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ARE THE WALLS CLOSING IN?

MOISTURE PERFORMANCE OF HIGH-R WALLS

June 2016

Finding Innovation a Home

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Outline

- Wall Construction Market: Materials and Trends
- Builders' Perspective: Results of Builder Survey
- Design Principles and Case Studies:
  - Vapor retarder selection
  - Vapor diffusion vs. air leakage
  - Is poly bad?
  - Do walls with foam sheathing dry?
  - Is interior RH important? What are observed RH levels?
  - Is construction moisture important?
  - Is spot ventilation needed?
  - Is moisture important?
  - Are the dew point calculations useful?
- Is there a perfect wall?

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Wall Market Trends

- Wall Framing (% new home starts)

Framing	2001	2006	2013	2015
2x4 @ 16" o.c.	74%	73%	60%	53%
2x4 @ 24" o.c.	2%	3%	1%	2%
2x6 @ 16" o.c.	22%	22%	32%	37%
2x6 @ 24" o.c.	2%	2%	6%	7%
Other	1%	0%	1%	0%
TOTAL	100%	100%	100%	100%

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Wall Market Trends

- Wall Sheathing (% new home starts)

Wall Sheathing (primary)	2001	2006	2013	2015
None (concrete, SIPs or others)	10%	12%	12%	8%
WSP (plywood, OSB, ZIP)	65%	68%	79%	84%
1/2 inch fiberboard	3%	3%	2%	1%
1/8 inch (Thermoply, EnergyBrace)	3%	2%	1%	1%
SIS	n/a	n/a	1%	2%
Foam (XPS, EPS, ISO)	17%	12%	4%	3%
Other	3%	4%	1%	1%
TOTAL	100%	100%	100%	100%

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Wall Market Trends

- Oversheathing (% new home starts)

	2006	2012	2013	2015
Homes with foam sheathing over wood structural panel	7%	9%	10%	11%

- House wrap (% new home starts)

	2006	2012	2013	2015
Homes with House wrap	54%	74%	74%	76%

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Wall Market Trends

- Cavity Insulation (% new home starts)

Insulation Type	2006	2011	2013	2015
Fiberglass batt	76%	68%	68%	66%
Fiberglass blown	7%	8%	8%	8%
Spray foam	3%	11%	10%	12%
Cellulose	11%	8%	9%	8%
Other or none	3%	5%	5%	5%
TOTAL	100%	100%	100%	100%

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Builder Survey of Key Challenges and Opportunities

- Web-based survey
- 308 builders
  - ✓ Decision-making authority or influence
- Range of categories
  - ✓ Occupant Comfort
  - ✓ Fire Resistant Construction
  - ✓ Indoor Air Quality
  - ✓ Energy Efficiency Issues
  - ✓ Durability
  - ✓ Disaster Resistance
  - ✓ Costs and Labor Availability

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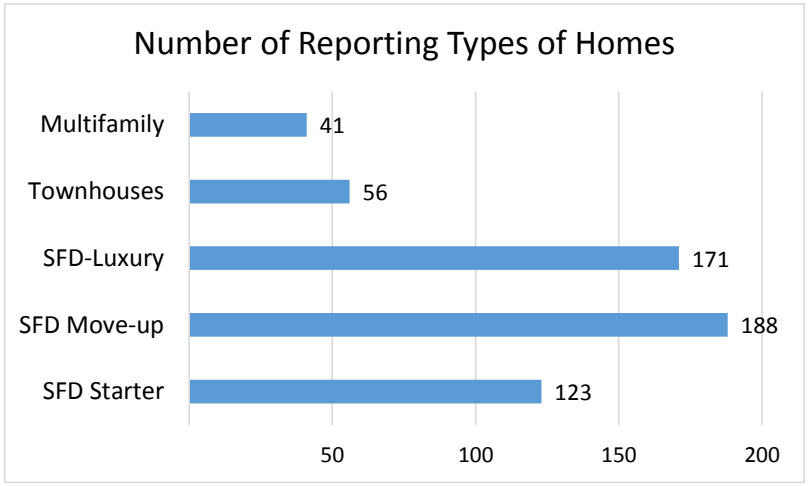
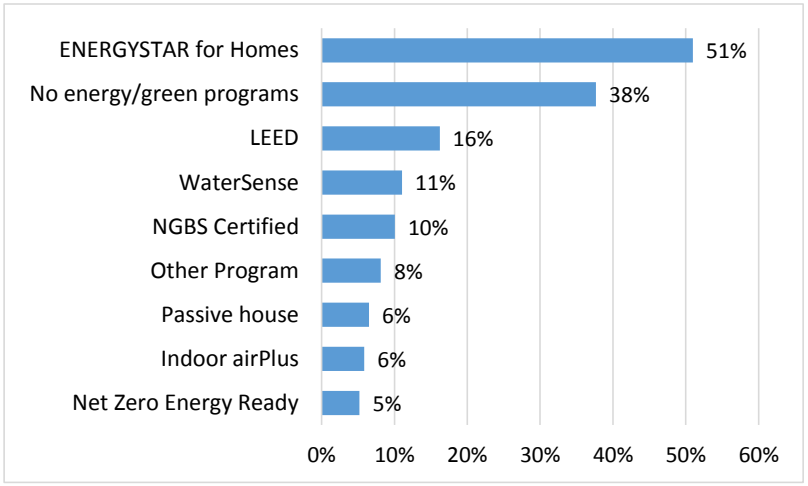
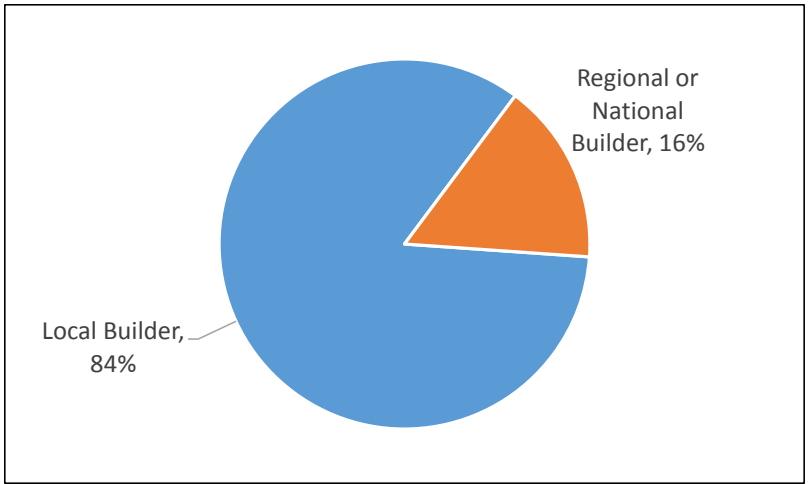
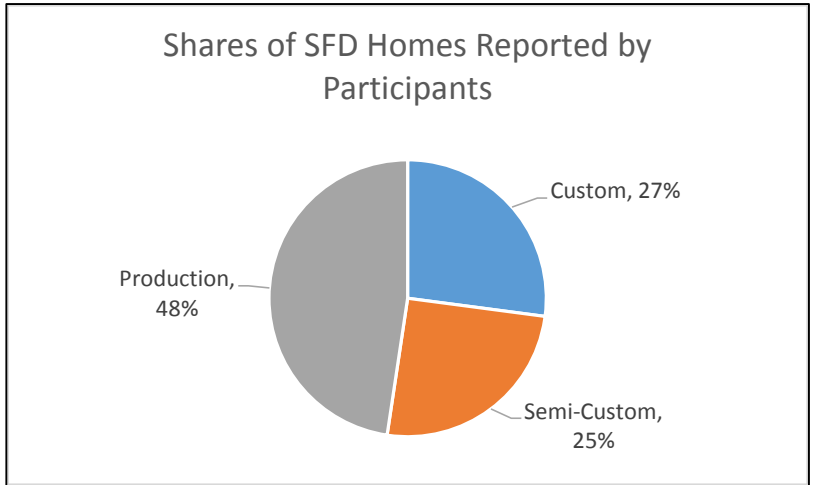
Builder Survey of Key Challenges and Opportunities









