Constructing Exterior Walls to Avoid Moisture Infiltration

Building Science Northeast
Building Envelope Systems ®

What you'll learn today

- **The Evolution of Residential Wall Construction**
- **The Function of the Building Enclosure**
- **Residential Building Design Principals & Benefits**
- **Membrane Systems To Manage Air, Moisture & Water**
- **Current Codes**
- **CONTINUOUS AIR BARRIER DISCUSSION**

Expectations of Performance, Design and Construction of the Residential Wall Assemblies are rapidly evolving!

Manufactured building materials used today are less tolerant of water, vapor and wet/dry cycling.

The Evolving Residential Wall

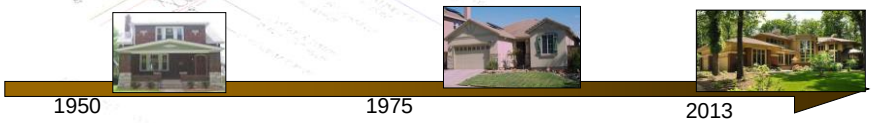
- **Introduction of Thermal Insulation**
- **Development of Tighter Building Enclosures**
- **Forced Air Heating and Cooling Systems**
- ***Sheet applied continuous air barriers***

The Evolving Residential Wall

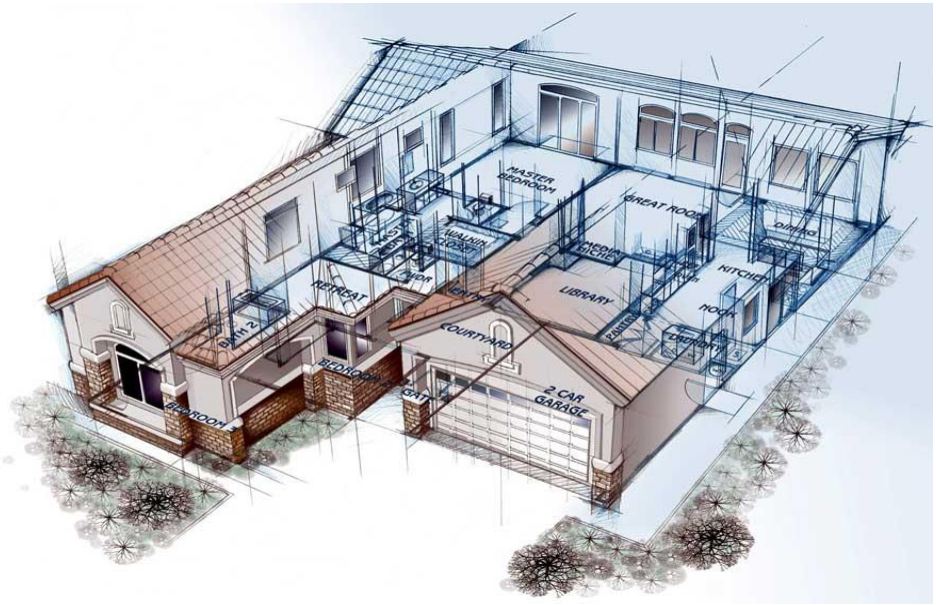
Integration of Building Systems

- First we added insulation for comfort
- Then, as our budgets got tight we added more insulation and tightened up the house
- ***Building materials need to dry out*** and fresh air needs to be exchanged
- **Build it TIGHT but vent it RIGHT**

Building Enclosures are sophisticated, high performance buildings operate intelligently and must be treated as integrated systems that address health, safety, durability, comfort and affordability.



The Building Enclosure



The Building Enclosure

The Building Enclosure must:

- **Handle positive and negative air pressure loads**
- **Keep heat in during the winter**
- **Keep heat out during the summer**
- **Keep rain water out**
- **Control vapor diffusion**
- **Let rain water & vapor out; if it gets in**

The Building Enclosure

The Building Enclosure Facts:

- ✓ Air Flow is the result of air temperature differences
- ✓ The velocity of Air Flow is the result of wind and mechanical ventilation
- ✓ **Air Flow transports *more* moisture than vapor diffusion**
- ✓ Airborne moisture causes condensation in walls and roof spaces.
- ✓ Vapor diffusion is the result of vapor pressure differences
- ✓ The Building Enclosure needs to dry-out

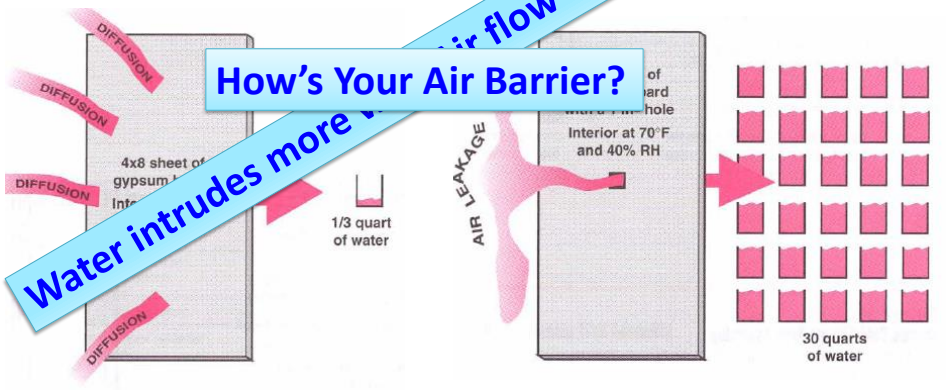
The Building Enclo

Vapor Diffusi… …Leakage

Vapor diffusion is acceptable, Building materials… …thermic,
Air leakage causes conde…

How's Your Air Barrier?

Water intrudes more … air flow than Vapor diffusion



The Building Enclosure

DESIGN CONCEPTS

Managing Air Flow with Air Barrier CAN:

✓Save Energy

✓Save $$

✓Avoids Moisture Transfer

✓Avoid Damage

So...

What's an **Air Barrier**? Are they all the same?

