More Bang for Your Buck: Combining Thermal, Air and Water Barrier

Linda Jeng, Dow Building Solutions

2014 RESNET

Atlanta, Jan. 29, 2014

Actual high: 30°F
Actual low: 12°F

Effect of polar vortex on Atlanta, GA:

- Hundreds of cars and thousands of people stranded!

Reflections for building performance:

- Snow and icy conditions even in climate zone 3

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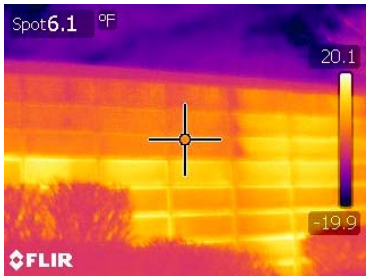
Midland, MI Jan. 22, 2014

Actual high: 12°F
Actual low: -3°F



Polar freeze led to more than just cold :

- Glass makes very poor insulators
- Relying on solar heat gain runs the risk of expensive bulk water damage from frozen pipes!

Amongst the Key Learnings:

- Insulate to prevent predictable, and expensive water damage!

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Agenda

- **Historical Background**
- Energy Codes
- What is Insulation
- Wood-frame Wall Limitations
- Why use Insulating Sheathing
- Summary
- Q&A

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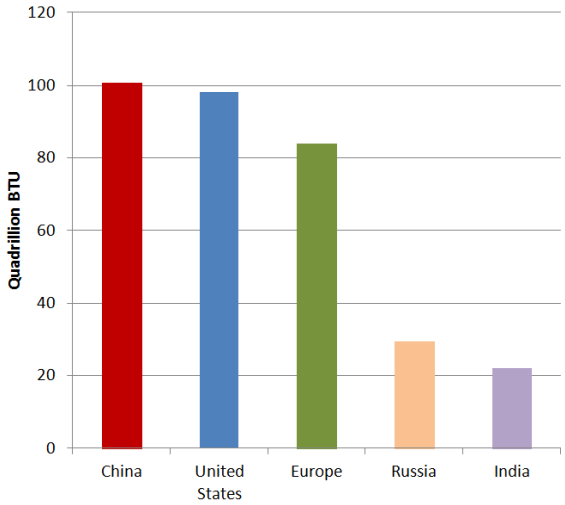
World's Top Five Energy Consumers - 2011



Source: Annual Energy Review 2011, www.eia.gov

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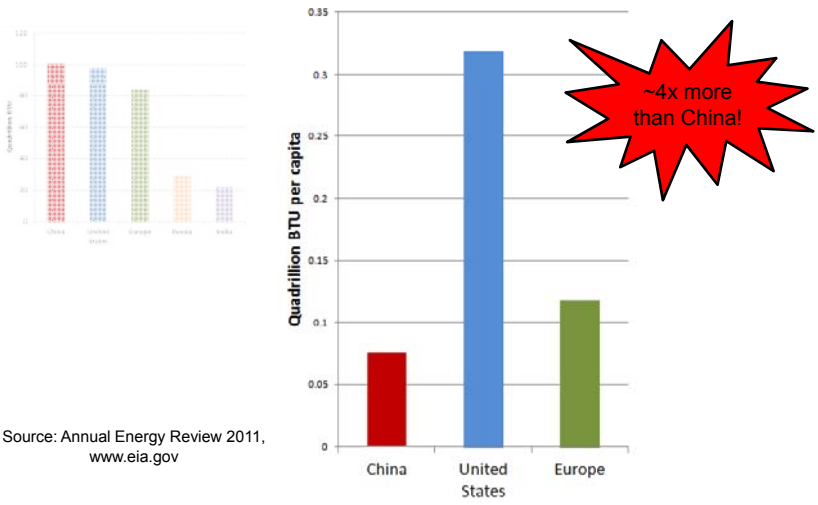
World's Top Five Energy Consumers – 2011 Per Capita



Source: Annual Energy Review 2011, www.eia.gov

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US Energy Consumption by End-Use Sector

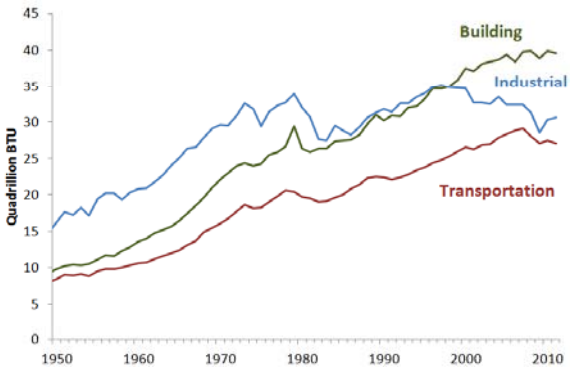
Residential Sector Energy use per capita rank:

1. North Dakota
2. West Virginia
3. Missouri
4. Tennessee
5. Kentucky

21. Michigan

25. Georgia
26. Delaware

30. Alaska



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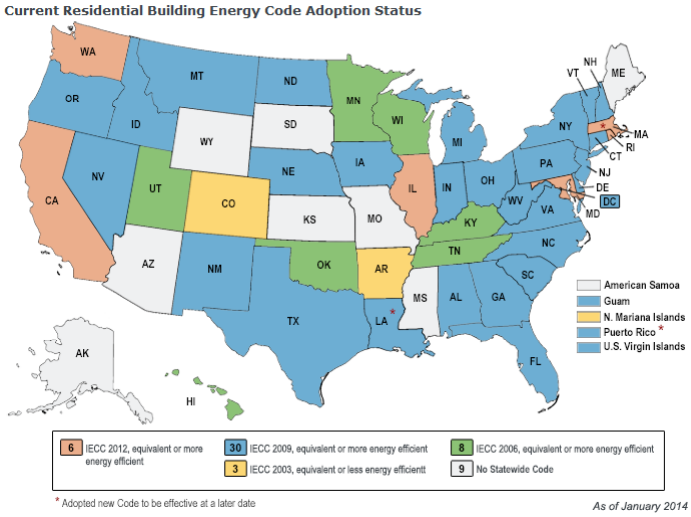
Overview of the Currently Adopted Residential Energy Code By State*



