

BUILDINGENERGY BOSTON

New England's Favorite Roof Retrofit: Moisture Data from Three MA Case Studies

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Kohta Ueno (Building Science Corporation)

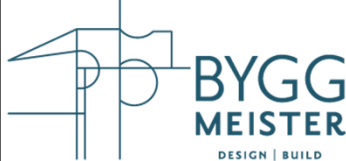
Curated by Anna Heath

Northeast Sustainable Energy Association (NESEA)
March 29, 2023

1

Brendan Kavanagh & Kohta Ueno
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Conference + Trade Show of the Northeast Sustainable Energy Association (NESEA)

2

Course Description

Dense packing cellulose in roof slopes has been a common insulation retrofit strategy in New England for a long time, however technically it has not been allowed by code without the inclusion of venting or foam insulation at the roof sheathing for condensation control. Previous BuildingEnergy presentations have suggested that further research should be done to evaluate whether vented attic space above unvented dense-packed slopes could manage moisture more effectively than insulating all the way up to the ridge. Byggmeister and Building Science Corp have collected 2 years of monitoring data on 3 case studies of this type and will be presenting this data and discussing future implications.

3

Learning Objectives

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

1. Identify insulation strategies permitted by the current building code for unvented roof slopes and the reasons for the limitations
2. Evaluate which roof situations could be good candidates for using only dense packed fibrous insulation in unvented sloped assemblies
3. Analyze monitored moisture performance data from an unvented sloped roof assembly
4. Evaluate whether these strategies could be implemented in your own practices

4

Housekeeping

- Slides will be available on website (<https://www.buildingscience.com/past-events>)
- Resources: list of links at end of presentation
- Questions—during plus reserved Q&A time at end

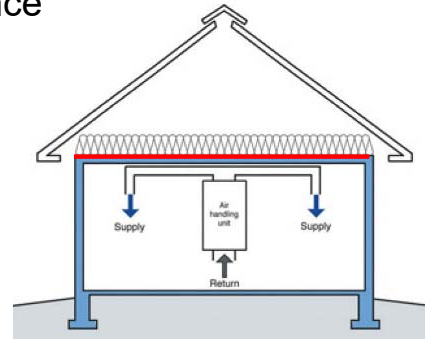
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Unvented Roofs Background

6

Ventilated Attics—Best Choice

- Roof sheathing dries to ventilated attic-moisture safe
- Interior moisture (air leaks) ventilated away in winter
- Air sealing at ceiling critical for best performance
 - (e.g., spray foam air barrier, detail with sealant)



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7

Then Why Unvented Roofs?

- Living space built into roof
- Vented cathedral assemblies—often poor performance
- Complicated rooflines, hip geometries—how to vent?
- Unworkable air barrier at ceiling line
- Blown-in rain (coastal)
- Hurricane tear-off
- HVAC in unconditioned attic—energy losses
 - Bring attic and ductwork into conditioned space



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8

Fibrous Insulation Unvented Roofs

- Dense pack of unvented roofs common in cold-climate retrofits
 - Moisture risks (see BSI-043 “Don't Be Dense—Cellulose and Dense-Pack Insulation”)—2 in 10 failure?
 - Violates I-codes (see IRC § R806.4/R806.5)
 - “Ridge rot”—localized problems (SIPS same problem)



NESEA



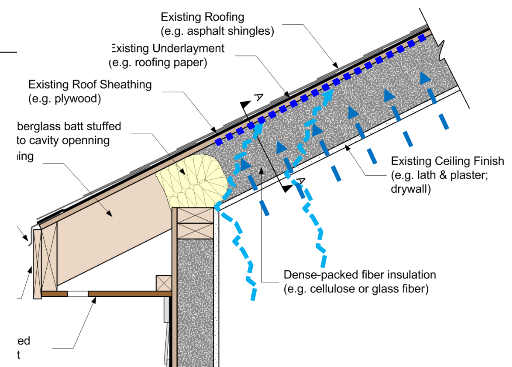
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Why Unvented + Fibrous Risky?

- Different than walls?
- Moisture risks at sheathing
 - Interior-sourced air leakage
 - Vapor contributing too?
 - Zero-perm exterior (“wrong side perfect vapor barrier”)
 - Night sky radiation cooling
 - Stack effect in winter
 - “Ridge rot” (thermal and moisture buoyancy)

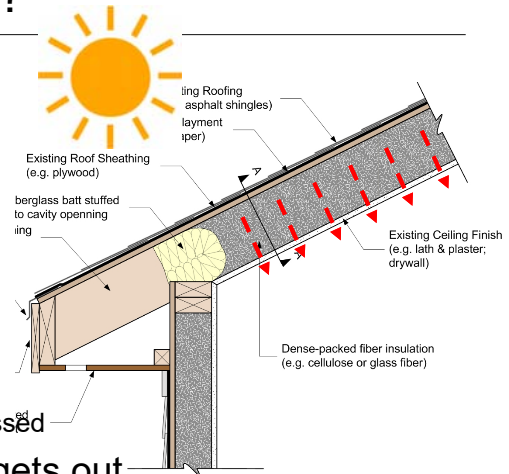


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10

Why Unvented + Loose Fill Risky?

- Risk reduced by:
 - Airtightness of ceiling
 - Dense insulations that suppress airflow
 - Solar drive (north vs. south)
 - But white roofs, shading
 - Lower interior RH (winter)
 - Why many of them work?
 - Lower permeance interior
 - Need good airtightness—vapor retarder not bypassed
- Moisture accumulation: what gets in vs. gets out



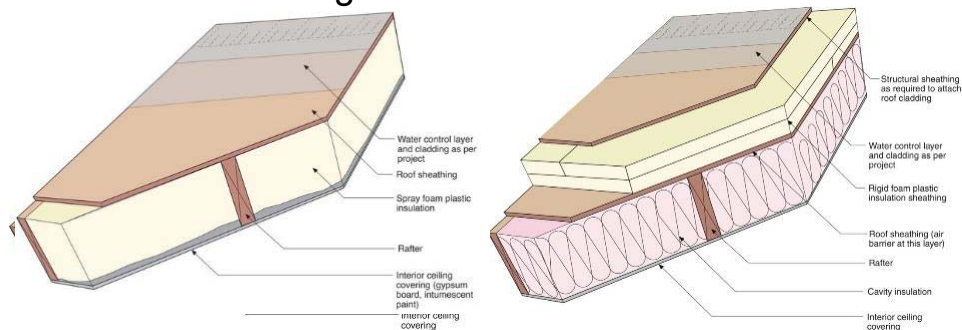
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Spray Foam/Exterior Insulation Roofs

- 2006 IRC: R806.4 Unvented attic assemblies
- Minimum R-value of “air impermeable insulation”
 - Actually ratio of R-values (BSI-100 Hybrid Assemblies)
- Nail base needed with rigid foam on roof deck



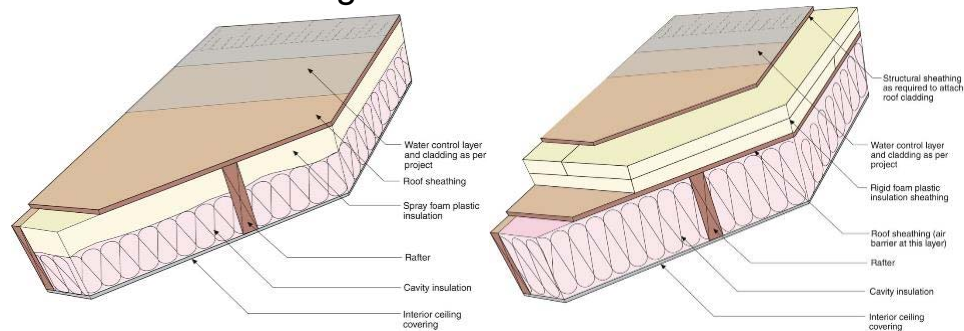
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Why Fibrous Fill Unvented Roofs?

- Unvented roofs without spray/board foams could reduce costs and increase market penetration... IF moisture damage risks are addressed
- Retrofit opportunities (existing uninsulated living space at roof line, without demolishing finishes)



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Unvented Test Hut Research

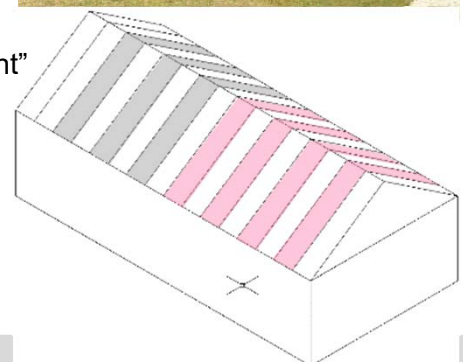
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Test Hut Experimental Approach

- Climate Zone 5A test hut
- Eight north-south roof bays; guard bays
- $\pm R-50$ (14- $\frac{3}{4}$ " framing, 2012 IECC)
- Test variables (changed year-to-year):
 - Fiberglass vs. cellulose
 - Vapor retarder: variable vs. fixed perm
 - Diffusion vent at ridge: full size, none, "small," or "tight"
 - "Control" comparison § R806.4 spray foam + fibrous
- Varying interior boundary conditions
 - Winter 1: "Normal" interior conditions
 - Winter 2: Elevated RH (50% constant)
 - Winter 3: Air leakage into rafter bays



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Test Hut Construction

- Test bays & guard bays alternate
- Cellulose & FG
- Various VBs
- Too much data to talk about here...



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17

Summer 2 Disassembly Work: Found Some Mold



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Recommendations and Further Work

- Unvented fibrous insulation roofs **can** work, **BUT**
 - Ensure complete packing of insulation/density
 - Still vulnerable to small (0.5 CFM) air leaks
- Mold found after Winter 2, despite “calculated safe” (mold index < 3.0)
 - Vulnerability to moisture damage at ridge
- Difficult to recommend for widespread use and acceptance in codes
 - High indoor RHs more likely w. tighter construction and high occupant density/multifamily
- Retrofit solution for failing assemblies?
 - Demolition + spray foam not possible?
 - No place in code to allow

19

Recommendations and Further Work

- If implementing unvented fibrous insulation roofs
 - Keep interior RH low for life of building
 - Airtightness of interior air/vapor control layer
 - Variable-perm vapor retarder (allows downward drying)
 - Large 300 perm diffusion vent recommended
 - Fibrous insulation without voids or empty cavities
 - Light colored roofs & shading increase risks

20

What About the Story and a Half?

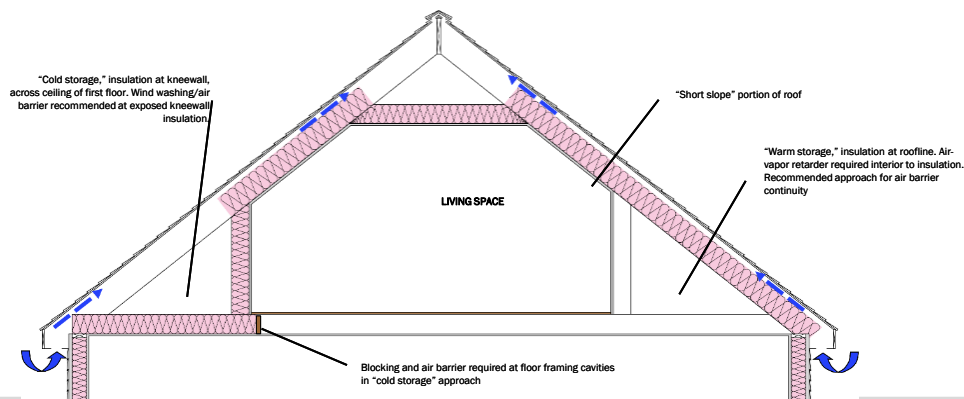
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Story and a Half (Cape Cod Short Slope)

- Possible application to retrofitting “short slope” of kneewall attic geometry
- Eliminates “chute,” possible to retrofit longer runs



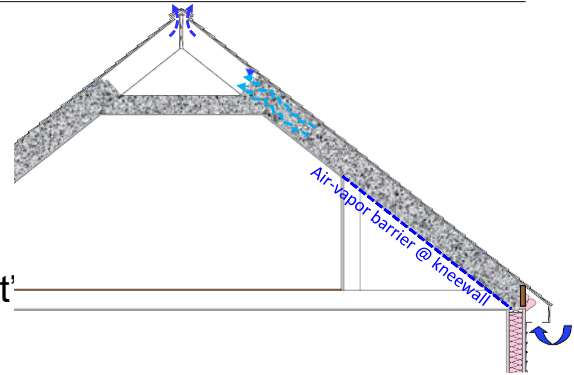
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Story and a Half (Cape Cod Short Slope)