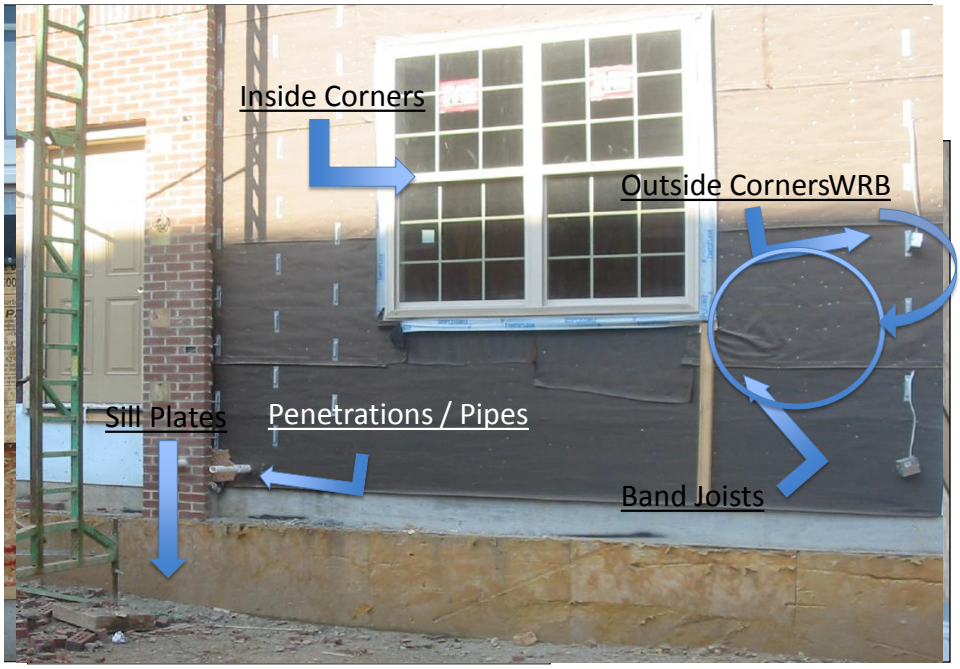
What's a **Continuous Air Barrier System**?

Where do **Continuous Air Barriers** GO?

(1) ASHRAE 189 STANDARD FOR THE DESIGN OF HIGH PERFORMANCE GREEN BUILDINGS, MODEL CODE – SUSTAINABILITY FOR COMMERCIAL BUILDINGS REQUIRES A CONTINUOUS AIR BARRIER FOR IMPROVED ENERGY SAVINGS.

(2) DOE & AIA HAVE CONCLUDED THAT 40% OF ENERGY USED TO HEAT & COOL OUR BUILDINGS IS WASTED THROUGH AIR SEEPAGE.

IMPACTFUL INDUSTRY STATEMENTS



*Richard Duncan, Ph.D., P.E., Honeywell & Roger Morrison, P.E., NCFI - American Chemistry Council & Spray Polyurethane Foam Alliance, "Effects of Air Infiltration and Mean Temperature on the Thermal Performance of Insulated Frame Wall AssembliesEffects"

DESIGN FEATURE
Manage Air Flow

The Building Enclosure

DESIGN CONCEPTS

Managing Air Flow with Air Barrier CAN:

✓Save Energy

✓ Save $$

✓ Avoids Moisture Transfer

✓ Avoid Damage

What's an Air Barrier? Is it continuous?

- **Exterior sheathing boards** Nailed to studs, no joint treatment.
- **I/S gypsum sheathing boards** Nailed to studs, numerous penetrations.
- **House Wraps** Loosely laid, Nailed to studs, not sealed at top or bottom
- **Heavy duty polyethylene**

The Building Enclosure

DESIGN CONCEPTS

Manage Air Flow: Design an Airtight Building Enclosure

✓ **Saves Energy $$, Avoids Moisture Transfer & Damage**

What's a Continuous Air Barrier System?

Where Does It GO?

The answer lies in the insulation…

The Building Enclosure

DESIGN CONCEPTS

Manage Heat Flow: Design a Continuous Thermal Barrier

✓ **Reduces Heat Loss, Indoor Climate Control, Greater Comfort**

TABLE R402.1.1 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

The Building Enclosure

Physics of Heat Transfer

Manage Heat Flow: Design a Continuous Thermal Barrier

Insulation works by trapping air, dead air insulates.

Air moving through insulation is called "Wind Chill" and "Wind Washing"

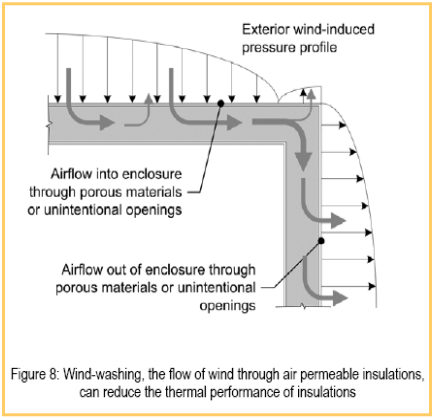
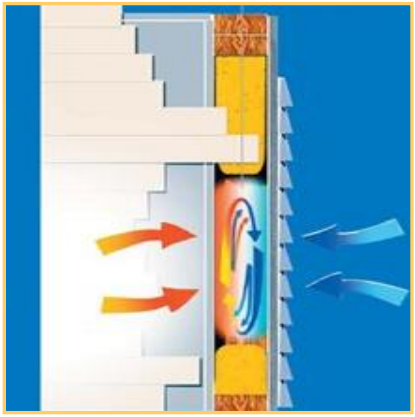


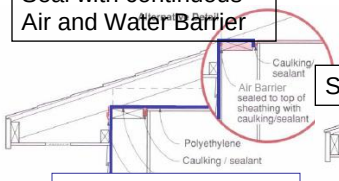
Figure 8: Wind-washing, the flow of wind through air permeable insulations, can reduce the thermal performance of insulations



The Building Enclosure

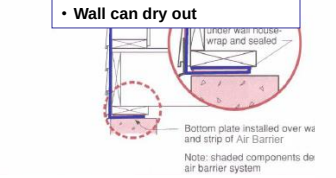
DESIGN CONCEPTS

Seal with continuous Air and Water Barrier

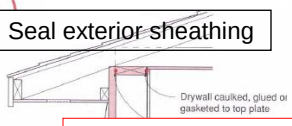


VAPOR PERMEABLE AIR & WEATHER BARRIER

- **CONTINUOUS AIR BARRIER SYSTEM**
- **Fully adhered at joints and connections**
- **Continuous WRB membrane protection**
- **Ideal for all wall types**
- **Provides Nail Seal-ability**
- **Provides drainage barrier**
- **Wall can dry out**