Source: http://www.energycodes.gov/adoption/states

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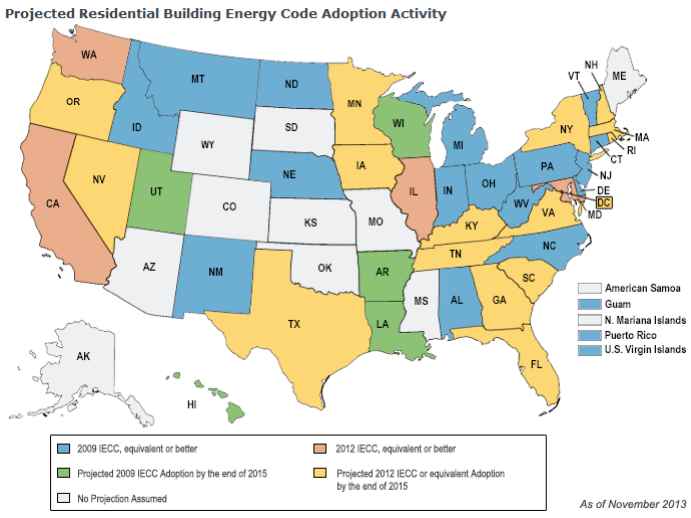
States Expected to Have Residential Energy Codes Meeting or Exceeding the 2009 IECC By the End of 2015*



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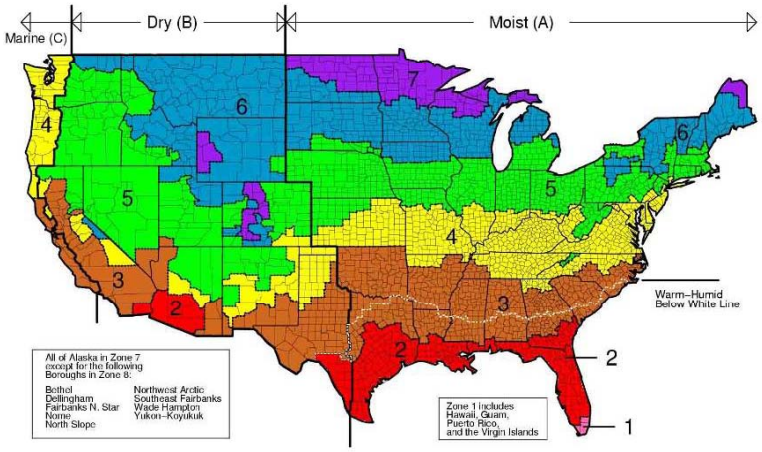
Climate Zones



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2009 IECC vs. 2012 IECC R-Value

Improvements over 2009 IECC are shaded in green

Insulation*	Wood Frame R-value		Basement R-value		Crawl Space R-Value	
Climate Zone	2009 IECC	2012 IECC	2009 IECC	2012 IECC	2009 IECC	2012 IECC
1	13	13	0	0	0	0
2	13	13	0	0	0	0
3	13	20 or 13+5**	5/13***	5/13	5/13	5/13
4 exc. Marine	13	20 or 13+5	10/13	10/13	10/13	10/13
4 Marine & 5	20 or 13+5	20 or 13+5	10/13	15/19	10/13	15/19
6	20 or 13+5	20+5 or 13+10	15/19	15/19	10/13	15/19
7&8	21	20+5 or 13+10	15/19	15/19	10/13	15/19

*Floor and Slab insulations levels remained unchanged
**Commonly available insulation in 2x6 cavity (R20) or in 2x4 cavity with sheathing (R13+x)
***R5 continuous or R13 for framed cavity insulation

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2009 IECC vs. 2012 IECC Air Leakage/Testing Requirements

Improvements over 2009 IECC are shaded in green

	Air Leakage Requirements		Air Leakage Testing Requirements	
Climate Zone	2009 IECC	2012 IECC	2009 IECC	2012 IECC
1	Continuous air barrier visual inspection checklist **OR** air leakage test required	Continuous air barrier visual inspection checklist **AND** air leakage test required	≤ 7 ACH 50	≤ 5 ACH 50
2				
3				≤ 3 ACH 50
4 exc. Marine				
4 Marine & 5				
6				
7&8				

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More Bang for Your Buck

Insulation*	Wood Frame R-value	
Climate Zone	2009 IECC	2012 IECC
1	13	13
2	13	13
3	13	20 or 13+5**
4 exc. Marine	13	20 or 13+5
4 Marine & 5	20 or 13+5	20 or 13+5
6	20 or 13+5	20+5 or 13+10
7&8	21	20+5 or 13+10

Options!

2x4 **or** 2x6 in <u>all</u> climate zones

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"Good materials and good workmanship no longer constitute a high quality home… we must now understand how homes work."