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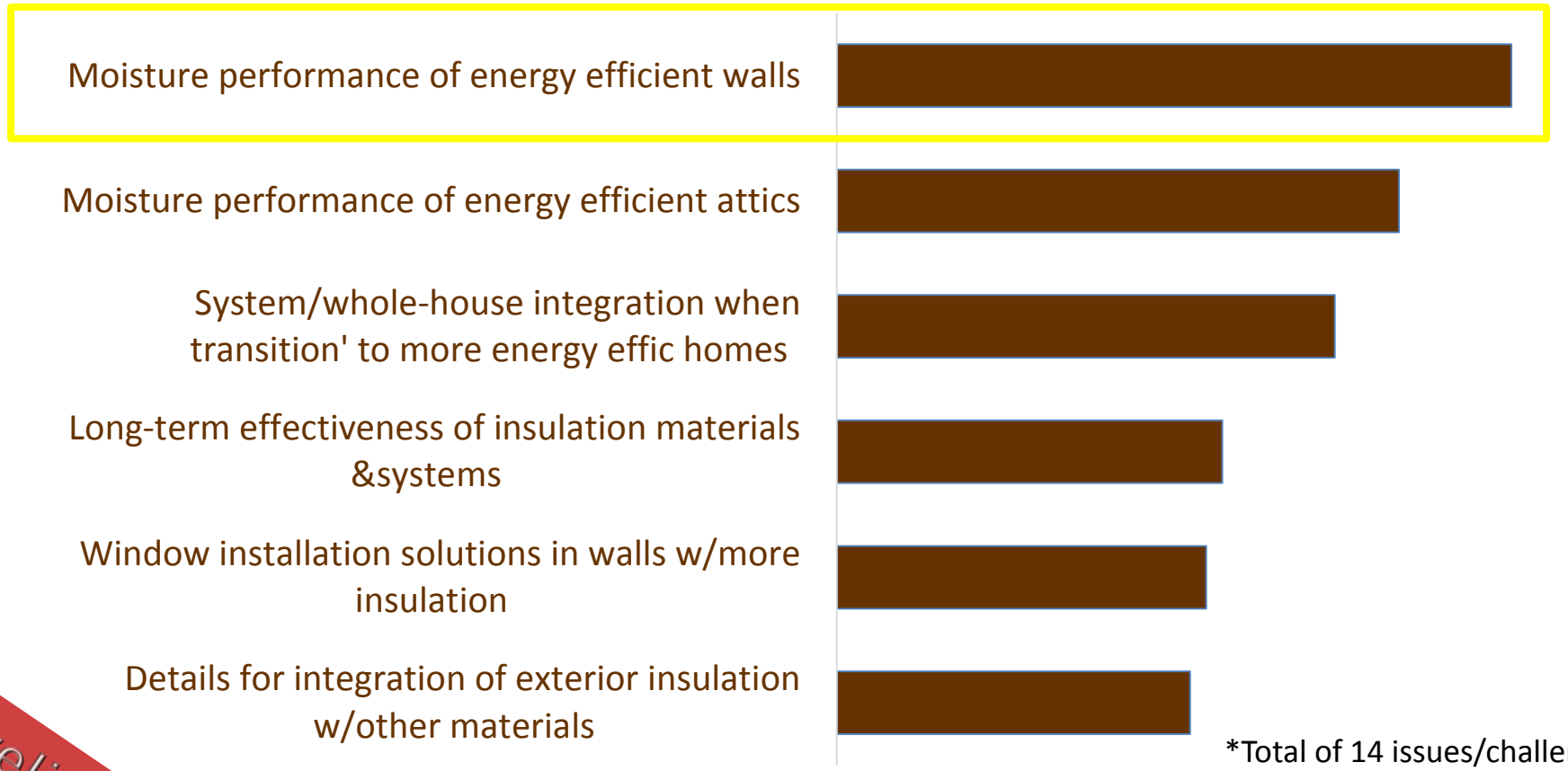
Top Challenges in Energy Efficiency



*Total of 14 issues/challenges presented to respondents

Preliminary

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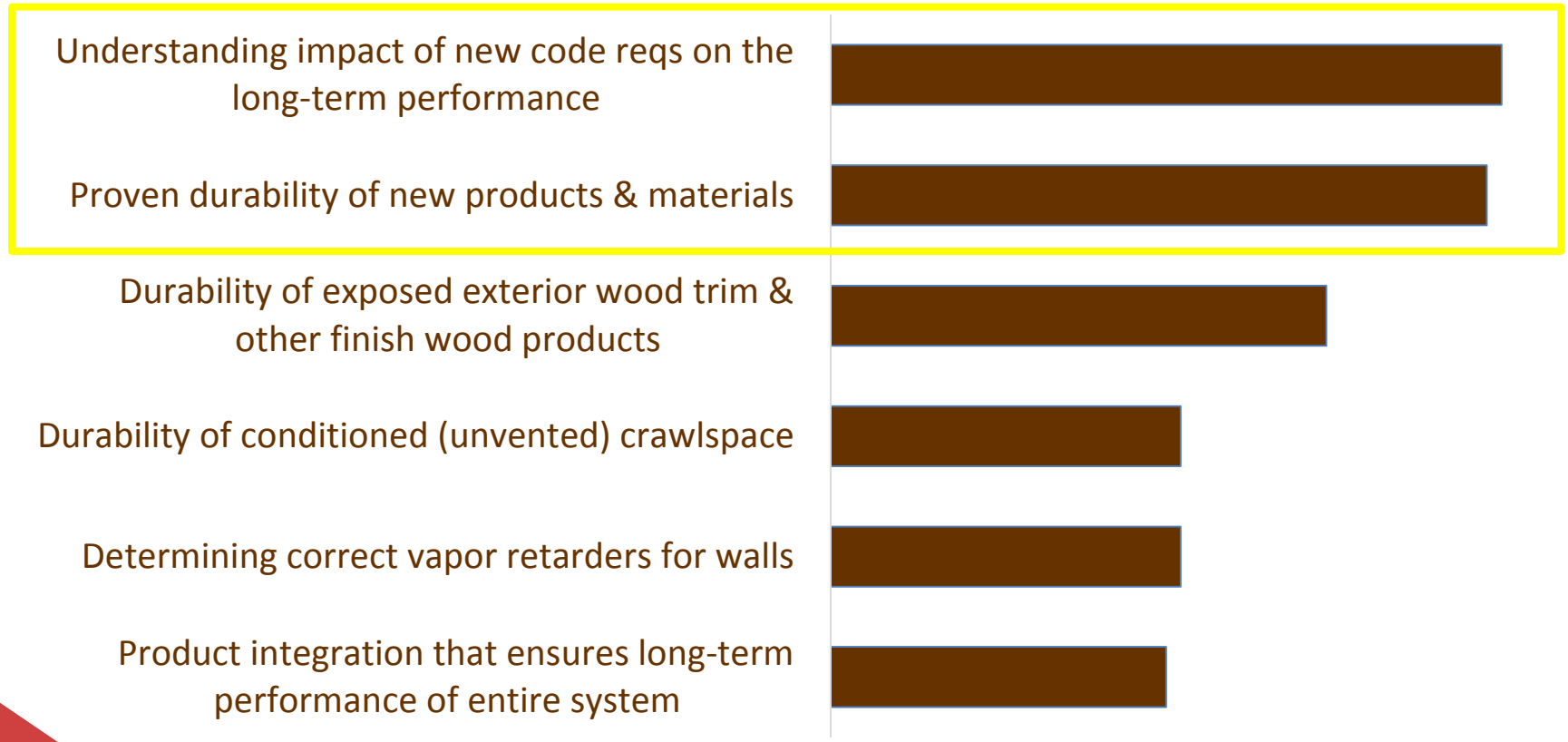
Top Challenges in Durability



*Total of 19 issues/challenges presented to respondents

Preliminary

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Moving and Interconnected Parts

- Higher insulation levels
- Location of insulation (CI vs cavity)
- Insulation ratio (CI/cavity)
- Permeance of insulation and other materials
- New materials with built-in characteristics
- Claddings
- Vapor retarders
- House interior relative humidity

Practical combination of variables in terms of walls used in residential construction is more manageable

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Case Studies on Moisture Performance of Energy Efficient Walls

Research:

- Field Study of 22 homes
- Test Huts
- Analytical Studies (WUFI)

Results (www.homeinnovation.com):

- Research Reports
- Wall Construction Guides
- Tech Notes
- [Draft Standard Practice for *DETERMINING MOISTURE PERFORMANCE OF WALL ASSEMBLIES FROM THE IN-SITU DATA* (intended for a consensus standard)]

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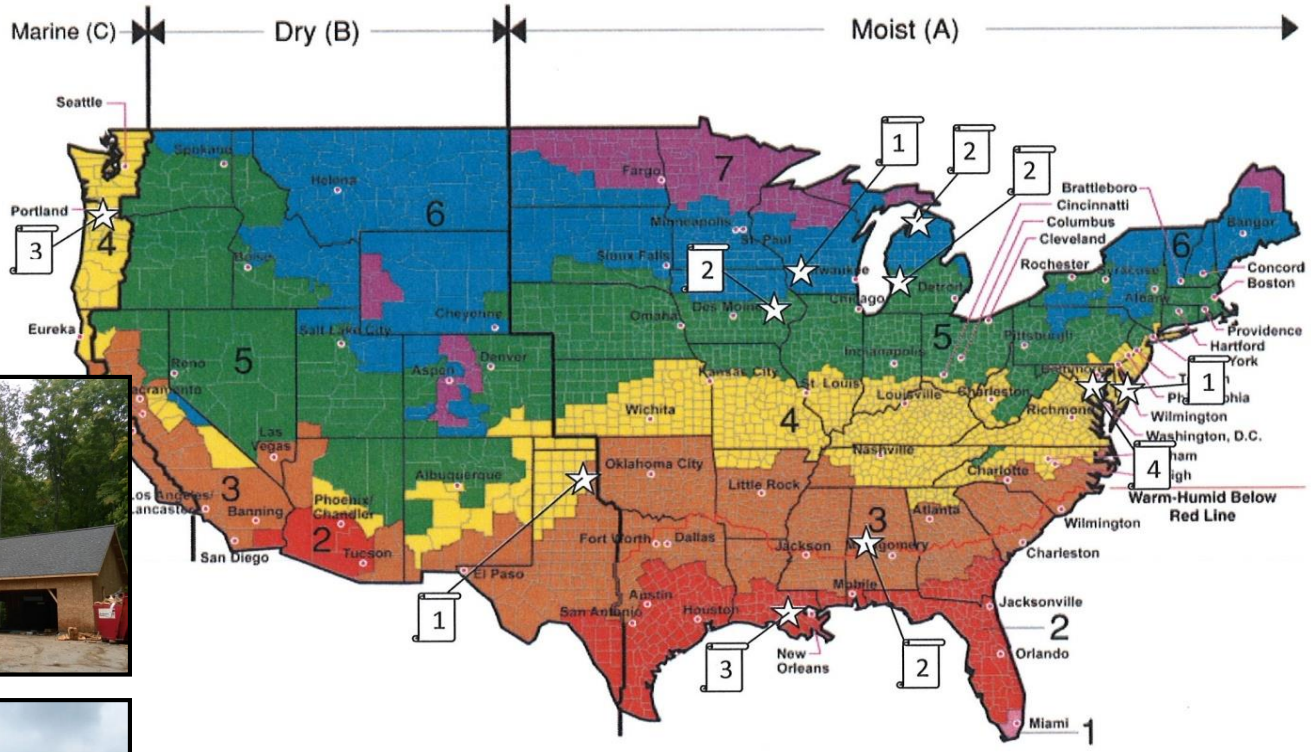
Moisture Monitoring of Energy Efficient Houses



- Cataloguing and monitoring EE walls used by builders in various climates

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Monitoring System

Transmit

Remote Server

378 sensors total

Download

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Test Huts – CZ 4

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Case Studies of Design Principles

- Vapor retarder selection
- Vapor diffusion vs. air leakage
- Is poly bad?
- Do walls with ext. foam sheathing dry out?
- Is interior RH important for walls?
- Is construction moisture important?
- Is spot ventilation needed?
- Do we care about moisture in walls?
- Are the dew point calculations useful?

