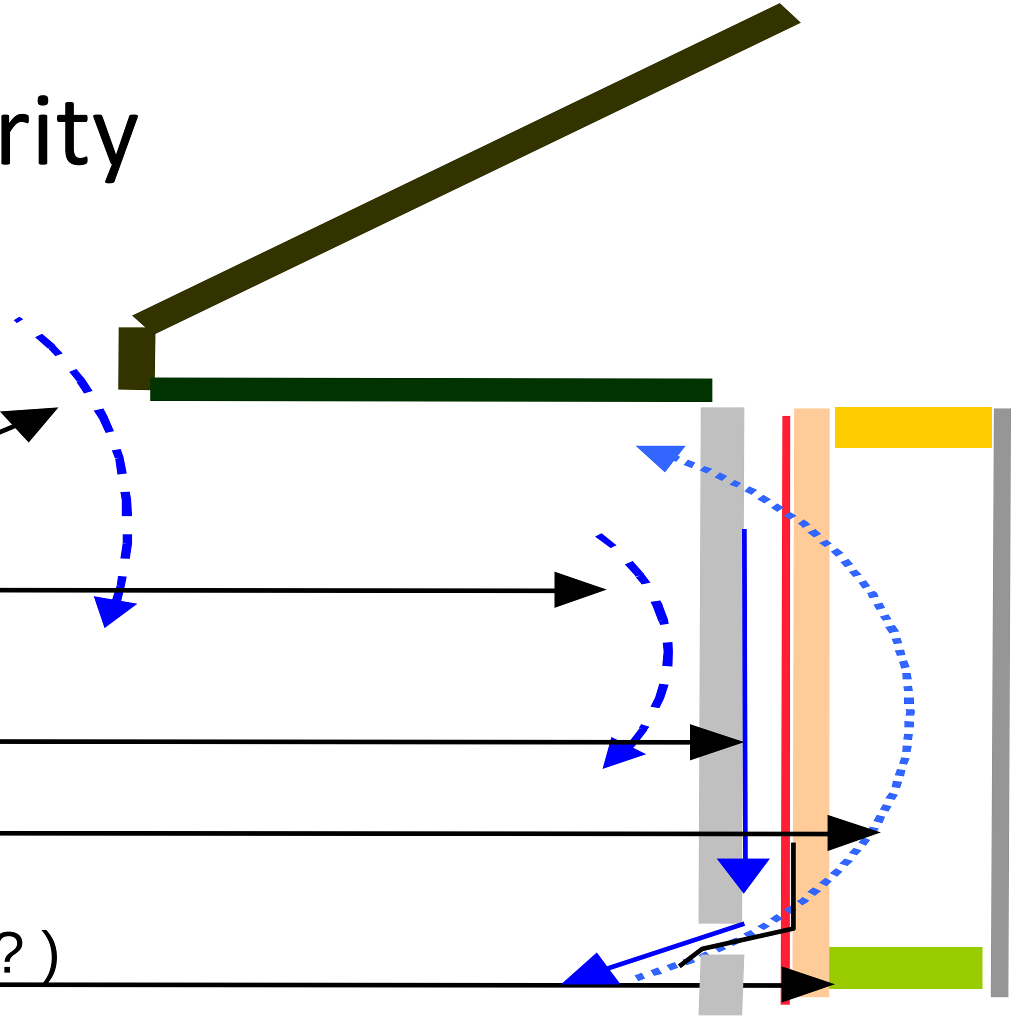
4 Moisture Flow Mechanisms

- Liquid Flow (gravity driven)
  - Rain
- Capillary
  - Material wicking
- Air Transport
  - Pressure induced flows of moisture laden air
- Diffusion
  - Vapor pressure drive

Liquid flow is the most important

The four D’s of wall design & moisture management

In order of priority



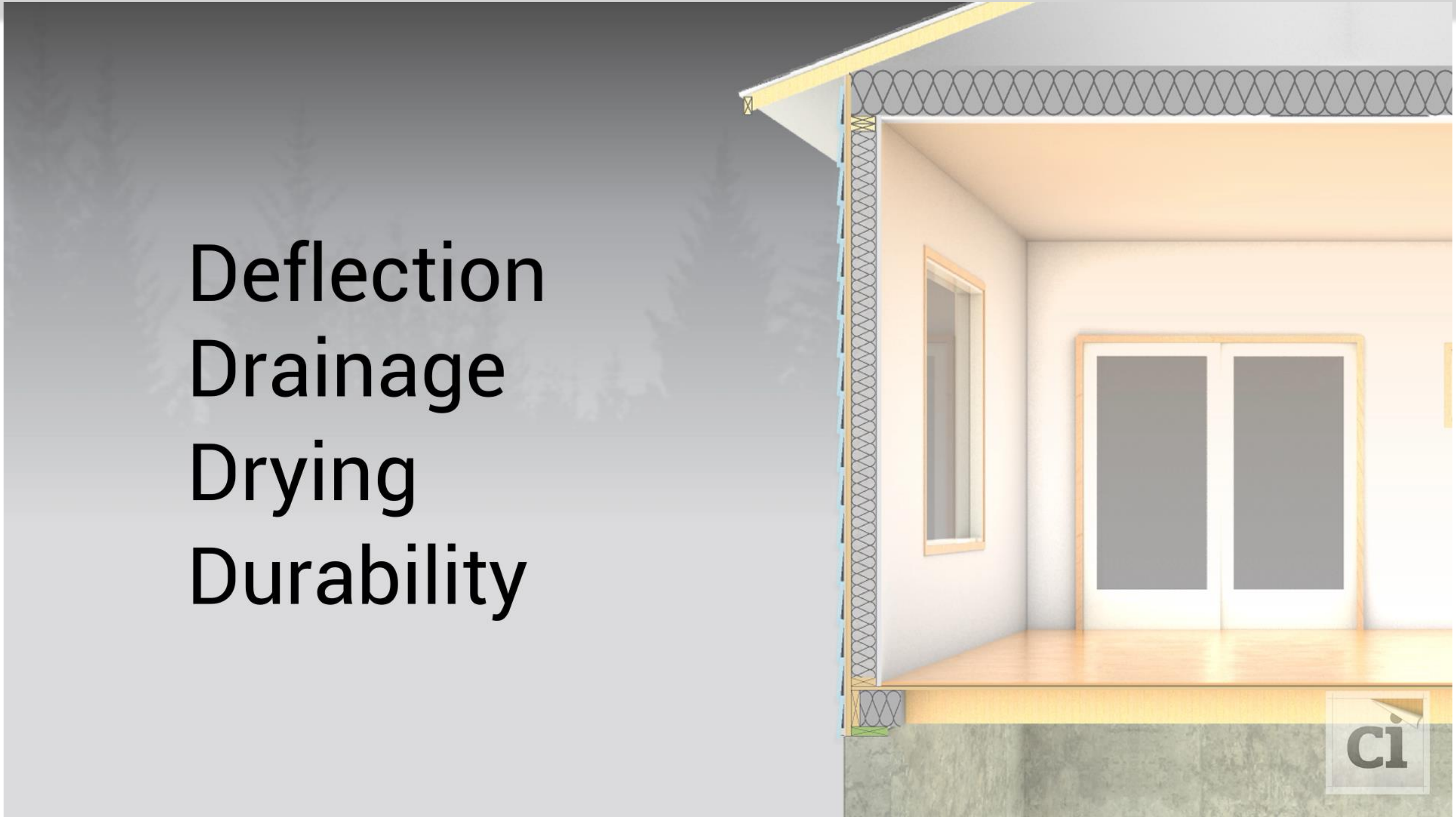
1. Deflection (80% of control)

