BUILDING ENERGY 15

MARCH 3-5, 2015 AT THE SEAPORT WORLD TRADE CENTER

AIA Provider: Northeast Sustainable Energy Association

Provider Number: G338

Super Insulated Walls and Moisture: Does Bad Stuff Happen?

Course Number

Chris Corson and Kohta Ueno

March 4, 2015

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

High-R or super-insulated walls are a common component of high performance housing. However, in cold climates, these walls run the risks of cold-weather condensation, and general durability issues due to reduced heat flow. Two practitioners have been monitoring the moisture performance of several high performance walls, and will share their results. Chris Corson has been examining highly vapor-open walls based on classic European Passive House designs, without the use of plastic foams. Kohta Ueno has been monitoring double stud walls insulated with cellulose and open-cell spray foam for three winters. His monitoring study was followed by disassembly of the walls, to examine conditions in the cavities. The two will talk about their data, whether various assemblies fall on the safer or riskier side, and how to make design choices. Keeping these walls buildable and cost-effective will be another aspect of the discussions.

Learning Objectives

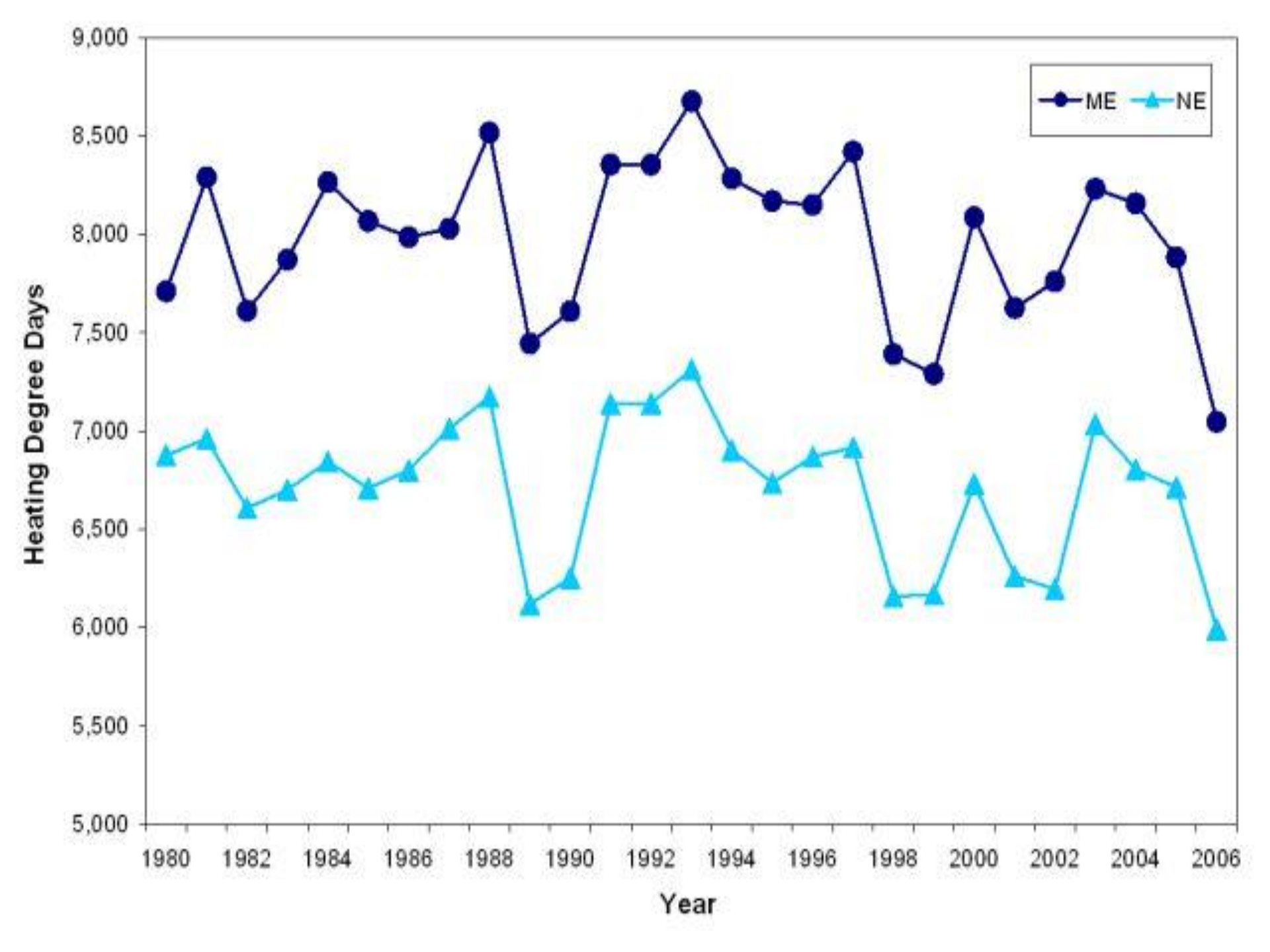
At the end of the this course, participants will be able to answer:

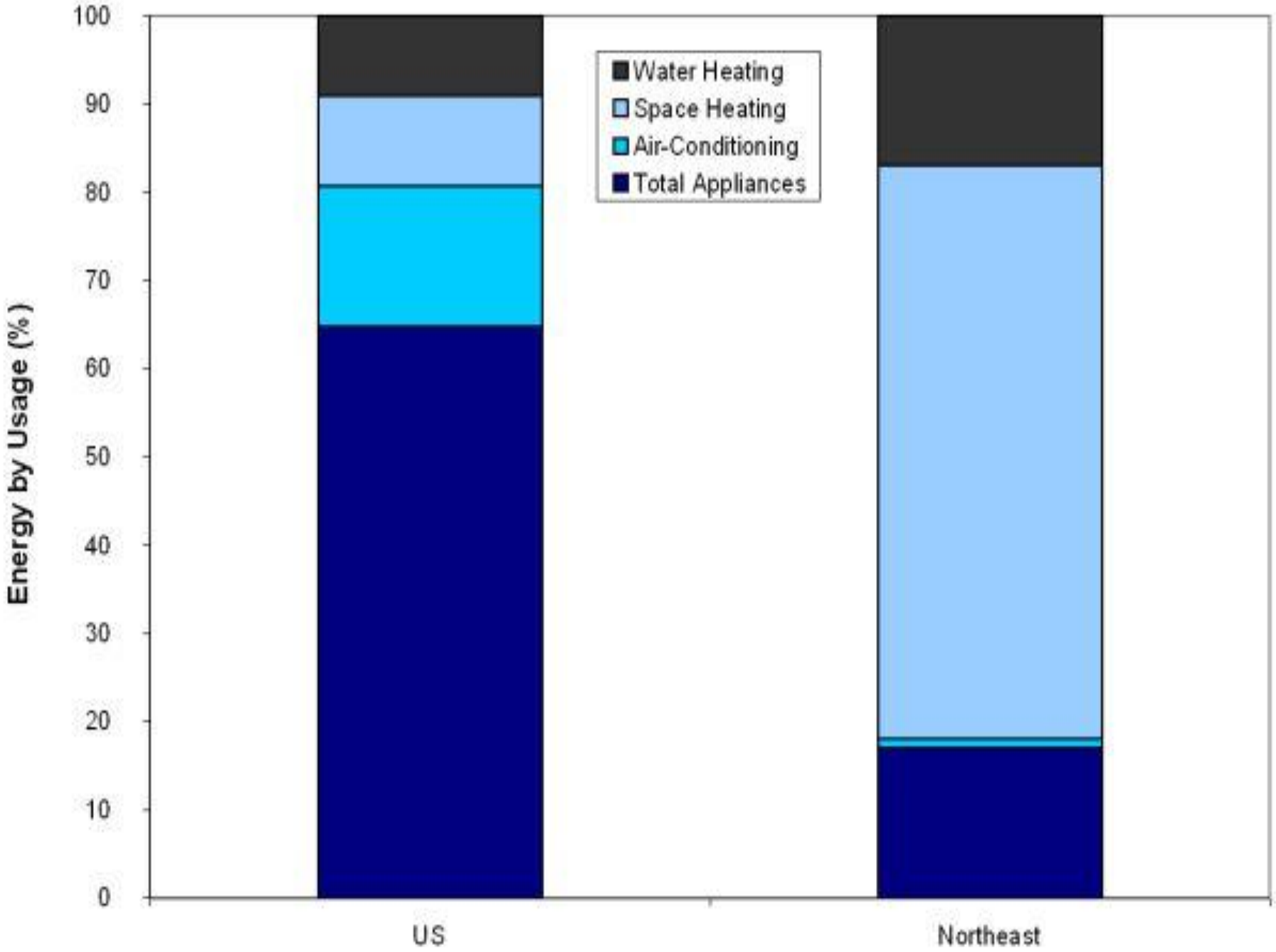
1. What are the risks associated with high-R or superinsulated walls, relative to conventional/code construction?

2. What are some of the options for constructing high-R walls in cold climates?

3. How does a particular vapor-open high-R wall behave in a very cold climate (Maine), in terms of moisture risks?

4. What moisture conditions and resulting damage are seen at double stud wall sheathing after experiencing high interior humidity conditions?

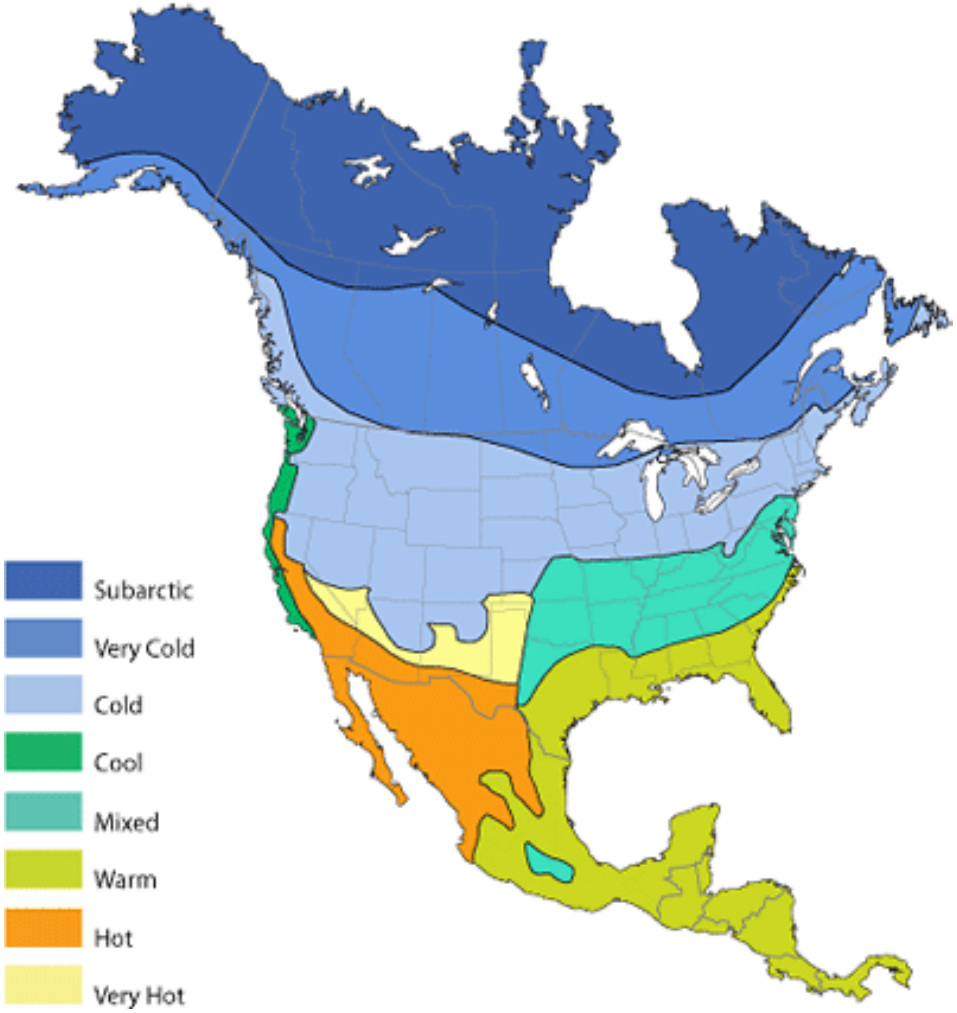

9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
Heating Degree Days
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
Year
ME
NE


Energy by Usage (%)
100
90
80
70
60
50
40
30
20
10
0
Water Heating
Space Heating
Air-Conditioning
Total Appliances
US
Northeast

In Situ

Where to Place the Vapor Retarder?