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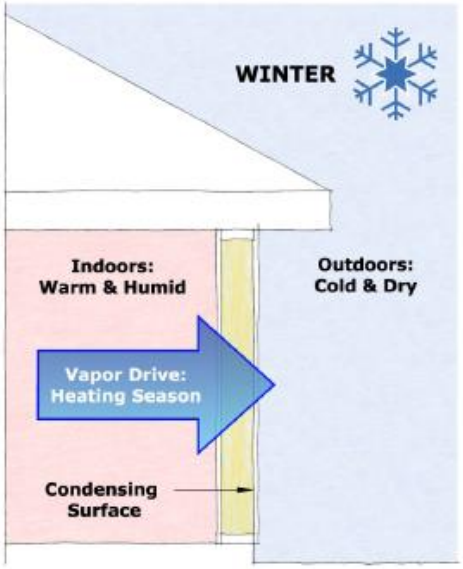
Three Interior Vapor Control Strategies in Heating Climates

1) Ext. continuous insulation (T controlled)
   - ✓ Class III
   - ✓ No vapor retarder

2) No exterior insulation (Vapor controlled)
   - ✓ Vapor retarder based on Climate Zone

3) Hybrid (T and Vapor controlled)
   - ✓ Class II vapor retarder
   - ✓ Smart vapor retarder



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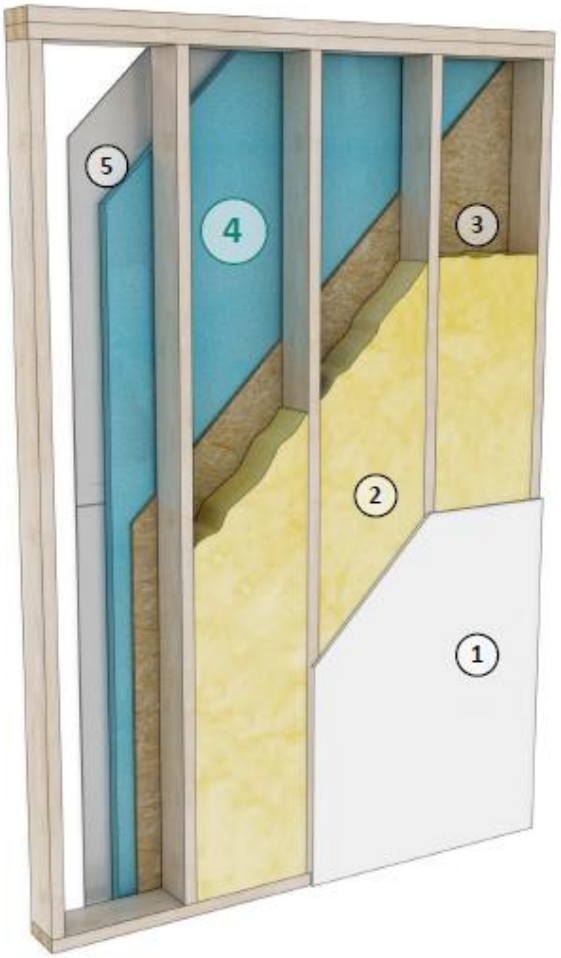
1. Exterior Continuous Insulation

1) T controlled
2) Minimum outboard R-value (code)
3) Ratio of outboard to cavity (design)
4) Primary drying to the inside
5) Drying to the outside based on material permeability
6) Class III or no VR



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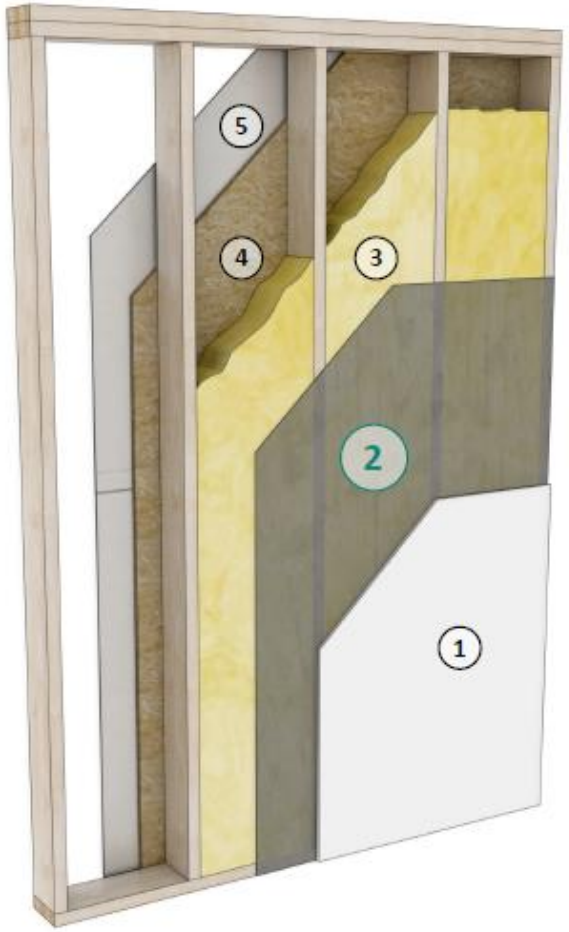
2. No Exterior Insulation

1) Vapor controlled
2) Vapor retarder based on CZ
   - ✓ Class I, II, III, vapor-open
3) Drying can be in either direction
4) Air sealing is more important



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3. Hybrid

1) T and Vapor controlled
2) Int. vapor retarder
   - ✓ smart
3) Primary drying to the inside
4) Drying to the outside depends on layer permeability
5) Allows for limiting exterior insulation thickness -- constructability

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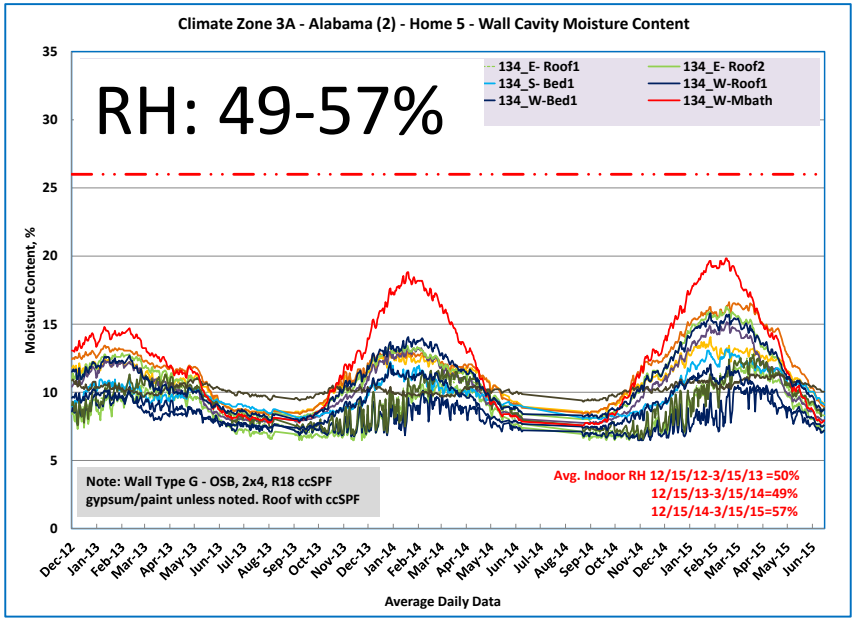
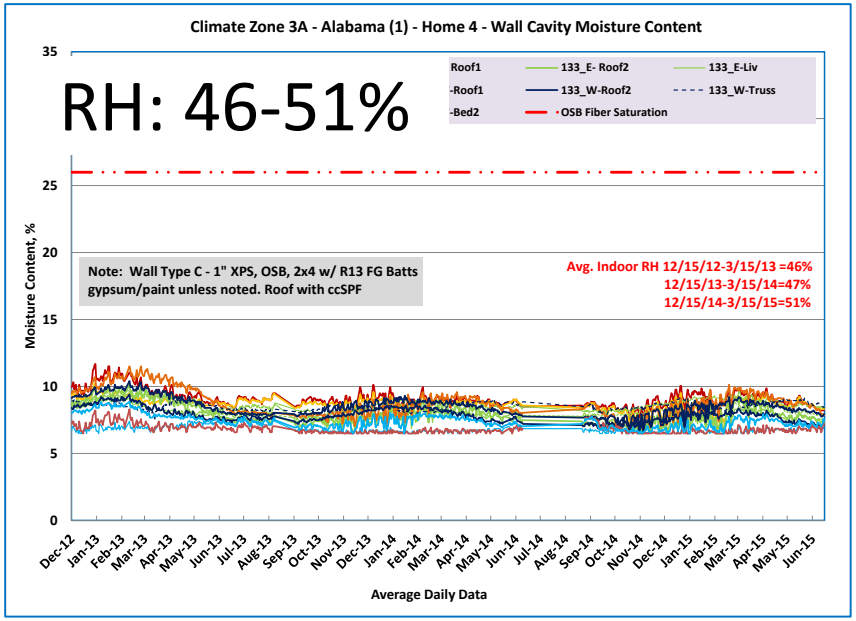
Example: Adjacent Homes