Joseph Lstiburek, P. Eng.
Building Science Corporation

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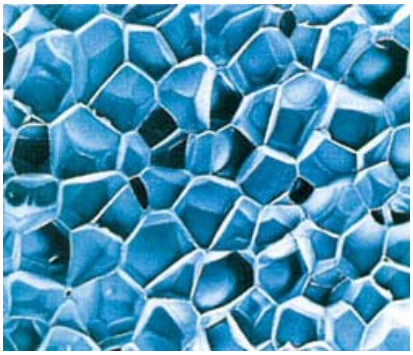
Insulation is…

- Compartments of trapped air
- Generally, the more compartments of air across the same span, the greater the thermal resistance (R-value)



- XPS under a microscope
- Each cell creates a compartment or 'pocket' of trapped air!

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Limitations of ANY Insulation Material...

- If the material is compressed, compartments of air are crushed thus reducing R-value
- If moisture takes over the compartments of air, its R-value is reduced
- If the air is forced to move from air infiltration or convection, then the insulation is less efficient

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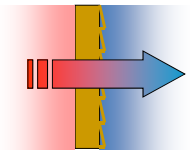
Thermal Performance & Wall Physics



- **Warm migrates toward cold**

- **More moisture moves toward less moisture**

- **Air moves from higher pressure to lower pressure**

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Standard Wall Design & **Limitations**

Key problems with wood frame walls today:

1. Thermal bridging through wood framing
2. Factors limiting the use of cavity insulation
   - Wood framing (more than 16” centers)
   - Plumbing
   - Heating and cooling ductwork
   - Electrical wiring, outlets and junctions
3. Wall cavity convection currents
4. Moisture issues

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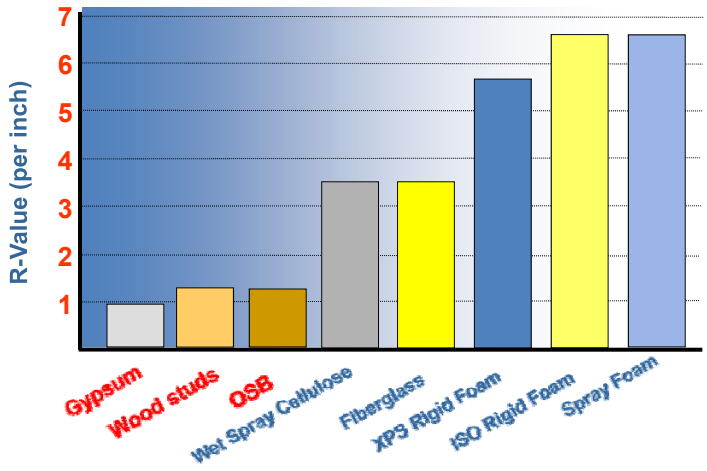
Standard Wall Design & **Limitations**

R-values of various products:



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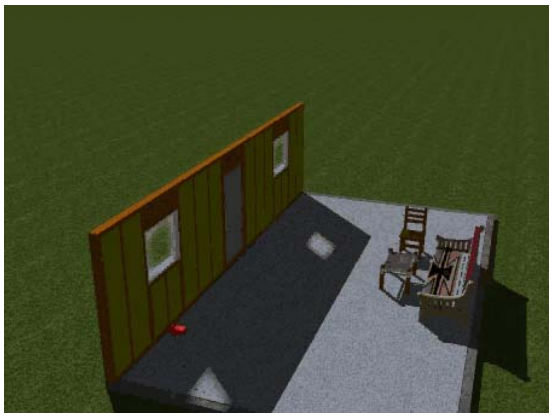
Standard Wall Design & **Limitations**

Thermal bridging through wood framing



Heating and cooling loss occurs on outside walls anywhere cavity insulation doesn't cover

Real heating & cooling losses!

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Standard wall design & limitations

Thermal bridging through wood framing

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Standard wall design & limitations

Thermal bridging through wood framing

Standard cavity batt wall design with vinyl siding, and no rim joint insulation

Hidden heat loss is like throwing money away in the air!
>15°F delta between stud and cavity!

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Standard Wall Design & **Limitations**

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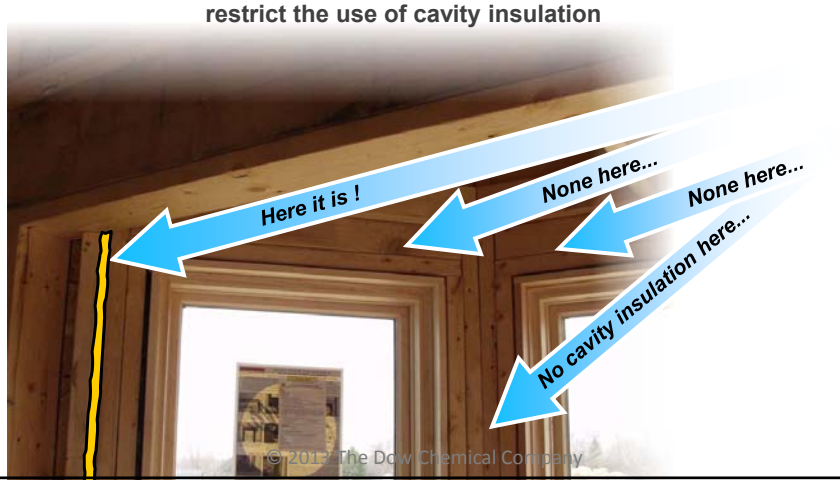
Standard Wall Design & Limitations

Cavity Insulation is Limited

Structural requirements often times completely restrict the use of cavity insulation



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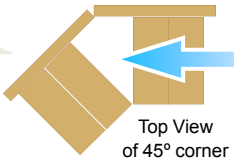
Standard Wall Design & Limitations

Cavity Insulation is Limited

Worse yet, there are open pockets created by structural designs that typically don't get filled.