- **Vapor retarders work best when moisture is flowing only in one direction, such as in below grade areas.**
- **In mixed heating and cooling climates, where should the vapor barrier be placed? During certain portions of the year, it will <u>always</u> be on the wrong side of the building assembly and allow moisture to accumulate behind it.**



Bad,Bad,Things…

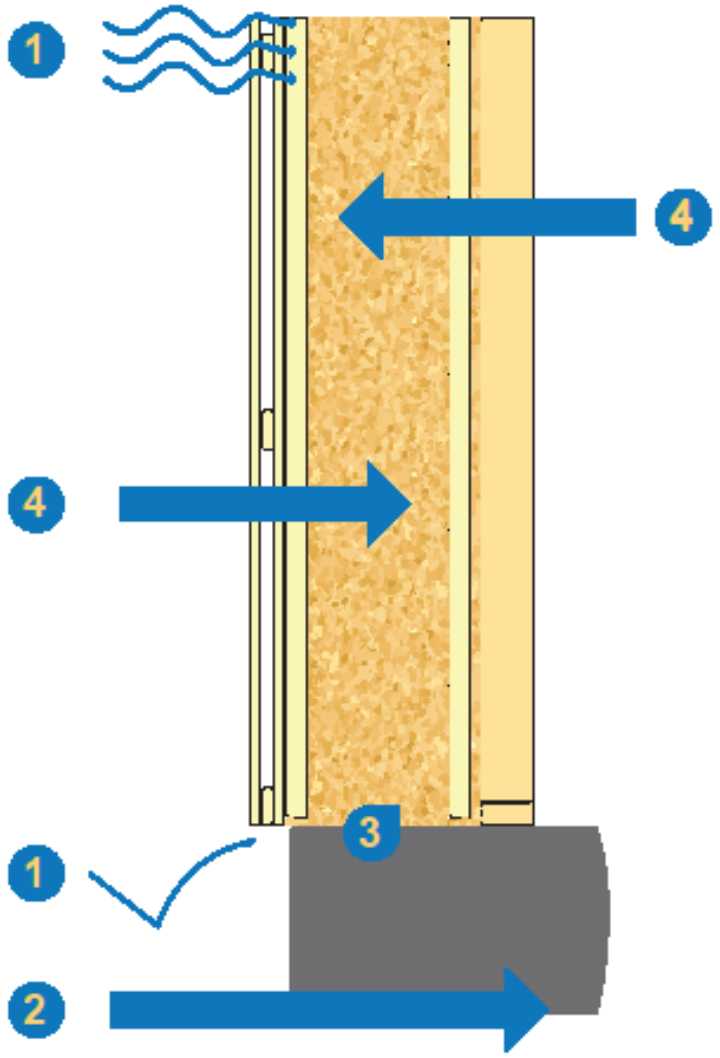
Wetting Mechanisms

1. **Bulk water: Adsorption of driving rain and splash-back at grade**

2. **Bulk water: Liquid and bound groundwater, driven by capillary suction, redistribution and gravity**

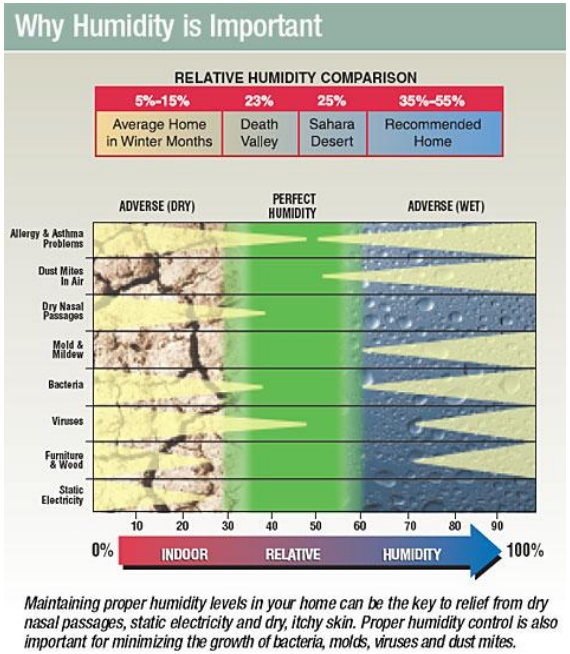
3. **Built-in and stored moisture, esp. in wood and concrete**

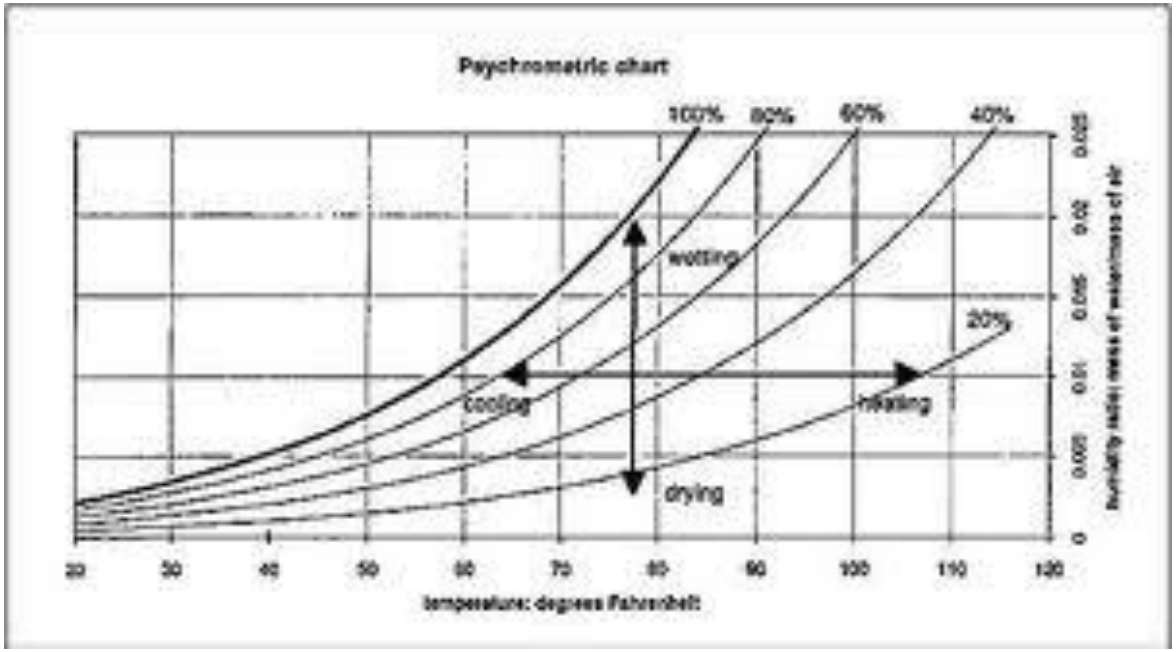
4. **Vapor transport via infiltration/exfiltration and/or diffusion**



Diffusional Moisture and the Psychrometric Chart

- Higher relative humidity increase's vapor pressures and the available moisture for wetting of building assemblies.





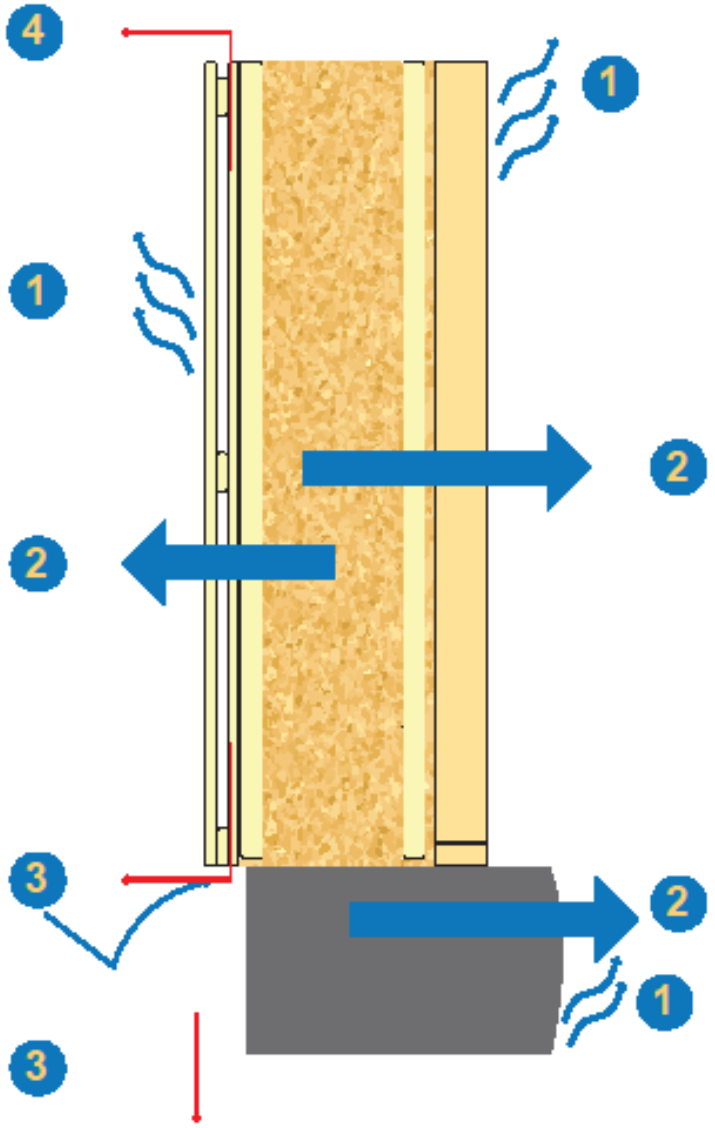
Drying Mechanisms

1. **Evaporation: Liquid water transported by capillary action to the inside or outside**

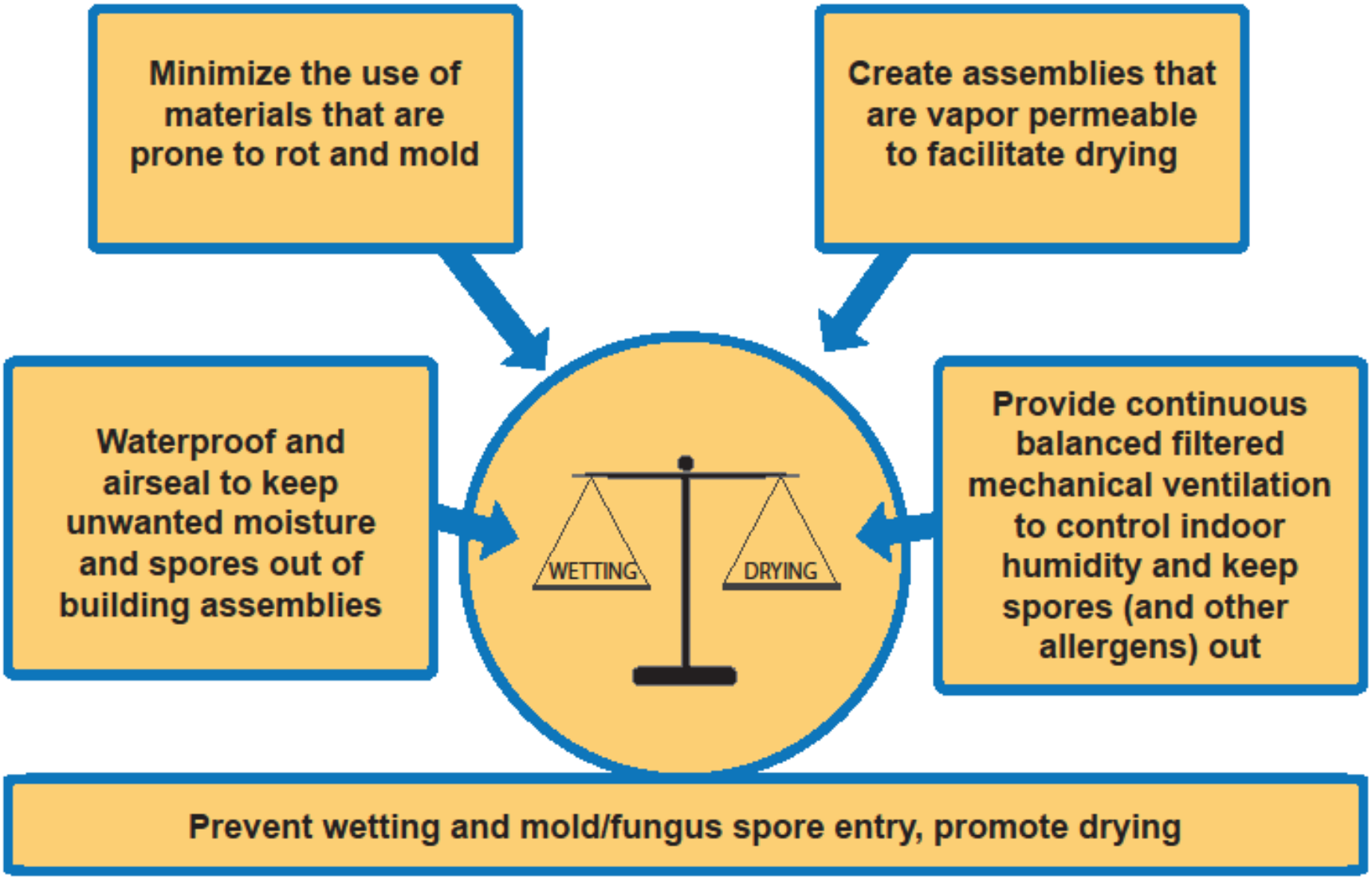
2. **Vapor transport via diffusion and/or effusion**