Vapor-controlled



Hybrid:

1”XPS+Kraft facing VR



CZ 3

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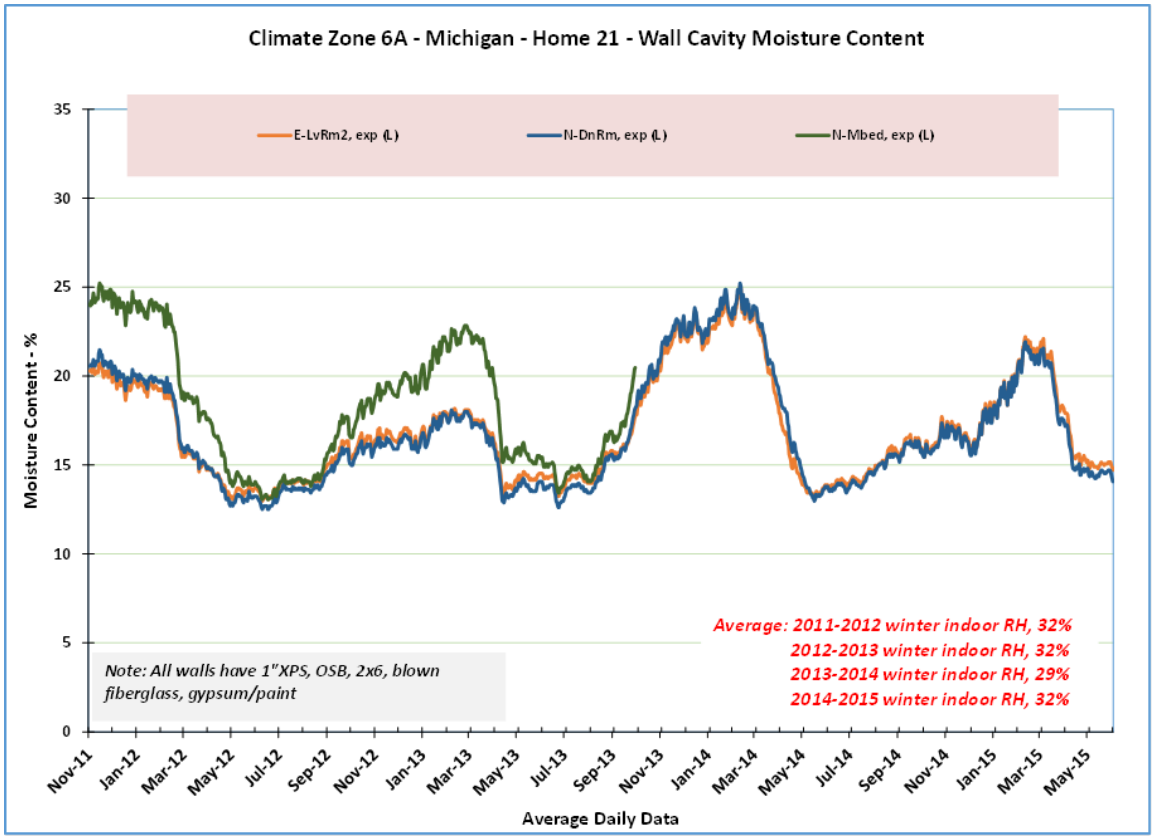
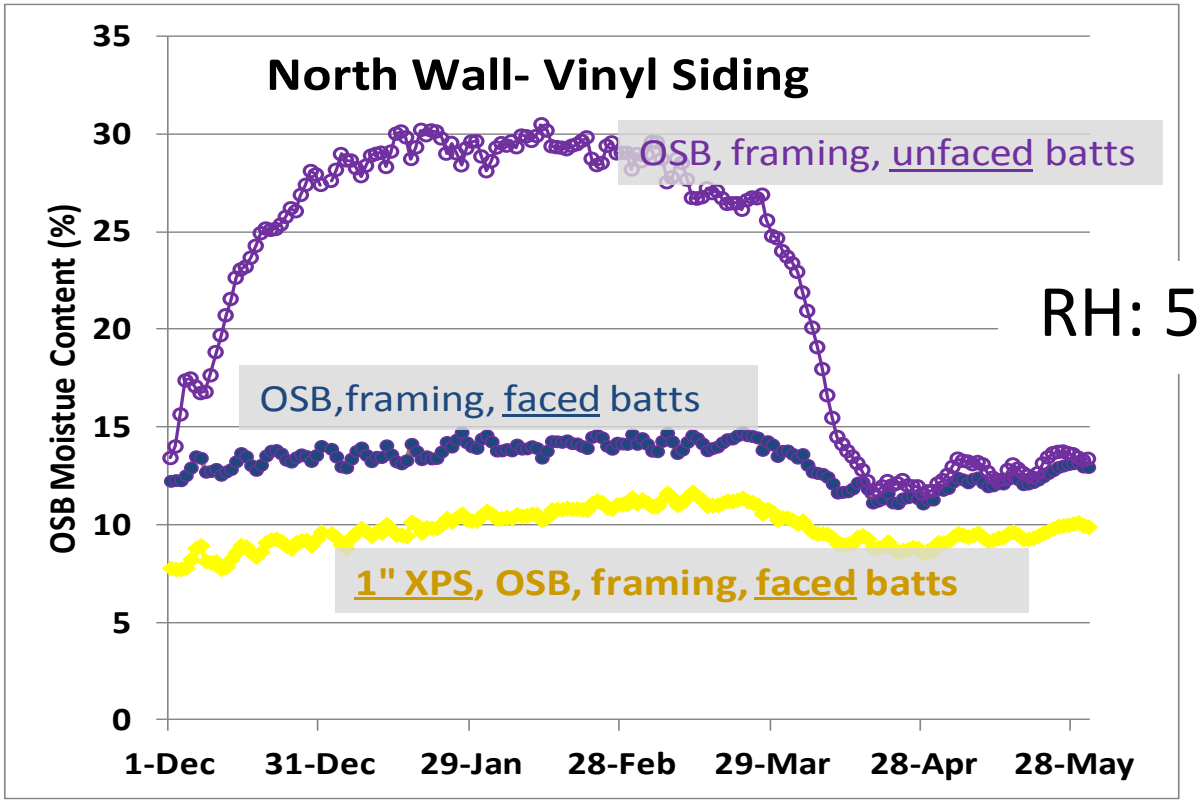
Example: Ext. Continuous Insulation

CZ 6A: Walls with 1” XPS w/o interior vapor retarder – – Insufficient CI R-value for the application



Test Huts – Direct Comparison

CZ 4



RH: 50-60%

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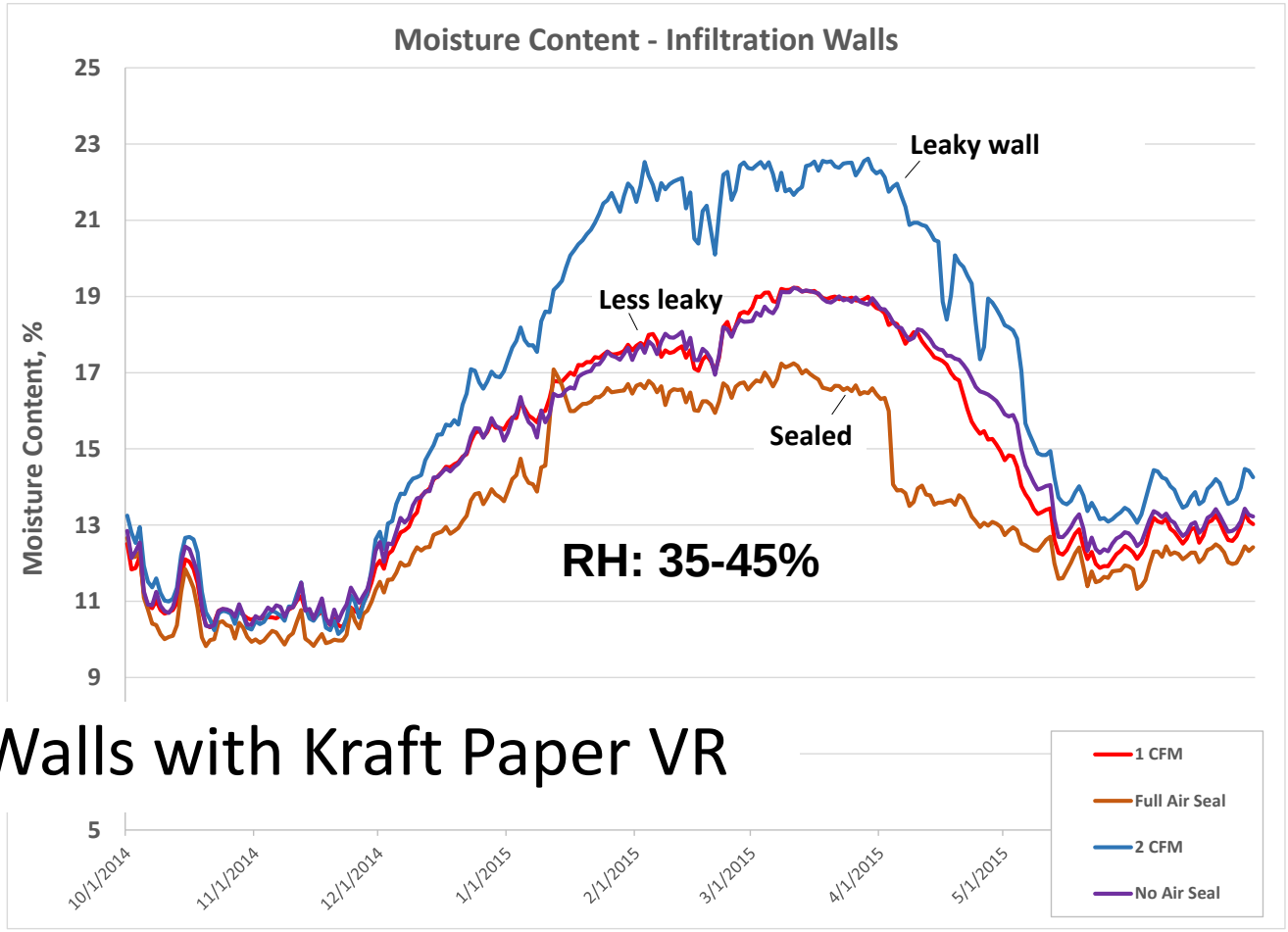
Air leakage vs. Vapor Diffusion

