Monitoring of Unvented Roofs with Diffusion Vents & Interior Vapor Control in a Cold Climate

2017 Building Technologies Office Peer Review

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Project Summary

Timeline:

Start date: October 2016

Planned end date: September 2019

Key Milestones

1. Instrumentation & Test Plan, November 2016
2. Needs Assessment-Manufactured Housing Roofs, July 2017
3. Winter 1 ("Normal") Report, September 2017

Key Partners:

DuPont	NAIMA
Owens Corning	Nu-Wool
Cosella-Dörken	
K. Hovnanian	

Budget:

Total Project $ to Date: $198,317

- DOE: $156,671
- Cost Share: $41,646

Total Project $: $544,687

- DOE: $430,302
- Cost Share: $114,385

Project Outcome:

In an effort to improve moisture-managed high-R envelopes to reduce heating and cooling loads, the moisture safety of roofs insulated with fibrous insulation in cold climates is being monitored. This will provide more options for unvented roofs, thus increasing market penetration. At 5% of new single-family housing start, this would be on the order of 40,000 units/year.

Purpose and Objectives

Problem Statement:

- Insulating at the roofline (unvented roofs): eliminate attic ductwork losses, improve airtightness, and reduce duct condensation risks
- Moisture-safe unvented roofs (spray foam): effective but costly
- Insulating roofs with fibrous insulation: more flexibility in cost competitive insulation material choices (increase market penetration)
- Research aligns with the DOE goal of developing Moisture Managed High-R Envelopes.

Target Market and Audience:

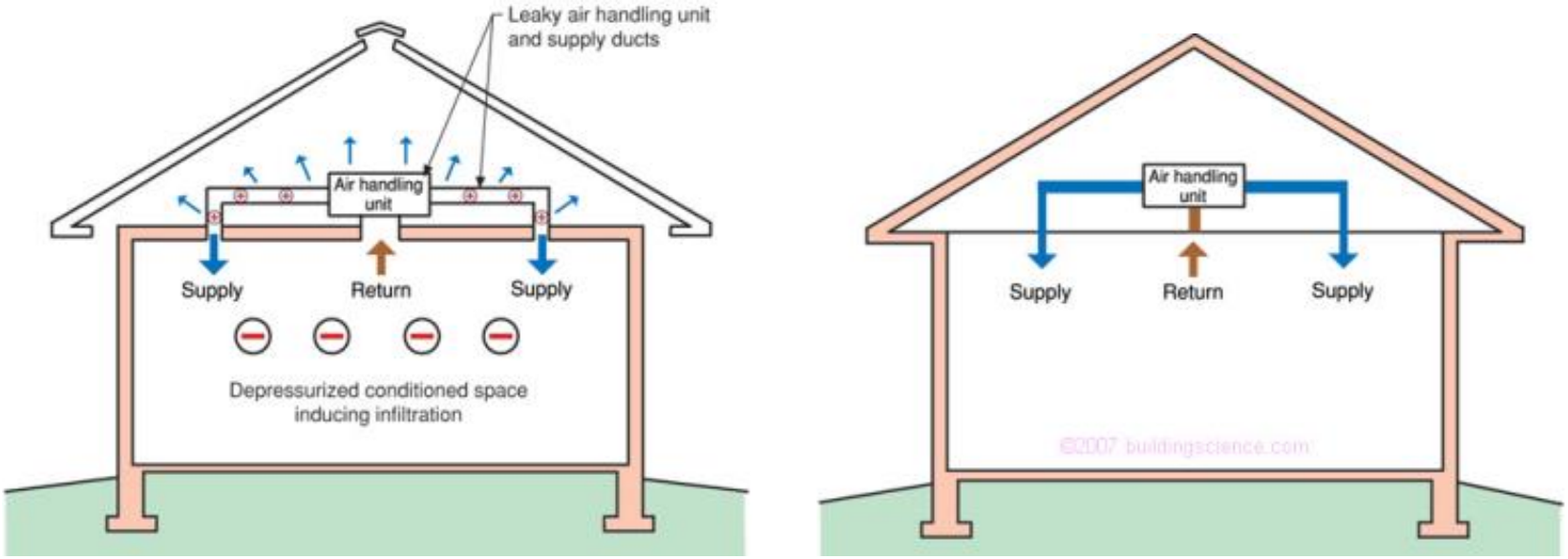
- Applications to roofs in new and existing housing
- Climate zones at least up to 5A
- Insulation manufacturers key to widespread implementation; are key stakeholders and cost share partners