Note pie-shaped gap!

Top View of 45° corner

Where does the cavity insulation go again?

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Standard Wall Design & **Limitations**

Cavity Insulation is Limited

Wood framing occurs far more than every 16 or 24 inches on center.
Everywhere there's wood framing, there can't be cavity insulation.

Note additional wood framing beyond 16" centers

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Standard Wall Design & **Limitations**

Cavity Insulation is Limited

The only consistent thing about batt insulation
is the inconsistent installation

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Standard Wall Design & **Limitations**

Cavity Insulation is Limited

Remember – compression of any insulating material reduces that materials R-Value!

Are you getting the advertised R-value here?

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Standard Wall Design & **Limitations**

Cavity Insulation is Limited

Even wet spray cellulose can't insulate the wood framing and it's also limited by electrical, plumbing and HVAC ducts

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Standard Wall Design & **Limitations**

Cavity Insulation is Limited

Voids and imperfections lead to a lower effective R-value

Are you getting the advertised R-value here?

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Standard Wall Design & **Limitations**

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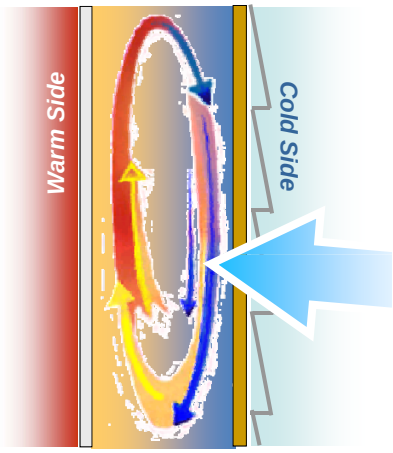
Standard Wall Design & Limitations

Wall Cavity Convection Currents



What is cavity convection?

Energy loss through movement or "looping" of heated and cooled air

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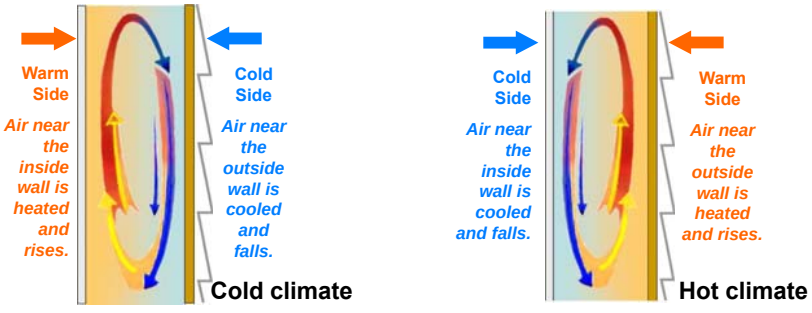
Standard Wall Design & Limitations

Wall Cavity Convection Currents

Air movement in the cavity reduces insulation efficiency, contributing to energy loss



Trapped air (insulation) becomes less efficient with movement

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Standard Wall Design & Limitations

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Standard Wall Design & Limitations

Dew Point Condensation

Moisture is the #1 enemy of most building materials

It only takes a small amount of consistent moisture to lead to:

- **Reduced R-value**
- **Deterioration / Rot**
- **Mold & mildew**

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Standard Wall Design & Limitations

Dew Point Condensation

What is dew-point condensation?

The point when moisture in the air condenses in to a liquid – a factor of <u>air temperature</u> and <u>humidity</u>.

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Standard Wall Design & Limitations

Dew Point Condensation

A dew-point calculation chart shows all.

% Relative Humidity

Temperature °F	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
110	110	108	106	104	102	100	98	95	93	90	87	84	80	76	72	65	60	51	41
105	105	103	101	99	97	95	93	91	88	85	83	80	76	72	67	62	55	47	37
100	100	99	97	95	93	91	89	86	84	81	78	75	71	67	63	58	52	44	32
95	95	93	92	90	88	86	84	81	79	76	73	70	67	63	59	54	48	40	32
90	90	88	87	85	83	81	79	76	74	71	68	65	62	59	54	49	43	36	32
85	85	83	81	80	78	76	74	72	69	67	64	61	58	54	50	45	38	32	
80	80	78	77	75	73	71	69	67	65	62	59	56	53	50	45	40	35		
75	75	73	72	70	68	66	64	62	60	58	55	52	49	45					
70	70	68	67	65	63	61	59	57	55	53	50	47	44	40					
65	65	63	62	60	59	57	55	53	50	48	45	42	40	36	32				
60	60	58	57	55	53	52	50	48	45	43	41	38	35	32					
55	55	53	52	50	49	47	45	43	40	38	36	33	32						
50	50	48	46	45	44	42	40	38	36	34	32								
45	45	43	42	40	39	37	35	33	32										
40	40	39	37	35	34	32													
35	35	34	32																
32	32																		

70° Temp + 35% RH =

40° Dew-Point Temp

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Standard Wall Design & Limitations

Dew Point Condensation

temperature lines cross.

A dew-point analysis can show what the wetting potential may be for certain wall systems under specific climate conditions.

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Standard Wall Design & Limitations

Dew Point Condensation

Dew-Point Analysis: Summer, 2x4, R-13 batt, 7/16" OSB, HW, Vinyl Siding

NOTICE: This calculation is based on the theory of water vapor migration presented in the ASHRAE '93 Fundamentals Handbood. Actual performance may vary depending upon air infiltration, workmanship and building materials. Since the information is provided without charge, The Dow Chemical Company assume no obligation or liability for its use.