3. **Drainage of unabsorbed water, driven by gravity**

4. **Convection through intentional (or unintentional) vented air cavities**



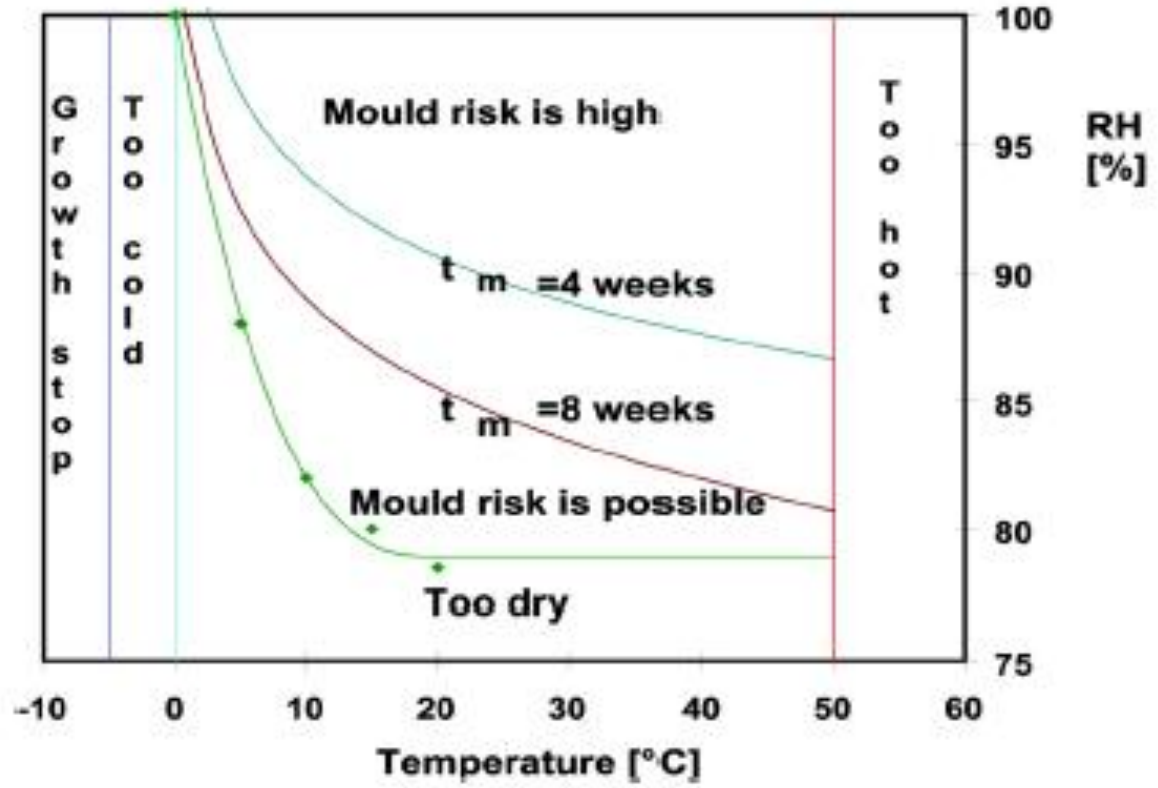
Moisture Management



Vapor Barriers:
Avoid the Vapor Sandwich

Conditions Favorable for Mold Growth

- **Mold growth is a function of temperature, relative humidity and time.**
- **Warmer and dryer surfaces help to reduce the risk.**



Wall Design

BUILDINGENERGY 15

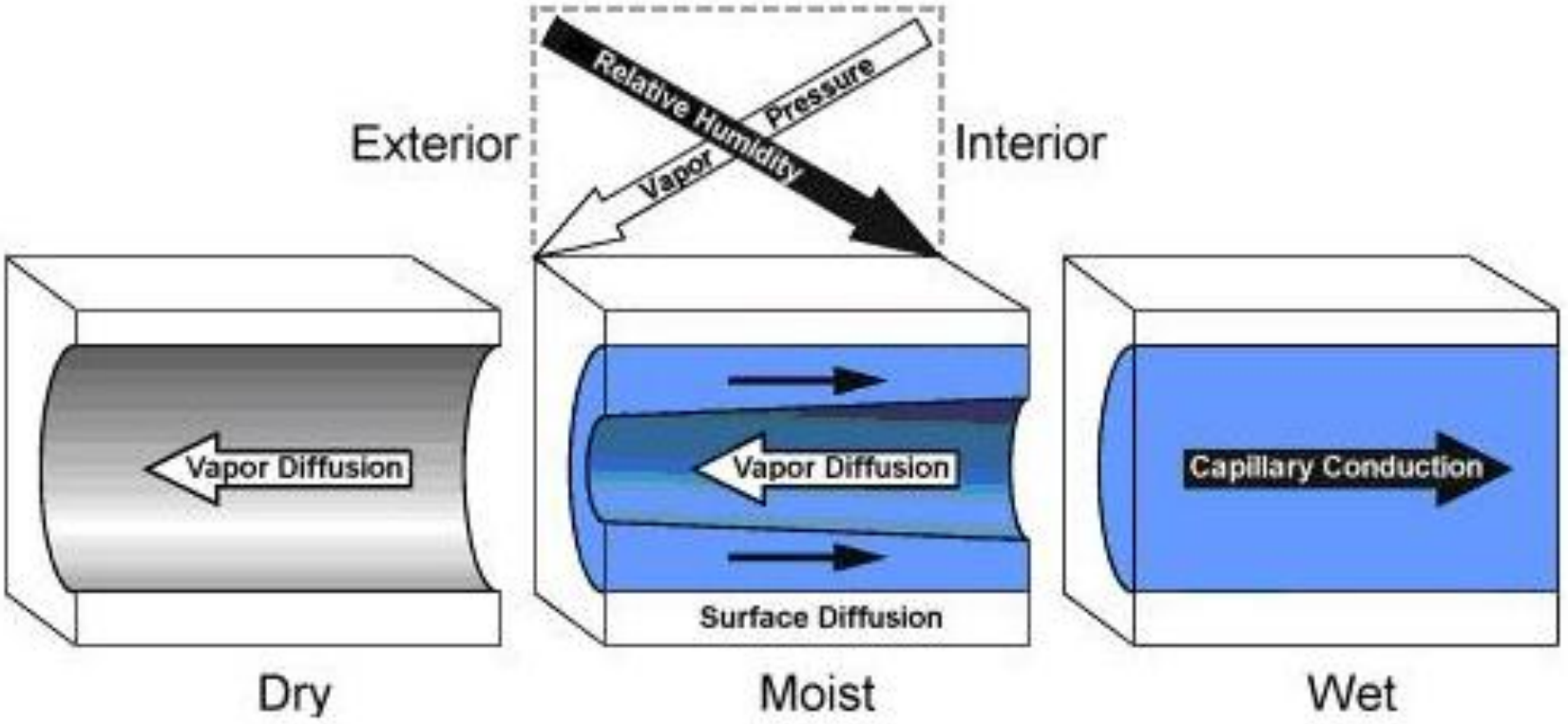
MARCH 3-5, 2015

SEAPORT WORLD TRADE CENTER BOSTON, MA

CONFERENCE + TRADE SHOW FOR RENEWABLE ENERGY AND GREEN BUILDING PROFESSIONALS

ECOCOR
high performance buildings

Moisture transfer in hygroscopic materials

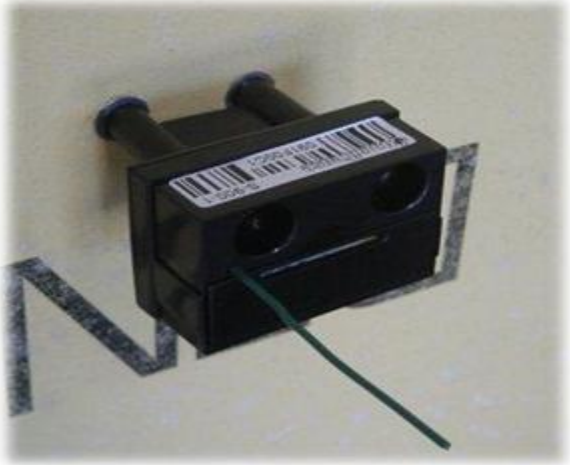


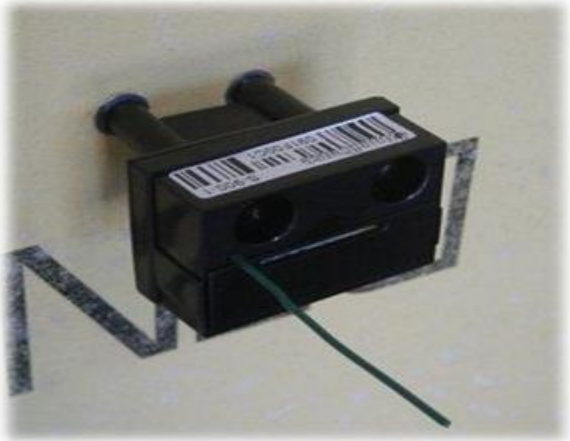
Hygroscopic materials redistribute moisture and can help dry building components that they are in contact with “hygric redistribution”.