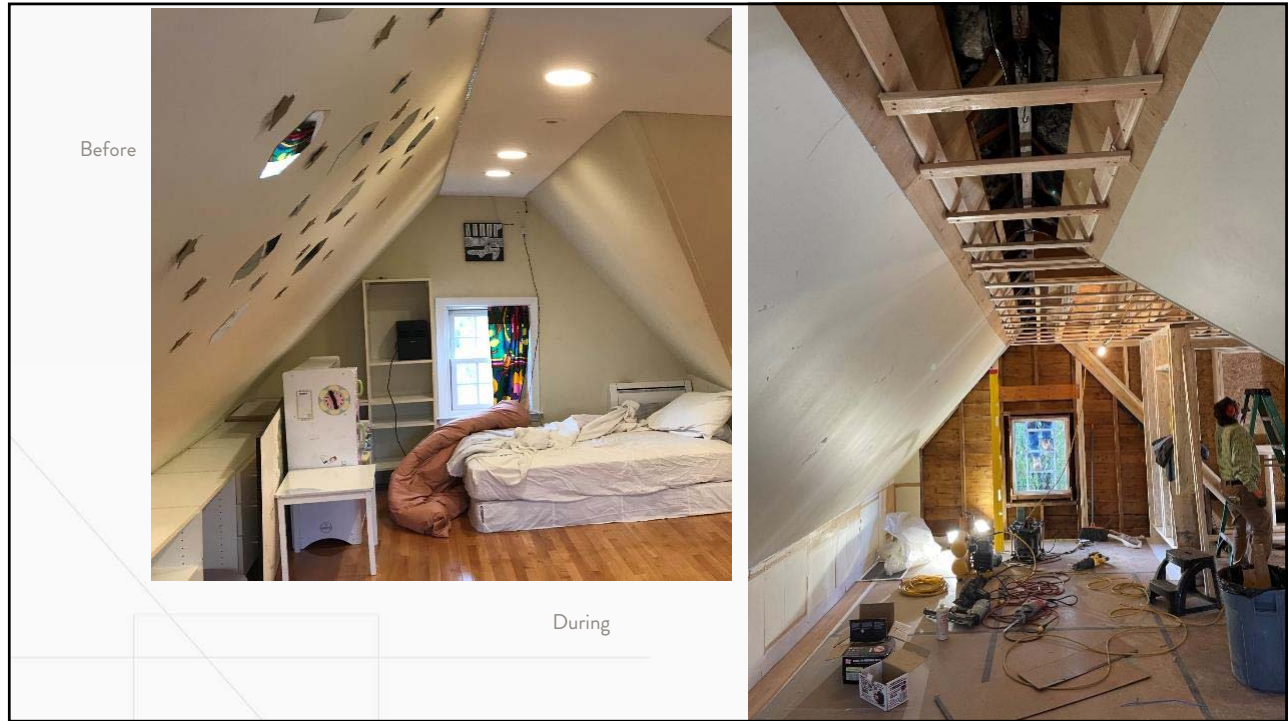
- Higher R-value in limited cavity
- Test hut: no problems low in roofs
- Not proven by BSC research, but this is “lower half of roof” geometry (low risk portion)
- Rafter bay has “full-size diffusion vent”
- Common practice in weatherization NE/Midwest



23

Byggmeister ears perked up

24






25

What makes a project a good candidate?

Roof sheathing

- OSB: Less resilient
- Plywood: OK
- Board: More resilient



26

Let's meet our line up

The Micro Attic



Belmont, MA

The Dormer Challenge



Brookline, MA

The Diffusion Vent



Lexington, MA



27



Case Study #1

The Micro Attic

- Completed Autumn 2020
- Clients want to convert to heat pumps and addressing the leaky 3rd floor first was important.
- Interesting conditions to test this approach

28

Pre-work Exterior Conditions

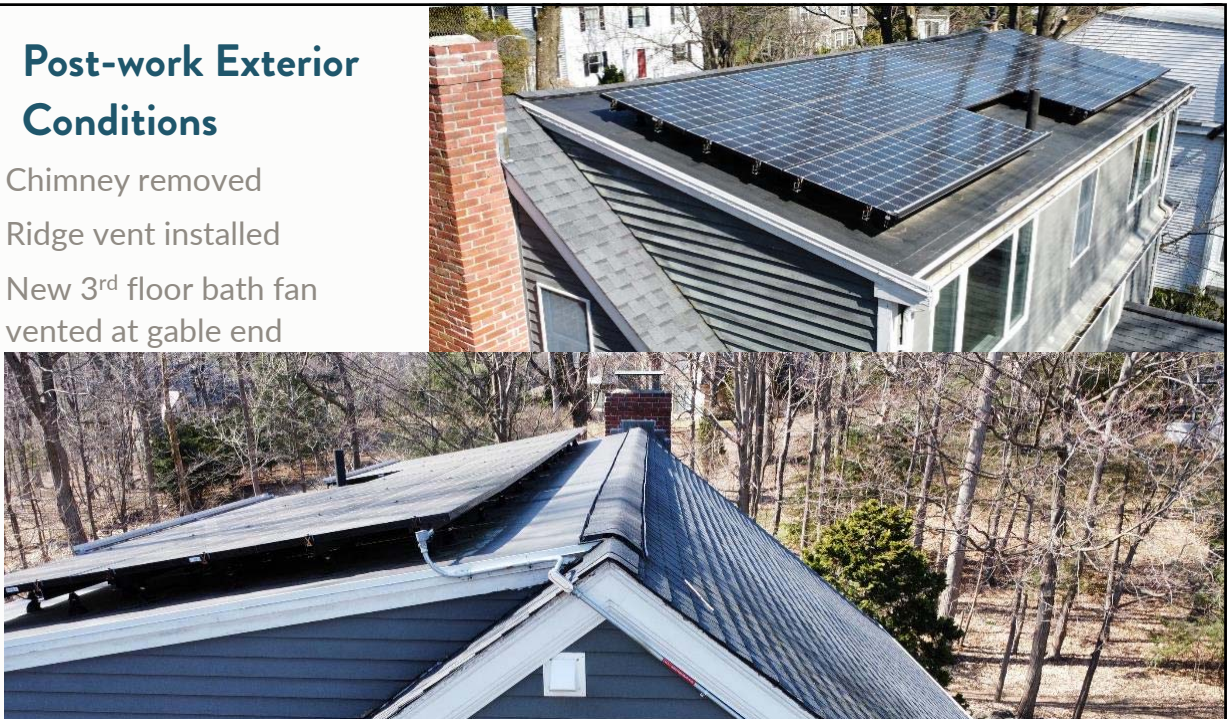
- No roof venting
- Front roof faces north, asphalt shingles, shading on the east side
- Chimney at center to be removed
- Rear roof faces south, large low slope shed dormer



29

Post-work Exterior Conditions

- Chimney removed
- Ridge vent installed
- New 3rd floor bath fan vented at gable end



30

Pre-work Interior Conditions

- Small portion of finished low slope on south side shed dormer
- Flat ceiling across much of the middle
- Recessed lights and duct work introduce many air leakage points



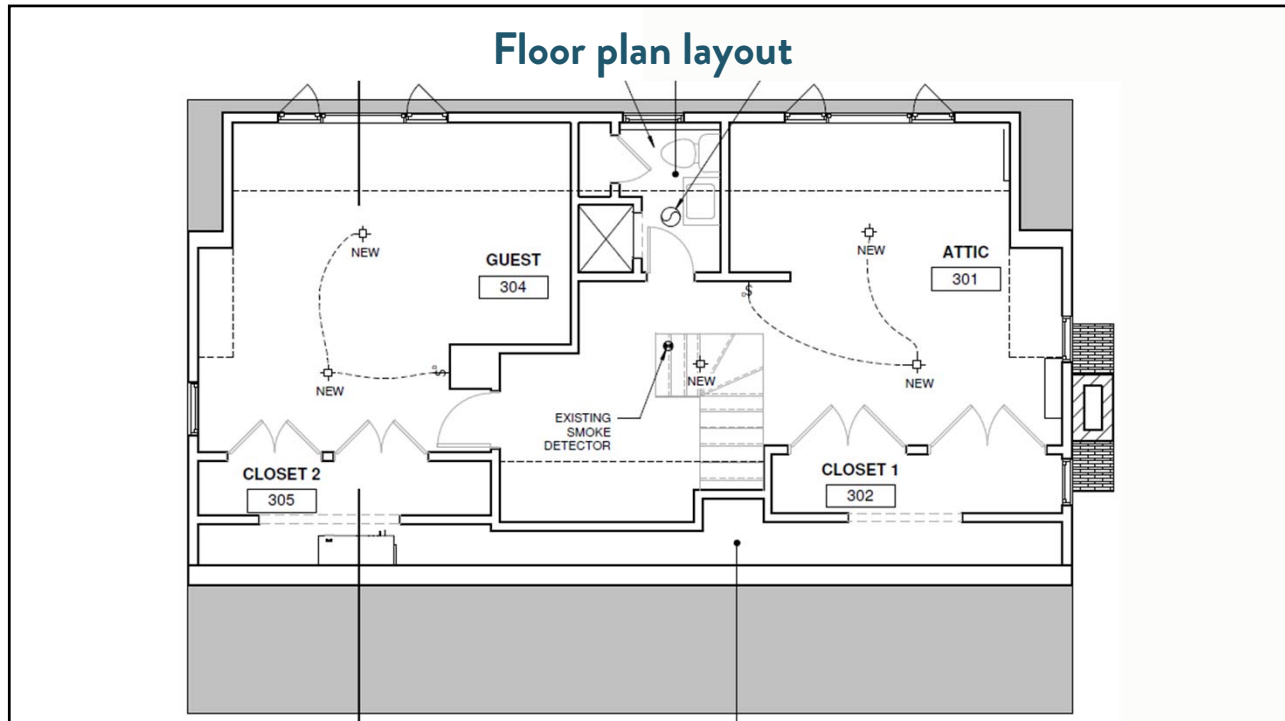
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Pre-work Interior Conditions

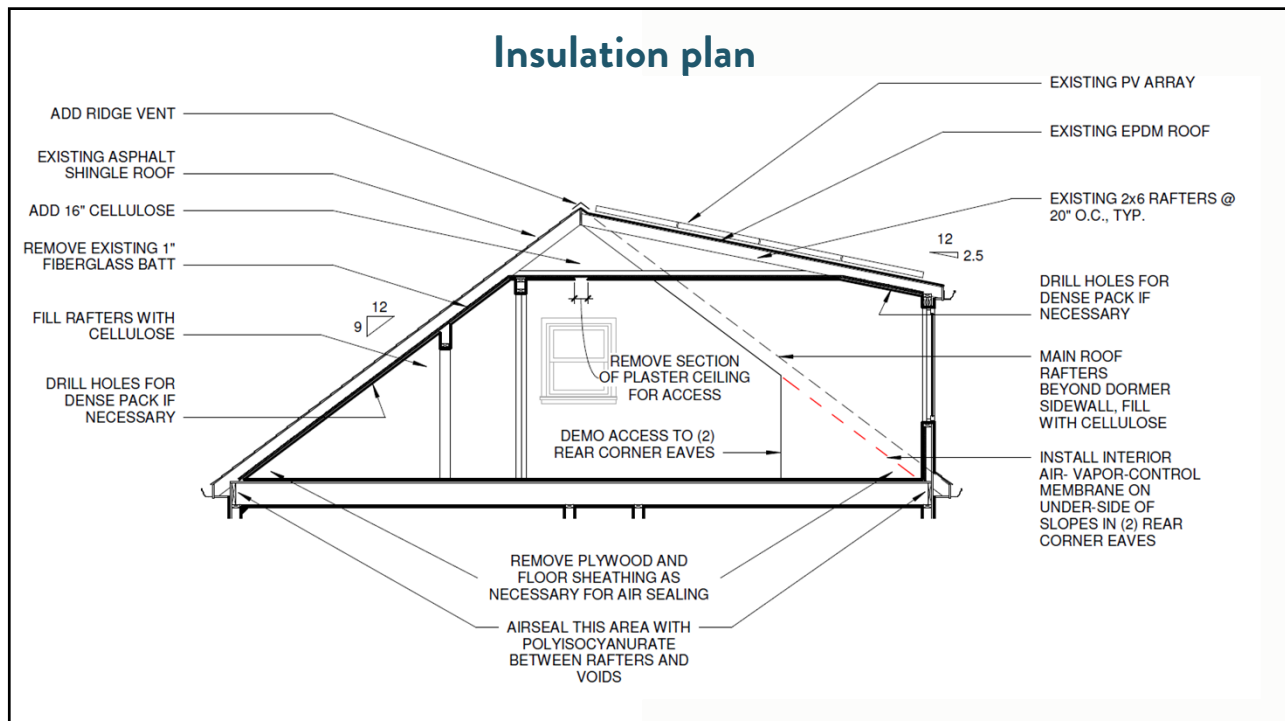
- North side roof has steeper pitch with plywood sheathing above AC system
- All spaces have 1" batt insulation, air space, and board roof sheathing with no venting