Purpose and Objectives

Impact of Project:

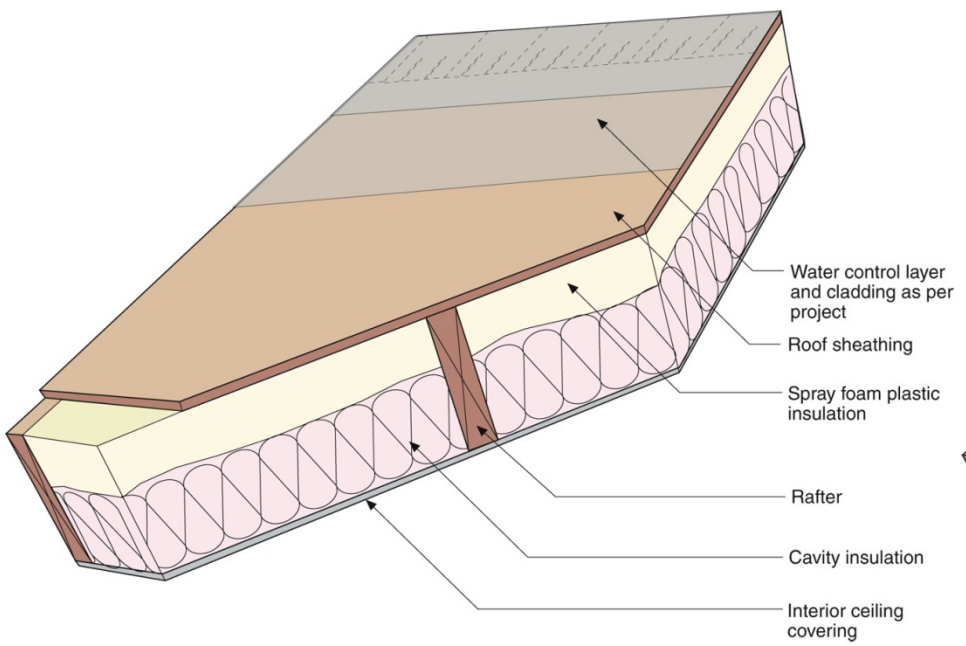
1. Planned project output:
   a. Validate moisture safety data of unvented roof assemblies
   b. Provide inputs for proposed building code changes
2. Project will measure moisture safety of high-R roof assemblies; experimental variables provide fine-tuning of recommended best practice; calculations estimate savings of >10% in HVAC energy use
   a. Near-term: acceptance of results by industry and development of proposed code language
   b. Intermediate outcomes: use of measure on smaller scale in high performance housing (industry thought leaders, NZE); process of incorporation into building codes
   c. Long-term outcomes: regular use of the code-compliant measure in standard construction, 40,000 units/yr. low est.