CZ 4



2x6 Walls with Kraft Paper VR

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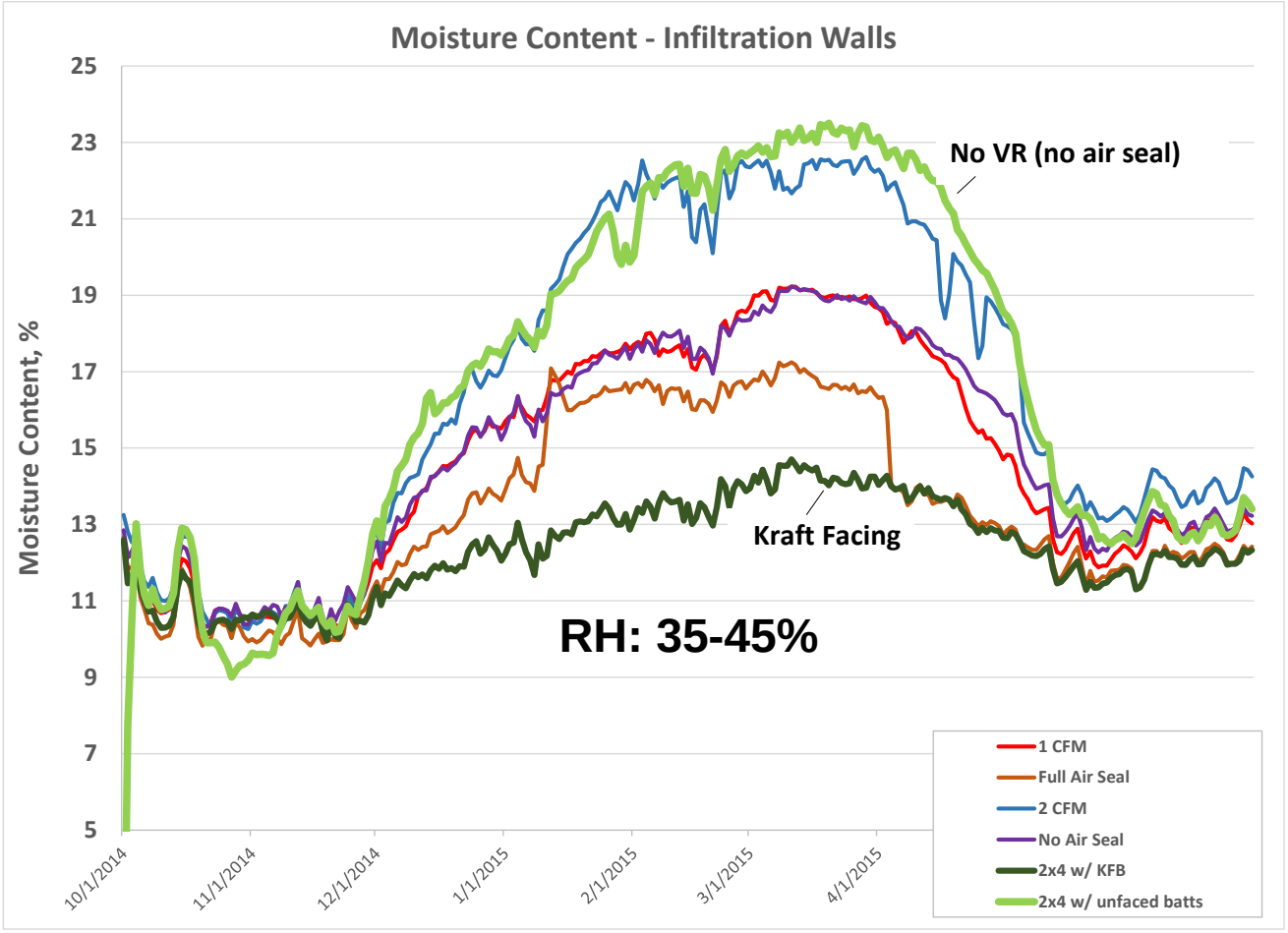
Air leakage vs. Vapor Diffusion

CZ 4



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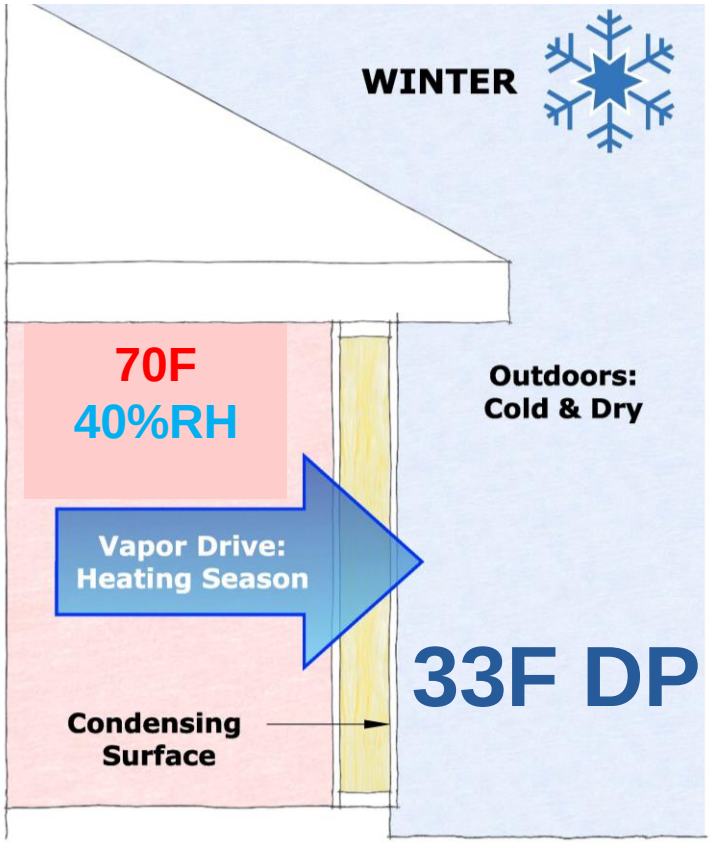
Air leakage vs. Vapor Diffusion

Both are important!



30 days

4'x8' sheet of drywall (50 perm)

+ Kraft Paper (1 perm)

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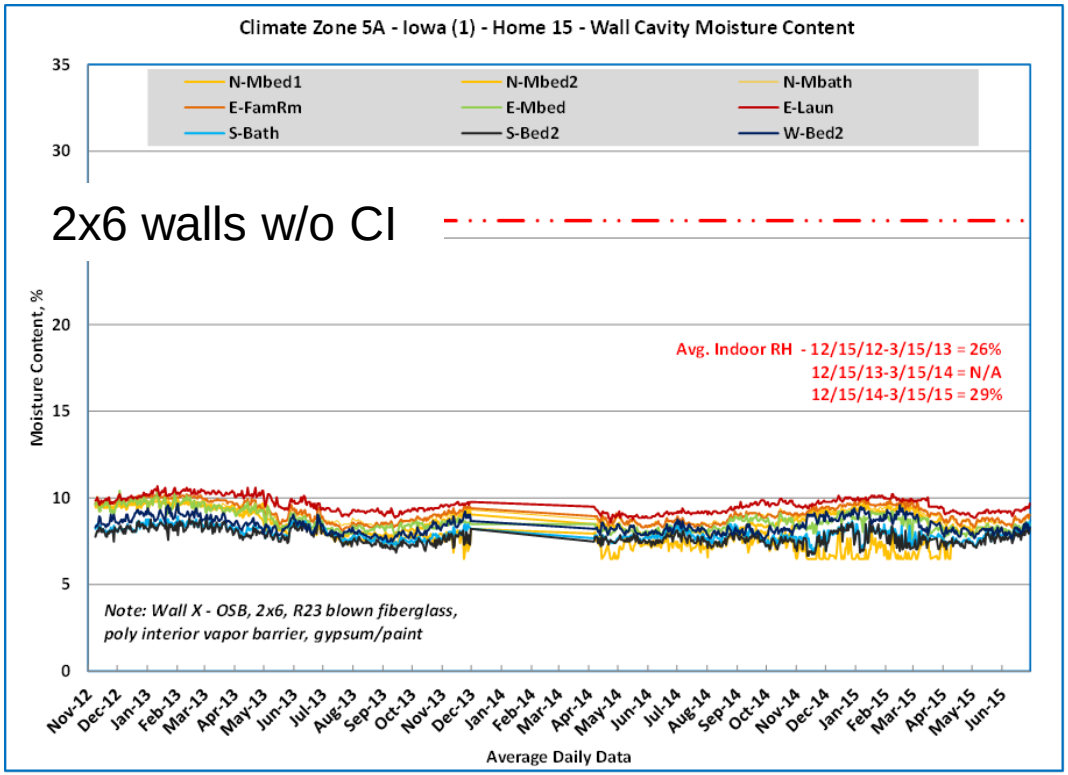
Polyethylene as an interior vapor retarder?