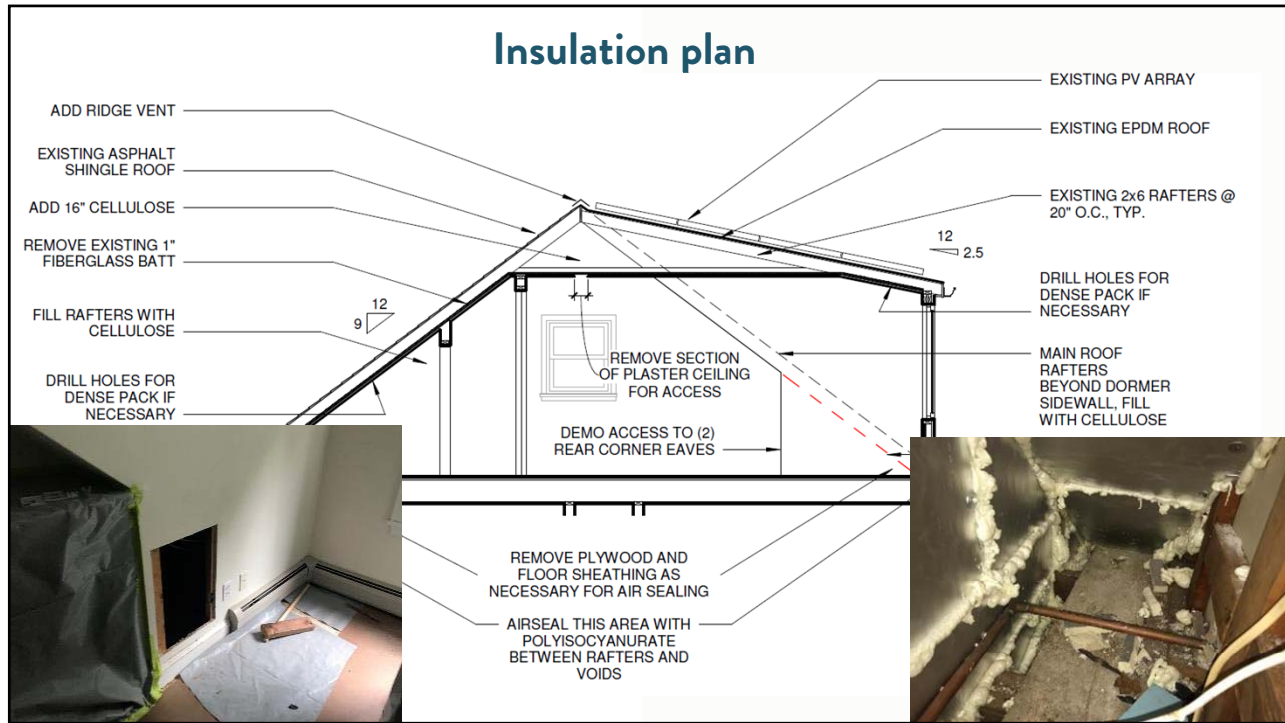
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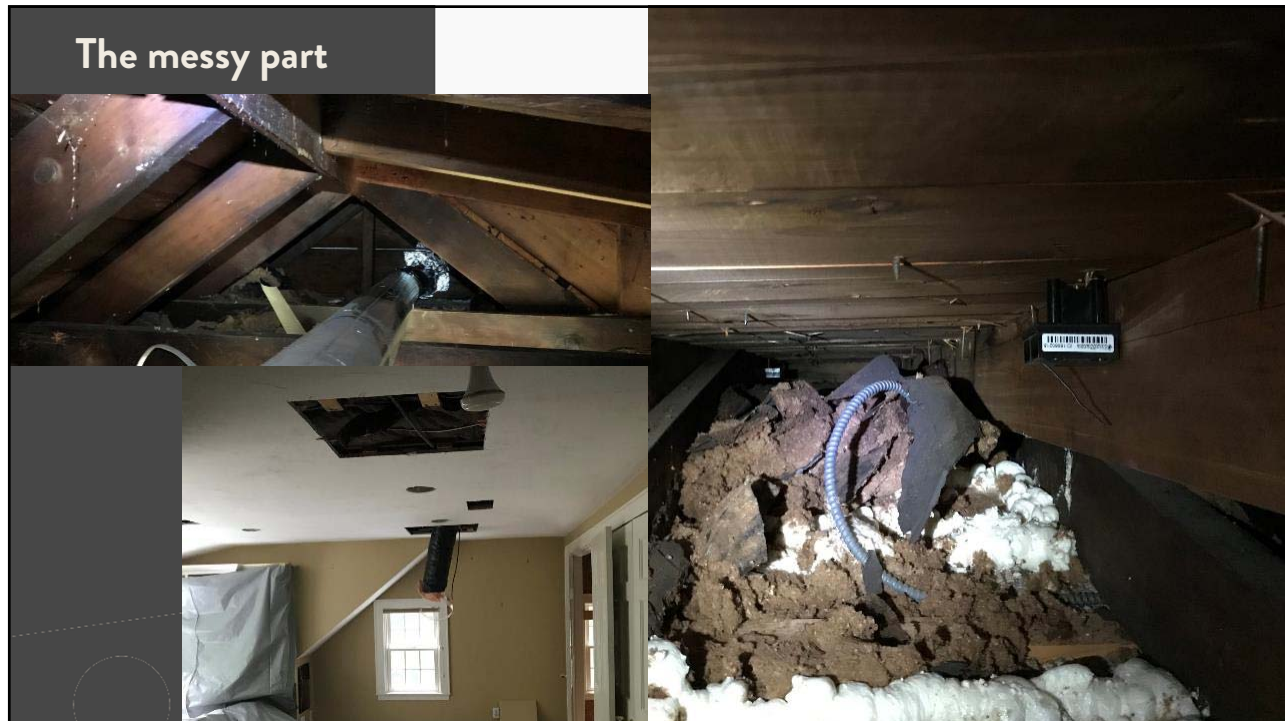
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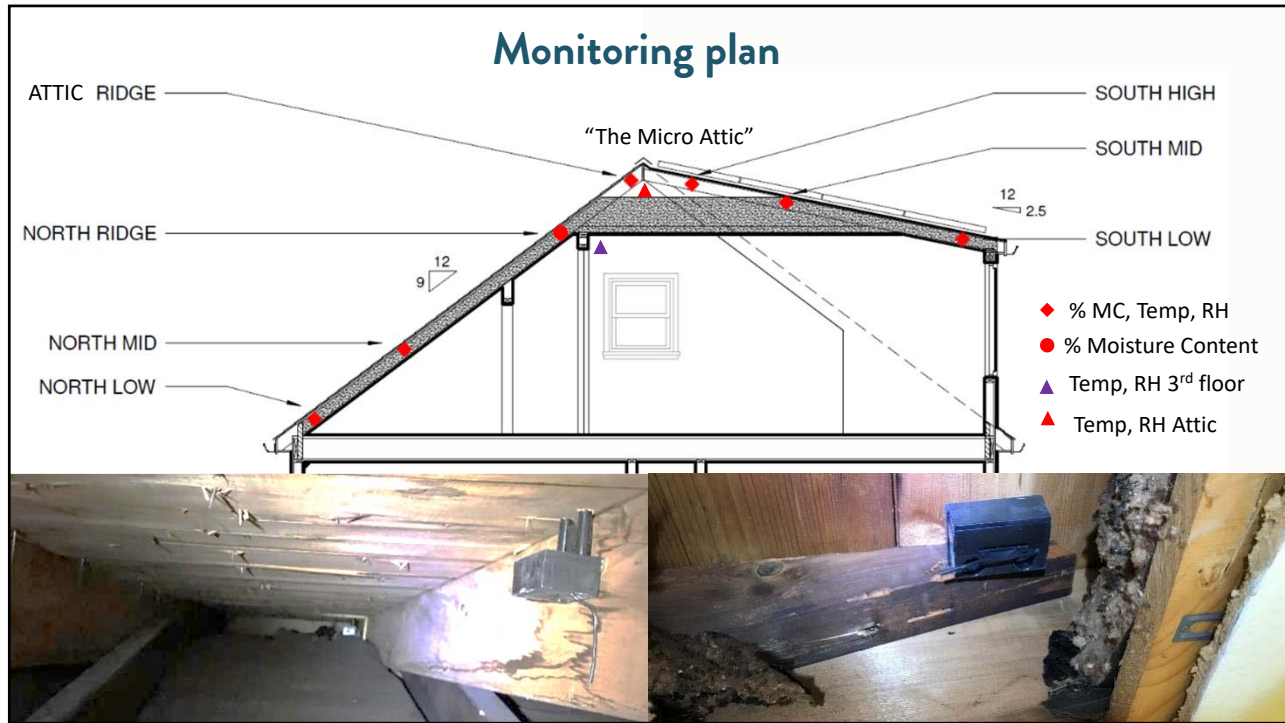
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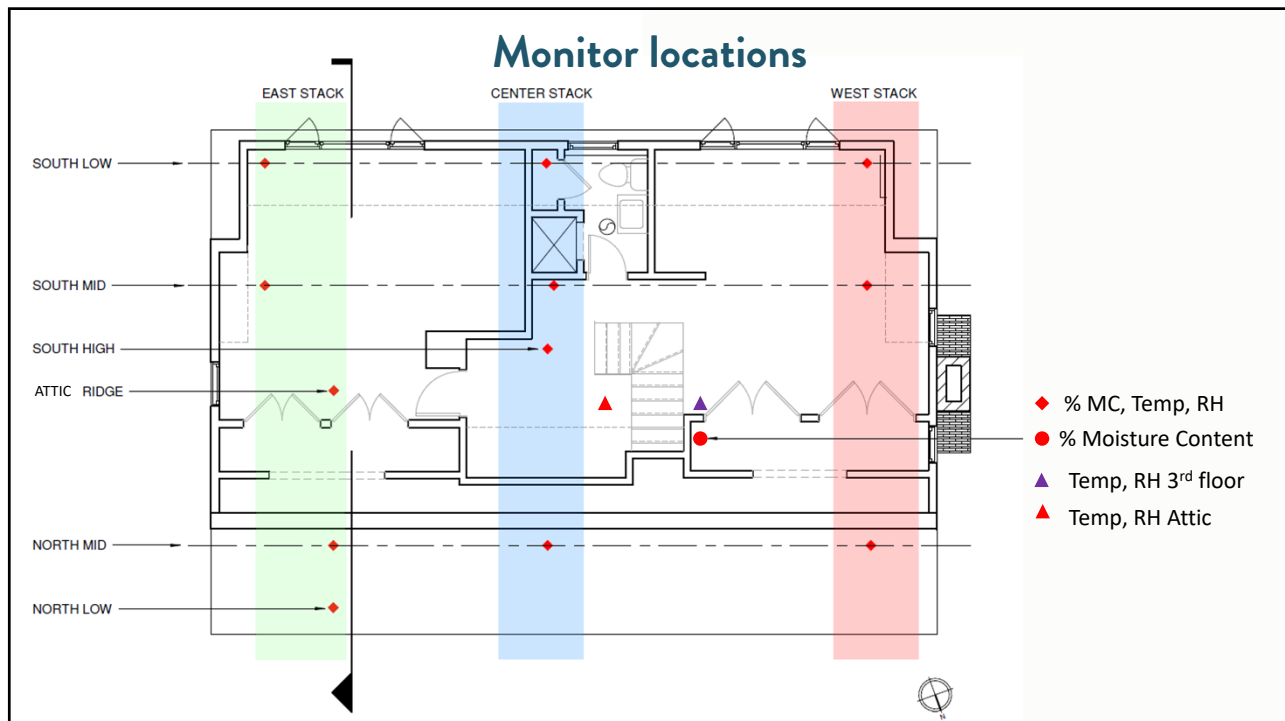
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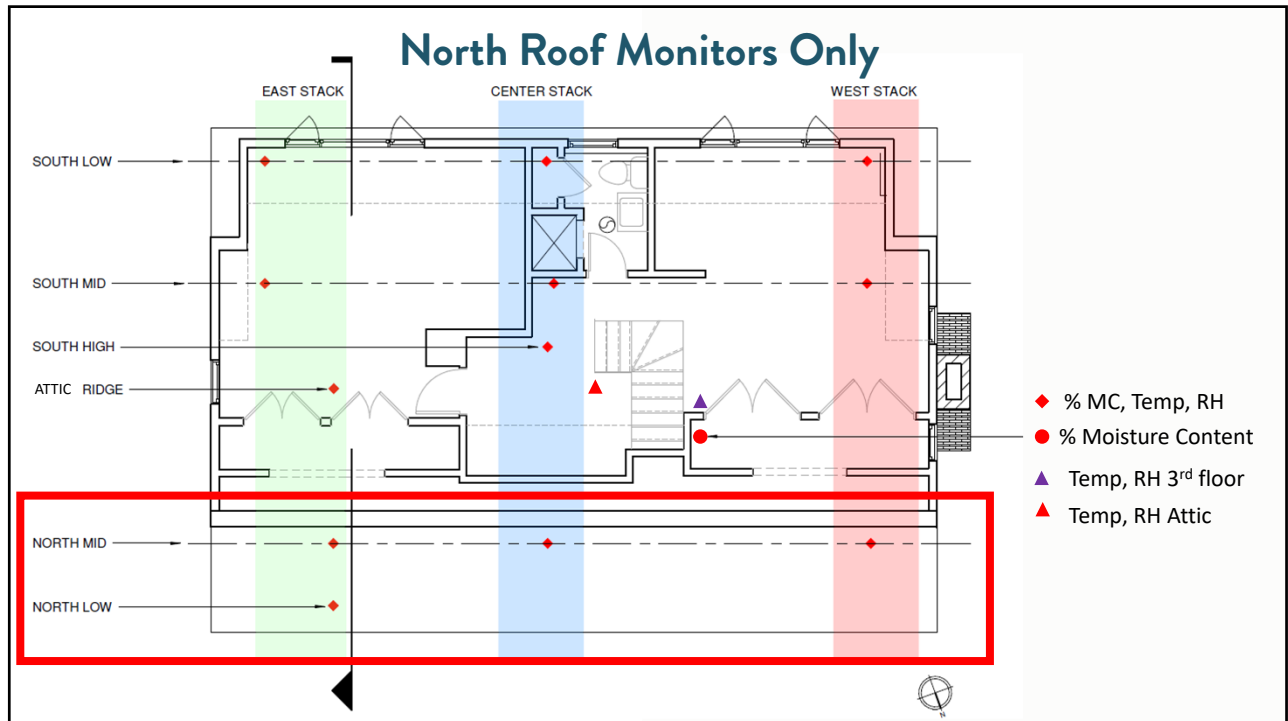