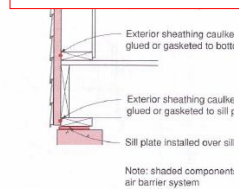


Seal exterior sheathing



DISADVANTAGES

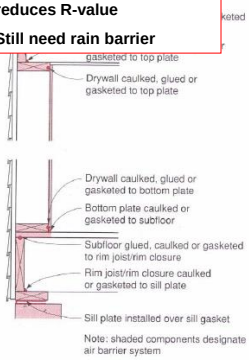
- **Requires site coordination between trades**
- **Labor to complete all seals and connections**
- **Still need rain barrier**
- **Multiple nail penetrations**
- **Need to accommodate shrinkage**
- **Wind-washing effect STILL reduces R-value**



Seal interior gyp board

DISADVANTAGES

- **Labor to complete all seals and connections**
- **Wind-washing effect reduces R-value**
- **Still need rain barrier**



DESIGN FEATURE – Manage Air Flow

Documented Benefits of Air Barriers

NAHB Study

"Wall Study About Heat Flow—R-Value Not The Whole Story"
By Craig Drumheller, NAHB Research Center
http://www.americanchemistry.com/s_greenbuilding/drumheller/drumheller.htm

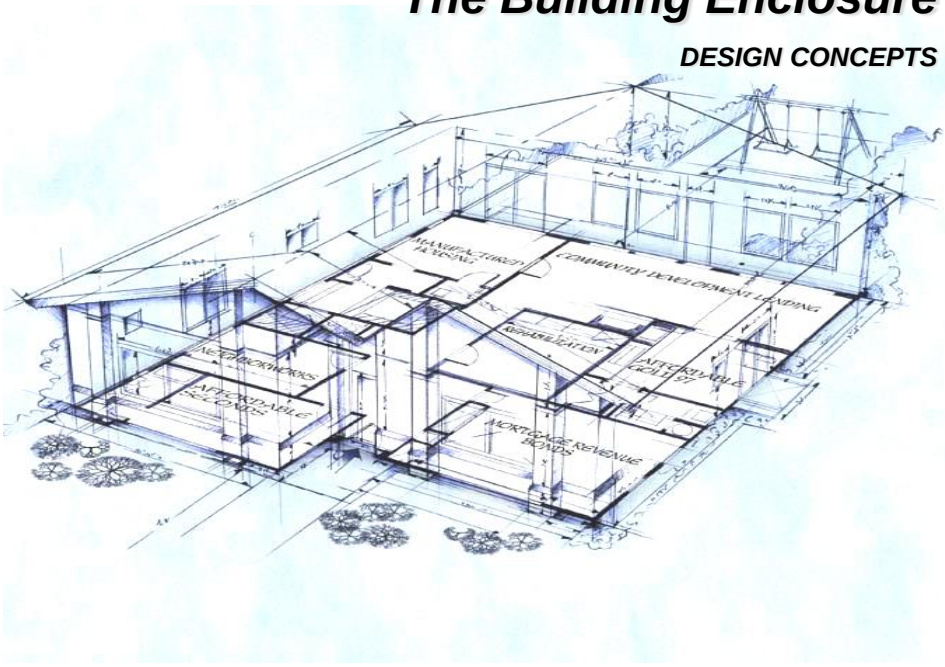
Concluded that various wall assemblies performed equally in various temperatures with no wind – however with mild wind loading, walls with plastic based air barrier components performed 14% to 29% better than base wall assemblies.

National Institute of Standards and Technology
NIST
...working with industry to foster innovation, trade, security and jobs

National Institute of Standards and Technology (NIST) 2005 report quantifies benefits of an Air Barrier System to save up to 36% of HVAC energy use based upon national blended average costs