2. Drainage (1/16th”)

3. Drying (perms/vent)

4. Decay resistance (treated wood?)

Managing liquid water flow

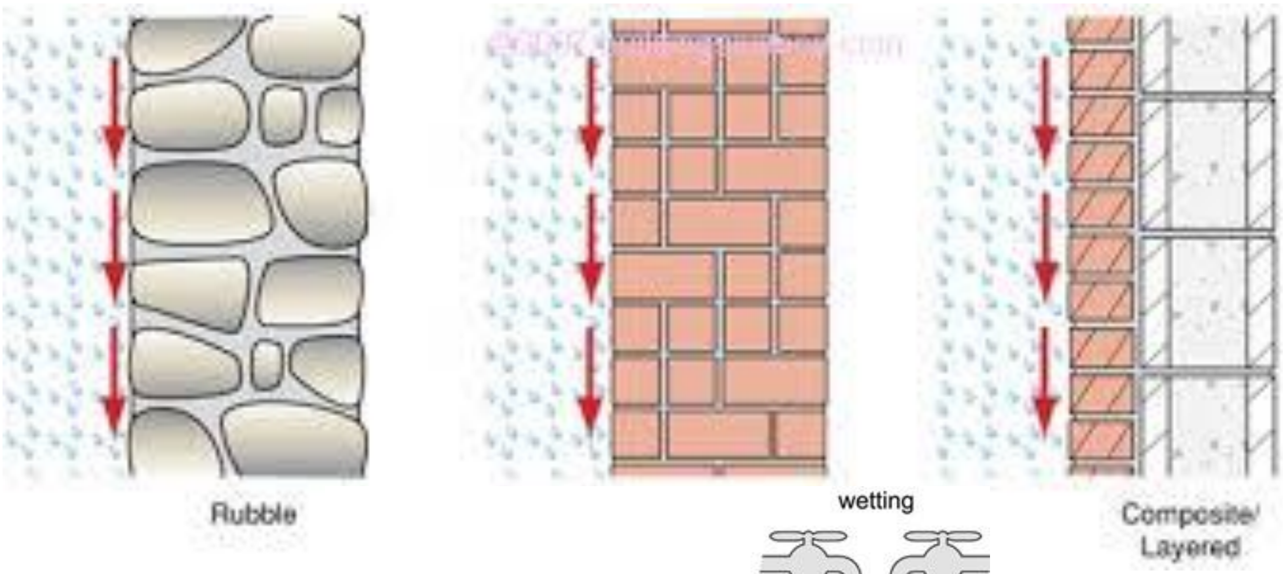


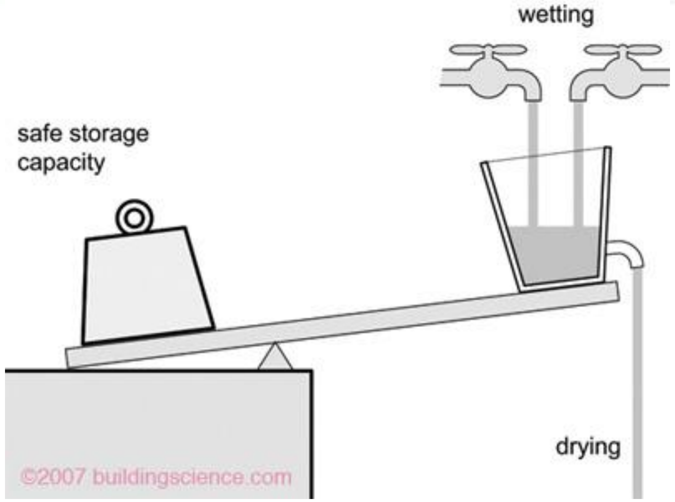
Water will get on the wall, so control it

- Once water is on the wall it <u>will form a film</u> and begin flowing downward under the force of gravity
- Wind on the surface can deflect the flow and in extreme cases may force the water upwards
- Surface features such as window / door openings and trims can greatly affect the flow path - concentrating or dispersing surface flows

We will always need to design and install claddings / windows that, once wet, can dry out.

Rain water control: Historical perspective





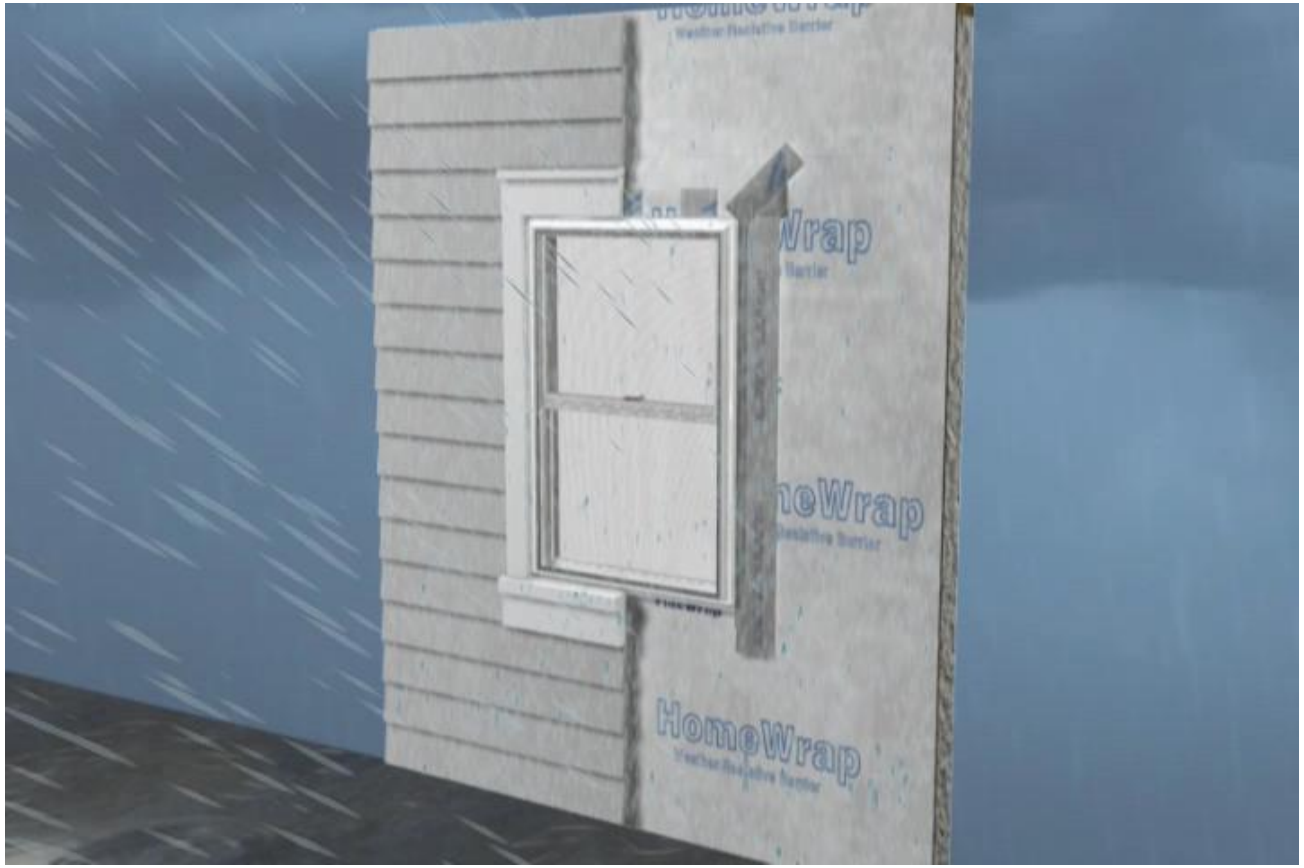
Protecting walls from Liquid Water

Cladding is only 1st line of defence.
Water gets behind **ALL** types of cladding by:

Liquid

Capillary

Air pressures



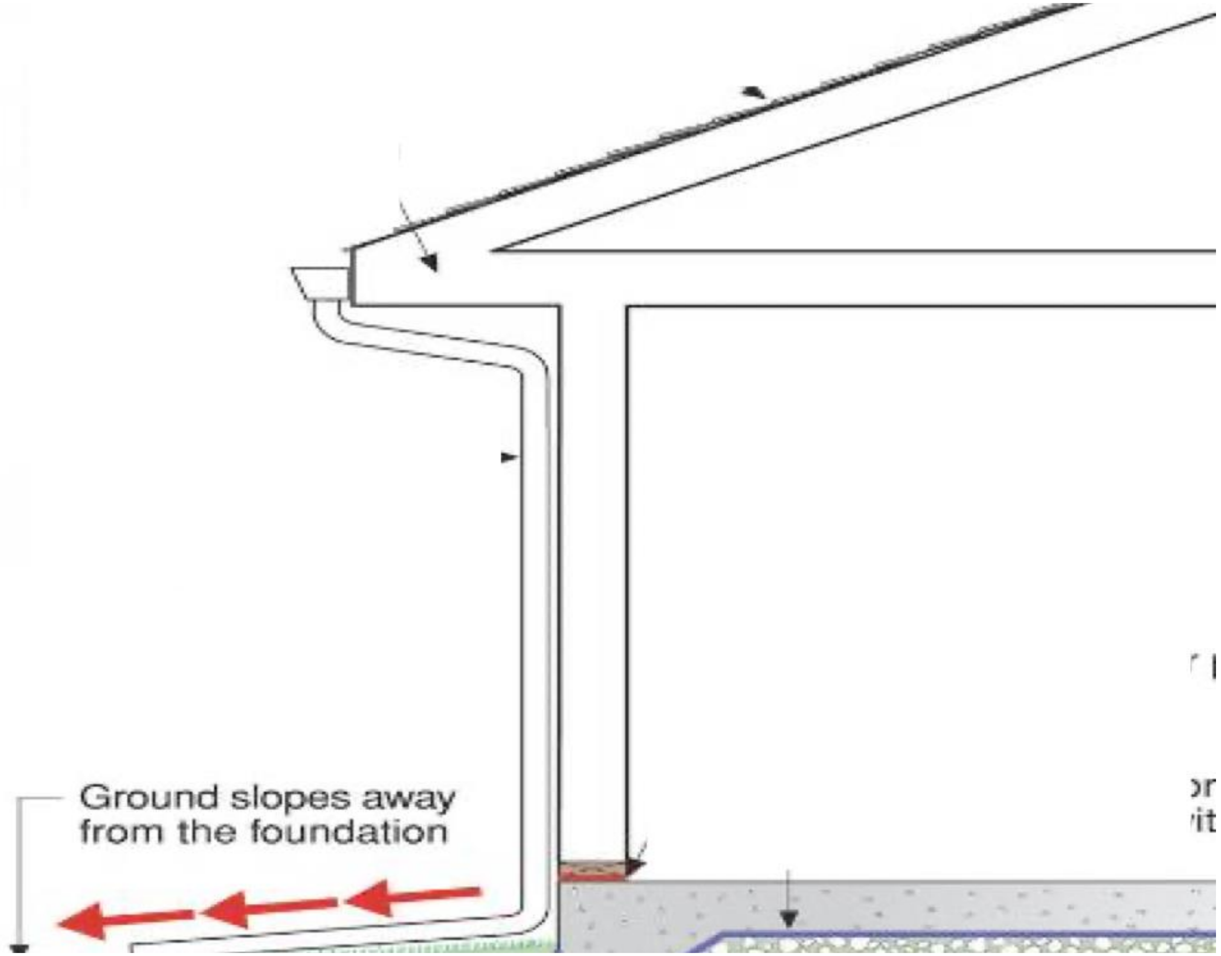
Methods of flow

Water is a powerful force in all it's forms

It starts with the design

Follow the path of water; will it create a problem?

Gutters are important to any water management strategy



Graphics from EEBA Water Management Guide

Kinetic (wind driven): Induced flows of moisture laden air

Kinetic Energy of a falling rain drop:
1st line of defense = The overhang!

Overhangs and peaked roofs can reduce rain deposition by 50% by shadowing and redirecting airflow

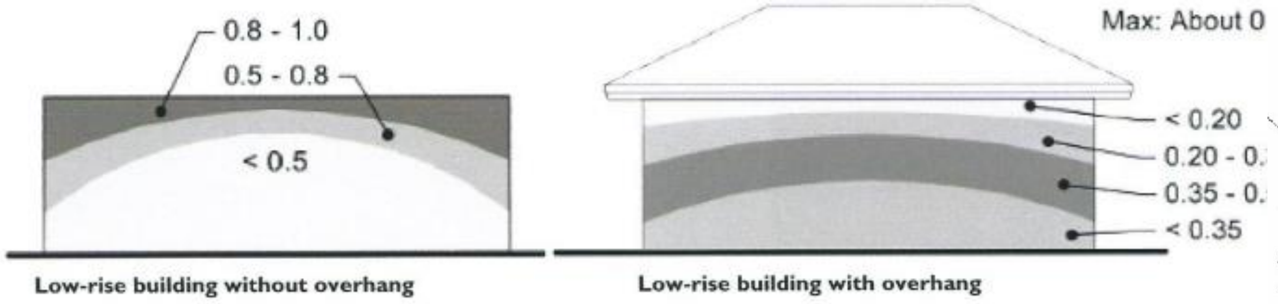
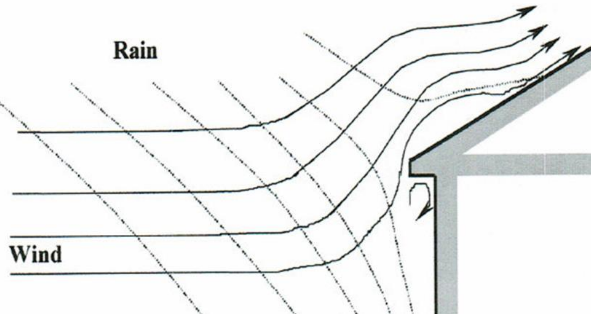


Figure A3-3 Typical rain wetting pattern on low-rise buildings (Straube and Burnett 2005).