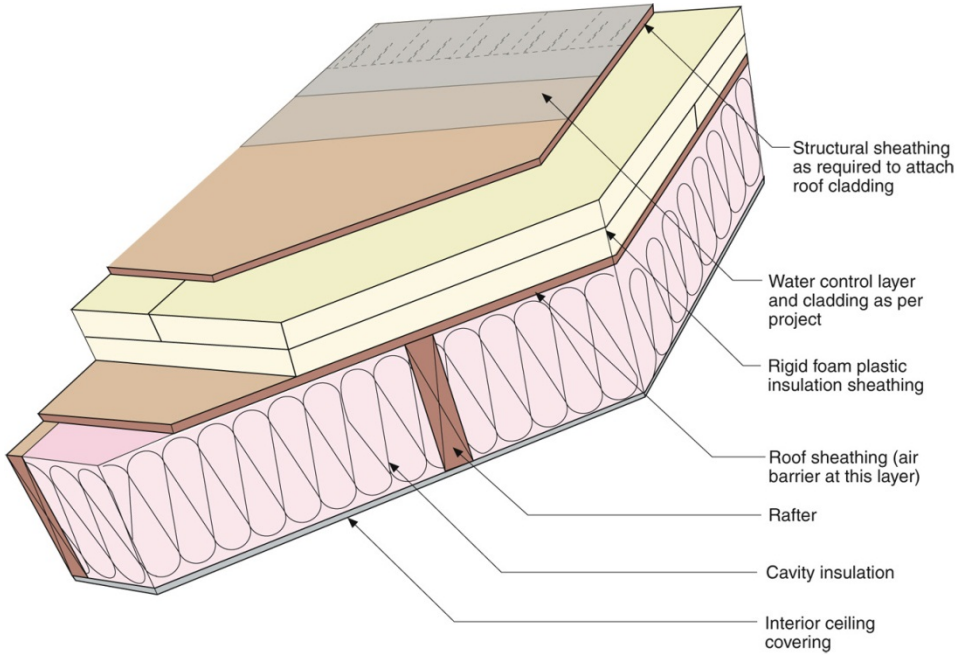
Background: Unvented Roofs



- Ducts in unconditioned attic = substantial energy losses
  - Industry reluctant to move ducts out of attic
- Solution: bring ducts into conditioned space
- Unvented/conditioned attic
  - Keeps ductwork in conditioned space, duct leak issues eliminated
  - Eliminates ice dam issues due to duct losses
  - Lowers risks for hot-humid climates ductwork and AHU condensation
  - Potential airtightness improvement

Background: Spray Foam/Exterior Insulation Roofs

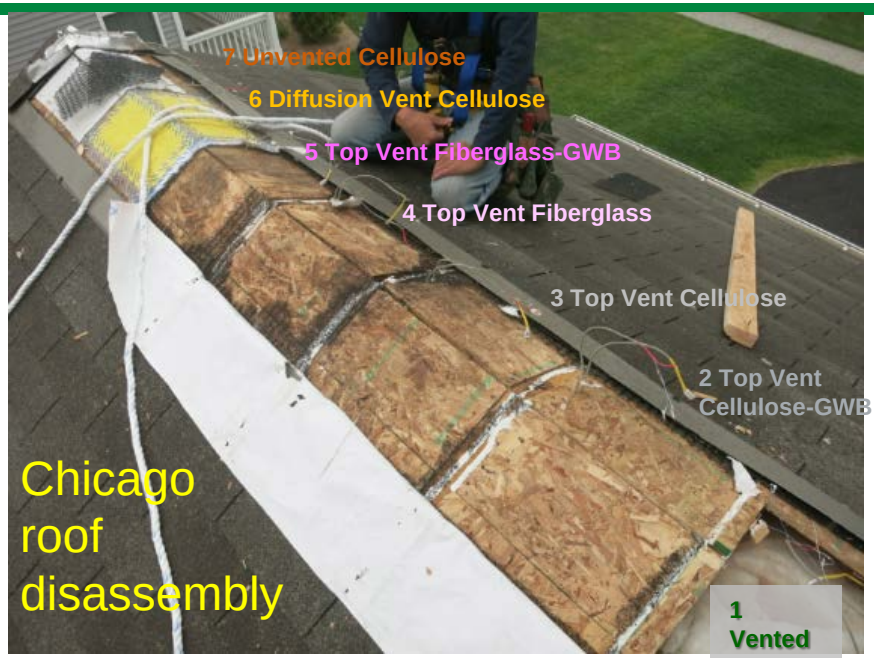




- Unvented roofs with fibrous insulation alone: moisture risks
- Poor performance of cathedral vented assemblies (air leakage)
- 2006 IRC onward: §R806.4 Unvented attic assemblies
  - Minimum R-value of “air impermeable insulation” (foam)
  - Cost of spray foam or rigid foam + nail base

Previous Building America Research

- Chicago (CZ 5A):
  - One winter, 50% RH
  - Unvented roofs-high risk
  - Cellulose lower risk than FG batt
- Houston/Orlando (CZ 2A):
  - 2 attics, multiple seasons
  - Diffusion vents allow greater drying, avoid moisture problems
- Europe/PassivHaus:
  - Allowing unvented roofs w. variable-perm vapor control, other constraints