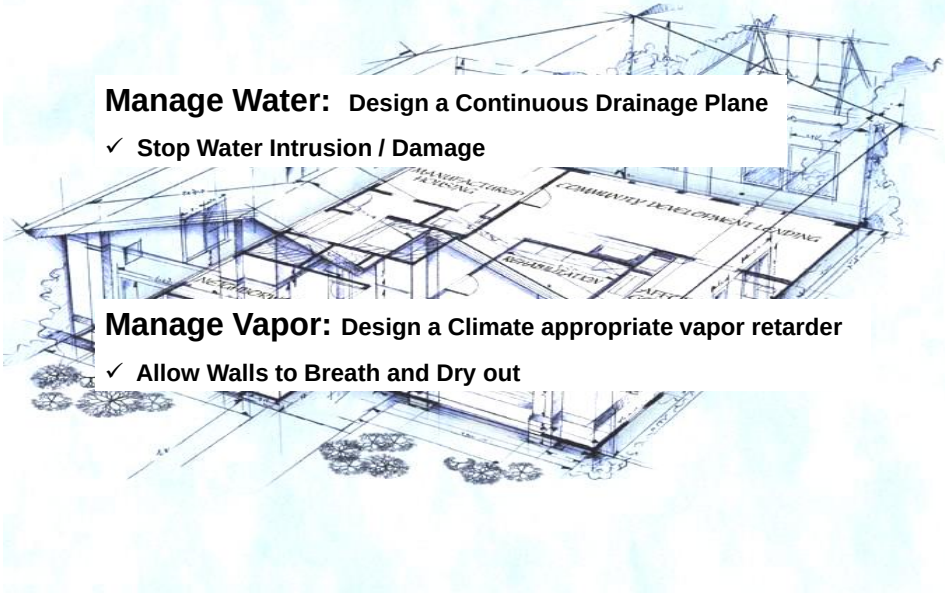
The Building Enclosure

DESIGN CONCEPTS



The Building Enclosure

DESIGN CONCEPTS



Manage Water: **Design a Continuous Drainage Plane**

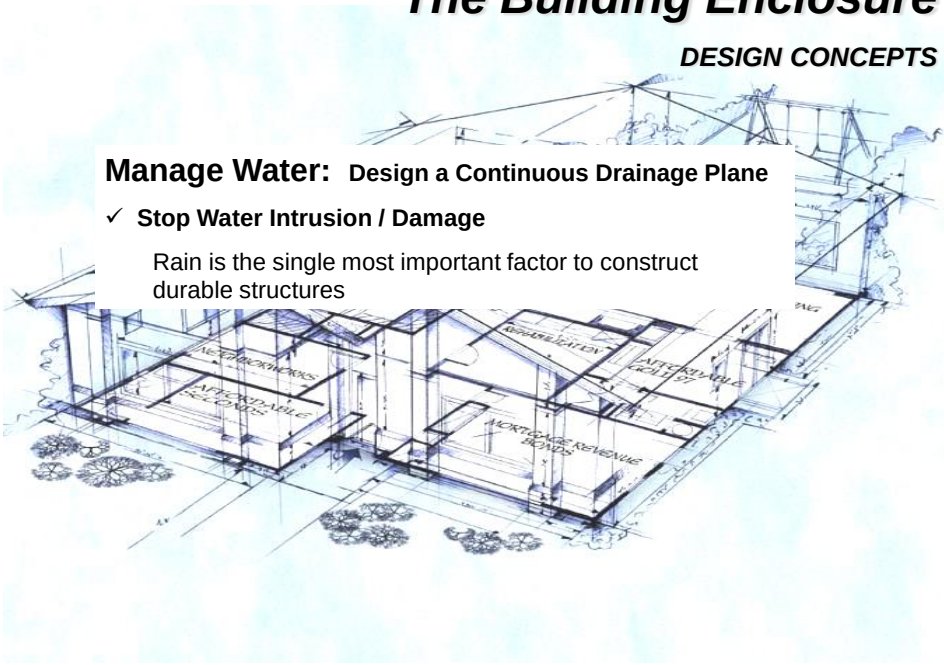
- ✓ **Stop Water Intrusion / Damage**

Manage Vapor: **Design a Climate appropriate vapor retarder**

- ✓ **Allow Walls to Breath and Dry out**

The Building Enclosure

DESIGN CONCEPTS



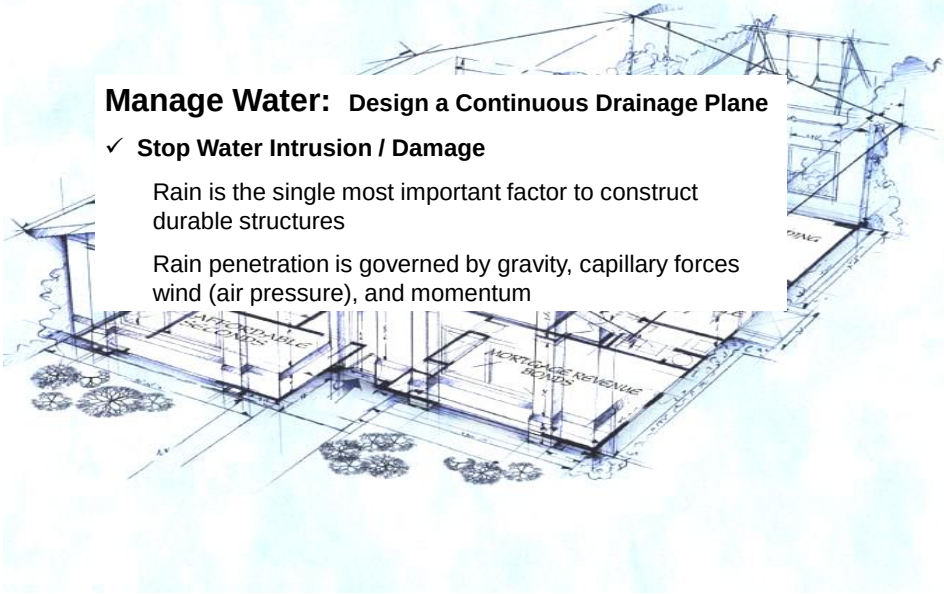
Manage Water: **Design a Continuous Drainage Plane**

- ✓ **Stop Water Intrusion / Damage**

  Rain is the single most important factor to construct durable structures

The Building Enclosure

DESIGN CONCEPTS



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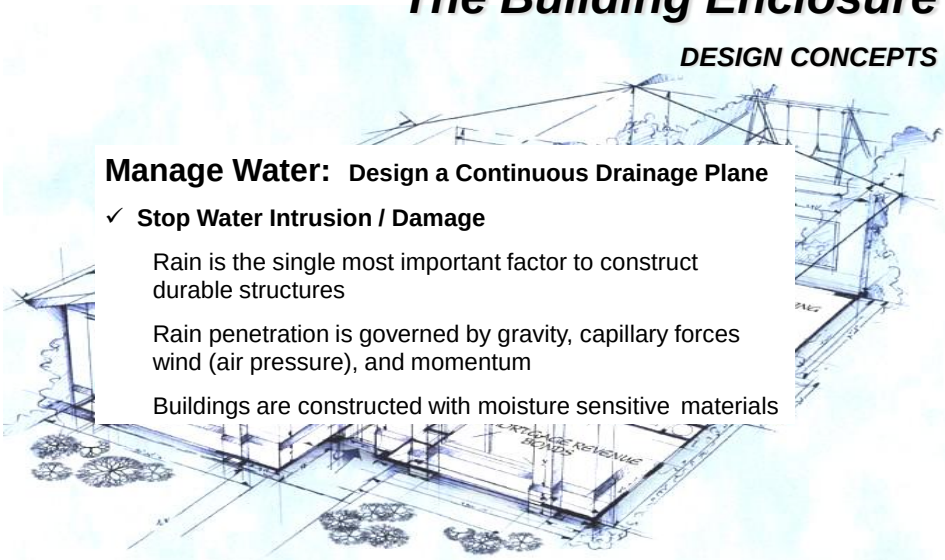
  Rain penetration is governed by gravity, capillary forces wind (air pressure), and momentum