The shape of roof and overhang has a critical impact

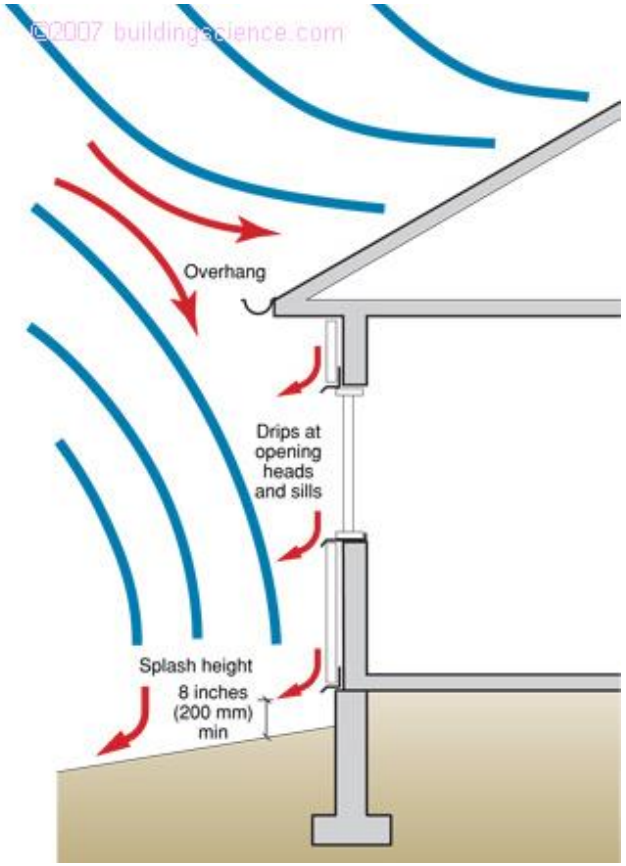
The old, ornery Canadian building science guys figured this out years ago

"The fundamental principle of water management is to shed water by layering materials in such a way that water is directed downwards and outwards out of the building or away from the building. The key to this fundamental principle is drainage. The most elegant expression of this concept is flashing. **Flashings are the most under-rated building enclosure component and arguably the most important**."

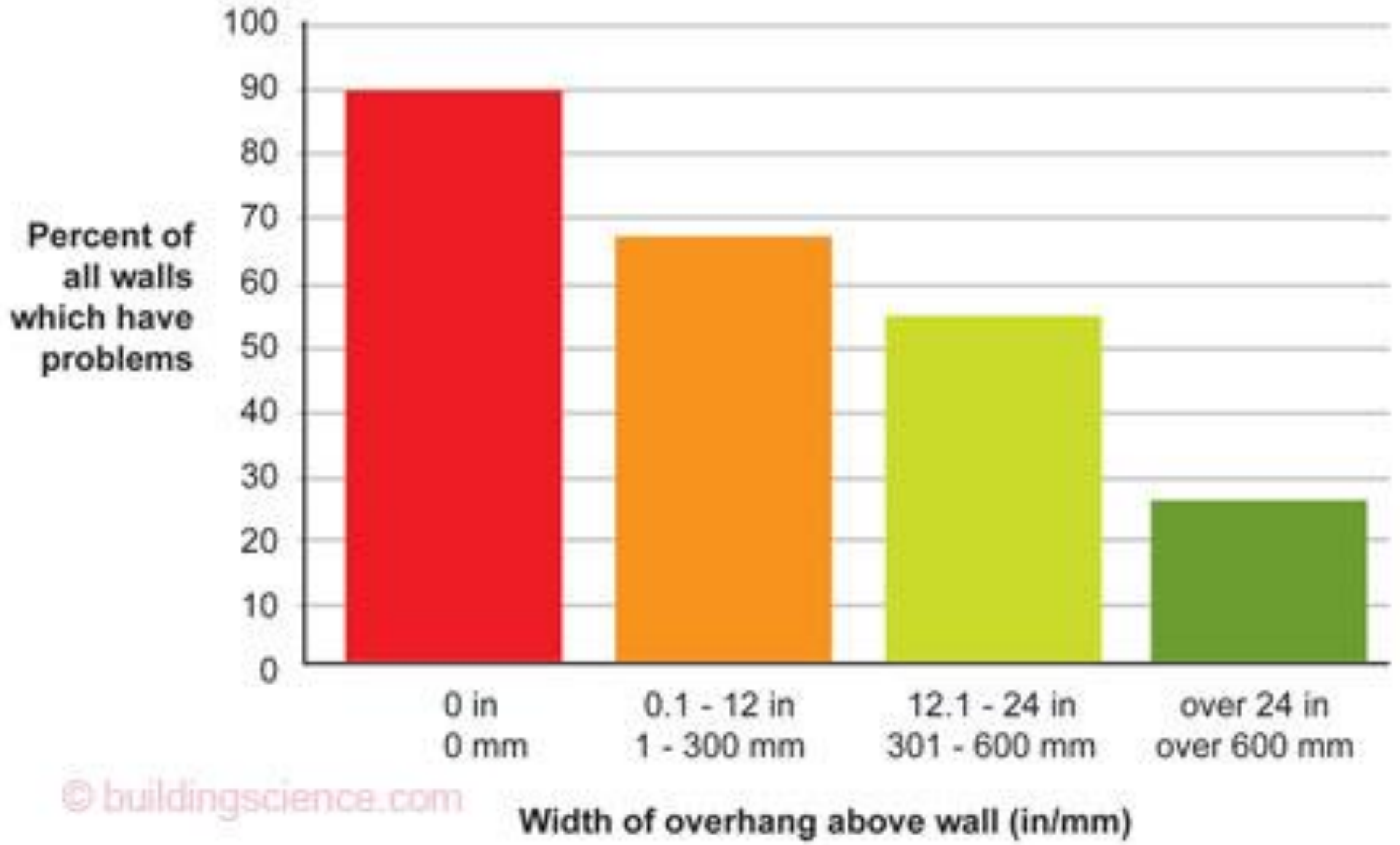
- EEBA (Energy & Environmental Building Association™) Water Management Guide by Joseph W. Lstriburek, Ph.D., P.eng. June 2004.

Deflection works! The forgotten art of “The Overhang”