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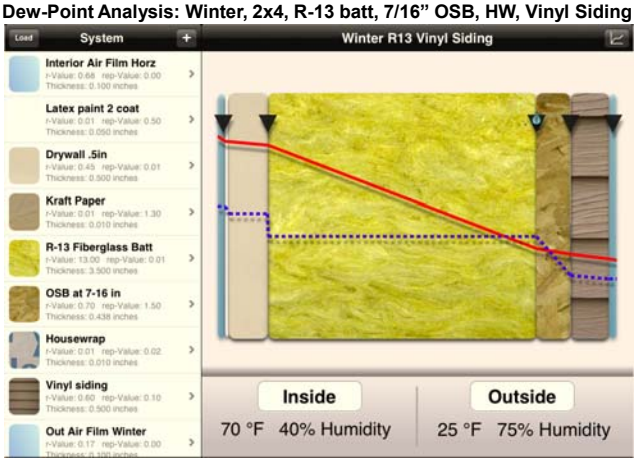
Standard Wall Design & **Limitations**

Dew Point Condensation

Dew-Point Analysis: Winter, 2x4, R-13 batt, 7/16" OSB, HW, Vinyl Siding



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More Bang for Your Buck

Key problems solved with insulating sheathing:

1. Thermal bridging through wood framing
2. Factors limiting the use of cavity insulation
   - Wood framing (more than 16” centers)
   - Plumbing
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More Bang for Your Buck

Thermal bridging through wood framing

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More Bang for Your Buck

Thermal Bridging - Stud Loss

Note the surface area of the wood compared to that of the cavity insulation

Is this wall completely insulated?

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More Bang for Your Buck

Thermal Bridging - Stud Loss

Now it is!

A layer of insulating sheathing covers the entire opaque wall, including the framing.

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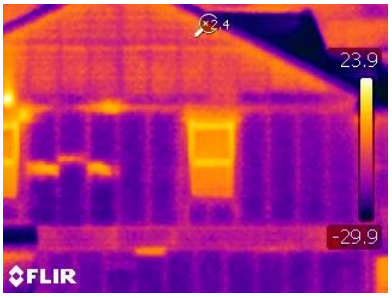
Is Thicker Wall Better? Polar Freeze Test

If I use R-20 cavity insulation with 2x6 wall instead of R13 with 2x4, am I building a better wall?

- Effective R-value for the R20 cavity is ~R14*
- Adding inches, but not much insulation value
- IR shows stud and cavity delta almost 30F!

- Note *: FF 0.2



2x6 wall "exposed"

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Is Thicker Wall Better? Polar Freeze Test

What if you save some trees and used 2x4 framing with ci?

- Effective R-value for the R5ci+13 is ~R16.3*
- Better effective R-value than the 2x6 with R20 cavity!
- But IR reveals the difference:
- **"Keeping the hot side hot, and cold side cold" with thinner walls!**

- Note *: FF 0.2

2x4 wall under IR

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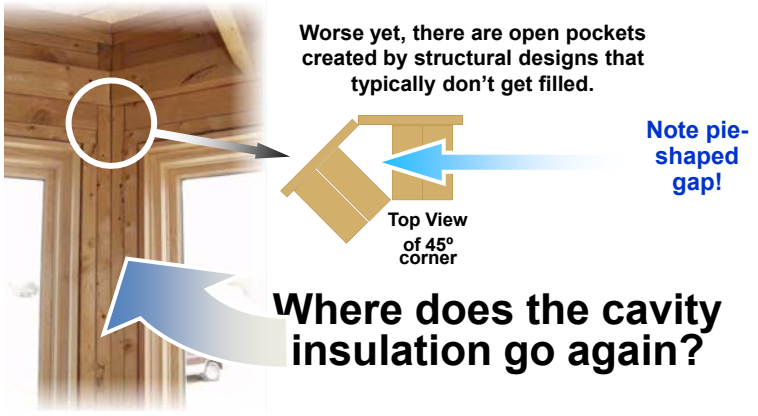
More Bang for Your Buck

Cavity Insulation is Limited



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More Bang for Your Buck

Cavity Insulation is Limited

Insulating sheathings are the first line of thermal defense and the only consistent layer of thermal protection for a home.

Insulating sheathings cover everything.

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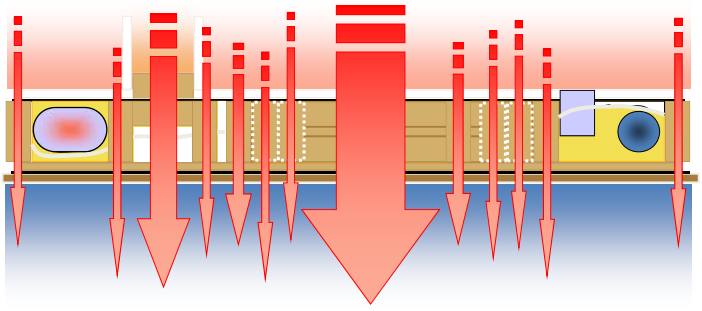
More Bang for Your Buck

Cavity Insulation is Limited

Heating and cooling loss occurs on outside walls anywhere cavity insulation doesn't cover



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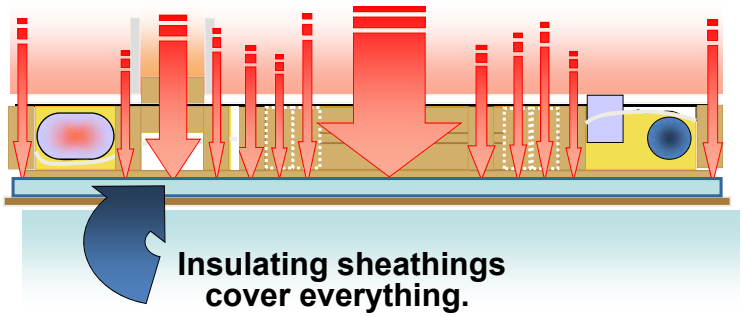
More Bang for Your Buck

Cavity Insulation is Limited

Insulating sheathings span the entire wall surface to provide the only consistent thickness of thermal protection.