The Building Enclosure

DESIGN CONCEPTS



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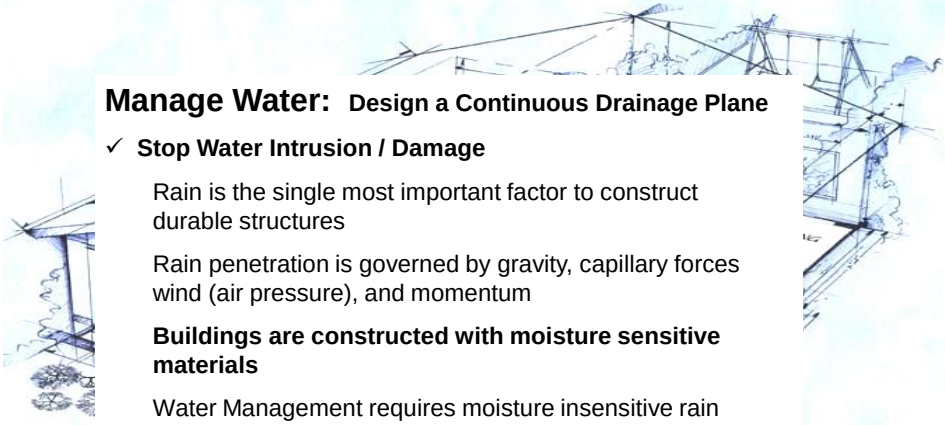
  Buildings are constructed with moisture sensitive materials

The Building Enclosure

DESIGN CONCEPTS



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  Rain is the single most important factor to construct durable structures

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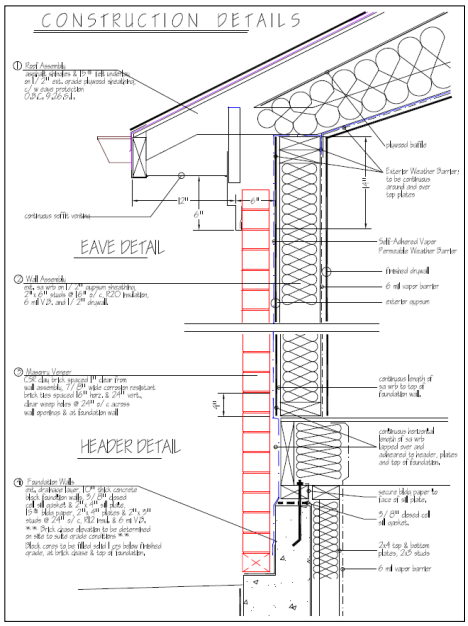
  Buildings are constructed with moisture sensitive materials

  Water Management requires moisture insensitive rain barriers with measures **designed to drain and dry the cavity**

The Building Enclosure



DESIGN CONCEPTS

Water Management:

Design a Continuous Drainage Plane

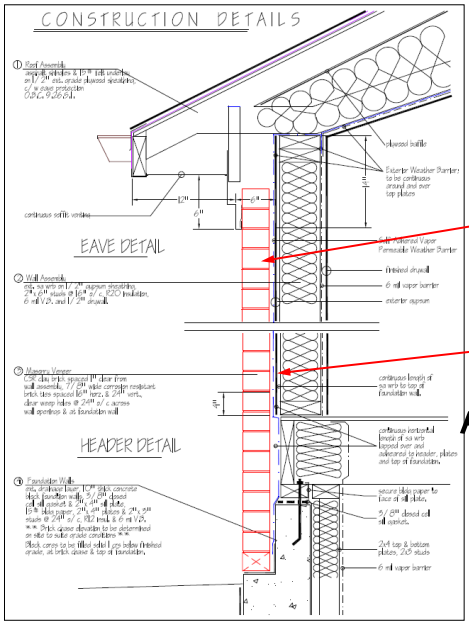
Rule #1: all claddings leak.

Rule #2: see Rule #1

Rule #3: caulking alone is cosmetic

Rule #4: let the water out

The Building Enclosure



DESIGN CONCEPTS

Water Management:

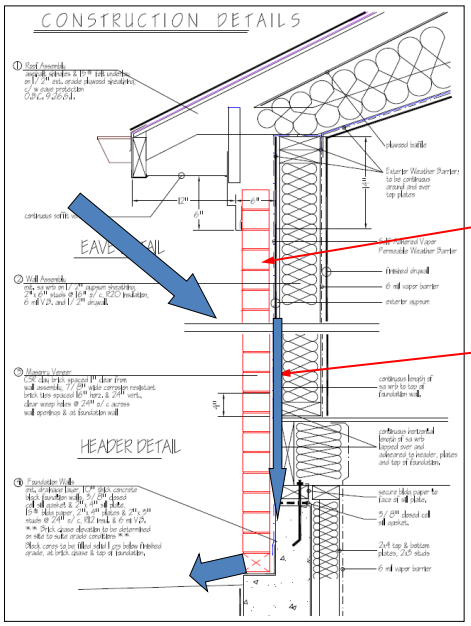
Design a Continuous Drainage Plane

Primary water shedding membrane

Secondary water shedding membrane
(Water Resistant Barrier)

Permeable or non- permeable?

The Building Enclosure



DESIGN CONCEPTS

Water Management:

Design a Continuous Drainage Plane

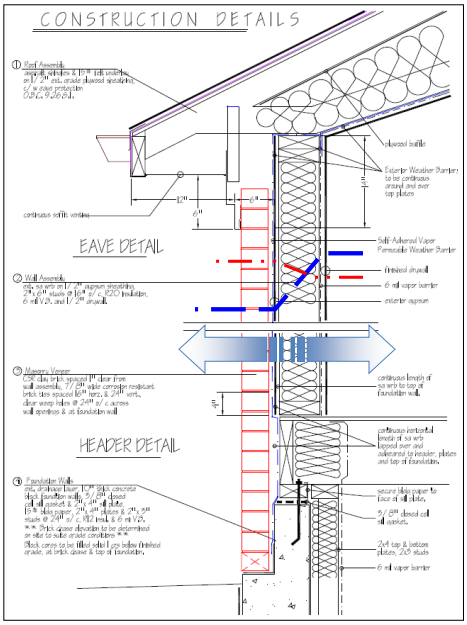
Primary water shedding membrane

Secondary water shedding membrane
(Water Resistant Barrier)

Vapor Permeable Rain Barrier

The drainage plane is interconnected with the flashings, windows, doors and other penetrations of the ***Building Enclosure***