- **Poly is an effective vapor (and air) barrier**
- **Use with caution**

CZ 5



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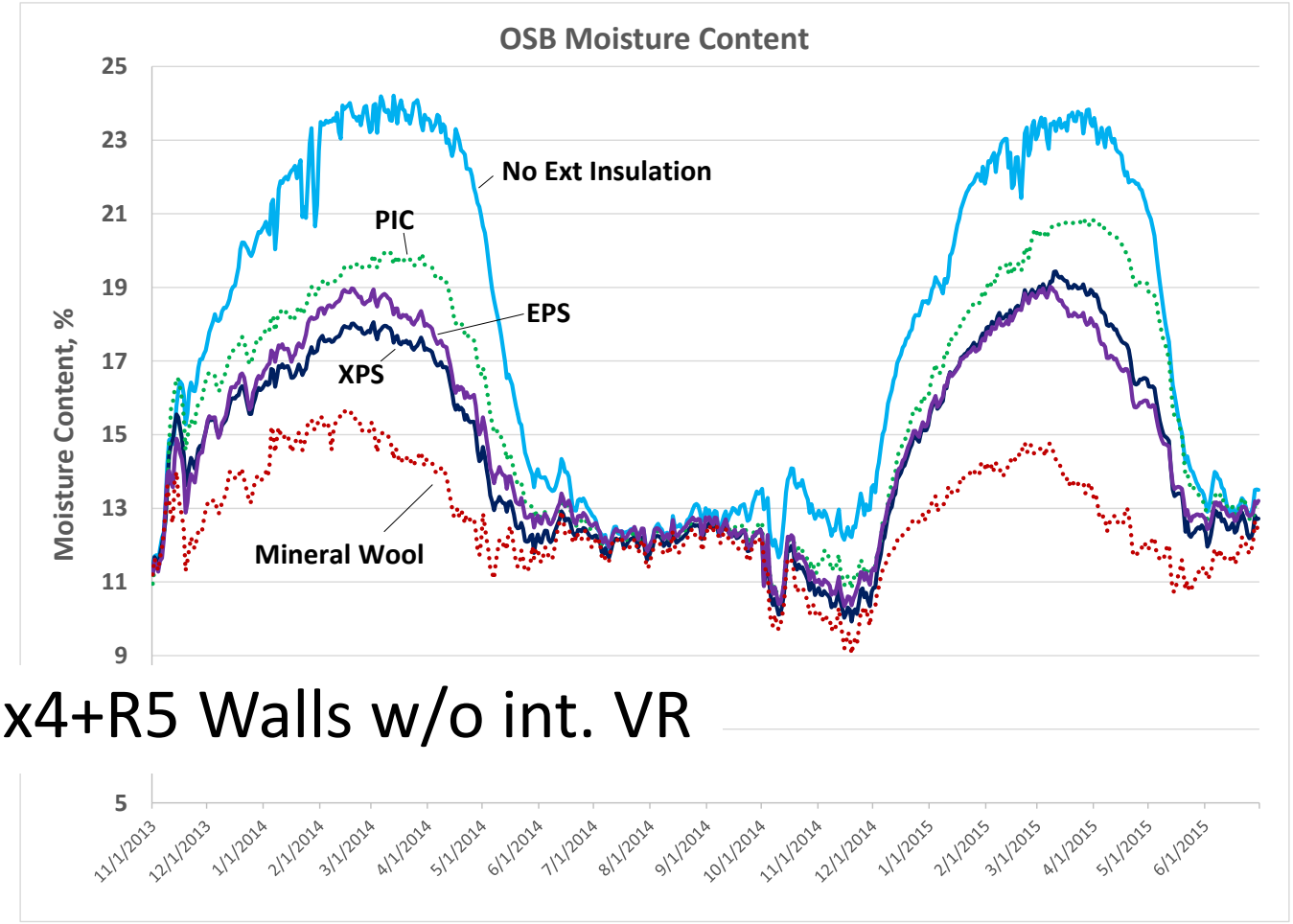
Do walls with ext. foam dry out?

CZ 4



2x4+R5 Walls w/o int. VR

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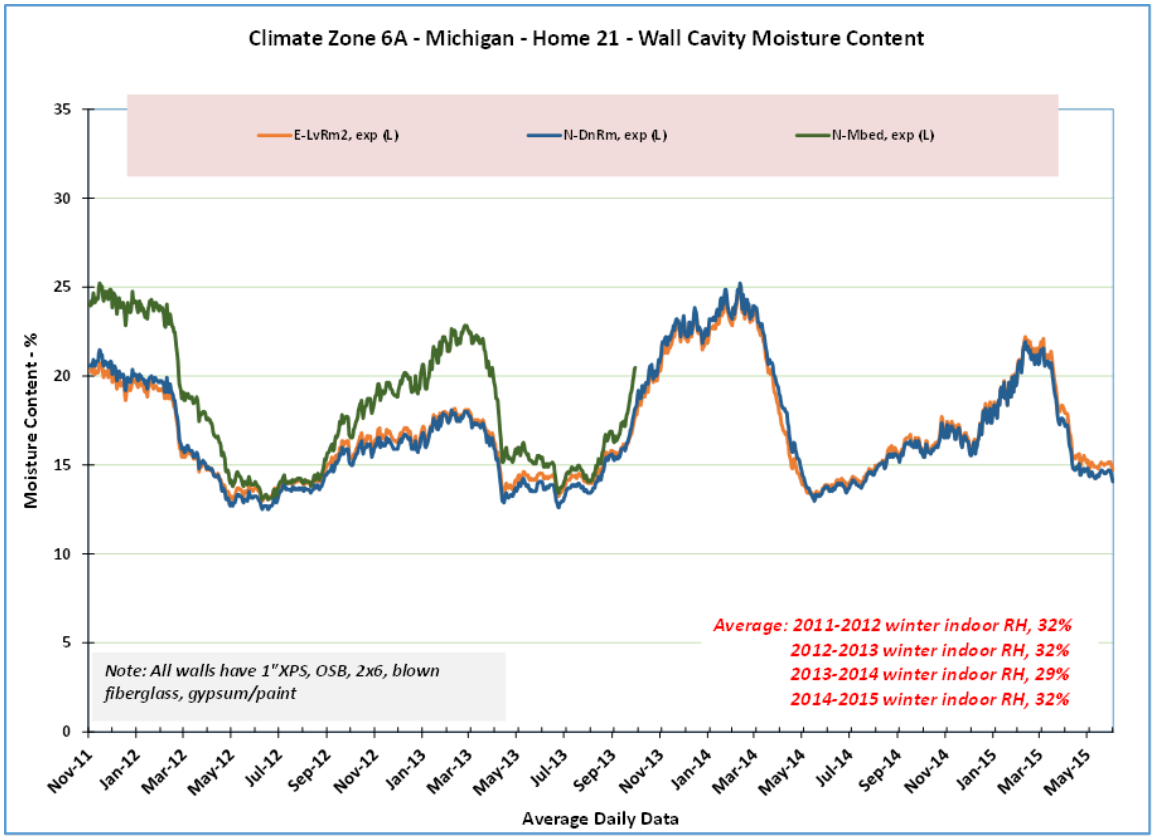
Do walls with ext. foam dry out?

CZ 6A: Walls with 1” XPS w/o interior vapor retarder – – Insufficient CI R-value for the application



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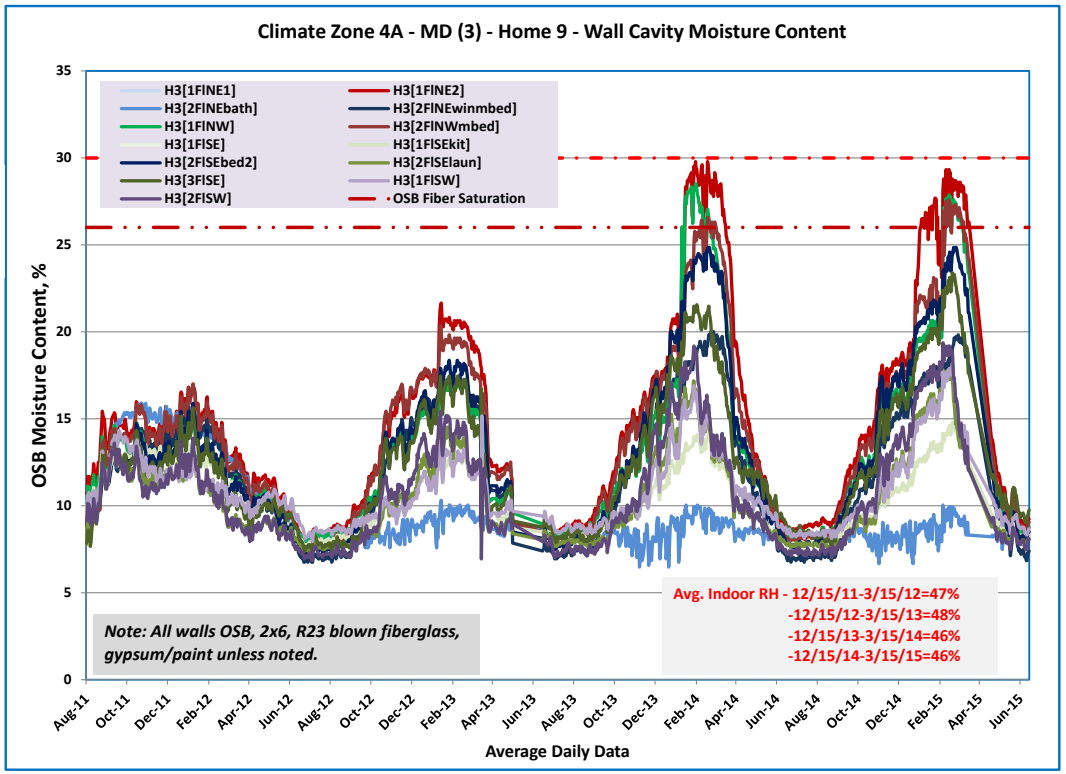
Are indoor RH levels important for walls?