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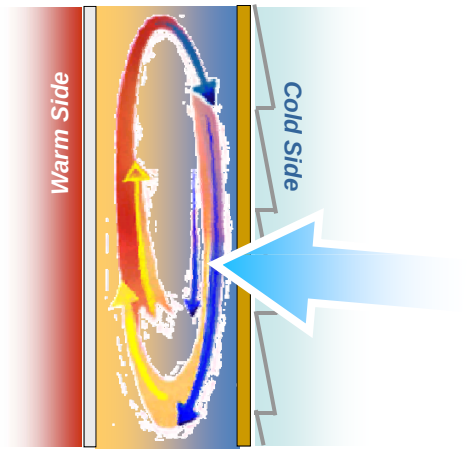
More Bang for Your Buck

Wall Cavity Convection Currents



What is cavity convection?

Energy loss through movement or "looping" of heated and cooled air

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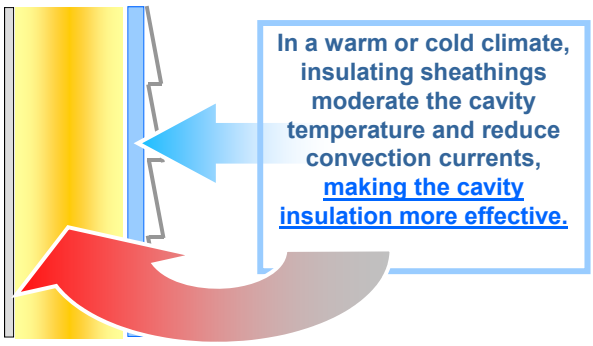
More Bang for Your Buck

Wall Cavity Convection Currents

Insulating sheathings will warm-up the exterior side of the cavity and improve the thermal efficiency of the entire wall.



In a warm or cold climate, insulating sheathings moderate the cavity temperature and reduce convection currents, making the cavity insulation more effective.

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More Bang for Your Buck

Dew Point Condensation

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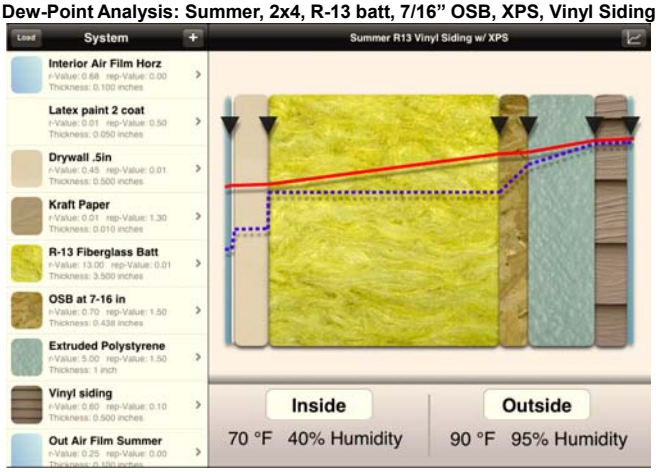
Why Use Insulating Sheathing?

Dew Point Condensation

Dew-Point Analysis: Summer, 2x4, R-13 batt, 7/16" OSB, XPS, Vinyl Siding



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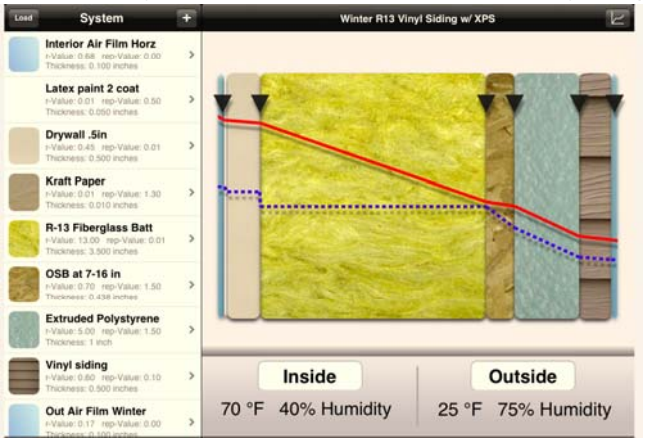

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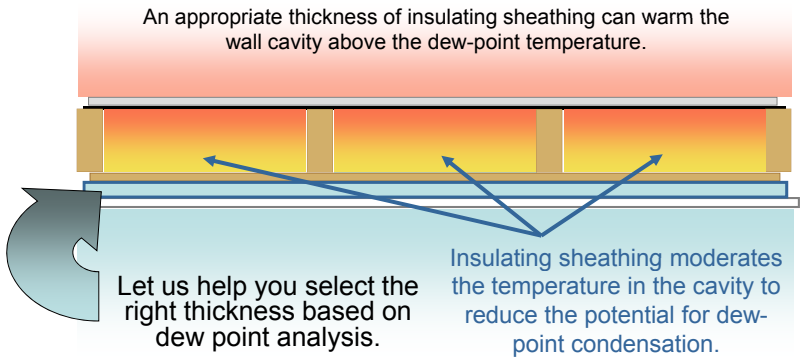
Why Use Insulating Sheathing?