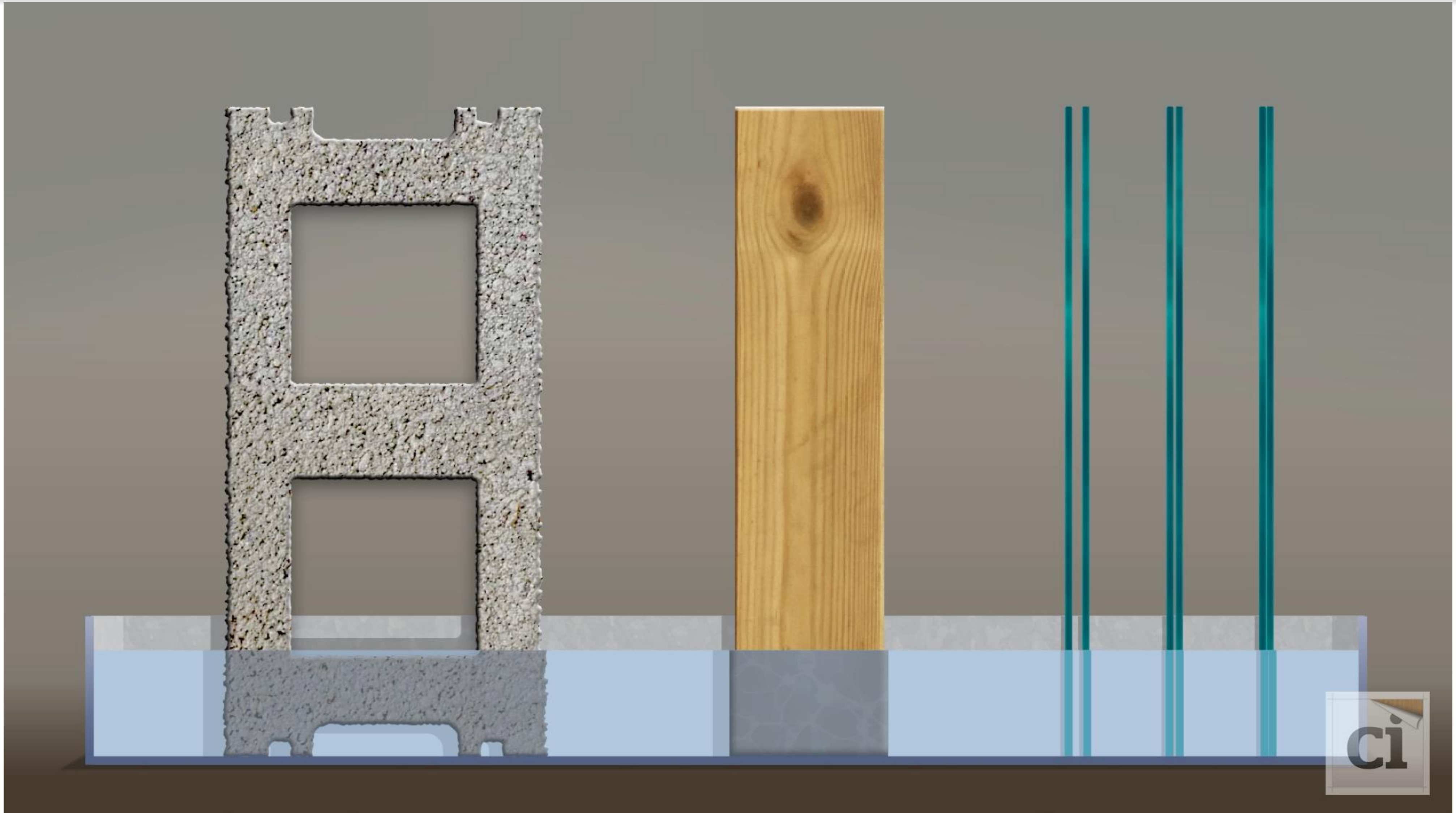
Overhangs + Proper Drip edge = Durable assembly!



Deflection works! The forgotten art of “The Overhang”



Capillary Flow

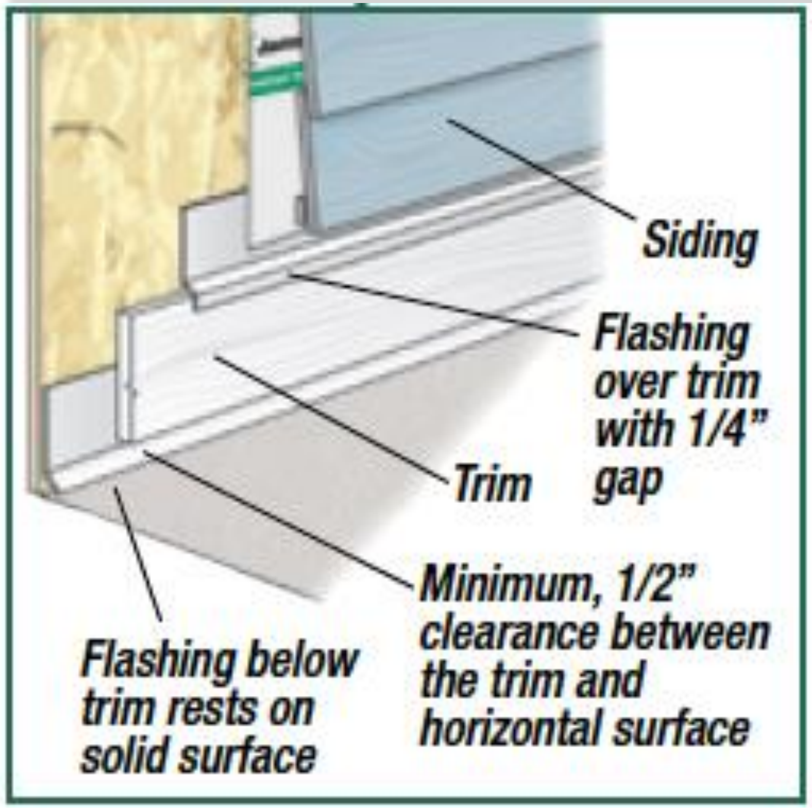


Capillary Flow

- Wood & concrete wick water
  - In wood water can climb in excess of 300 ft!
  - In concrete water can climb in excess of 1,000 ft!

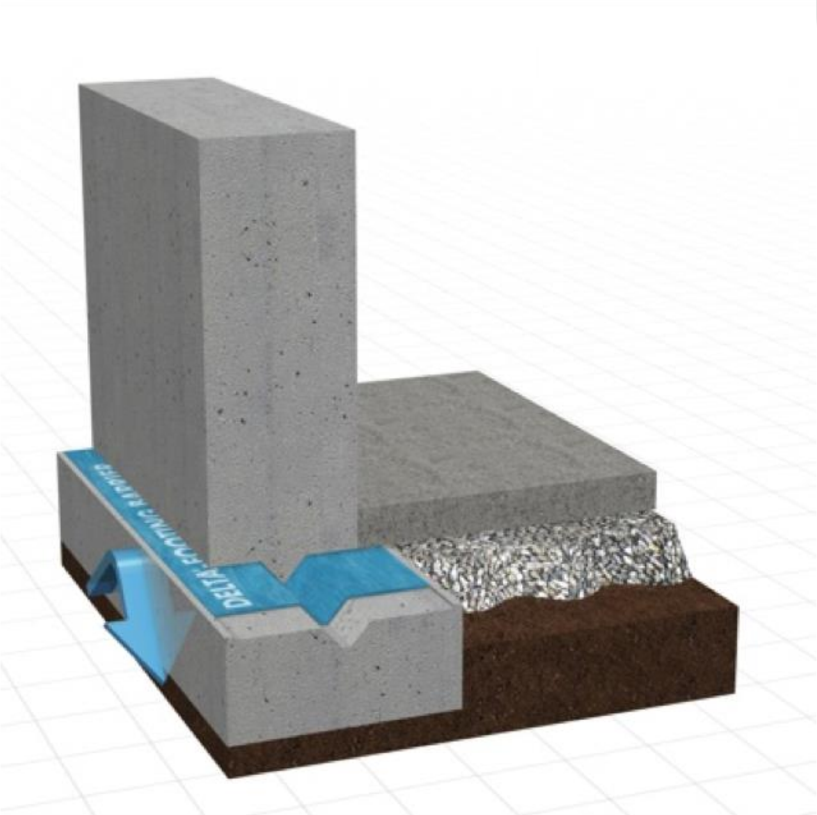
Capillary Flow

There are 2 ways to manage capillary flow



Create 1/4” to 1/2” gaps

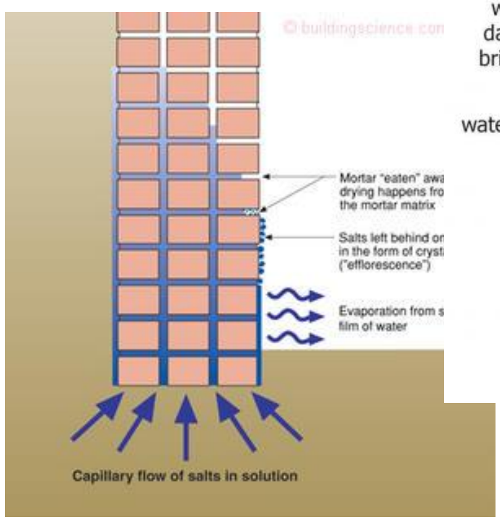
There are 2 ways to manage capillary flow