- **Yes, in combination with other variables**

RH: 46-48%

CZ 4



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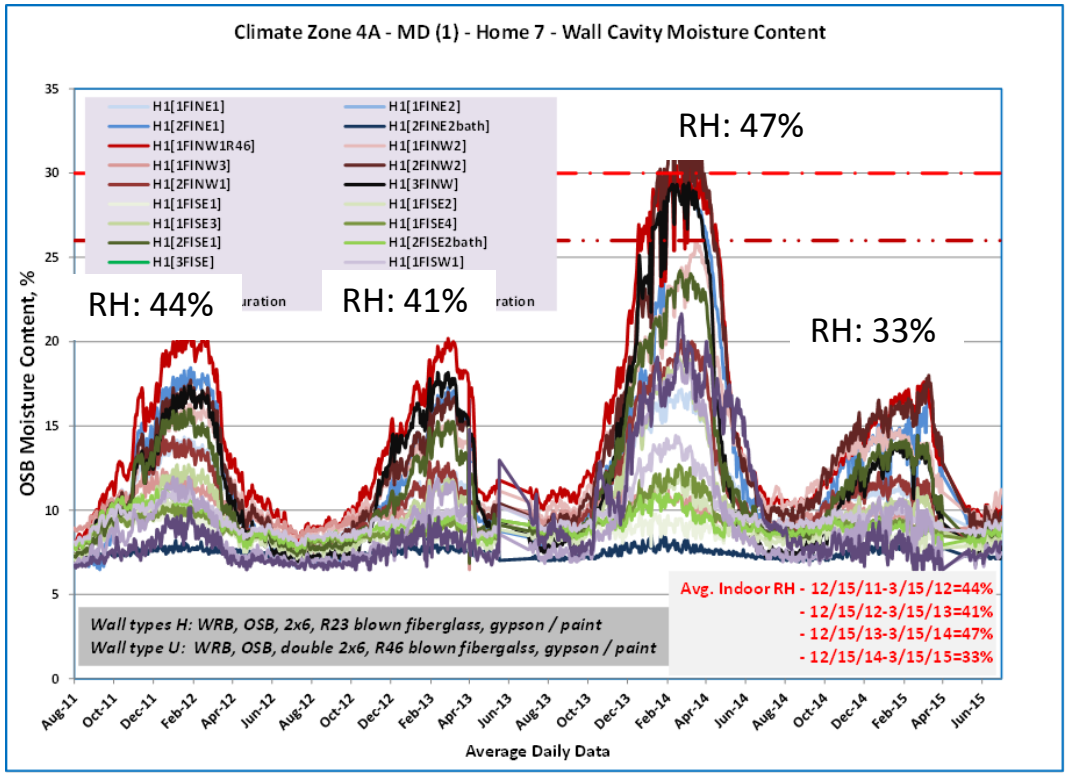
Are indoor RH levels important for walls?

- **Yes, in combination with other variables**

CZ 4



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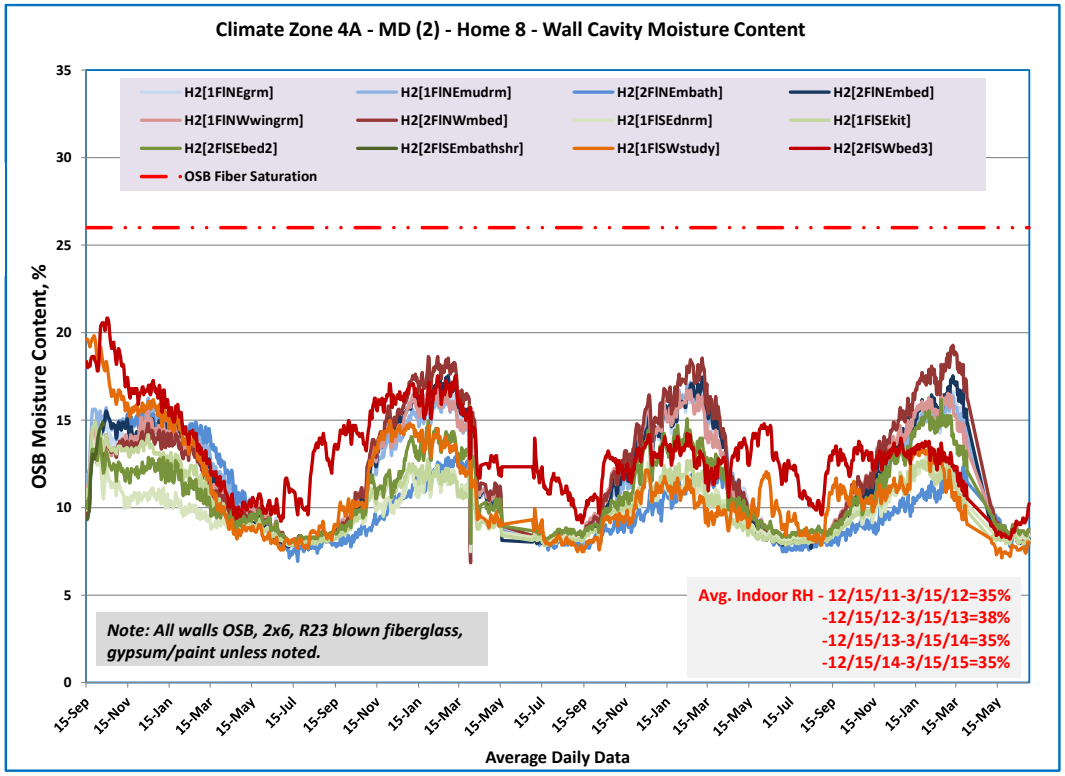
Are indoor RH levels important for walls?

- **Yes, in combination with other variables**

RH: 35-38%

CZ 4



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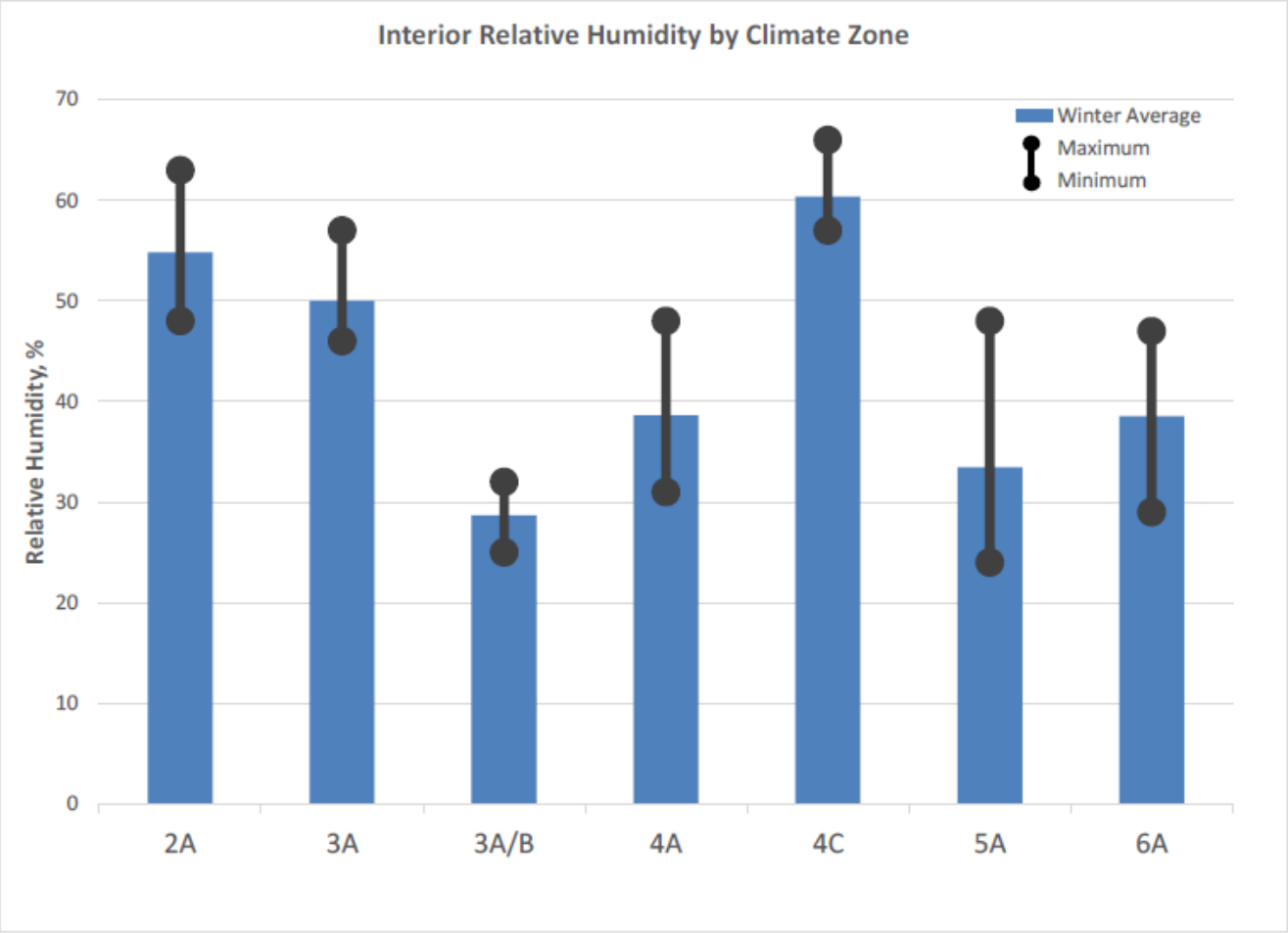
What are the observed indoor RH levels ?