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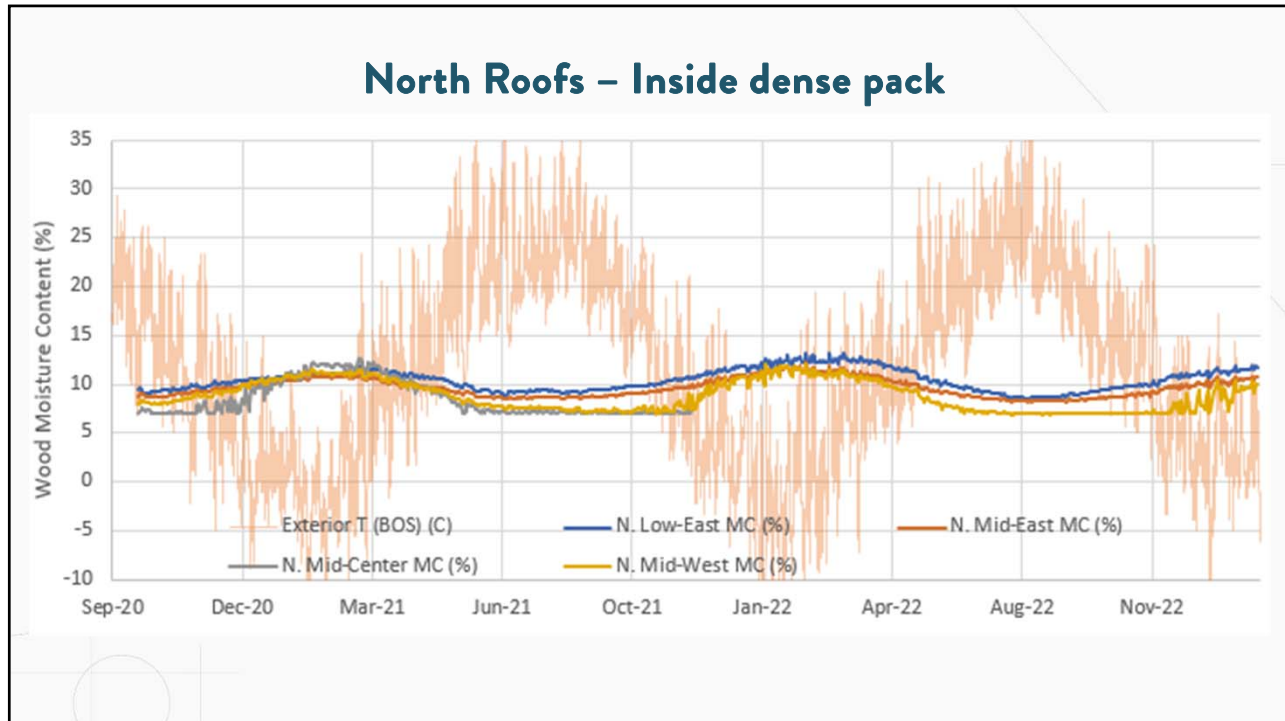
Ambient Temp & Humidity

- Attic just below ridge board
- 3rd floor just above closet
- No exterior probe

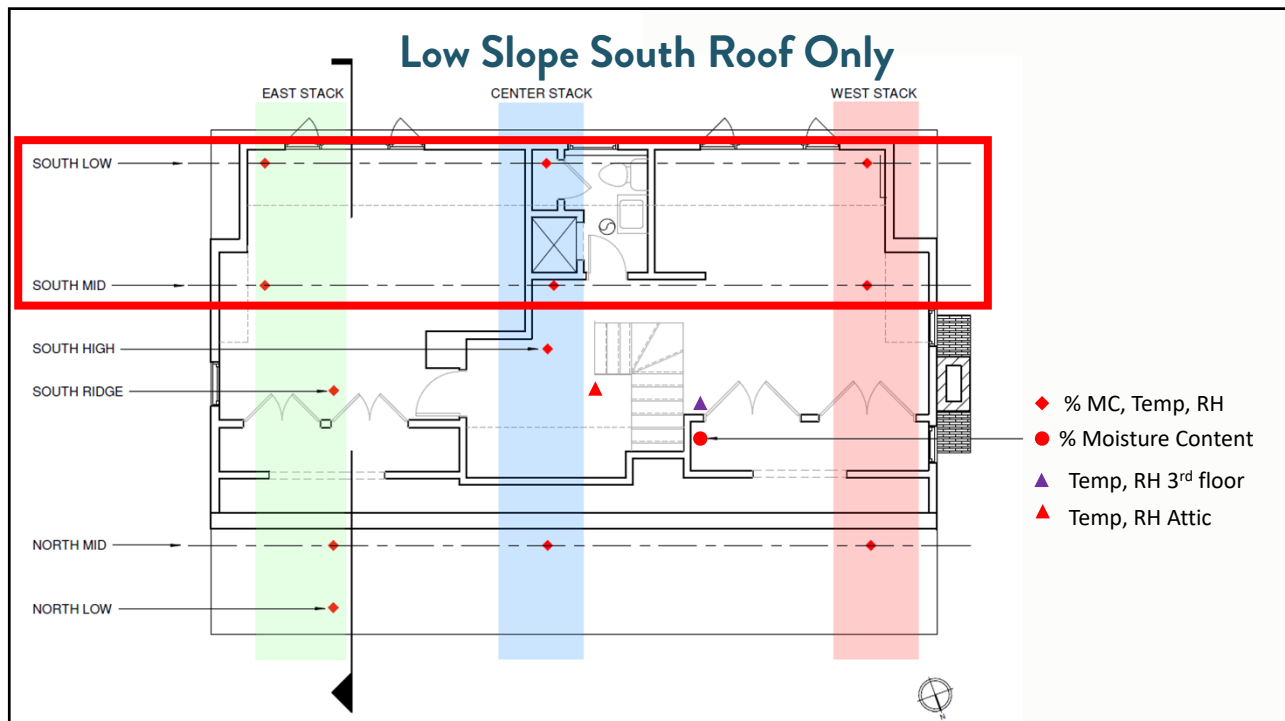
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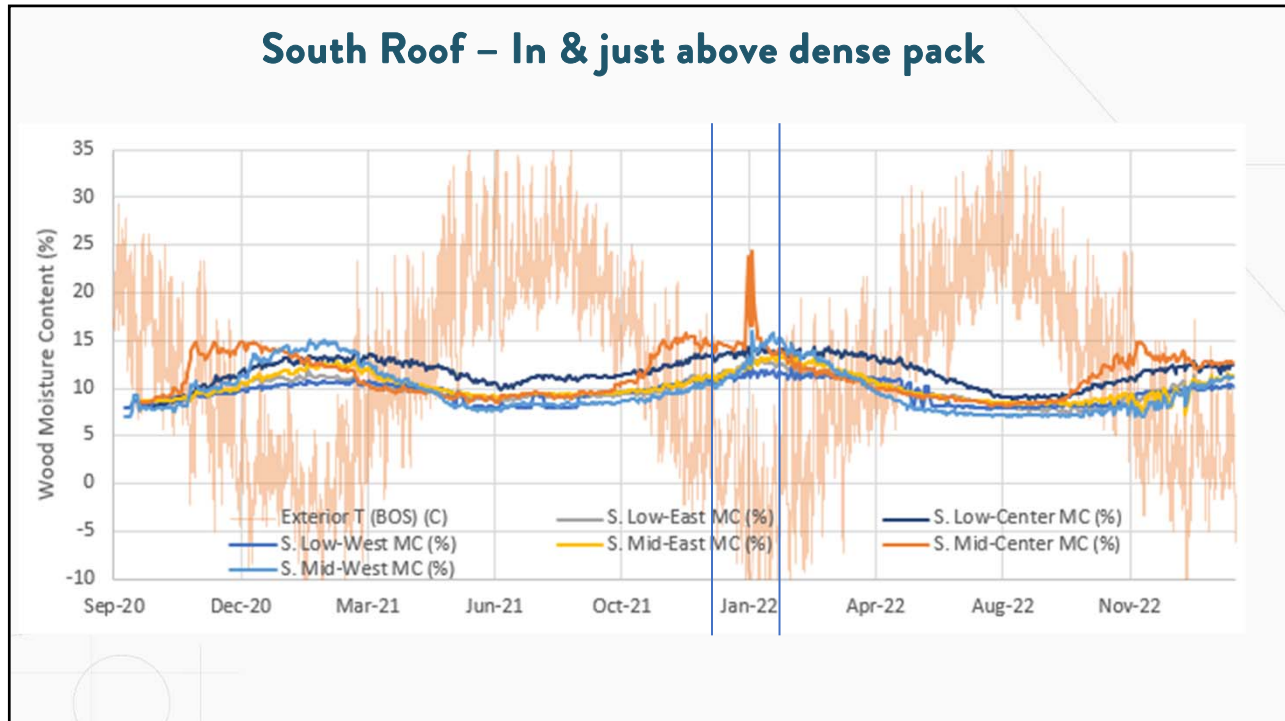
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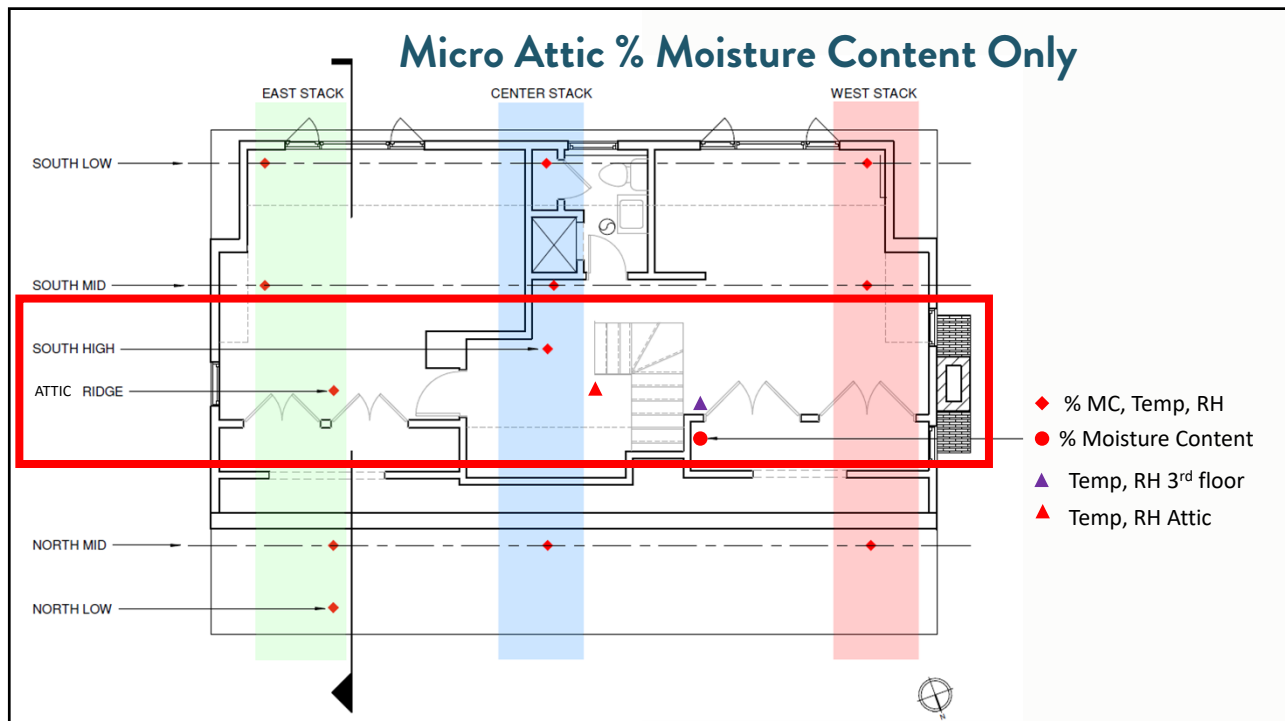
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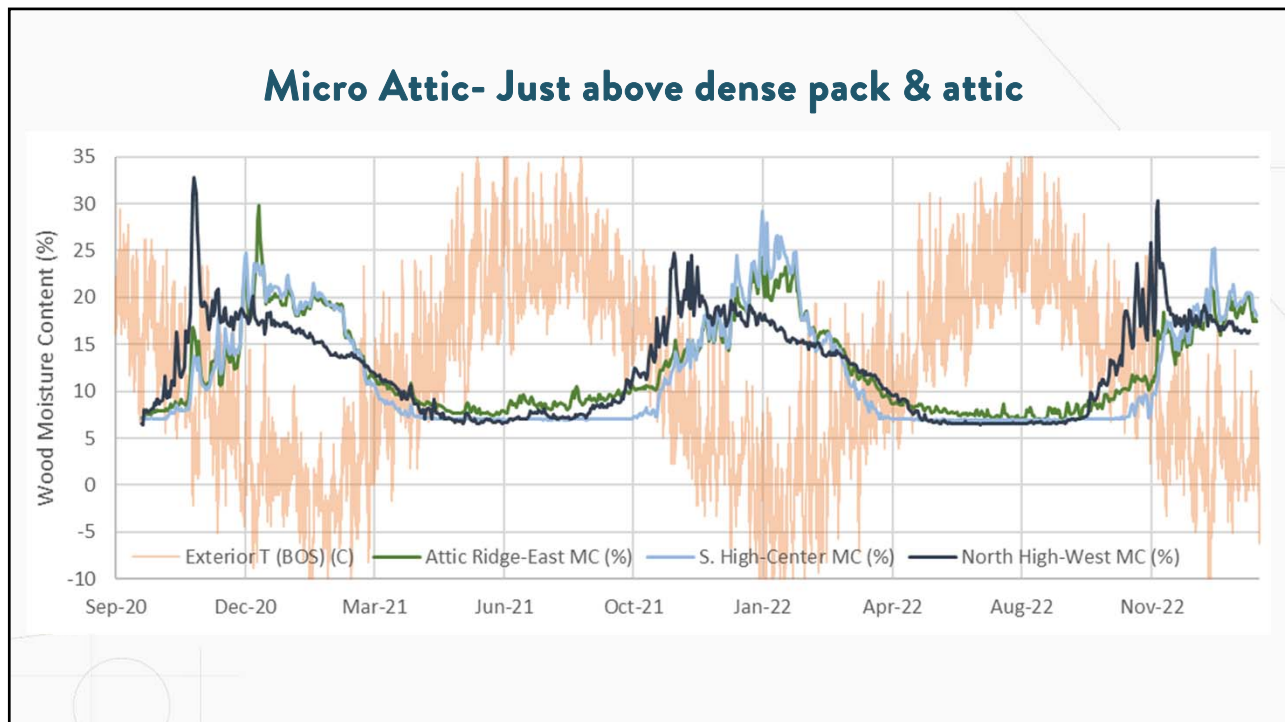
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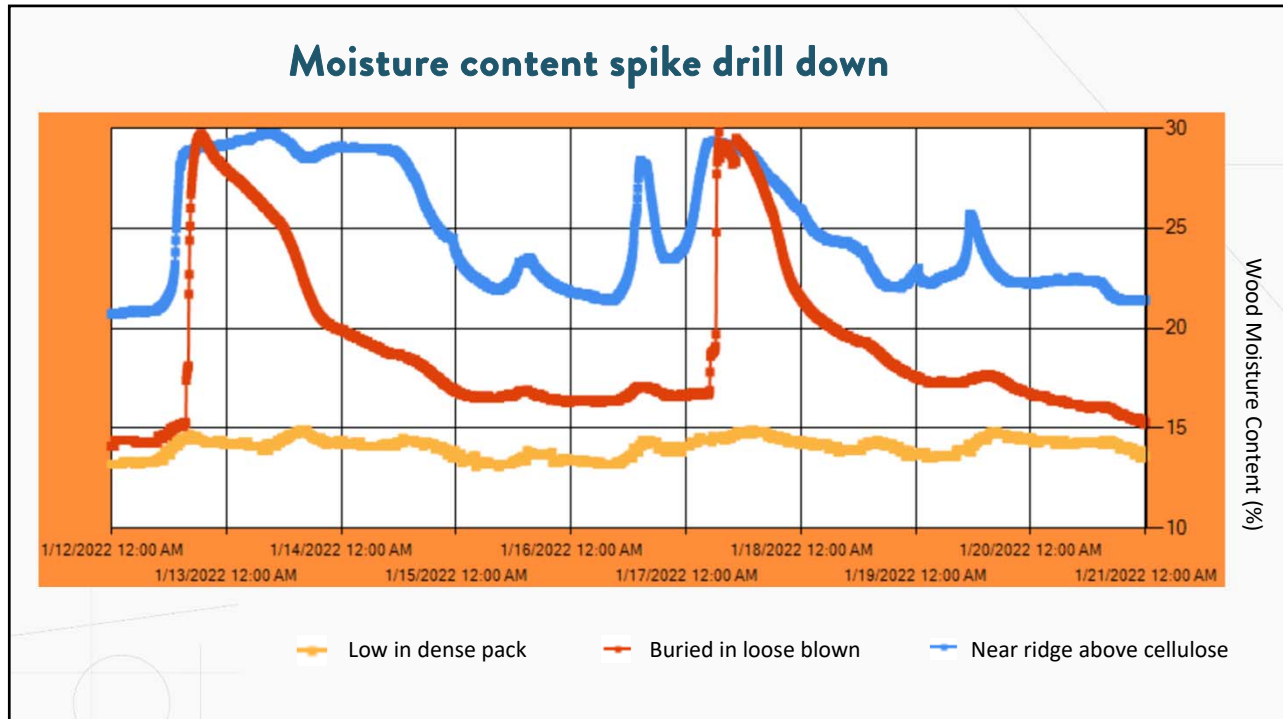
45