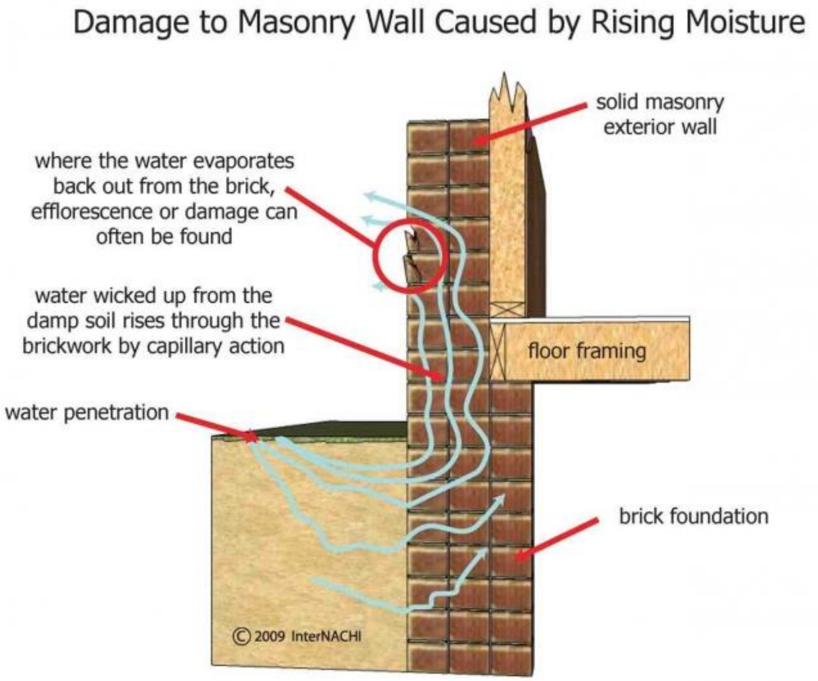


Use capillary break materials

Historical lessons: Why some masonry walls fail (and why parging isn't just lip-stick!)

Insulating the interior of the basement with low-perm insulation may change the drying profile of the wall



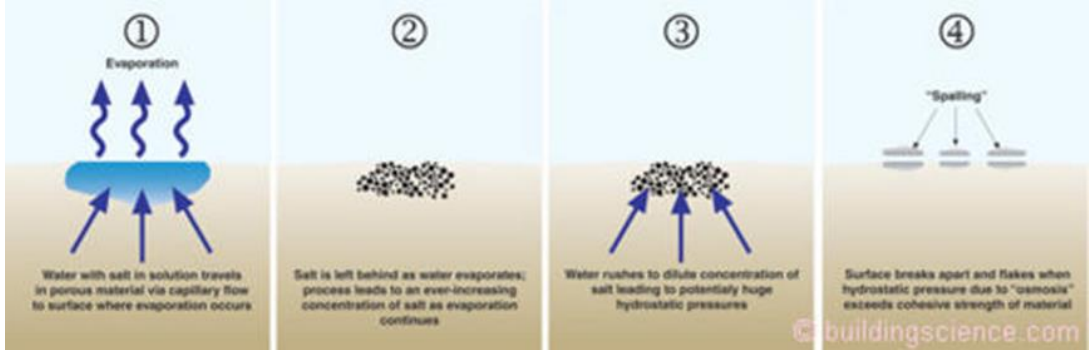


Link: https://www.buildingscience.com/documents/insights/bsi-011-capillarity-small-sacrifices

Courtesy buildingscience.com

Historical lessons: Why some masonry walls fail (and why parging isn't just lip-stick!)

IF foundation is still "connected" to soil(with water and salts), capillary action can lead to sub-fluorescence.

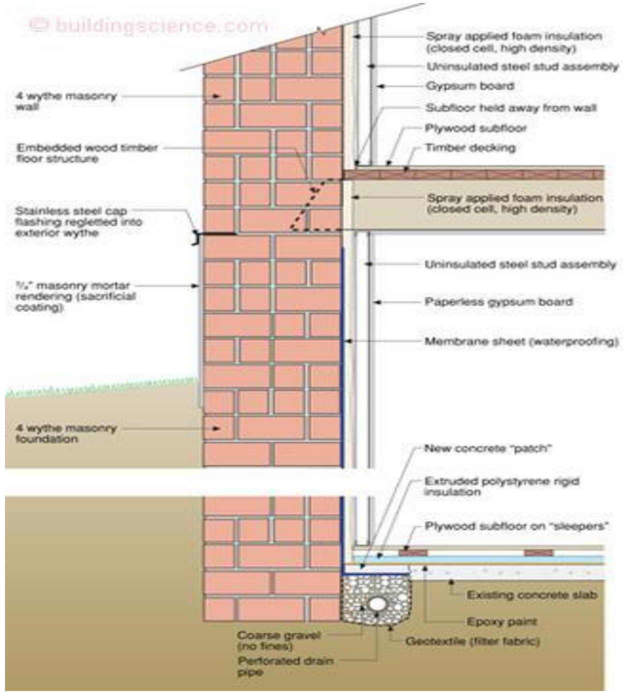


Spalling of porous materials—Without salt present evaporation of water from porous surfaces can often be easily managed—with salt present significant damage can occur.

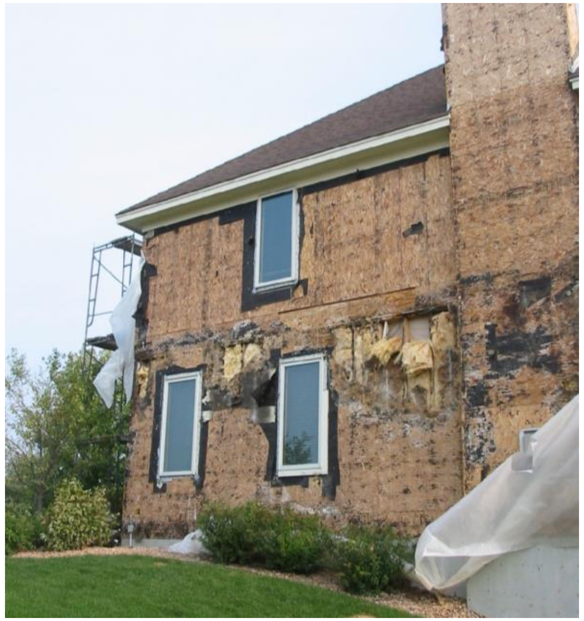
Courtesy buildingscience.com

Rubble, Brick, CMU(and solid –pour) existing foundations :Parging may be critical critical

Parging –Sacrificial coatings have preserved buildings for years!