The Building Enclosure



DESIGN CONCEPTS

Manage Vapor:

Use Climate appropriate vapor retarder
Allow Walls to Breath and Dry out

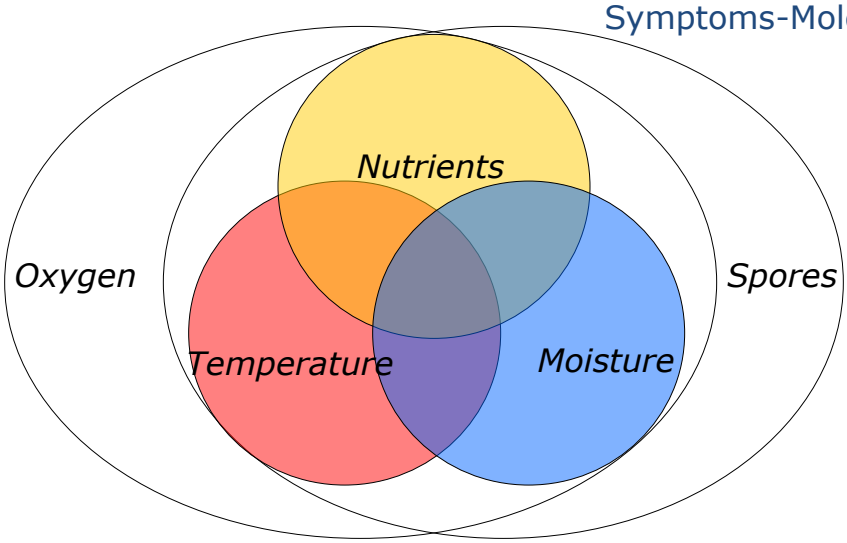
What is vapor, where does it come from?
What is relative humidity?

Relative humidity is the measurement of the amount of moisture an given air temperature can hold.

Vapor diffusion is acceptable,
Building materials are Hygrothermic,
Air leakage causes condensation!

Uncontrolled Air Leakage

Symptoms-Mold



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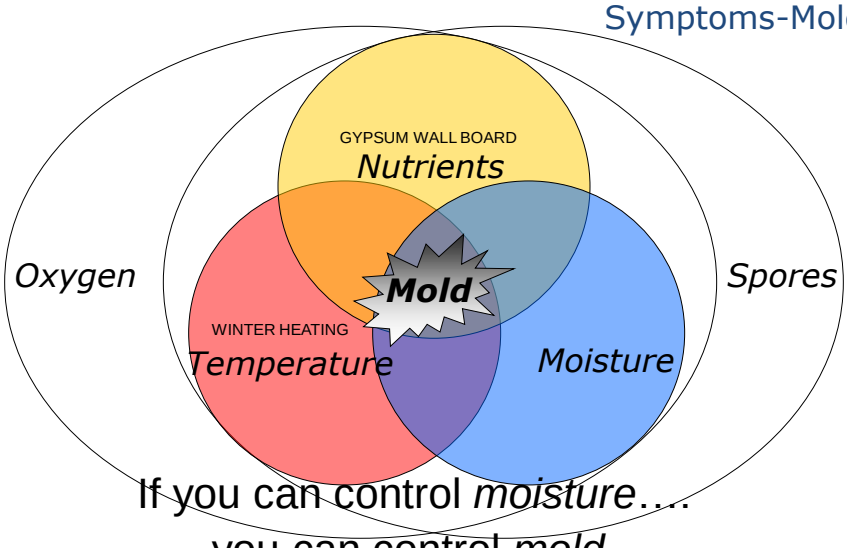


If you can control *moisture*….
you can control *mold*.

The Building Enclosure

Air-Bourne Moisture Causes Condensation

The Building Enclosure

Air-Bourne Moisture Causes Condensation

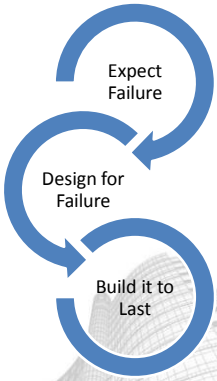
Design for Failure

Designing for failure means…..

Design for the Worst Case Conditions

Design a continuous plane of air & rain control

Design a complete load transfer path



Single-Source is best Solution

The Evolving Residential Wall

Solutions to Managing Air Flow, Heat Flow & Water

Performance Comparison Air Barrier Systems

	Water Resistant Barrier	Rain Screen	Vapor Permeable	Class A Fire Resistance	Air Barrier System	Integrated Component System	ASTM D-1970 Nail-Sealability
Fluid Applied Membranes	√	√	√	√	√	√	**Some**
Sheet Applied Continuous Air Barrier	√	√	√	√	√	√	**Some**
House Wrap**	√	√	√	√			
Building Paper	√	√	some				

***** with typical mechanically attached installation methods***

Brace yourself for Code Discussion

The Evolving Residential Wall

Managing Air Flow, Heat Flow & Water

What are the regulations?