Successful Cellulose Insulation

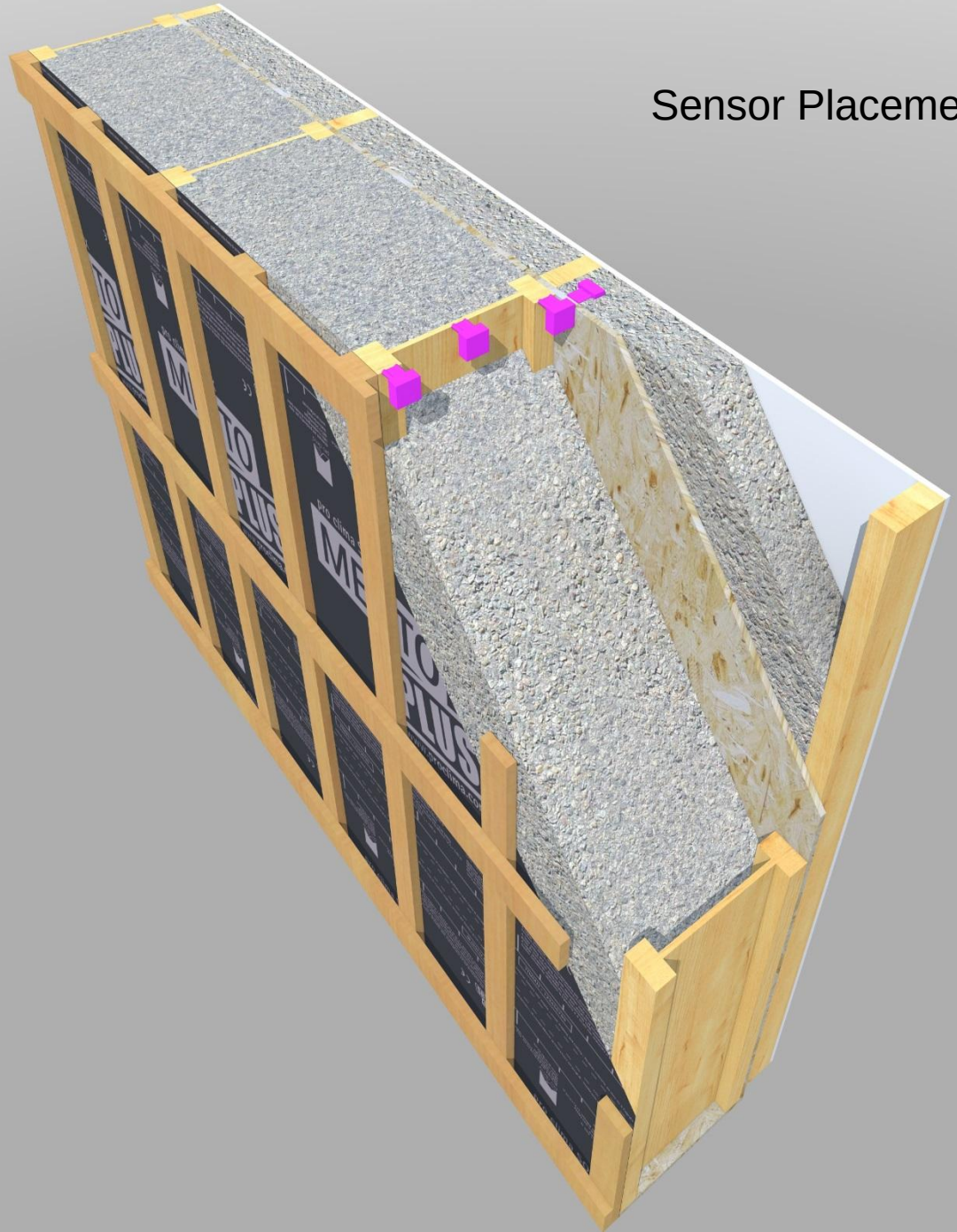
- Use only "all-borate" cellulose insulation
- Deep cavities require the cellulose to be installed at higher densities, 3.7 lbs/cuft at 12", 4.0 lbs/cuft at 18" and 4.2 lbs/cuft at 24" depths to remain self supporting.
- Deeper cavities will require experienced installers to perform multiple passes of the hose to build the density both laterally and vertically.
- Cellulose should be installed behind Insulweb or other air barrier fabrics to allow for quality control along with bag counts of material installed

Instrumentation





Sensor Placement



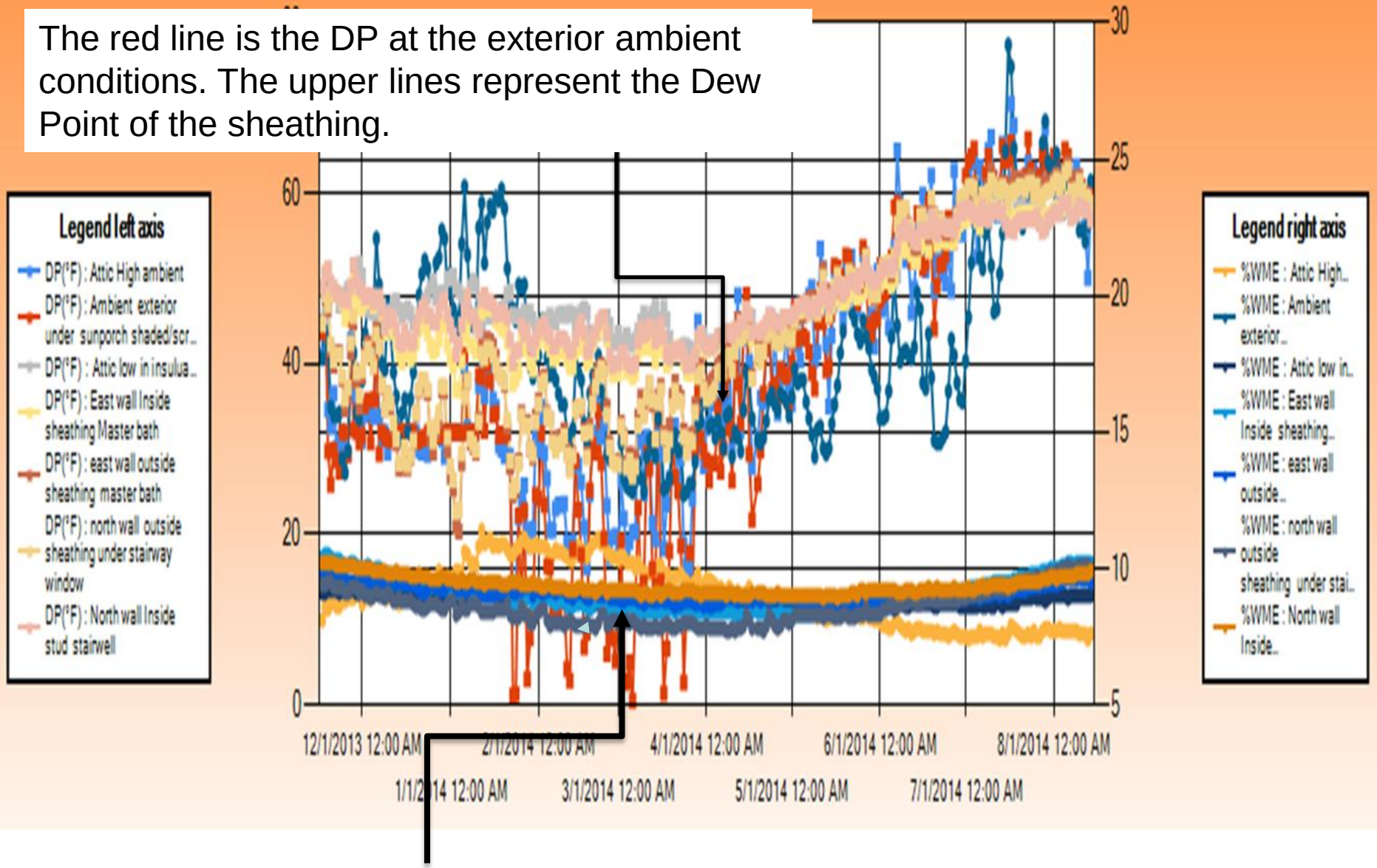
Certified
Passive House
Passive House Institute

EnerPHit
Certified
Retrofit
Passive House Institute

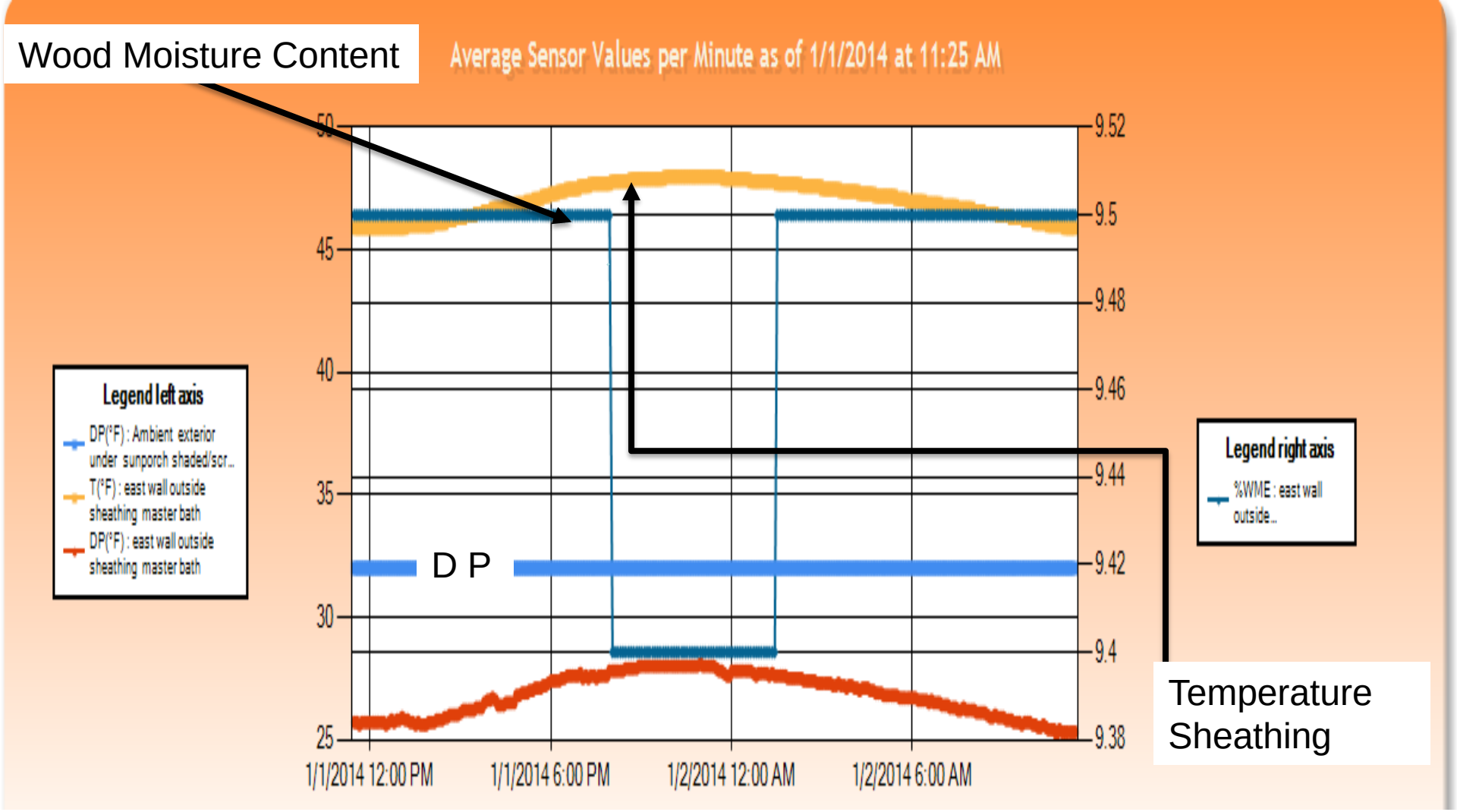
What really happens…….you know……like……in real life……and what should we be looking for?

1. Wood Moisture Content
2. Where the DP falls in the wall and when
3. Temperature of the condensation planes
4. Exterior ambient conditions

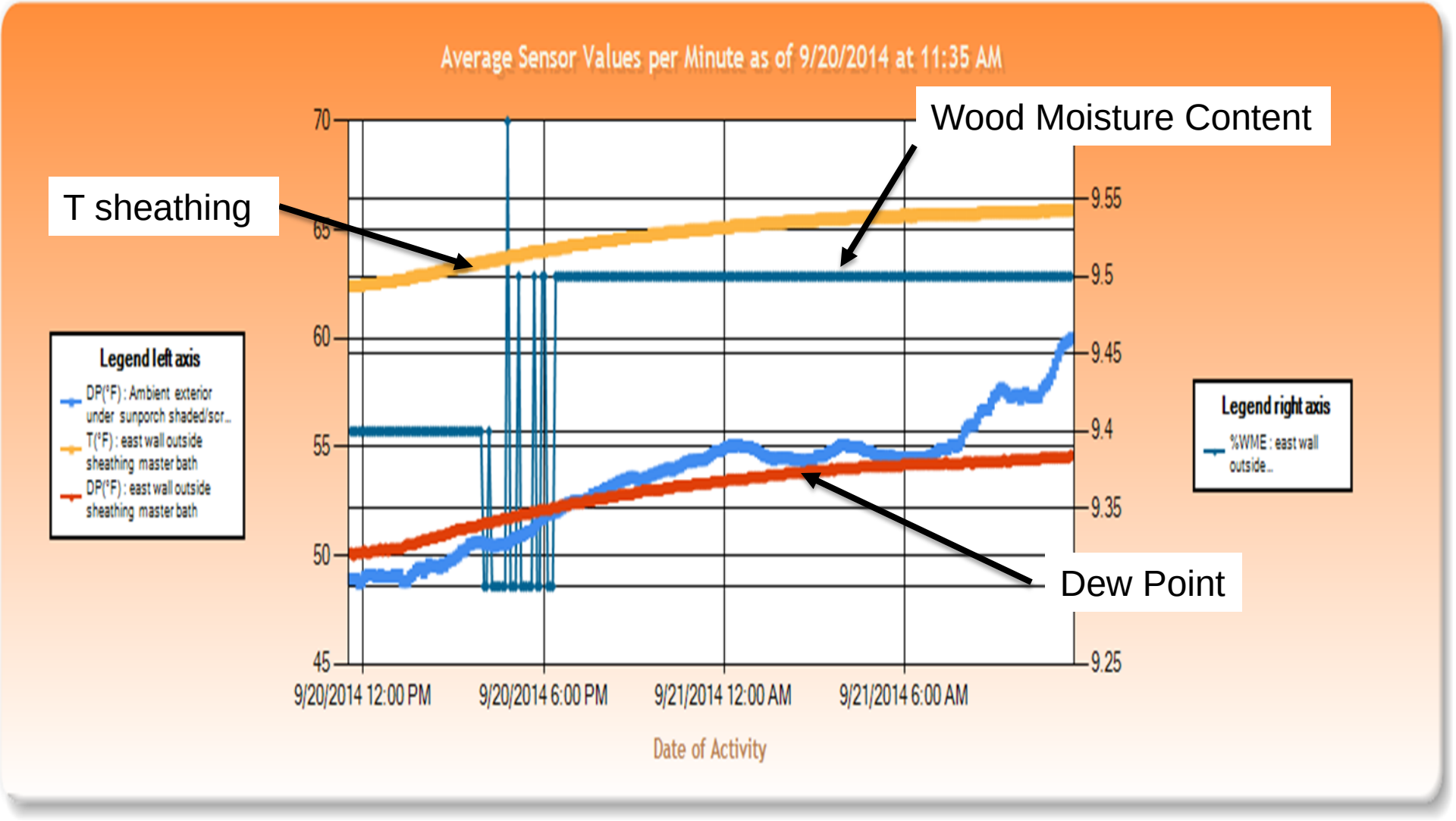
The red line is the DP at the exterior ambient conditions. The upper lines represent the Dew Point of the sheathing.