Courtesy
buildingscience.com



This is air leakage

This is air leakage

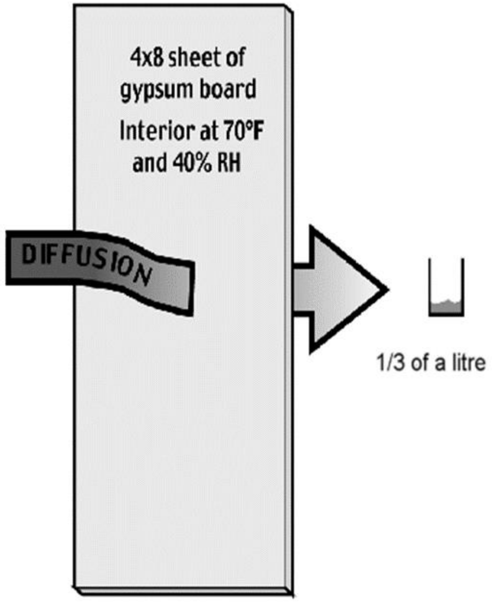
This is air leakage

Lessons we need to remember…

Air Barriers became part of North American Building Codes because of this….(not because it saved energy)

IN THE EARLY 1900'S WE SAW A NEED FOR VAPOR BARRIERS…

- Migration of moisture by means of **vapour pressure differential**
- Occurs in either direction based on climate conditions and interior levels of humidity
- A small amount of moisture movement
- ACCOUNTS FOR LESS THAN 2% OF ALL WATER IN ENCLOSURES.



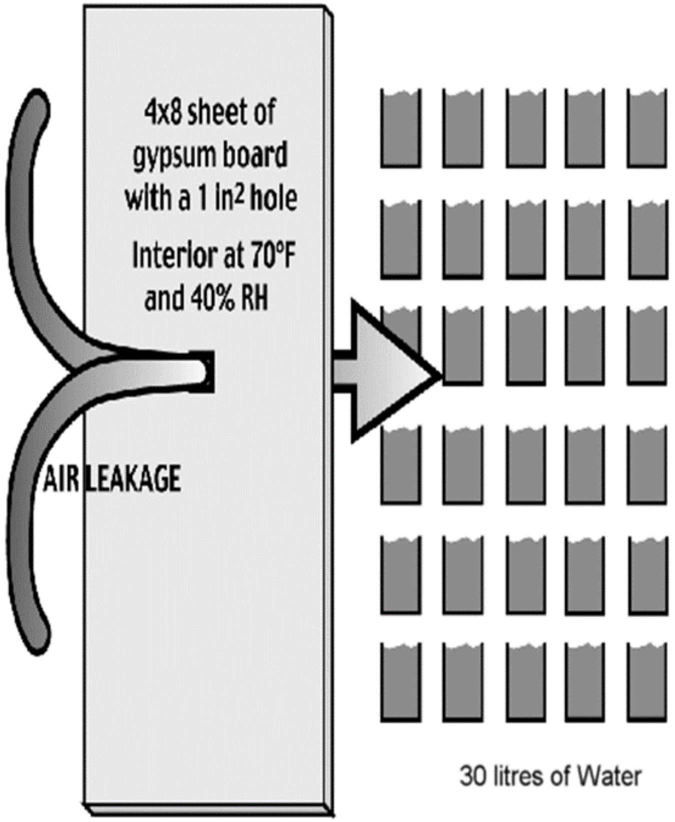
IT TOOK UNTIL THE 1970'S FOR US TO FIGURE OUT IT WAS THE AIR BARRIER THAT REALLY MATTERS.

Air Leakage

- Moisture flow through a 1in² hole by air leakage

Flow quantity

- 30 liters over the heating season
- A more significant flow



Air barriers are far more important than vapor retarders in most cases

AIR BARRIER / MOISTURE MOVEMENT BY AIR LEAKAGE

Why were AIR BARRIERS adopted by North American and Canadian building codes in the early 80’s?….