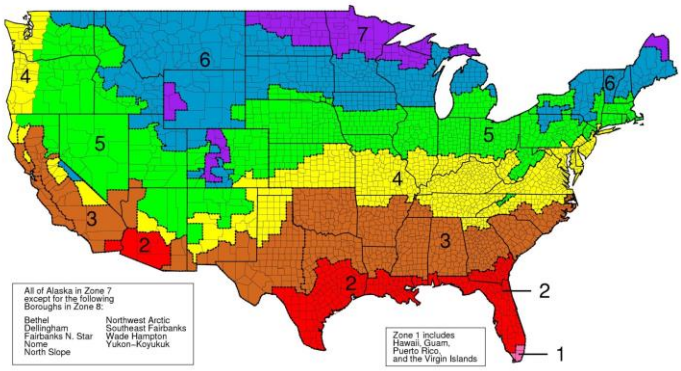
Building Code

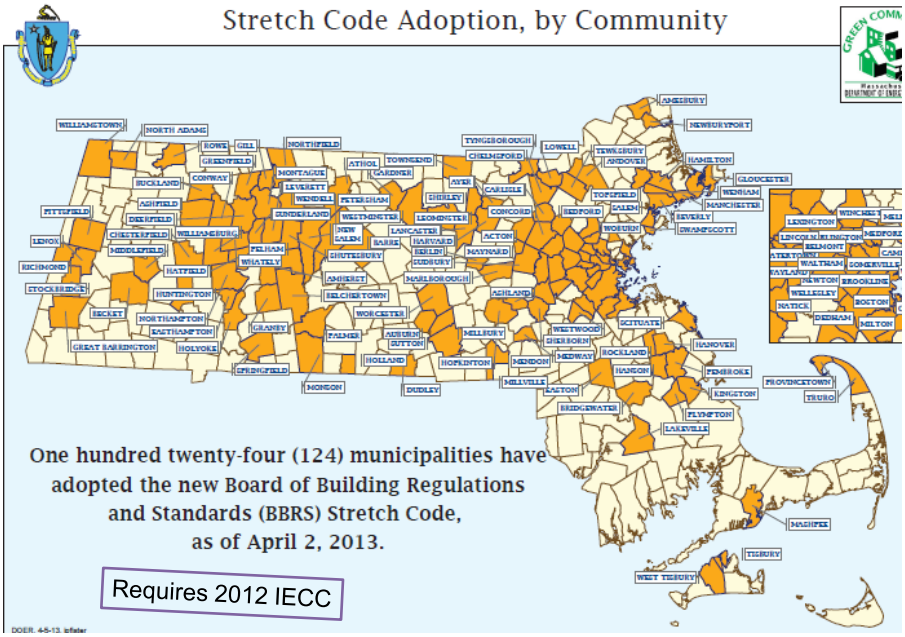
- Minimum performance of the Building Envelope
- Regulate issues related to energy conservation
- Increase thermal performance
- Prevent uncontrolled air leakage

Understand the Building Science of current Technology

……. step out of the box!

2012 IECC Air Barrier Requirements





STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
Department of Administration
BUILDING CODE COMMISSION
One Capitol Hill
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Roland J. Risser
Building Technologies Program Manager
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Avenue SW, Mail Stop EE-2J
Washington, DC 20585-0121

July 30, 2013

RE: State Certification of Residential and Commercial Building Energy Codes

Dear Mr. Risser:

In compliance with Title III of the Energy Conservation and Production Act (ECPA) of 1976, as amended, this is to certify that the State of Rhode Island has adopted the 2013 Rhode Island Energy Conservation Code, which references ICC International Energy Conservation Code the 2012 version of the International Energy Conservation Code (IECC) for low-rise residential buildings, as well as ASHRAE Standard 90.1- 2010 for nonresidential buildings. The code was advertised and a public hearing was held on May 15, 2013. The code became effective on July 1, 2013.

I would like to note that funding from the U.S. Department of Energy is critical for implementation efforts of the 2013 Rhode Island Energy Conservation Code possible. It is our hope that support from DOE will continue to ensure demonstrated compliance with the code in the State of Rhode Island, and encourage future updates to the code.

If anything further is required as evidence of Rhode Island's compliance with the requirements of Title III of ECPA, please advise John P Leyden State Building Code Commissioner at 401-222-3529.

Sincerely,

John P Leyden
State Building Code Commissioner
State of Rhode Island

IECC 2012 Amendments

International Energy Conservation Code 2012

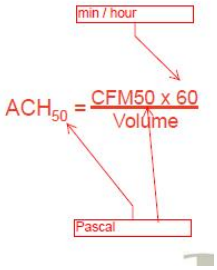
According to section R402.4.1.2 of the 2012 IECC, "The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 5 air changes per hour in Climate Zones 1 and 2, and 3 air changes per hour in Climate Zones 3 through 8.* Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals). Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope."

* All New England & Tri-State Area are Zones 4 or above.

2012 IECC Requirement

402.4.2.1 Envelope Tightness

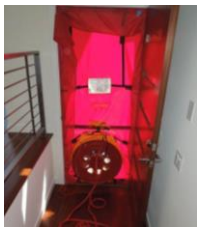
- REQUIRED Blower Door test
  - CZ1-2 Test out at less than **5 ACH_{50}**
  - CZ 3-8 Test out at less than **3 ACH_{50}**



Blower Door Test Results

Project 1 - **Unit 1** used 60 min. asphalt felt and a name brand interior spray-on air sealing material. **Unit 2** is BlueskinVP alone.

Unit 1	Unit 2
•2 Stories	•3 Stories
•1,800 ft²	•2,200 ft²
•2.6 ACH	•1.8 ACH



Project 2 - **Unit 1** used the no. 1 brand in housewrap. Next door on **Unit 2** is BlueskinVP alone.

Unit 1	Unit 2
• 1 Stories	• 1 Stories
• 1,232 SF	• 1,295 SF
• 7.35 ACH	• 1.33 ACH

DESIGN FEATURE – Manage Air Flow

REVIEW: Evolution of Wall Systems & Design

- Eliminates water intrusion behind WRB
- Minimizes fasteners/staples
- Offers nail seal-ability
- Sealed laps
- Integrated flashings
- Handles positive/negative pressure
- Self-adhered membrane or spray applied
- *Eliminates wind washing allowing for insulation to preform to installed R-Value*
- *Solution for updated & tighter Air Barrier codes*

"Of all environmental conditions, moisture poses the biggest threat to integrity and durability, accounting for up to 89% of damage in building envelopes"

Building Envelope and Environmental Control: Part 1-Heat, Air and Moisture Interactions by M.T. Bomberg and W.C. Brown, "Construction Canada" 35(1) 1993, p. 15-18