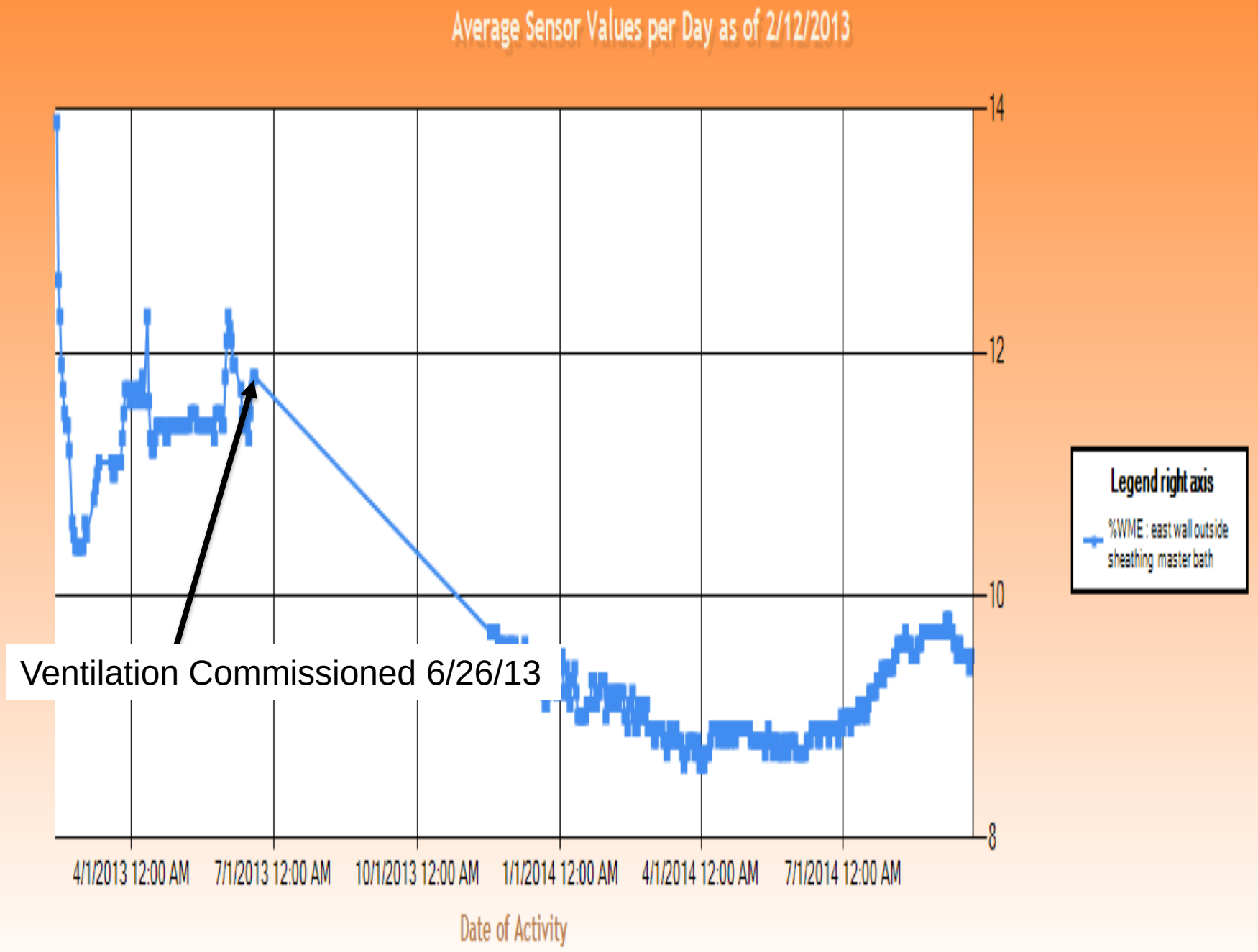
Wood Moisture Content of condensation planes

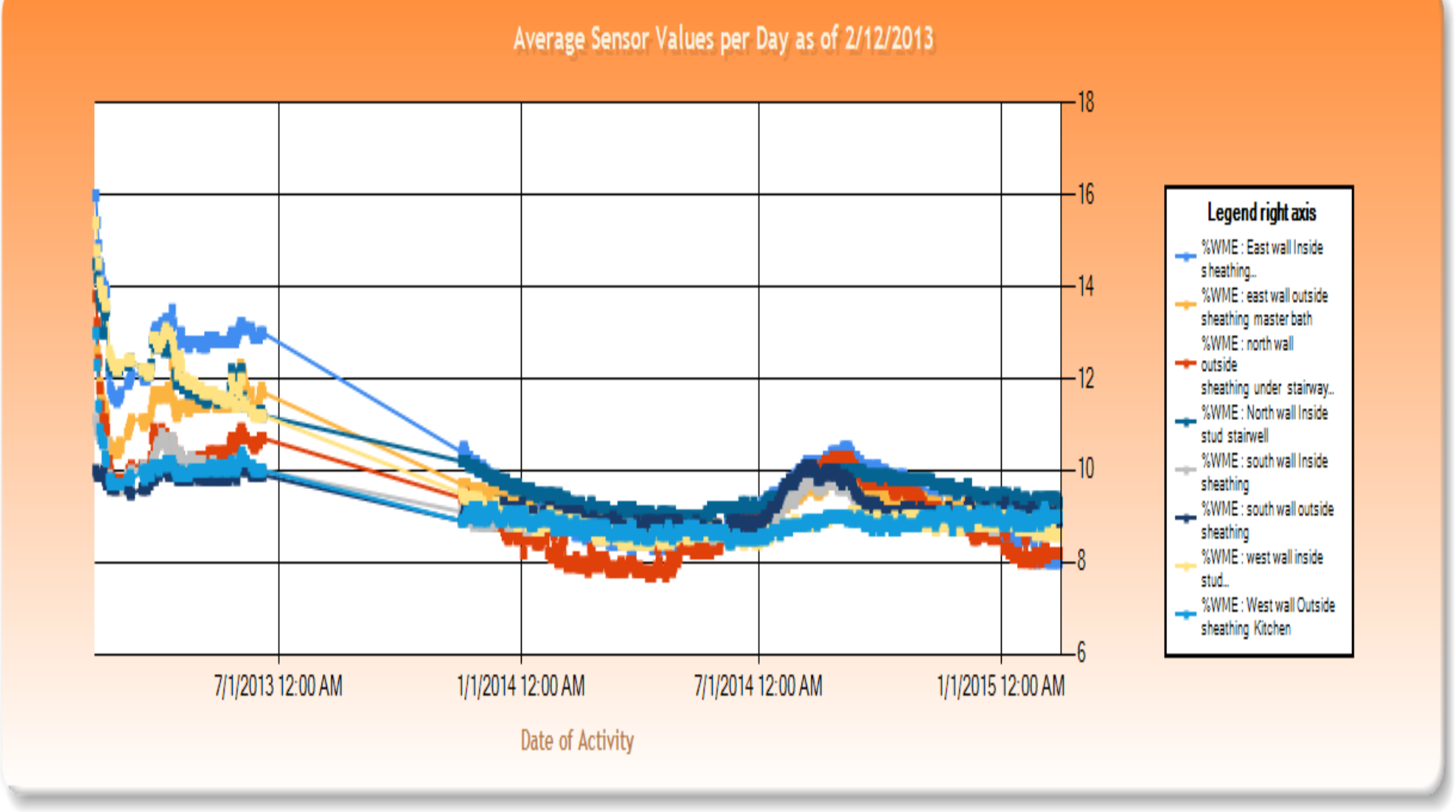


Slice of life…
Dew Point 32F
Dew Point of the sheathing 27F
Temperature sheathing 47F
WME 9.5% Bone dry



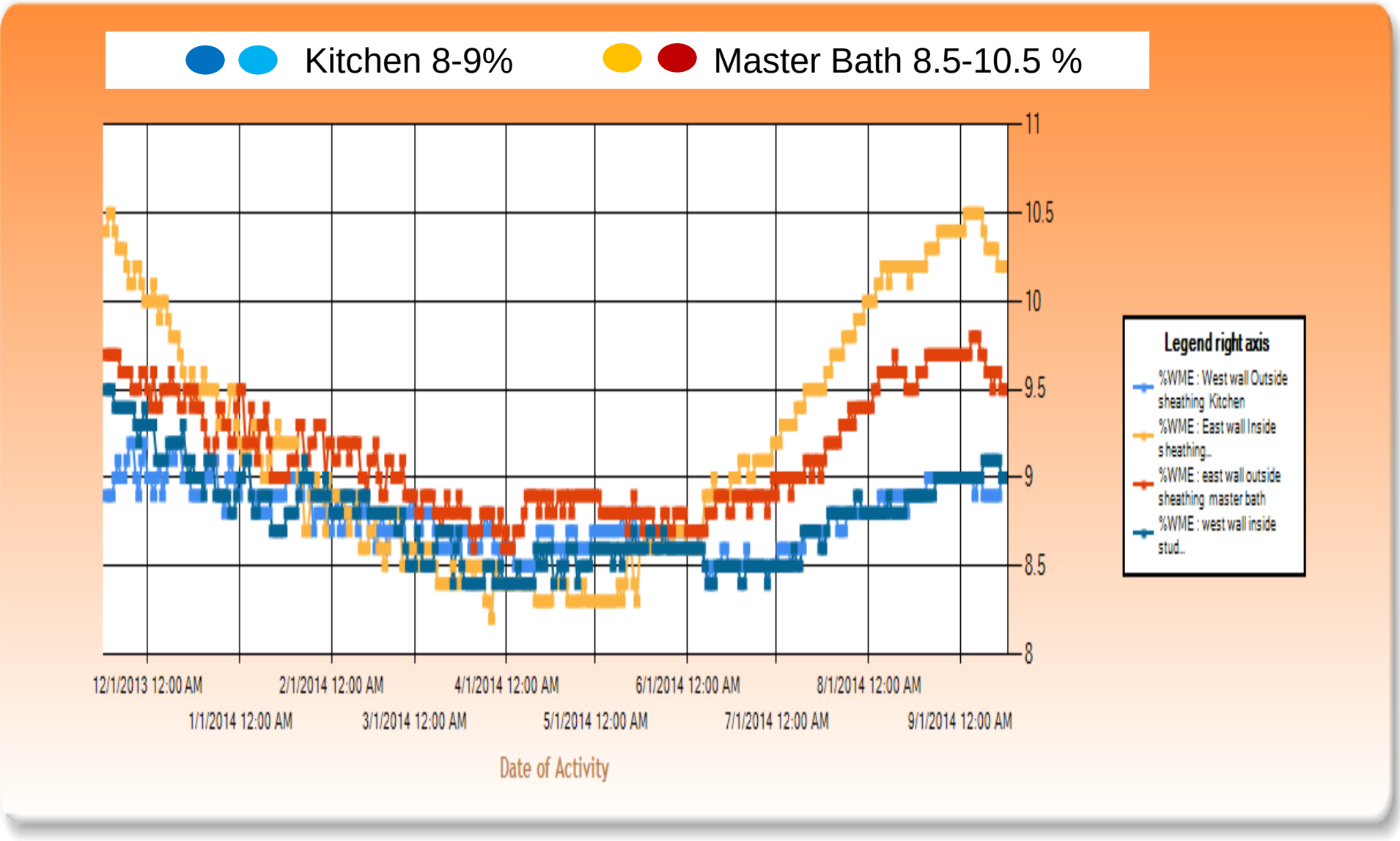
T of sheathing always warmer than dewpoint:
Sheathing always ~ 15F warmer