Moisture spikes near shower

- New recessed light in shower (air sealed)
- New bath fan just outside (also air sealed)
- Timer switch for bath fan

CENTER STACK

46



47

Micro attic observations and conclusions...

- Moisture accumulates near ridge as expected
- Solar panels and/or roof pitch can reduce solar drive
- We should be careful around humidity sources like showers

Generally I feel the risk for growth on the roof sheathing is low, if it were to happen it would likely take a very long time.

No greater risk than roof leaks?

48



Case Study #2

The Dormer Challenge

- Completed Spring 2021
- Various dormers make roof geometry and venting challenging
- Converting top floor to heat pumps, insulating will be important
- Homeowners want to maintain as much existing plaster as possible

49

Pre-work Exterior Conditions

- Roofing, solar panels, and ridge venting installed just before
- Pre-existing soffit & gable vents
- Insulation in some areas, not others
- Dormers & bump outs added on, built over old roof system



50

Post-work Exterior Conditions

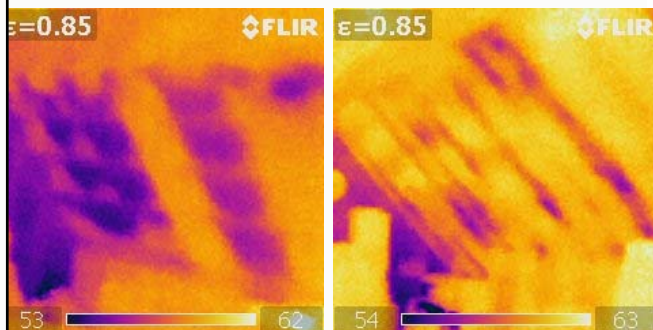
- Chimney removed
- Ridge vent patched
- ERV installed & vented at rear gable end



51

Pre-work Interior Conditions

- Small scuttle to access attic
- Variable insulation quality in finished slopes, none in walls
- No recessed lights or ducts



52



Pre-work Interior Conditions

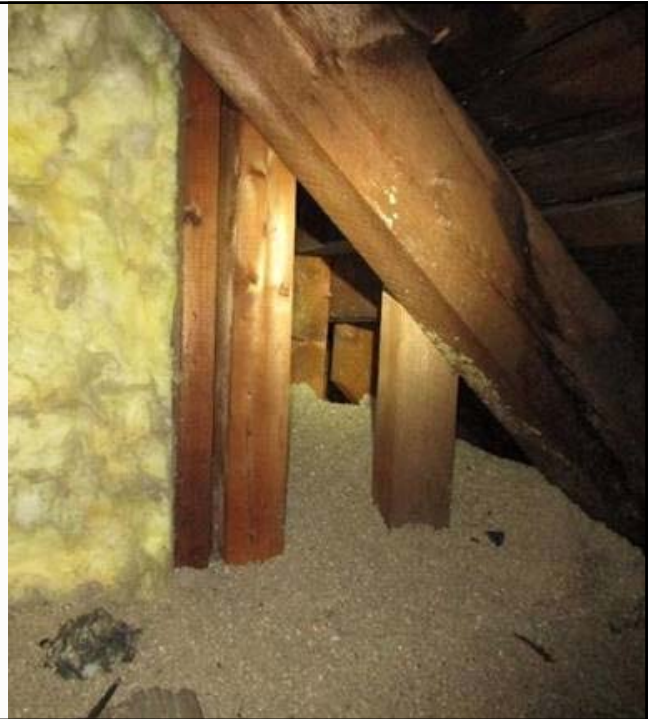
- Board roof sheathing again
- No baffle venting installed in finished slopes
- Gable & ridge vents move a lot of air



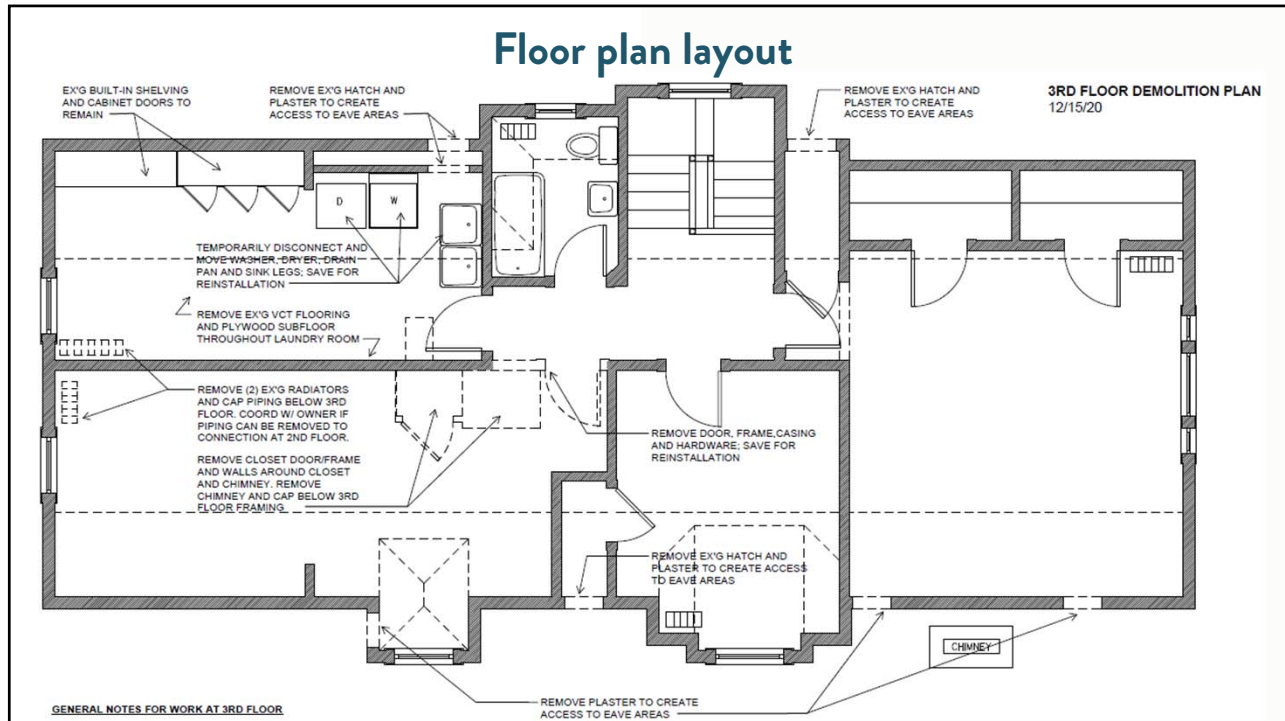
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Pre-work Eave Conditions