The Evolving Residential Wall

Managing Air Flow, Heat Flow & Water

Avoid Moisture Infiltration

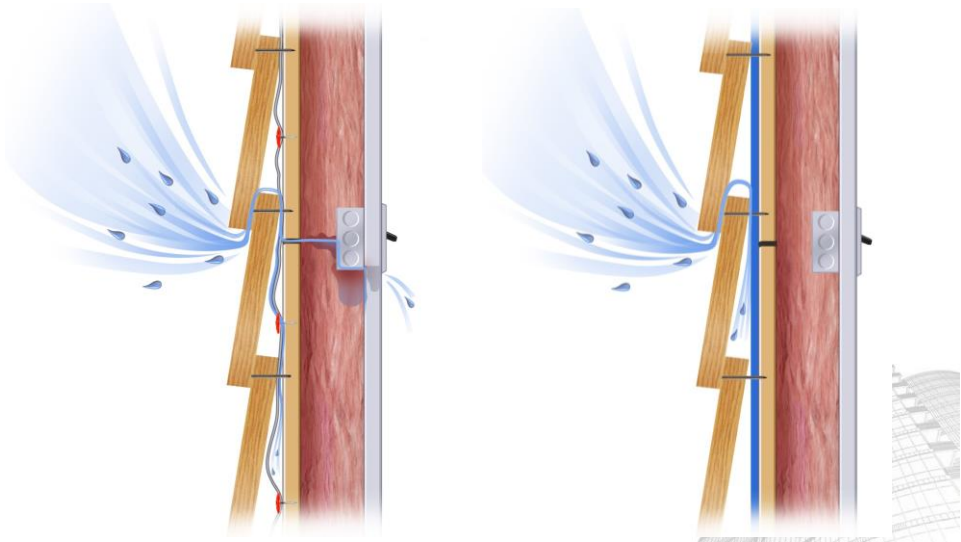
- Evolve to todays fully-adhered air barrier
- What are client's or town's demands?
- Increase your customer's comfort
- Reduce energy waste ($)
- Well Written Specifications
- Rely on a manufacturer you trust!

Thank You!

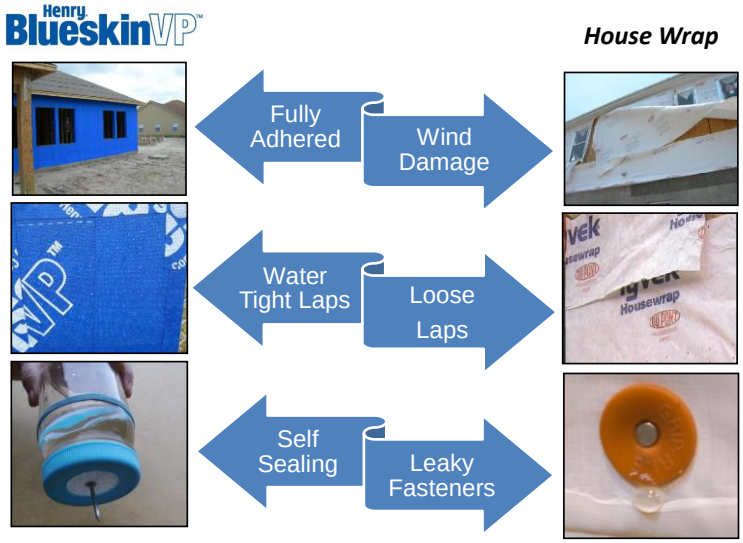
This concludes the AIA portion of the presentation

Henry. BlueskinVP™

Fully Adhered or Mechanically Attached



Which would you and your client prefer?



Traditional solution to a new problem

The Evolving Residential Wall

Managing Air Flow, Heat Flow & Water

Self-Adhered Permeable Air & Rain Barrier

- ✓ **Air Tight**
- ✓ **Water Tight**
- ✓ **Weather Tight**

c meeting Water
ard

air barrier

FEATUR S

- No exposed fasteners
- Fully adhered to sheathing
- Vapor Permeability of 29 perms
- Fully water resistant
- Meets industry standards
- EZ to apply

- Continuous plane of air-tightness
- Handles positive/negative pressures
- Prevents moisture entrapment
- Functioning Water Resistant Barrier
- Complies with ICC standard AC-38, ASTM 2178, 2357, Class A Smoke & fire
- Applied with hand-tools

BlueskinVP™100

Energy Savings UP TO 50%*

Pays for itself in energy savings
BlueskinVP™100 is the next generation air and water barrier technology for wood framed construction. By choosing BlueskinVP™ 100, you protect your home, your budget and your peace of mind. BlueskinVP™100 is your best defense against the damaging effects of water and moisture intrusion while maintaining the ability of the wall to breath.

Annual Savings $384†

Starts paying back right away!

See back for more details.

* Savings off of heating and cooling costs only. Based on energy modeling.
† Based on Hot2000 Simulation, Denver, CO; for a two-story, 2,000 sq. ft. home. Based on energy modeling.

BlueskinVP™100

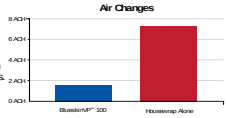
Next generation air and water barrier technology for wood frame construction

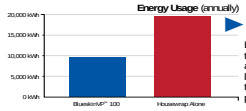
Figure 1

BlueskinVP™100 is an upgrade over traditional house wrap. However, as the comparison belo confirms, BlueskinVP™100 provides significant opportunities for energy savings that, over tim can pay for this upgrade.

The following figures were derived from actual case studies where BlueskinVP™100 was installed. ACH (air changes per hour) values were derived from experience gained in actual blower door tests. Blower door tests as seen in figure 1 provide important data such as ACH that provide accurate air leakage rates for buildings. Many building codes and high performar energy standards have come to rely on field verification to calculate the expected energy consumption of a building. There are also many comprehensive tools that can be utilized to forecast energy savings, such as energy modeling software.

Test confirms much lower air changes per hour with BlueskinVP™100 than with typical alternate approaches. Lower air changes means higher energy efficiency.





Energy modeling confi that energy use for hea and cooling is 23-50% lower with BlueskinVP™ than typical alternate a proaches.

*Based on Hot2000 Simulation, Denver, CO, for a two story, 2,000 sq. ft. home. **ACH values were derived from experience gained in actual blower door tests.
***Savings are derived from the increased air tightness only. ****Costs of upgrade and energy costs used are based on national averages.

Annual payback, $384. Savings over 30 years, $11,250!

Comparison with BlueskinVP™ 100	Housewrap Alone*
Cost of Upgrade	up to $1,830
Return on Investment	up to 4 Years
Monthly Energy Savings	up to $41
Monthly Upgrade Cost in Mortgage	up to $10
Monthly Payback	up to $32
Annual Payback	up to $384

* Costs and savings based on experience gained in actual blowerdoor tests. Costs and savings may vary based on conditions of structure, such as whether building contains existing air sealing.


JLG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Surface Preparation?