Dew-Point Condensation



NOTICE: This calculation is based on the theory of water vapor migration presented in the ASHRAE '93 Fundamentals Handbood. Actual performance may vary depending upon air infiltration, workmanship and building materials. Since the information is provided without charge, The Dow Chemical Company assume no obligation or liability for its use.

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More Bang for Your Buck

WRB & Air Barrier – a double play

Some insulating sheathing products also serve as a WRB with taped joints as well as meet E2357 approval for air barrier. Check specific manufacturer's code report for details.

Ex: ICC-ESR 2142

3.3 Joint-sealing:

WEATHERMATE™ Construction Tape is nominally 2 7/8 inches wide and is used in conjunction with STYROFOAM brand insulation boards and Dow fan-fold products to seal joints between two or more edges of the boards, when the insulation boards are installed as a water-resistive barrier. The installation must be as described in Section 4.3 of this report.

WEATHERMATE™ Flashing Tape with a minimum 4-inch (102 mm) width, and GREAT STUFF™ Pro Gaps & Cracks sealant (ESR-1961), are used in conjunction with

October 2013

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More Bang for Your Buck

The 'gasketing' effect

- Case study involving 31 homes across 4 housing developments in Maryland
- 17 homes without insulating sheathing (ci)
- 14 homes with insulating sheathing & taped seams

MD Builder

Maryland: 2012 IECC
Walls R20 or R15 + 5 ci
ACH50 ≤ 3

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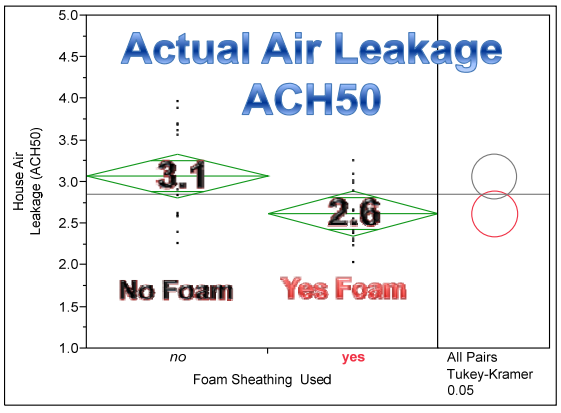
More Bang for Your Buck

Key Takeaway:
House Air Leakage (ACH@50 PA) went from average of 3.1 to 2.6 **(~15% tighter)** with insulating sheathing and **meets 2012 IECC**!



ci for 2012 IECC MD: ACH50 ≤ 3

Statistically significant at 95% confidence level.
Data set includes homes with and without attic duct sealing

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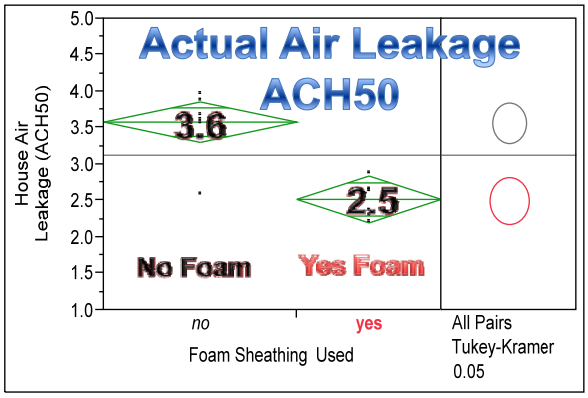
More Bang for Your Buck

Key Takeaway:
Gasketing benefit of foam sheathing is most pronounced when attic duct is not air sealed. ***> 30% tighter & meets 2012 IECC!***



ci for 2012 IECC MD: ACH50 ≤ 3

Homes without attic duct sealing: Statistically significant at 95% confidence level

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Side-by-Side Comparison – Duplex Case Study

Air Sealing Challenge:
Can sealing the exterior envelope be as effective as sealing interior gaps and cracks?

Construction and Procedure:

- ❑ 1" XPS sheathed duplex
- ❑ Blower Door test baseline after drywall
- ❑ Total Duct Leakage after duct sealing
- ❑ One blower test only after drywall stage

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Side-by-Side Comparison – Duplex Case Study

Spray Foam Cavity vs. Liquid Flashing:
Cavity interior air sealing vs. simple exterior air sealing

Target Area	Left Unit – SPF Cavity Insulation 2131 Total sqft	Right Unit – Exterior Flashing Only 2131 Total sqft
Cavity Insulation	2# SPF	Fiberglass only
Window Flashing	Sill pan with normal detailing	Sill pan with normal detailing
XPS Joint Sealing	Tape	Liquid flashing and sealant on XPS board joints
Attic insulation	Sprayed cellulose	Same as Control.
Can lights and other interior penetrations		Not done.
Stud to Stud interfaces	Latex caulk	Not done.
Building Volume (ft3)	25, 196	25, 196
Adjusted Blower Door Leakage (cfm)	755	853 *(+13%)*
ACH50	1.8	2.0
HERS	63	62

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Side-by-Side Comparison – Duplex Case Study