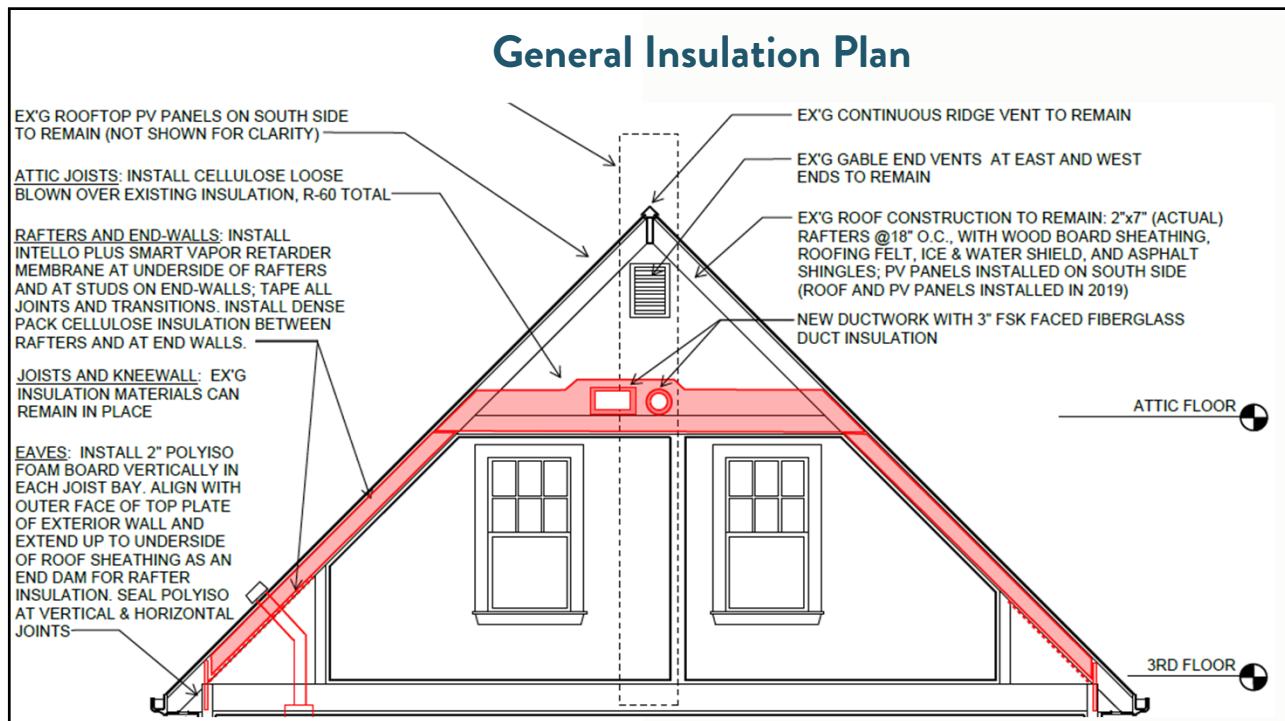
- Fiberglass stuffed to dam slopes
- Open to walls, no air sealing