Average Sensor Values per Day as of 2/12/2013
14
12
10
8
Ventilation Commissioned 6/26/13
4/1/2013 12:00 AM
7/1/2013 12:00 AM
10/1/2013 12:00 AM
1/1/2014 12:00 AM
4/1/2014 12:00 AM
7/1/2014 12:00 AM
Date of Activity
Legend right axis
%WME : east wall outside sheathing master bath



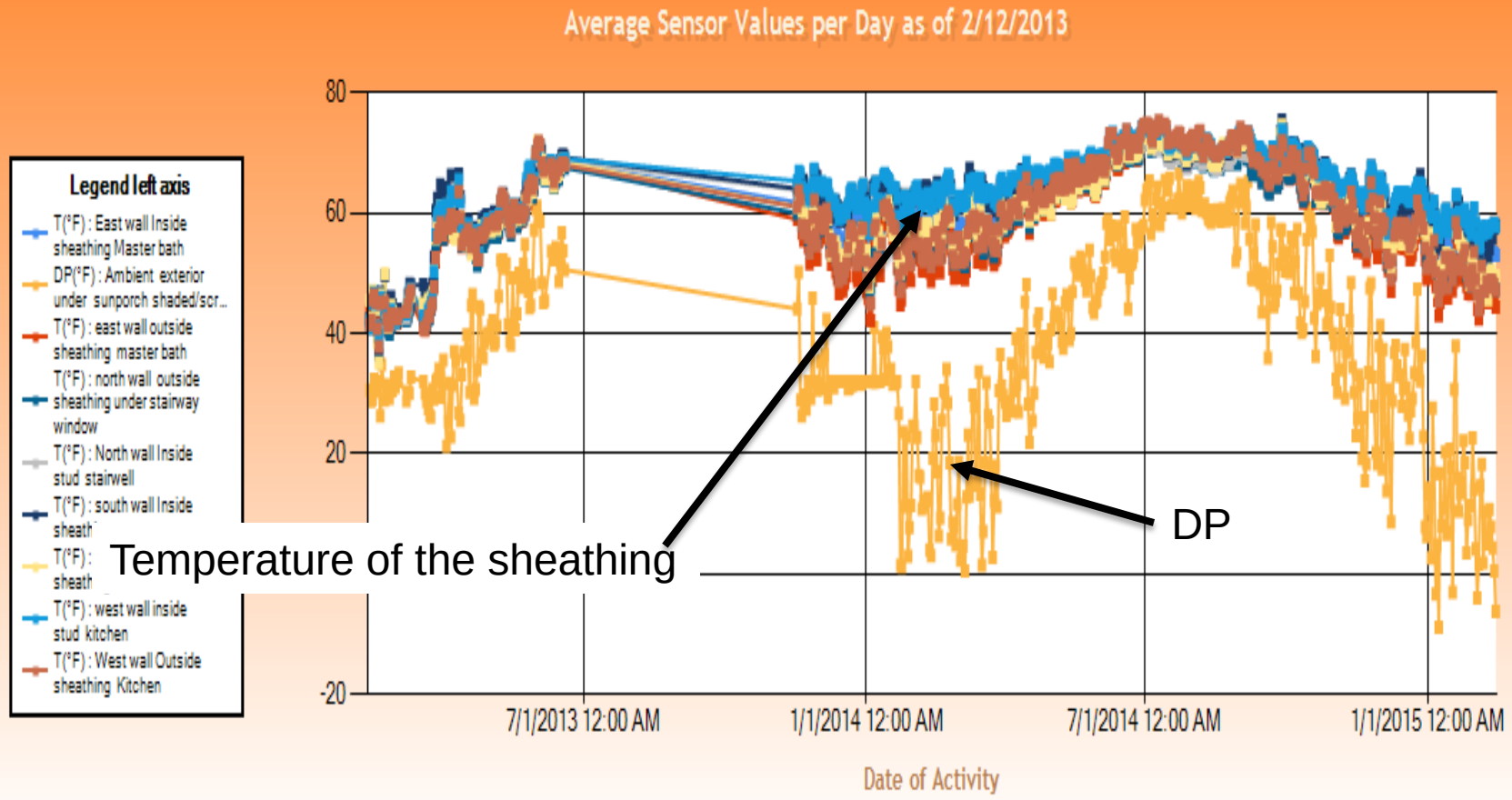
WMC of lumber and sheathing over period of two plus years

Values 15.8 % (high) during construction
8.1 % low
Mean ~ 9% post ventilation commissioning



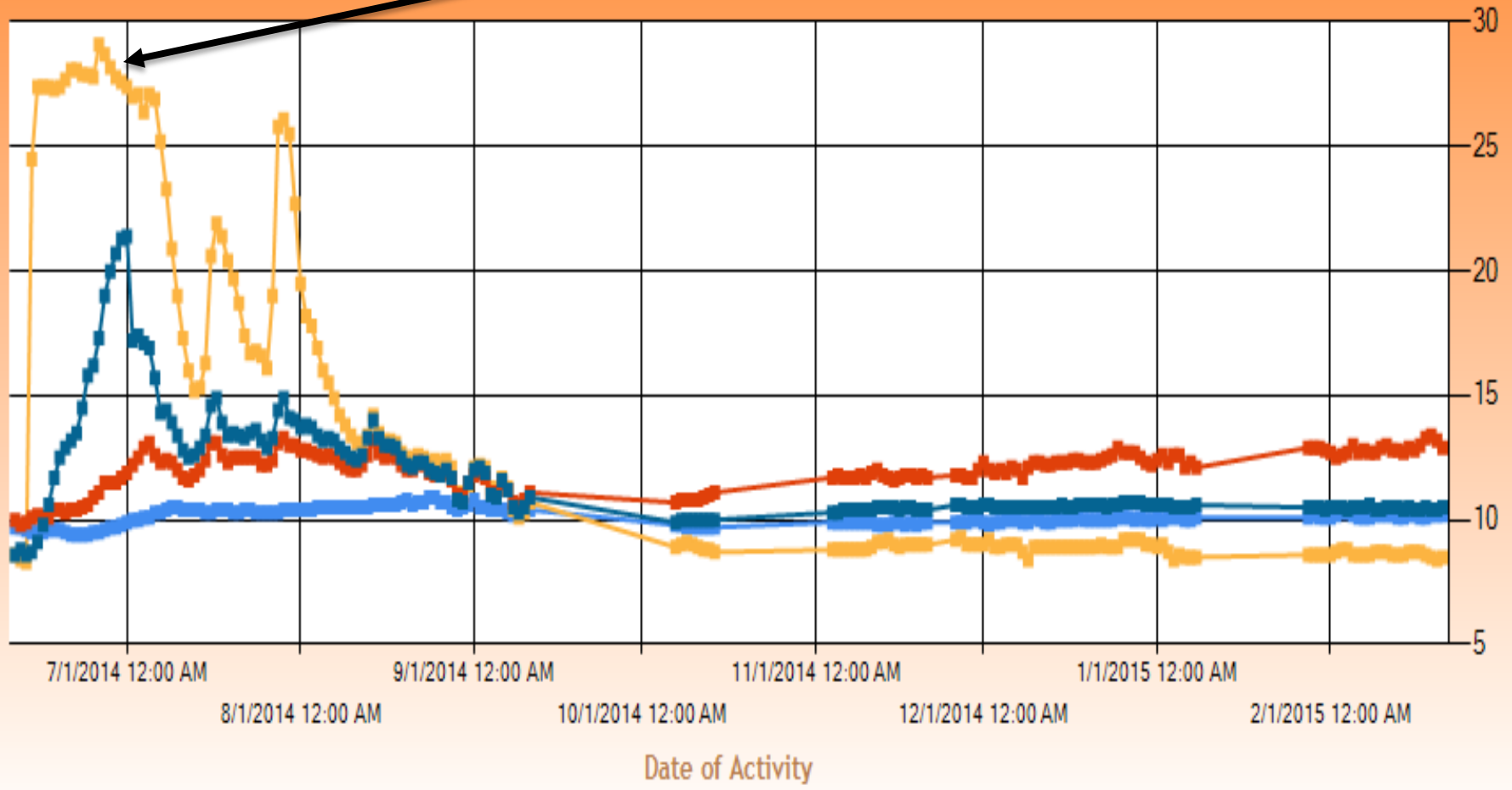
WME of condensing surfaces in Kitchen and Master Bath

Inside surface of Master Bath the highest, but well within safe levels.

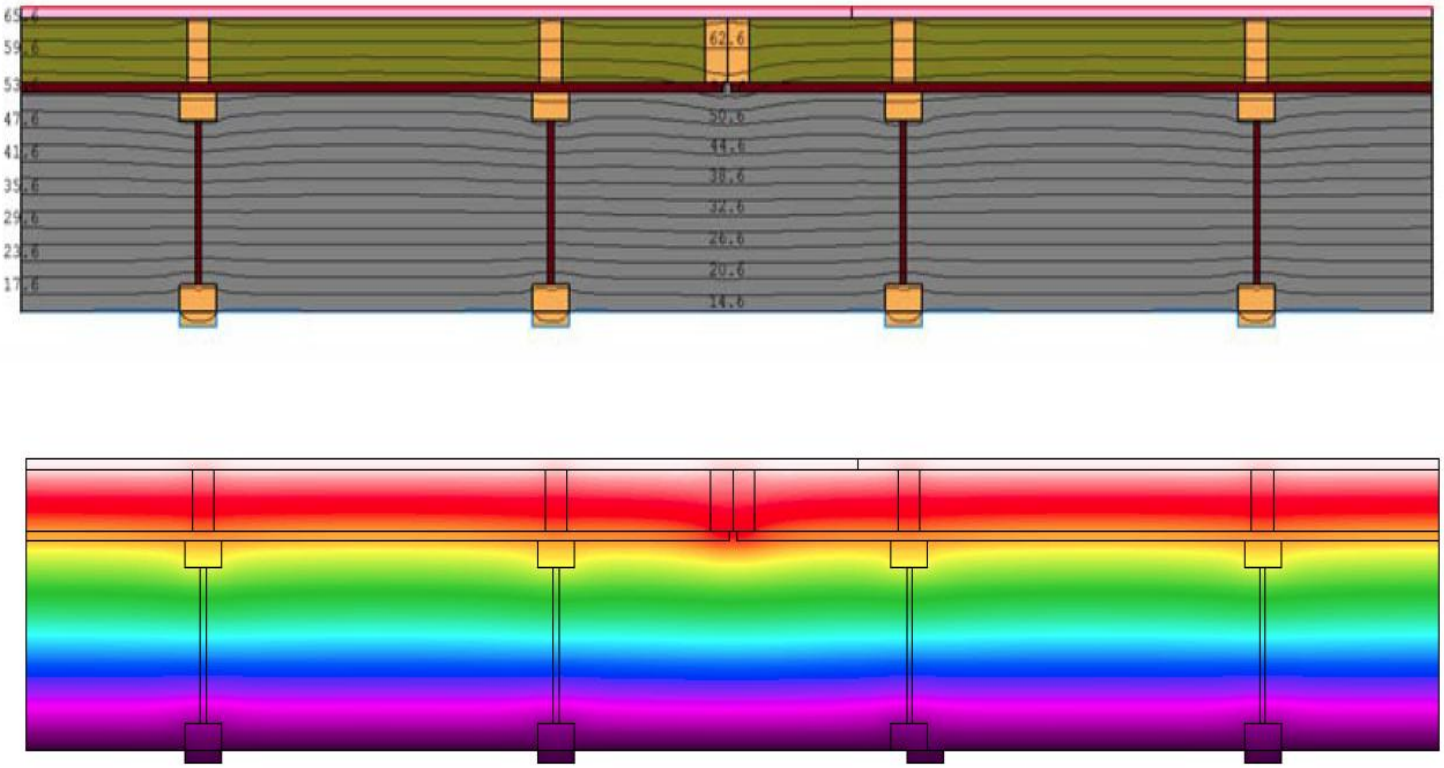


Temperature of the sheathing always warmer than the DP temp. Probability of condensation occurring at the sheathing plane 0% ?