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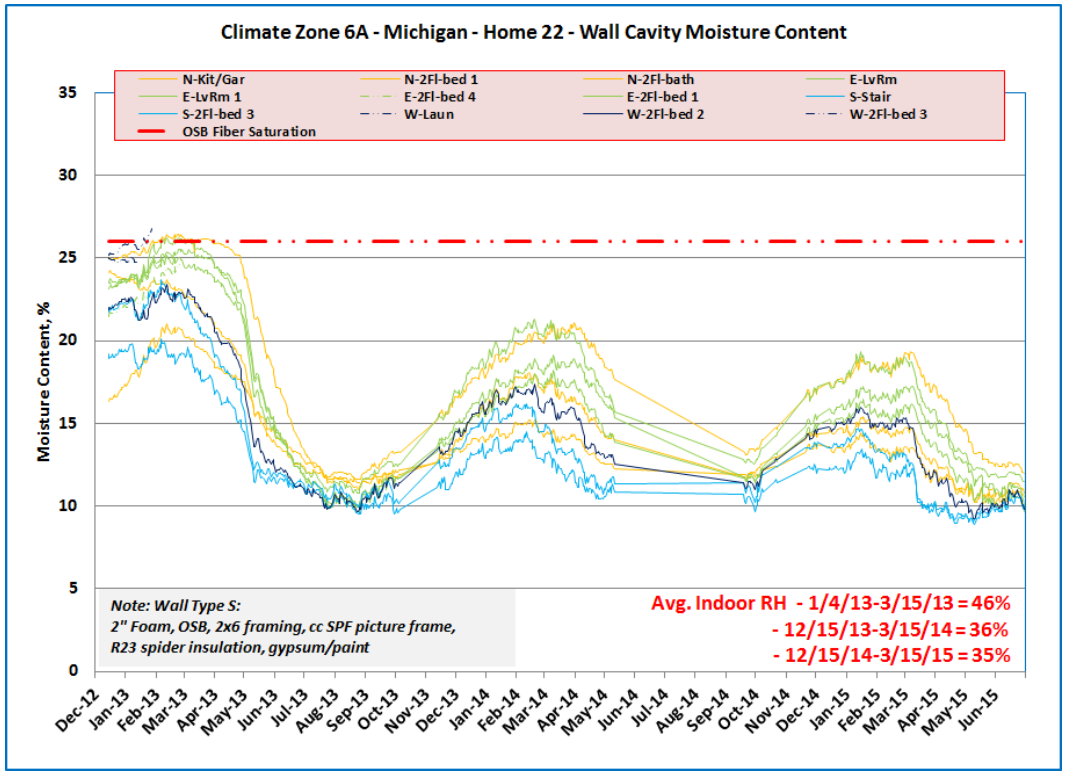
Is Construction Moisture Important?

- **Construction moisture can be highest moisture load in walls**



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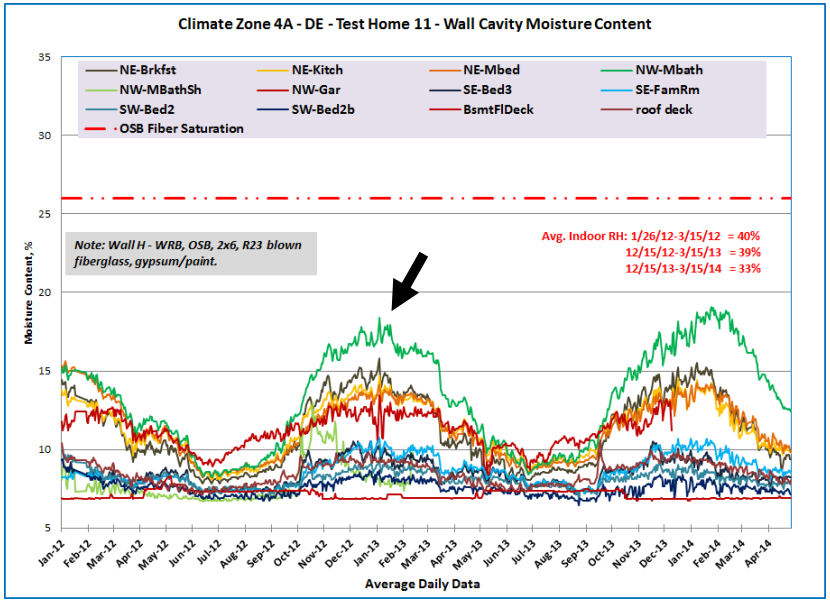
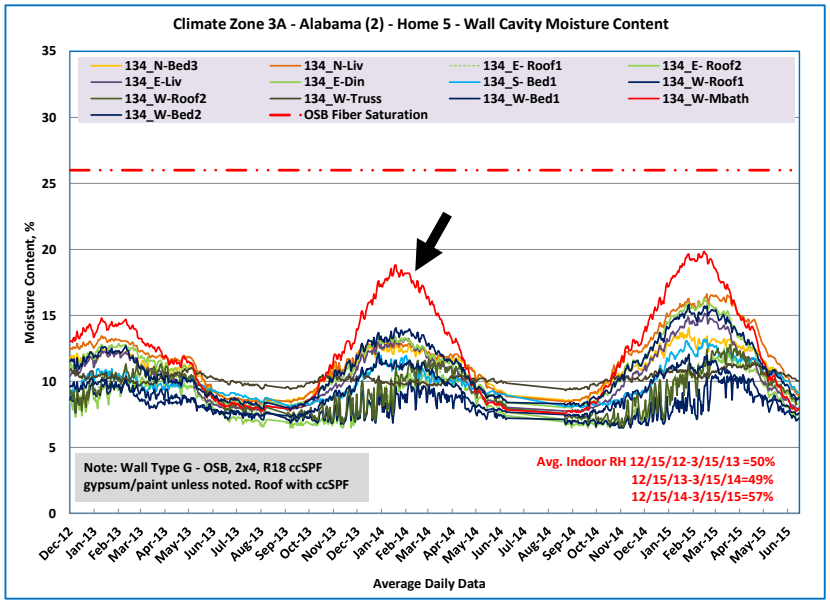
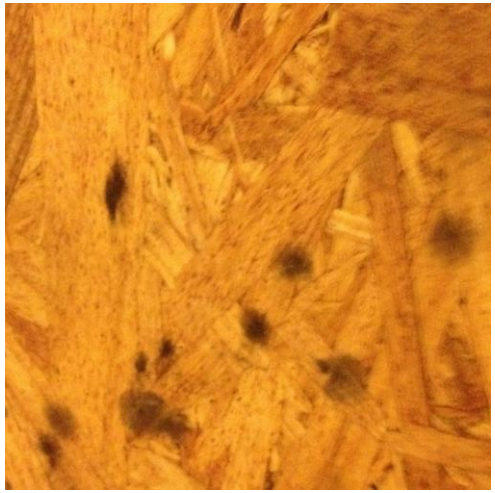
Is point source ventilation important?

- **MC is often highest in the bathroom**





Is water damage from vapor drive real?



19% drop in bending strength after one winter season

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Are conventional dew point calculations accurate?

- Conservative
- Tend to overestimate the risk, particularly in terms of duration
- Steady-state assumption
- Walls' response dynamic following daily temperature and RH cycles
- Wood has moisture storage capacity (buffer)
- WUFI provides good trends; absolute values are more challenging

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Why there are so many different wall systems?

- Any system has its pros and cons
- Broad range of metrics

✓ R-value	✓ Fire resistance
✓ Air barrier	✓ Sound control
✓ Drainage of exterior water	✓ Other Green attributes
✓ Vapor control	✓ LCA
✓ Structural	✓ Cost
✓ Constructability	✓ Value

- There is more than one "*sweet spot*" based on the specific value proposition

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Resources

- BASC – https ://basc.pnnl.gov/
- Wall Construction Guides:

www.homeinnovation.com/wallguides

- Tech Notes

www.homeinnovation.com/technotes

- Reports:

http://www.homeinnovation.com/reports

Search: *moisture, walls*

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Code and Design Recommendations

- Interior vapor retarder in CZ 4A (Class II, smart)
- Coordinate energy code provisions for R20+5 walls and int. vapor retarder provisions
- Rated paints as a vapor retarder (standard latex paint not a Class III vapor retarder)
- Avoid a double vapor barrier configuration
- Add classification for variable vapor retarder
- Not to use Class I int. vapor retarder in CZ 1-2

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Ongoing Study

- Monitoring of additional energy efficient homes
- Broader range of materials and wall configurations
- Still can add a couple of homes in the **Hybrid** category in CZ 5 or 6 (vkochkin@homeinnovation.com)

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THANK YOU

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