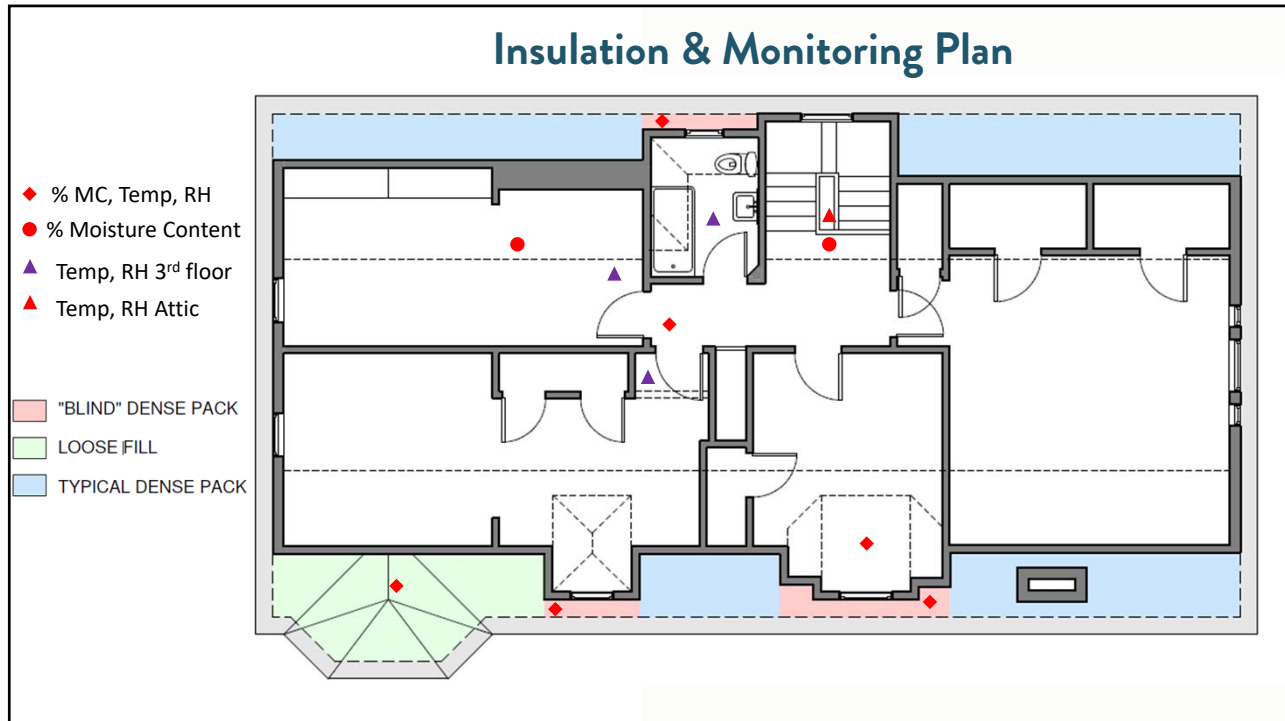
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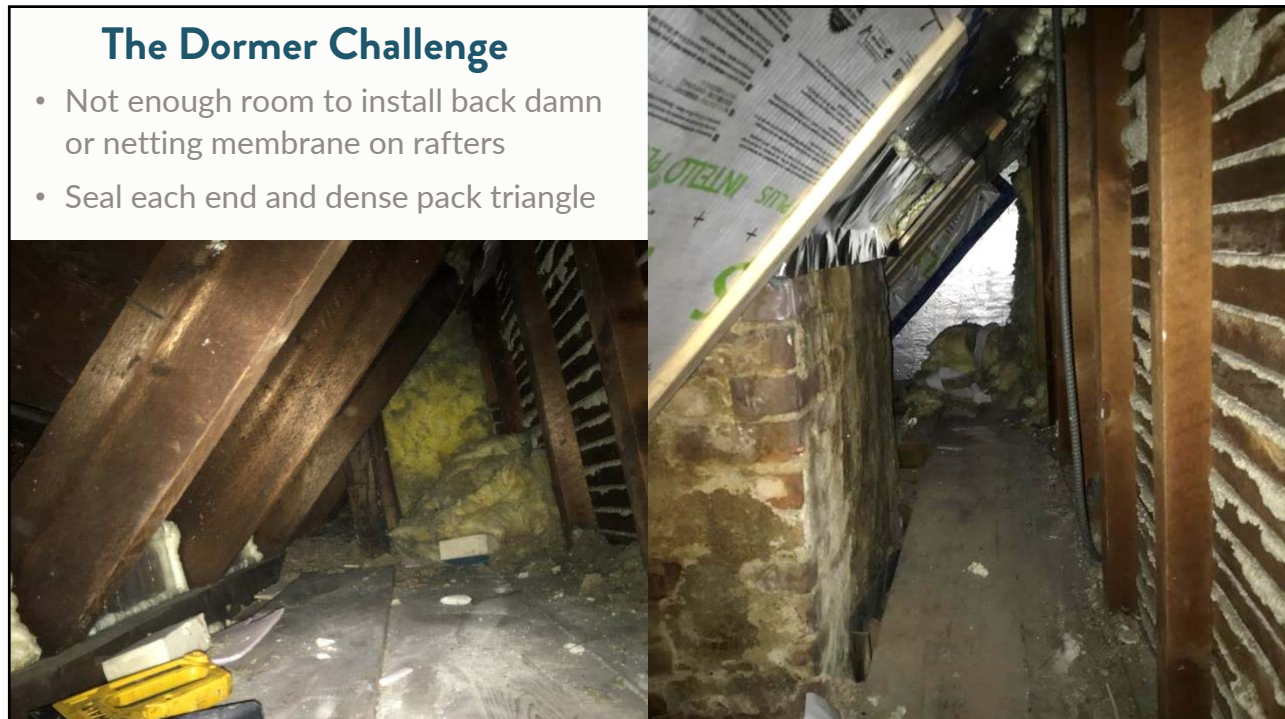
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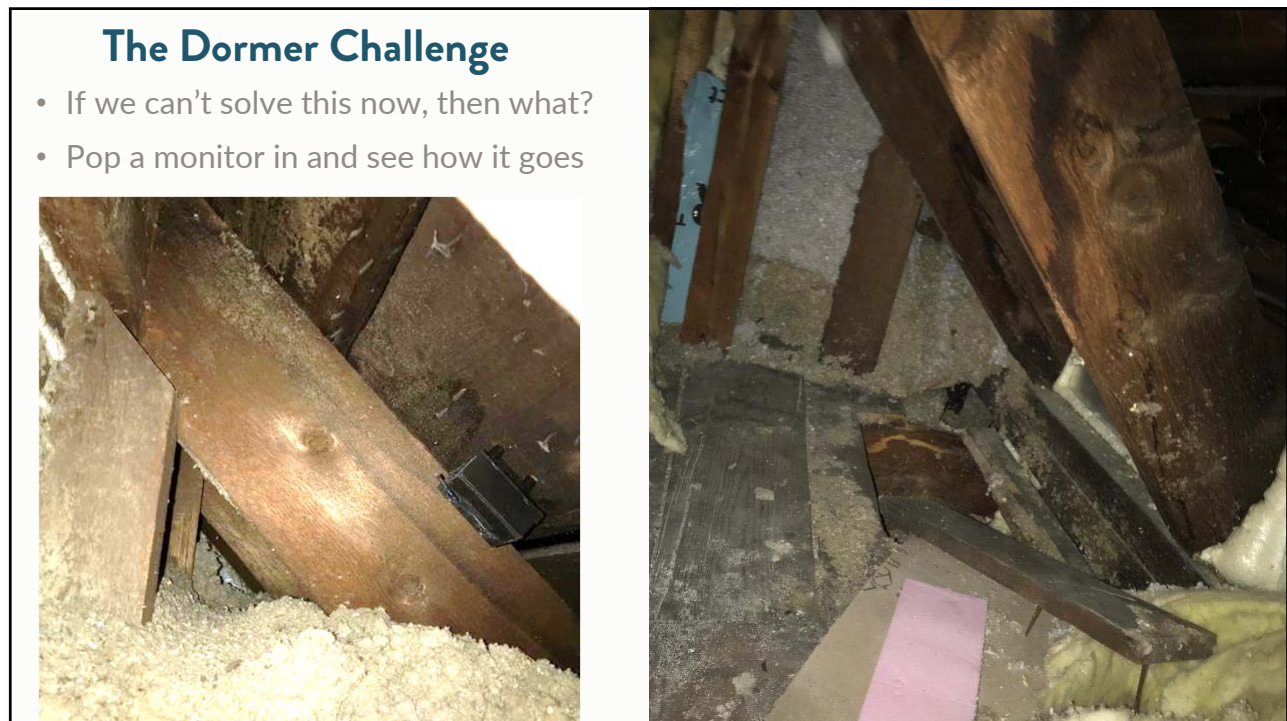
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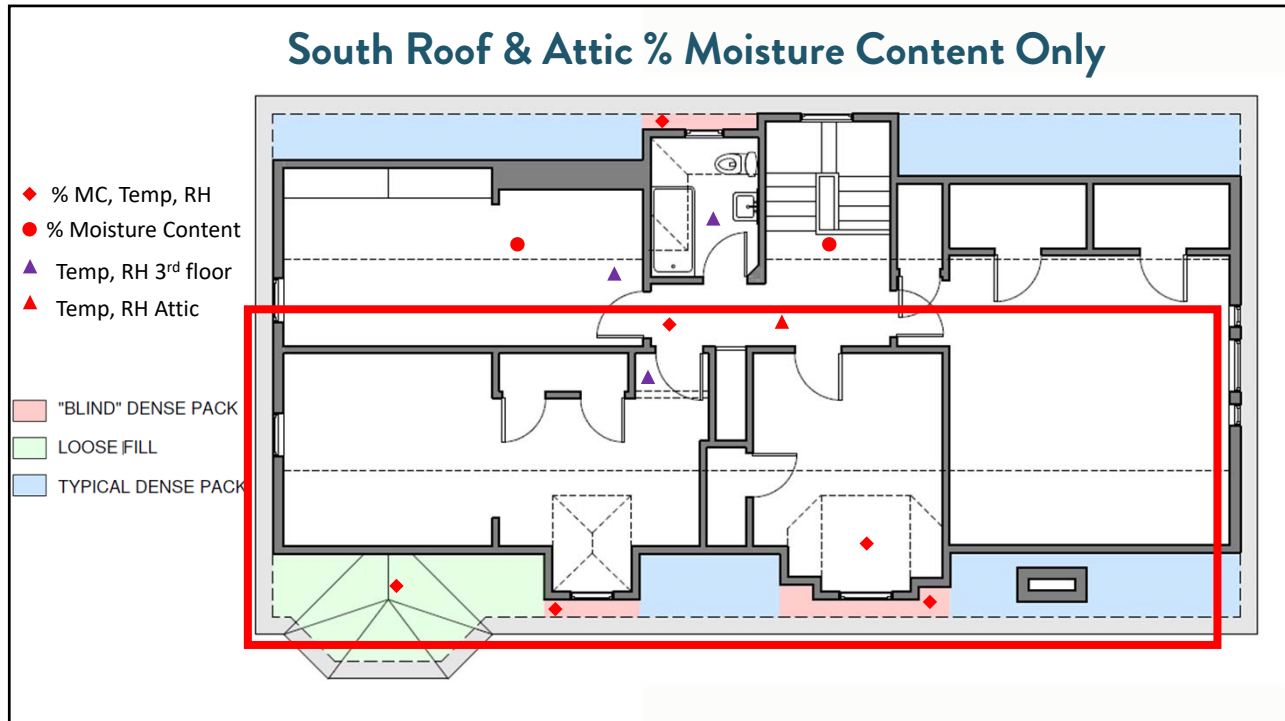
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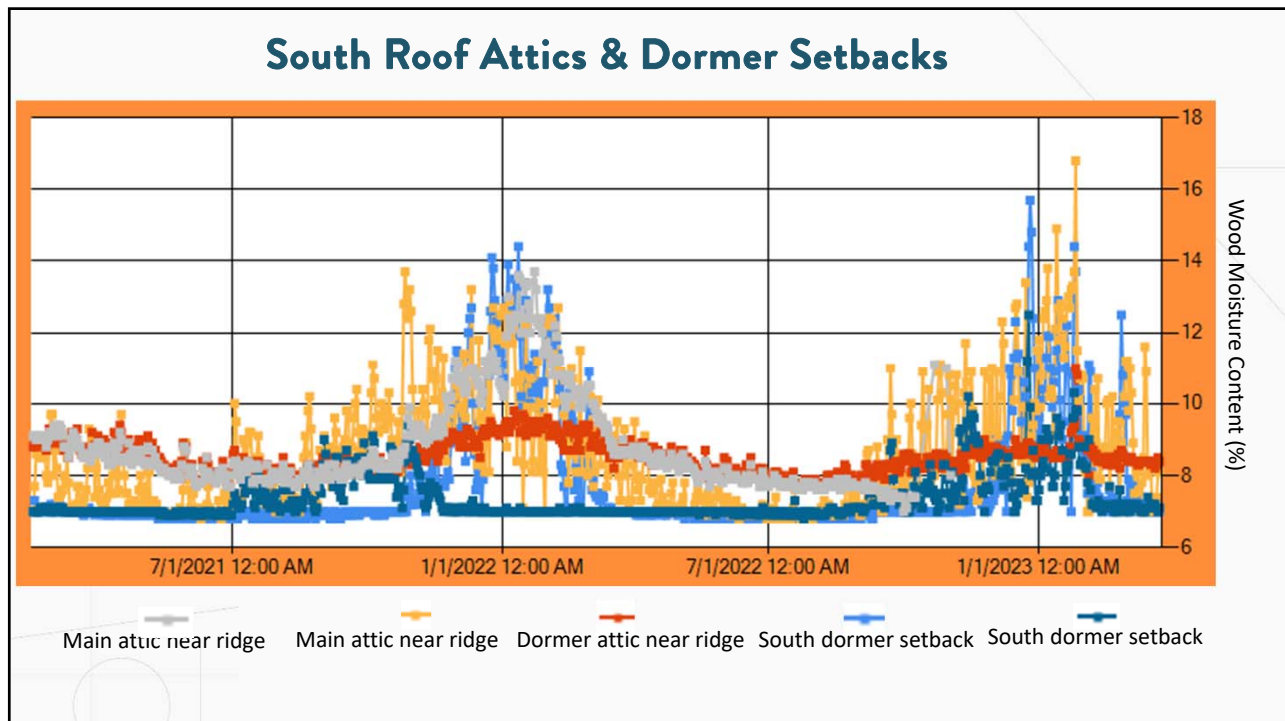
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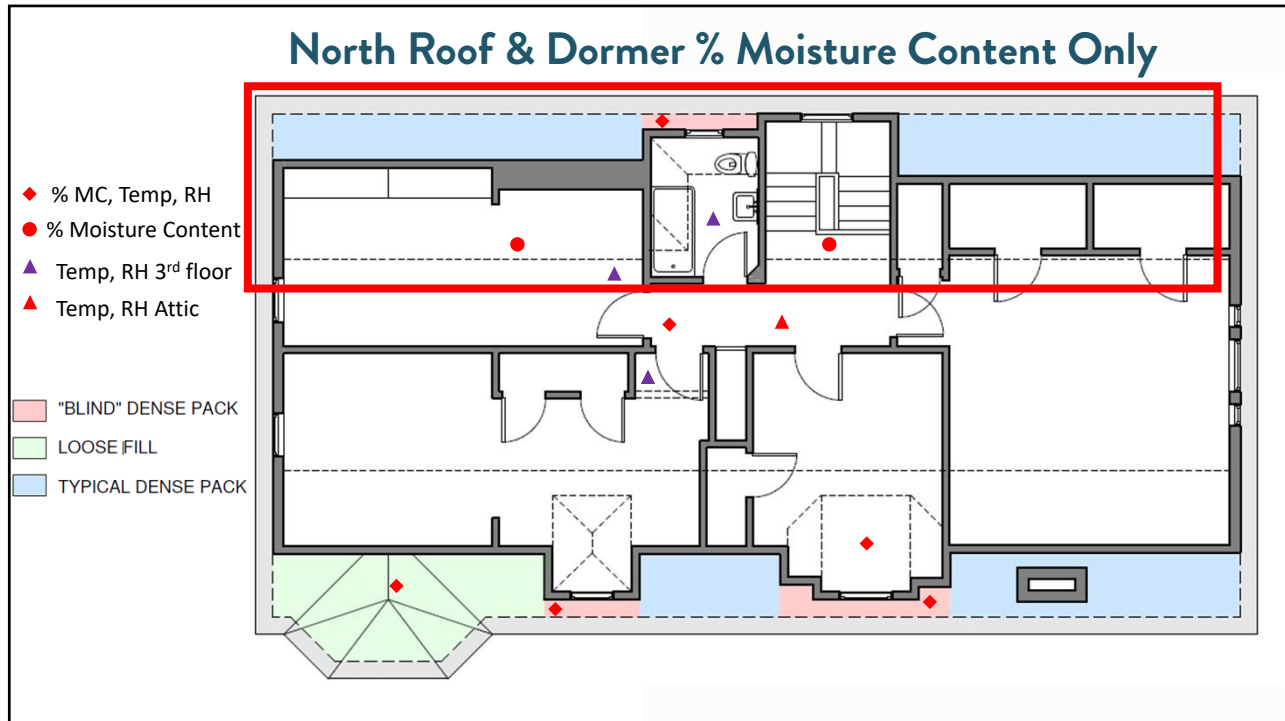
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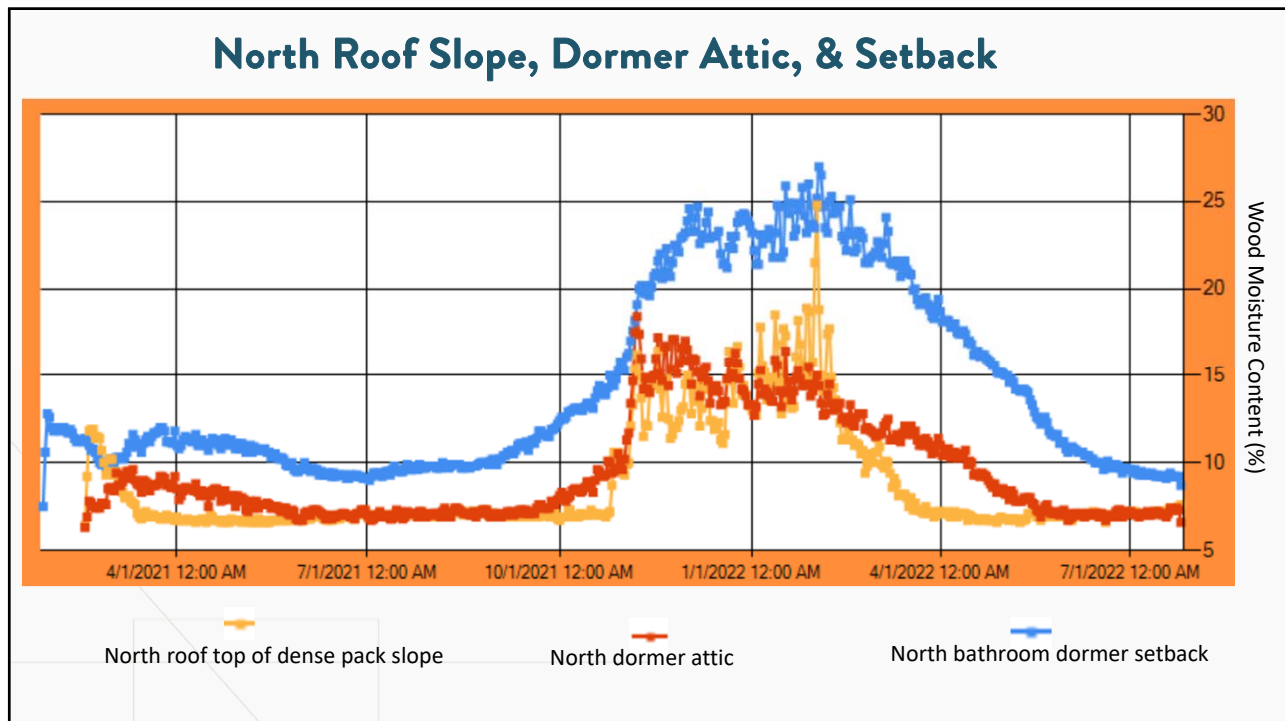
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63



64

North Roof Monitor Locations

- ◆ % MC, Temp, RH
- % Moisture Content
- ▲ Temp, RH Attic

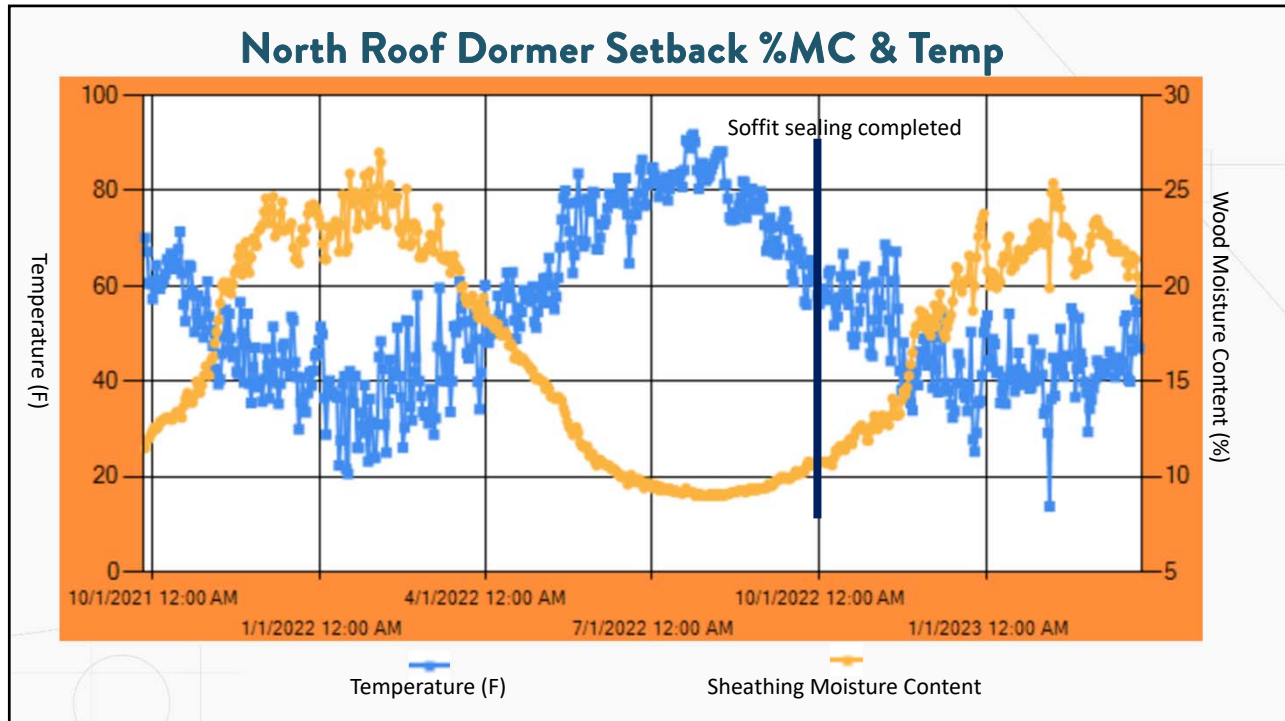
The image shows a composite of three parts: a close-up of a sensor in a wooden wall, a cross-section diagram of a roof with sensor locations marked, and a photograph of a house roof with red symbols indicating sensor positions. Red arrows connect the symbols to their respective locations on the roof and in the wall.