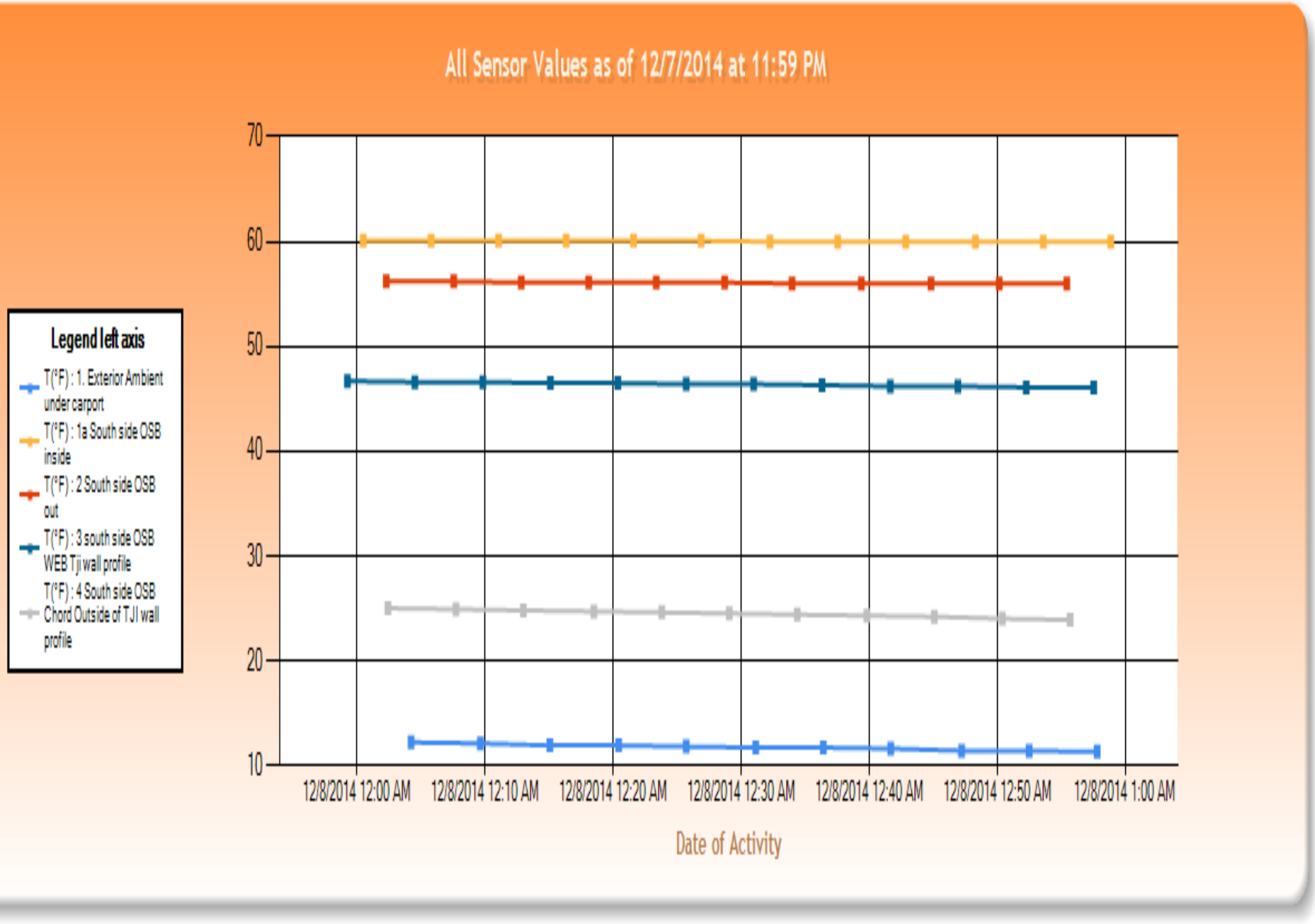
Whoa wait a minute , what's going on here???????



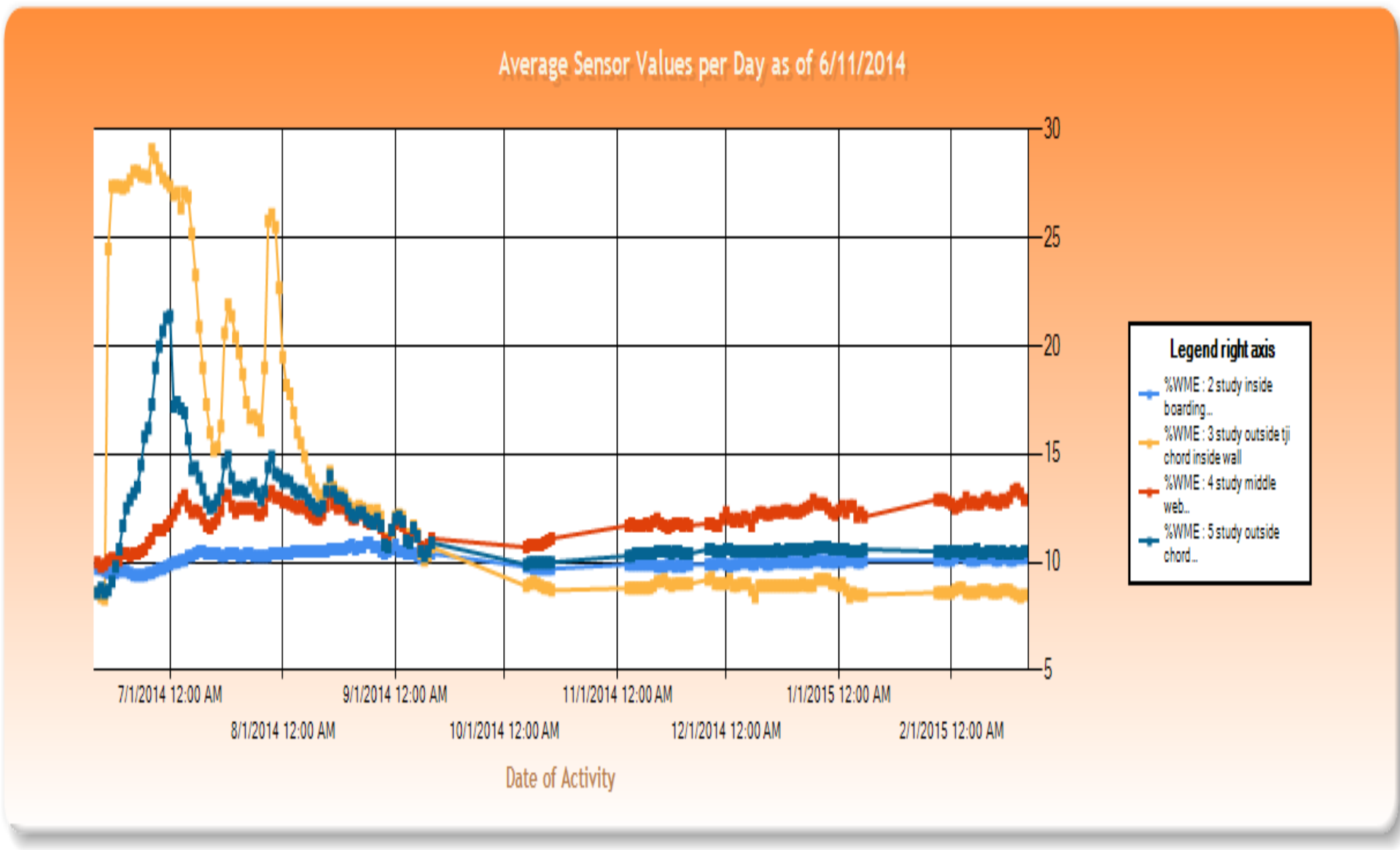
June 26th 2014: Roof leak Bulk water intrusion WMC spike's to 30%



The thermal part of Hygrothermal



Cross sectional View Corollary to THERM



June 26th 2014: Roof leak Bulk water intrusion

Sensor Placement

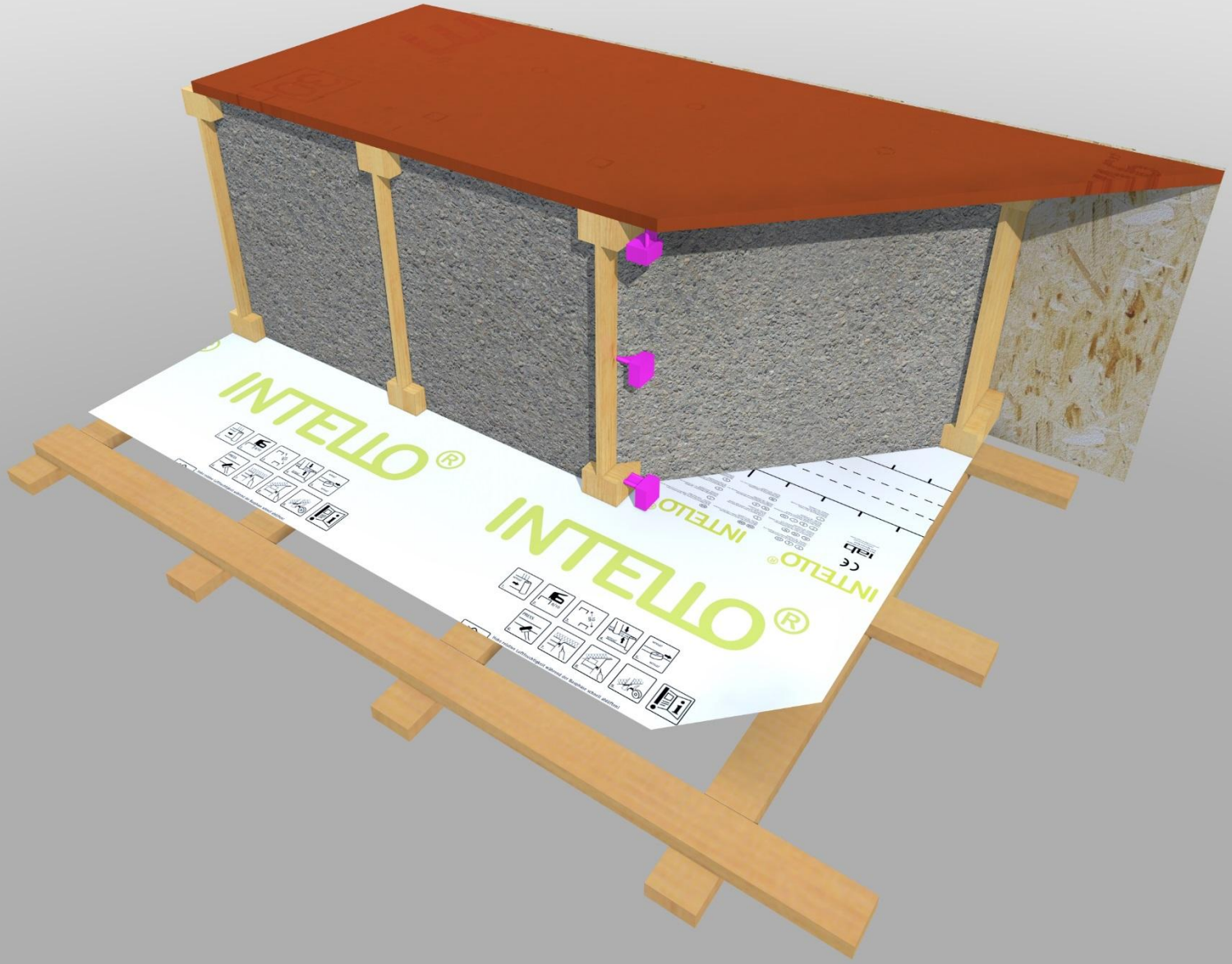
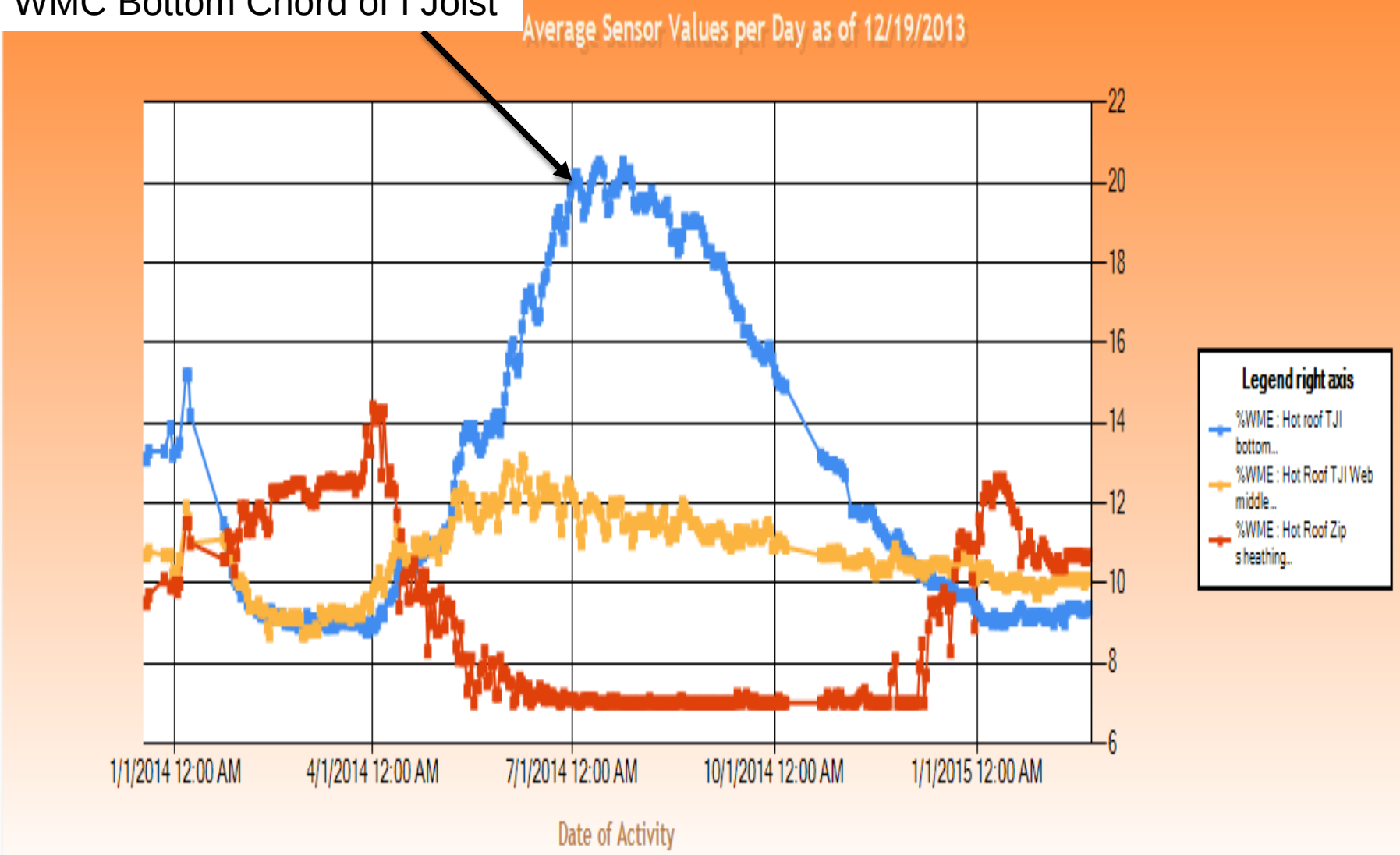