Summary:
XPS with properly sealed board joints is an excellent air barrier

Less linear feet of gaps from exterior boards than from interior cavities

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More Bang for Your Buck

Three homes built for each energy efficiency design, climate zone 5/6

Baseline **HERS 82**	Meet 2006 IECC lowest possible price point	Establish baseline for comparison
2012 Performance Minimum cost **HERS 57**	Meet 2012 IECC lowest possible price point	Collect data for this likely choice of many builders
2012 Performance Premium Package **HERS 57**	Meet 2012 IECC building science best practices	Show that with minimum additional up front cost, generate higher ROI through lower energy use
Beyond Code Premium Package **HERS – mid 40s**	Exceed 2012 IECC Renewable ready	With more significant up front cost, achieve higher ROI

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2014 RESNET

More Bang for Your Buck

Key Takeaway:
Modeled vs. actual energy consumption is closer for designs with continuous insulation

Category of Homes	Difference between Actual Annual and Modeled Energy Use (%)
2006 IECC	-53%
2012 IECC	-16%
2012 IECC Prem	-5%
2012 IECC Beyond	7%

Less offset in prediction for the Higher Performance Homes

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Why Use Insulating Sheathing?

How do you afford all this?

3,100 SF Conditioned

2006 Code Home: $250,000.00
- 2 x 6 16" o.c.
- OSB & Housewrap
- R-19 Fiberglass
- R-11 Vinyl Faced FG Basement
- 80% AFUE Furnace
- 13 SEER 2 ton AC

Outperformance Home: $255,000
- 2 x 4 16" o.c.
- R-5 Insulated Sheathing
- R-16 ccSPF
- R-15 Basement Walls
- 92% AFUE Furnace
- 14 SEER 2 ton AC

Why Use Insulating Sheathing?

How do you afford all this?

Code Home: $250,000
20% Down Payment: $50,000

Outperformance Home: $255,000
20% Down Payment: $50,000

Why Use Insulating Sheathing?

How do you afford all this?

Code Home: $250,000
20% Down Payment: $50,000
Financing: $200,000 (4% 30-Yr)

Outperformance Home: $255,000
20% Down Payment: $50,000
* Some Lenders Offer Energy Efficient Mortgages (EEM's) that do not require additional down payment for the cost incurred to make the EE upgrades. Essentially you are financing the cost of the upgrades with no additional out of pocket expense.
Financing: $205,000 (4% 30-Yr)

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Why Use Insulating Sheathing?

How do you afford all this?

Code Home: $250,000
20% Down Payment: $50,000
Financing: $200,000 (4% 30-Yr)
Mortgage Payment: $955.00

Outperformance Home: $255,000
20% Down Payment: $50,000
* Some Lenders Offer Energy Efficient Mortgages (EEM's) that do not require additional down payment for the cost incurred to make the EE upgrades. Essentially you are financing the cost of the upgrades with no additional out of pocket expense.
Financing: $205,000 (4% 30-Yr)
Mortgage Payment: $978.00

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Why Use Insulating Sheathing?

How do you afford all this?

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Why Use Insulating Sheathing?

How do you afford all this?

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20% Down Payment: $50,000
Financing: $200,000 (4% 30-Yr)
Mortgage Payment: $955.00
Avg. Monthly Heating/Cooling: $71
Mortgage + Heating: $1026

Outperformance Home: $255,000
20% Down Payment: $50,000
* Some Lenders Offer Energy Efficient Mortgages (EEM's) that do not require additional down payment for the cost incurred to make the EE upgrades. Essentially you are financing the cost of the upgrades with no additional out of pocket expense.
Financing: $205,000 (4% 30-Yr)
Mortgage Payment: $978.00
Avg. Monthly Heating/Cooling: $41
Mortgage + Heating: $1019.

Why Use Insulating Sheathing?

How do you afford all this?

Code Home: $250,000
20% Down Payment: $50,000
Financing: $200,000 (4% 30-Yr)
Mortgage Payment: $955.00
Avg. Monthly Heating/Cooling: $71
Mortgage + Heating: $1026

Outperformance Home: $255,000
20% Down Payment: $50,000
* Some Lenders Offer Energy Efficient Mortgages (EEM's) that do not require additional down payment for the cost incurred to make the EE upgrades. Essentially you are financing the cost of the upgrades with no additional out of pocket expense.
Financing: $205,000 (4% 30-Yr)
Mortgage Payment: $978.00
Avg. Monthly Heating/Cooling: $41
Mortgage + Heating: $1019.
Savings= $7.00/month

Agenda

- Historical Background
- Energy Codes
- What is Insulation
- Wood-frame Wall Limitations
- Why Use Insulating Sheathing
- **Summary**
- Q&A

Summary

- Insulating sheathing offers flexibility with both 2x4 and 2x6 wall assemblies, and ***is cost effective***
- Insulation is most **effective** when there is no air movement, moisture, or compression
- Insulating sheathing helps to greatly **reduce the impact of thermal bridging**
- Insulating sheathing can be very effective at **combating dew-points** within the wall cavity
- Insulating sheathing w/ taped seams provides 'gasketing' effect with **less air leakage**

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Why Use Insulating Sheathing?

2" FG = R7

1.5" XPS = R7.5

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Why Use Insulating Sheathing?

Quality Over Quantity

Additional Resources

www.DowBuildingSolutions.com

www.AirSealWithDow.com

www.SprayFoamAtDow.com

www.STYROFOAMinYourHome.com

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For Further Information

Customer Technical Support:

1-866-583-BLUE (2583)

On-Line **Answer Center** Help:

http://dow-styrofoam.custhelp.com/

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