65

Air sealer's concern

The image shows a composite of three parts: two cross-section diagrams of a roof showing air flow paths and a photograph of a roof edge showing air leakage and insulation issues.

66



67



68

The Dormer Challenge observations and conclusions...

- A bigger attic with more ventilation helps a lot
- Air sealing to outside and vapor control to the inside are crucial, especially in vulnerable areas
- Roof leaks are still bad

Generally I feel the risk for growth on the roof sheathing here is virtually none, we'll keep an eye on the area behind the bathroom but no concerns elsewhere.

69



Case Study #3

The Diffusion Vent

- Completed Summer 2021
- Homeowners have had major issues with ice damming
- Various dormers make roof geometry and venting challenging
- Top floor has a large amount of finished slopes

70

Pre-work Exterior Conditions

- Front faces North & slightly east
- Soffit vents in most areas are minimal small circular vents only
- Small ridge vent across both roof areas
- Gable vents on either side of main roof only



71

Pre-work Exterior Conditions

- Rear faces south & slightly west
- Low slope roof had larger soffit venting installed, didn't help
- Substantial shading from surrounding trees, however few pines so solar exposure in winter increases



72

Pre-work Exterior Conditions

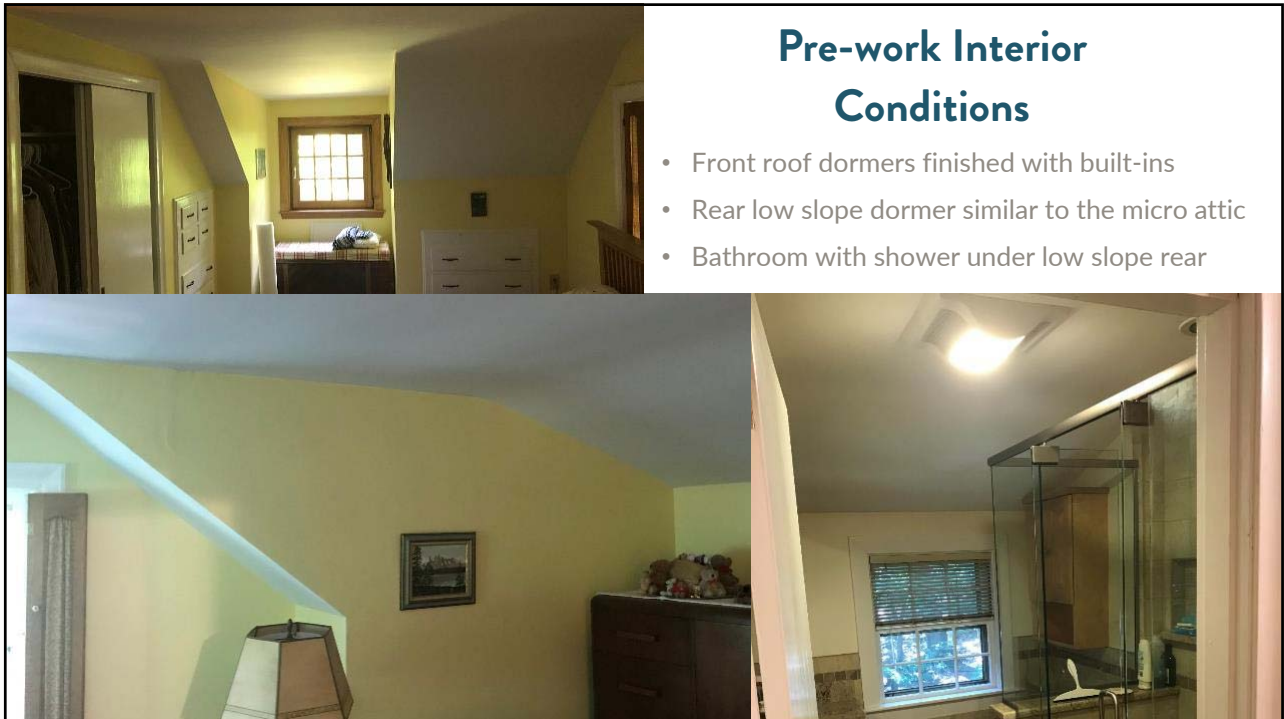
- Ice dams throughout
- Winter management difficult for aging homeowners
- Electric cable & panels installed at high roof after increased soffit venting didn't help



73

Pre-work Interior Conditions

- Front roof dormers finished with built-ins
- Rear low slope dormer similar to the micro attic
- Bathroom with shower under low slope rear



74



Pre-work Interior

- Lower side roof has smaller inaccessible attic cap, dormer at rear, & accessible eaves at front and back

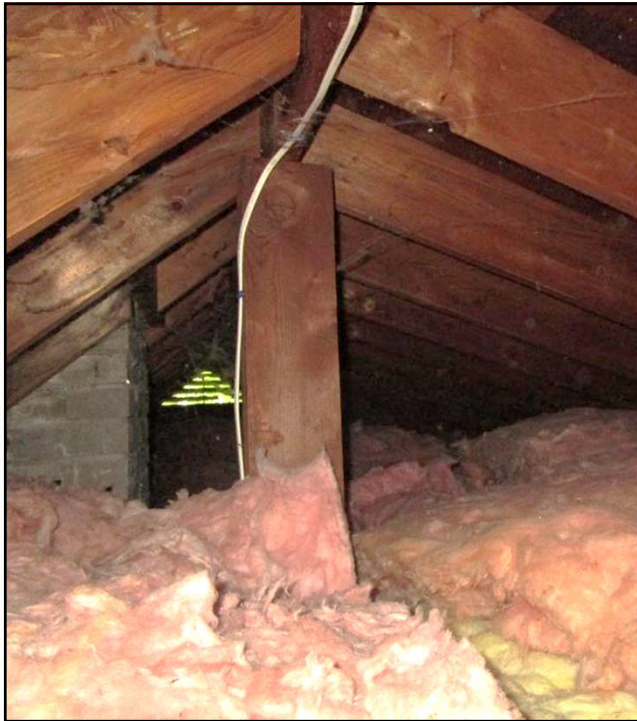
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Pre-work Interior

- Main roof has accessible eaves & access to main attic space via space above the stairway ceiling

76



Pre-work Interior

- Main attic has gable vents and make shift power venting system by homeowner



77



Insulation prep

- Cut openings to dormer roofs
- Installed membrane at tops of finished slopes for high density packing



78

Insulation prep

- Create insulated air tight access to attic
- Install Intello membrane on rafters



79

Insulation prep

- Opened up various areas of roof to install cellulose from exterior
- Install monitors in lower roof cap



80

Monitor & Insulate

- %MC monitor in roof sheathing near ridge
- Temp & RH installed in attic below ridge



81

Insulate & Air Seal

- Insulated around the wood stove flue with mineral wool and then air sealed the opening with tape



82

New Roof & Ridge Vent?

- High perm roofing membrane installed at lower roof ridge & accidentally at main ridge too



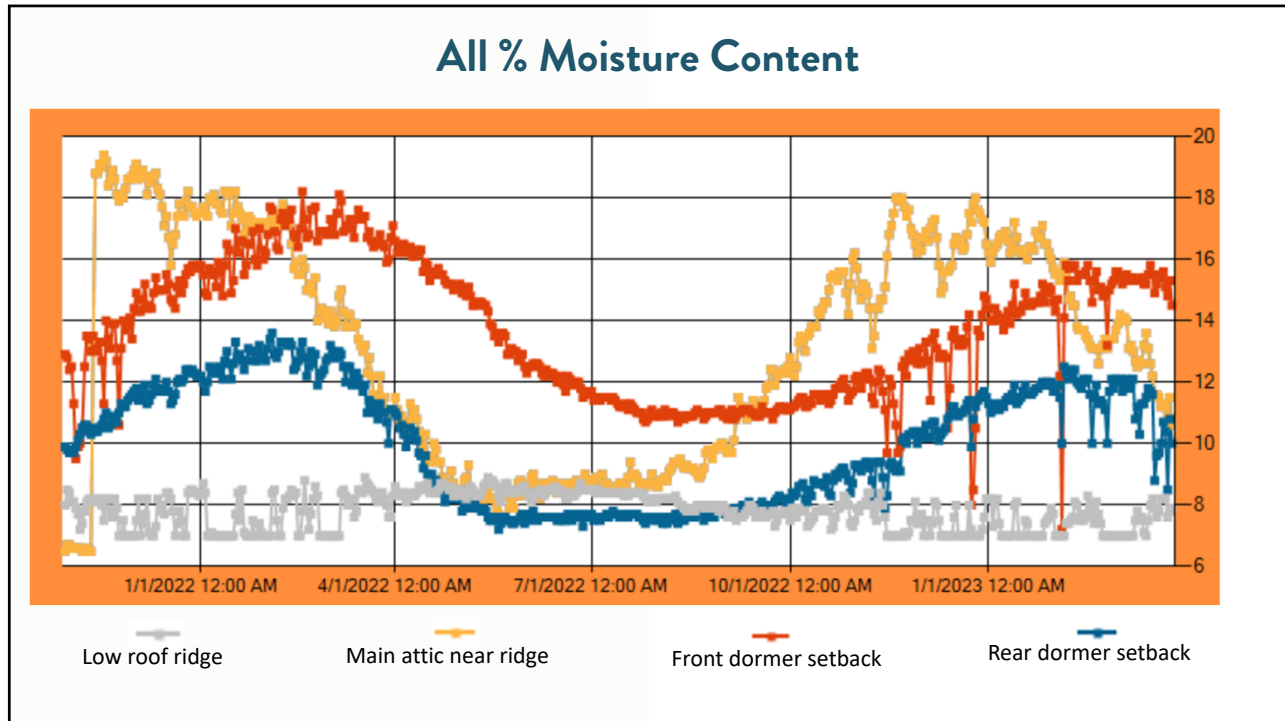

83

Monitor locations

- ◆ % MC, Temp, RH
- % Moisture Content
- ▲ Temp, RH 3rd floor
- ▲ Temp, RH Attic



84



85



86

The Vapor Diffusion Vent observations and conclusions...

- Results consistent with the 2 previous case studies
- Less monitors might mean less interesting data
- Wondering what is truly less risk, insulating to the ridge or this approach?

No concerns at all here, very happy with the performance.

87

Questions?

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Presentation will be available at:

<https://buildingscience.com/past-events>

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88

Document Resources

- NESEA Building Energy Boston 2020: Unvented Roofs Without Spray Foam: The Rest of the Story
<https://buildingscience.com/other-event/nesea-building-energy-boston-2020-unvented-roofs-without-spray-foam-rest-story-0>
- BA-2001: Monitoring of Unvented Roofs with Fibrous Insulation, Diffusion Vents, and Interior Vapor Control in a Cold Climate
<https://buildingscience.com/documents/building-america-reports/ba-2001-monitoring-unvented-roofs-fibrous-insulation-diffusion>
- BA-1409: Field Testing Unvented Roofs with Asphalt Shingles in Cold and Hot-Humid Climates
<https://buildingscience.com/documents/building-america-reports/ba-1409-field-testing-unvented-roofs-asphalt-shingles-cold-and>
- BSI-043: Don't Be Dense—Cellulose and Dense-Pack Insulation
<https://buildingscience.com/documents/insights/bsi-043-dont-be-dense>