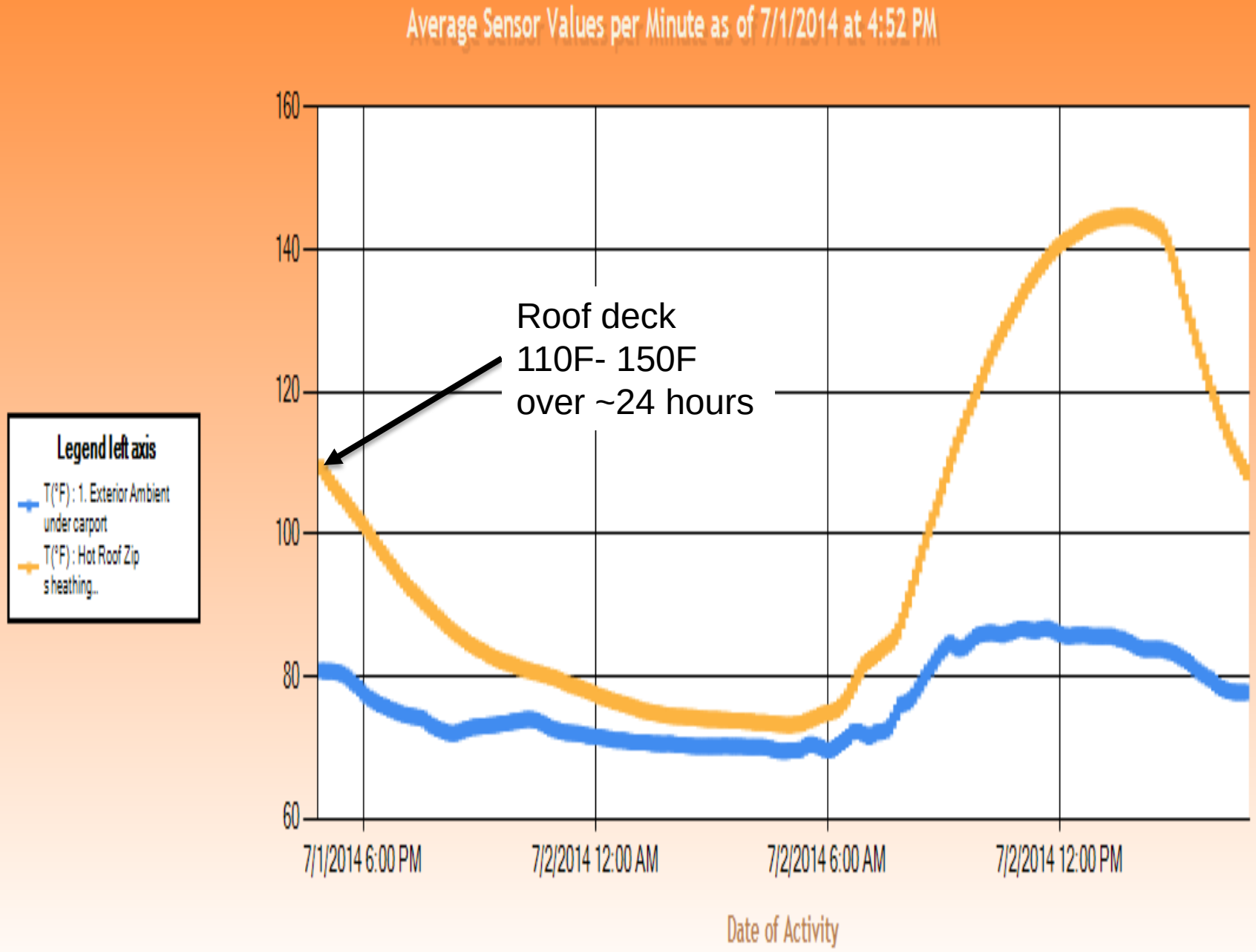
TABLE R806.5 INSULATION FOR CONDENSATION CONTROL

CLIMATE ZONE	MINIMUM RIGID BOARD ON AIR-IMPERMEABLE INSULATION *R*-VALUE[a]
2B and 3B tile roof only	0 (none required)
1, 2A, 2B, 3A, 3B, 3C	R-5
4C	R-10
4A, 4B	R-15
5	R-20
6	R-25
7	R-30
8	R-35

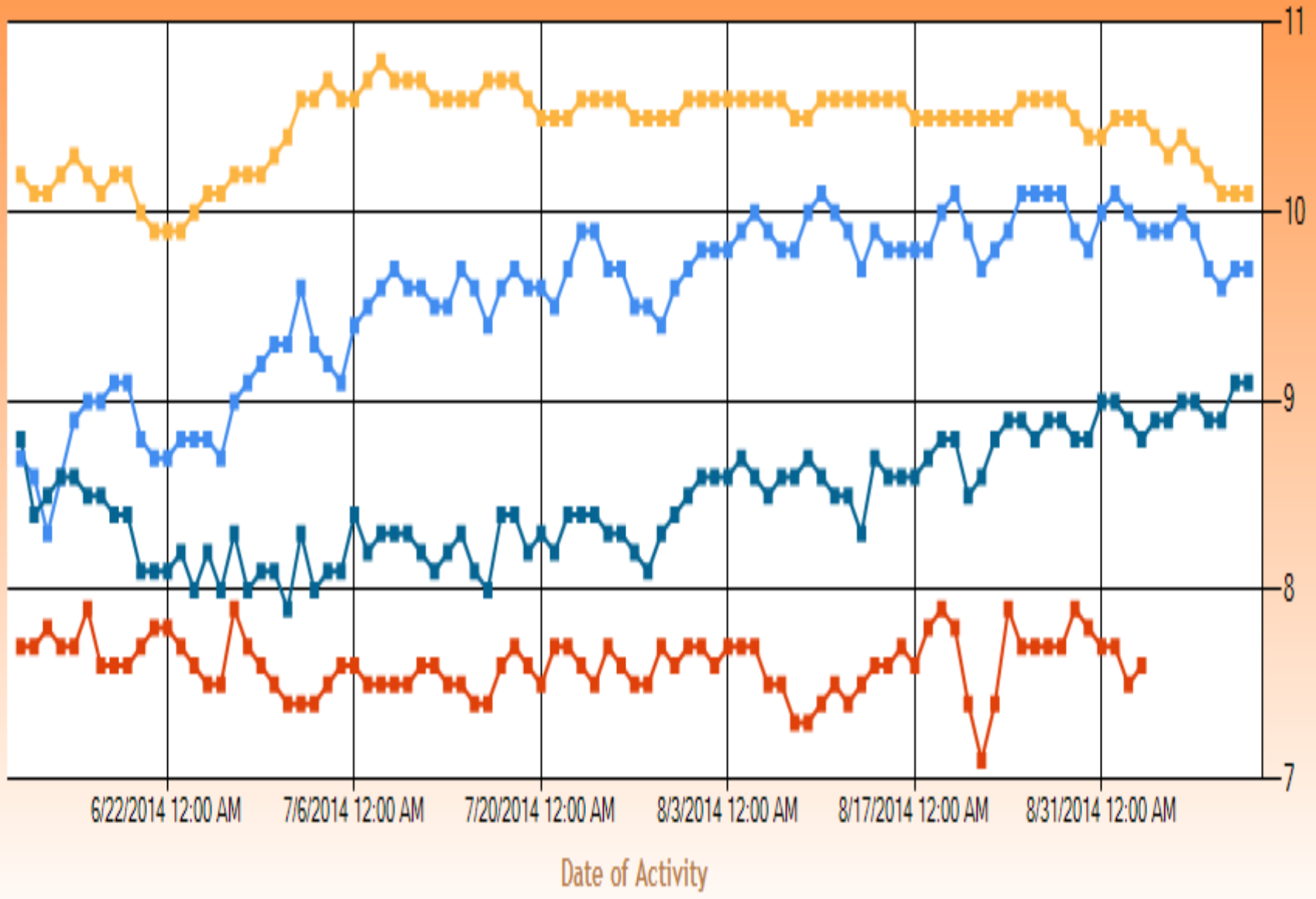
WMC Bottom Chord of I Joist



As the Temp of the sheathing increases Vapor is driven inward
The sheathing remains dry


Average Sensor Values per Minute as of 7/1/2014 at 4:52 PM
160
140
120
100
80
60
Roof deck
110F- 150F
over ~24 hours
Legend left axis
T(°F) : 1. Exterior Ambient under carport
T(°F) : Hot Roof Zip s heathing..
7/1/2014 6:00 PM
7/2/2014 12:00 AM
7/2/2014 6:00 AM
7/2/2014 12:00 PM
Date of Activity

Wood Moisture Content through a section of dense pack cellulose hot roof



Summary

Vapor open assemblies with hygroscopic insulations offer reliable hygrothermal performance in the Northeast and offer the potential for use over a wide climatic range.

When installed properly cellulose provides sufficient hygric buffering to prevent moisture buildup in exterior sheathing materials even (potentially) in unvented hot roofs.

Regardless of interior or exterior conditions walls stay warm and dry!

This concludes The American Institute of Architects
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