Air tightness is tied to insulation levels

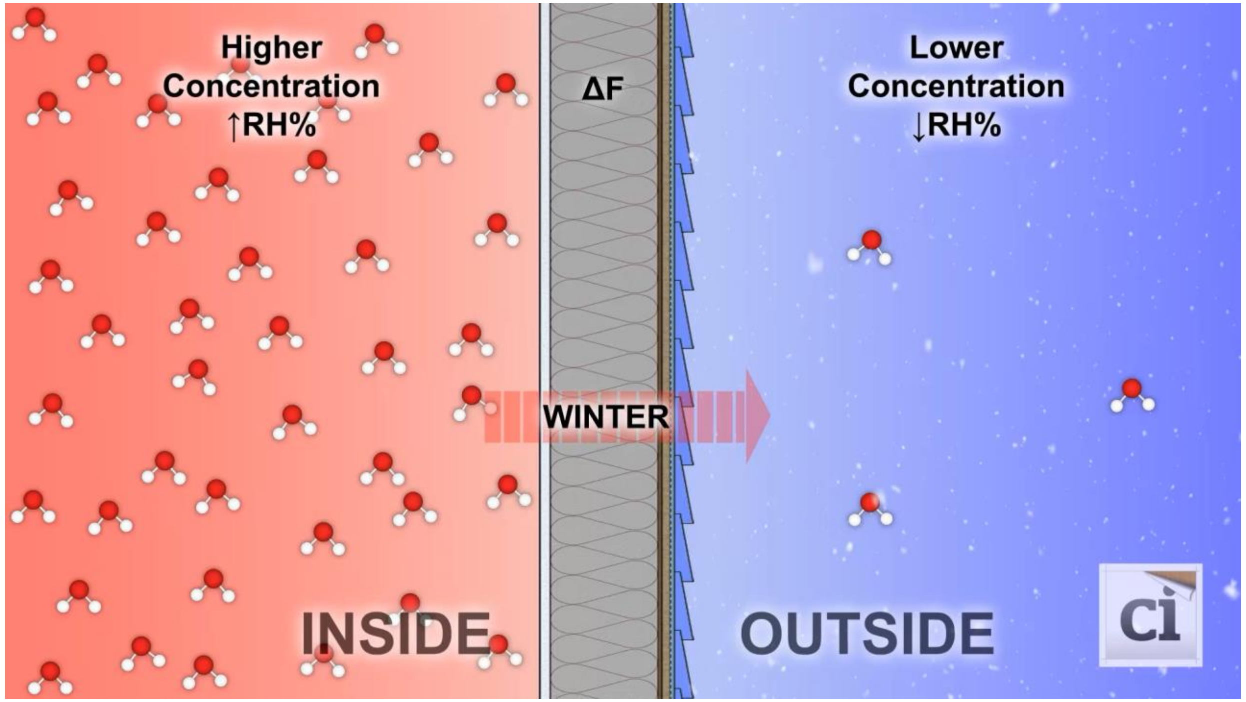
More insulation

=

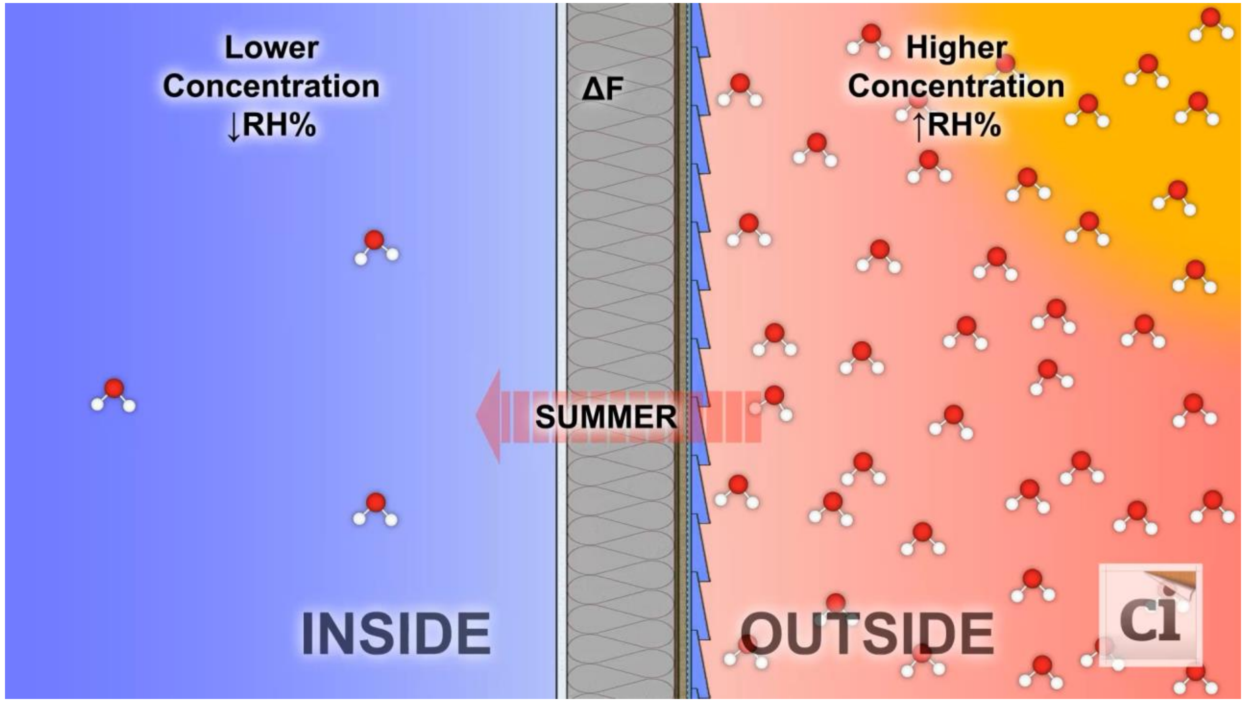
Less Drying Potential and

Colder surfaces

Vapor Diffusion is Complex



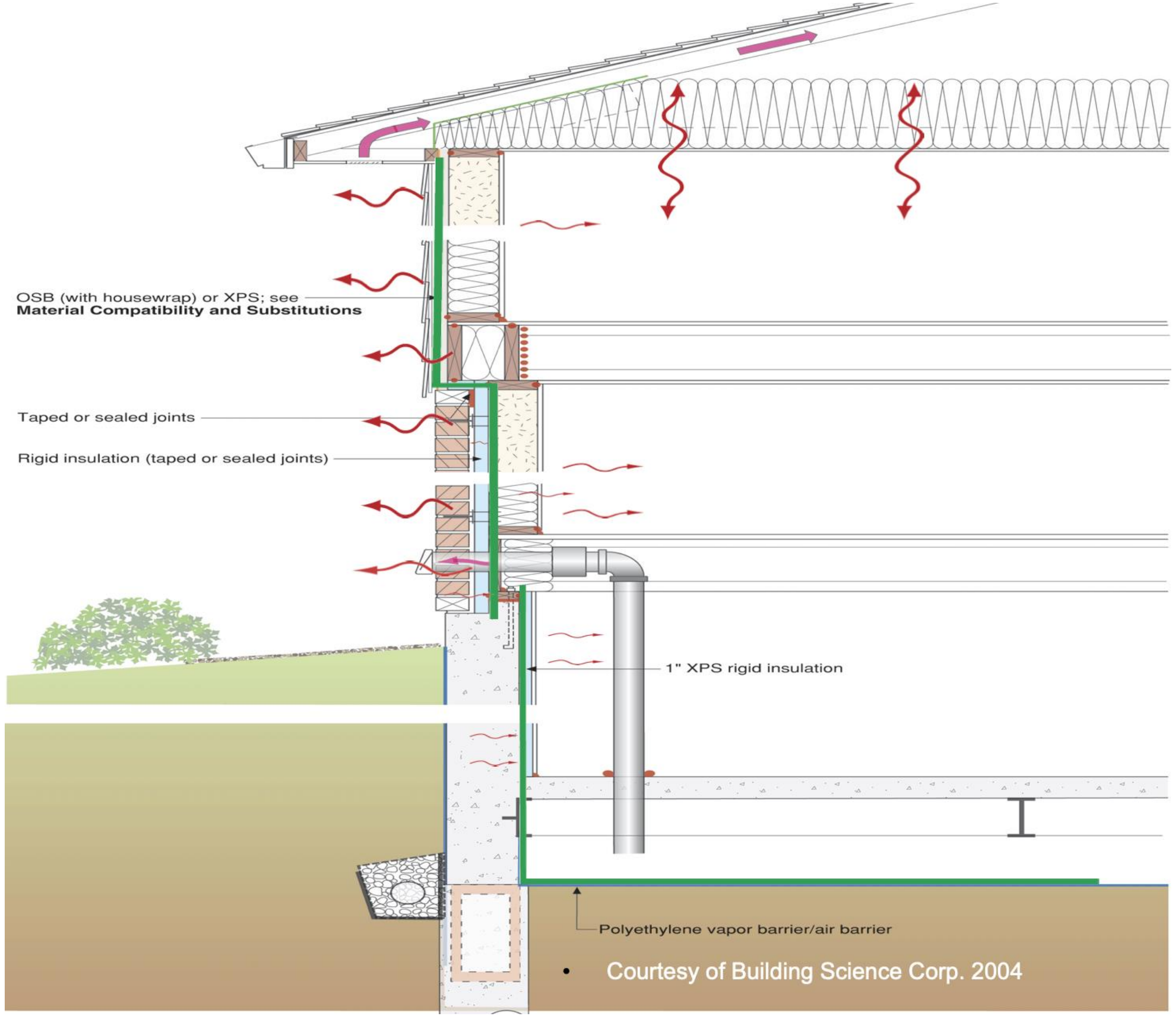
Winter



Summer

Vapor Diffusion

- Diffusion is a “weak” wetting mechanism
- …But It can be a useful drying mechanism



Quick review

- Increasing levels of insulation reduces the drying potential of assemblies (walls, roof, floors)
- Walls do not “breathe,” but they do need protection from liquid water (rain) and interior condensation due to air leakage and cold condensing surfaces.
- Low permeability exterior insulation can be used as long as it is enough- e.g. the in-board/out board insulation levels are appropriate.
- Limiting air infiltration - making walls ”tighter”; **reduces potential moisture** damage inside walls.
- The 2 predominant sources of moisture in enclosures comes from rain water/exterior water and air leakage, not vapour diffusion.

The Physics of Buildings

- Moisture moves from more to less
- Moisture moves from warm to cold
- Heat flows from warm to cold
- CFM (air) out equals CFM (air) in
- Heat, air & moisture are one
- Drain the rain
- Things always get wet - let them dry
- All the action happens at the surface

End of module One

- End of Module One
- In the next segment:

NOW THAT WE KNOW THE BUILDING SCIENCE BASICS....

We can begin to create walls, roofs and foundation systems that work