Approach

Approach:

- Climate Zone 5A Test Hut: side-by-side test roofs constructed and monitored for moisture behavior over 3 winters
- Manufactured Housing Project: possible implementation of unvented roof assemblies with fibrous insulation, diffusion vent ridge

Key Issues:

- Constructability of fibrous insulation at roofline/unvented
- Costs vs. current practice—estimated factor 2-3 typical
- Moisture safety to be gauged by mold index model (from data)

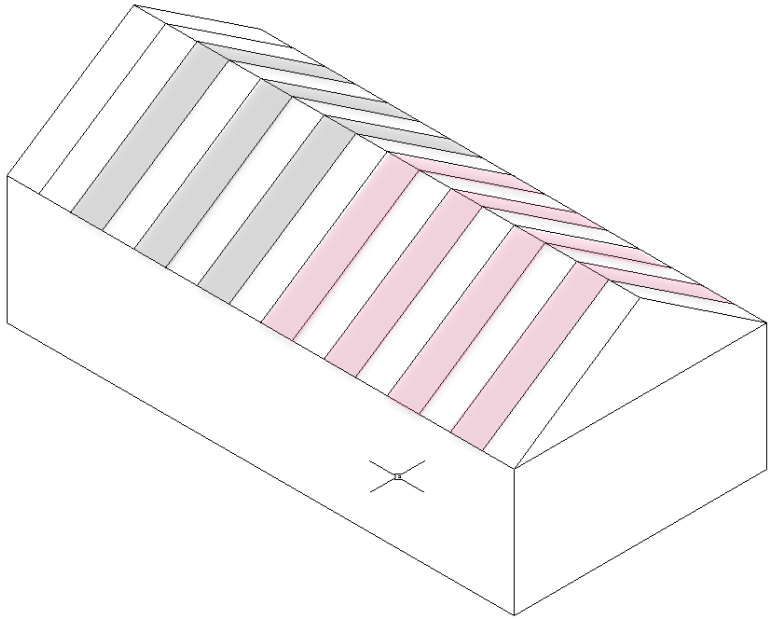
Distinctive Characteristics:

- Side-by-side assembly and north/south test hut approach
- Cooperation from manufacturers in multiple insulation industries; DOE providing third party unbiased research

Test Hut Experimental Approach

- Climate Zone 5A test hut
- Eight north-south roof bays
- ±R-50 (14-¾” framing, 2012 IECC)
- Test variables:
  - Vapor retarder: variable perm vs. fixed perm
  - Diffusion vent at ridge vs. no diffusion vent
  - Fiberglass vs. cellulose
  - “Control” comparison §R806.4 spray foam + fibrous
- Varying interior boundary conditions
  - Winter 1: “Normal” interior conditions (constant T, ~30% RH)
  - Winter 2: Elevated RH (50% constant)
  - Winter 3: Air leakage into rafter bays

Test Hut South Elevation



Progress and Accomplishments

Accomplishments:

- Test hut experimental and instrumentation plans reviewed and accepted by industry partners
- Test hut construction, instrumentation, and insulation complete (December 2016)
- Preliminary data being collected and analyzed (Winter 1)

Market Impact:

- Impact to be ensured by tracking of costs, ease of construction (vs. implementation hurdles in practice), and hygrothermal performance
- Actual vs. planned impacts: early in research, only preliminary data

Project Integration and Collaboration

Project Integration: BSC collaborating closely with industry partners (major insulation manufacturers): provide input on experiment, information on potential market opportunities, and material donations.

- NAIMA (fiberglass industry insulation trade group)
- NuWool (cellulose)
- Owens Corning (fiberglass, rigid board foam)
- Johns Manville (fiberglass, rigid board foam, spray foam)
- Saint-Gobain/CertainTeed (fiberglass, rigid board foam, spray foam)
- Roxul (mineral fiber)

Partners, Subcontractors, and Collaborators: Manufactured housing effort managed by Washington State University/Michael Lubliner

Communications: Year 1 results to be presented at energy industry or weatherization conference (EEBA or similar); communications with construction trade publications (*JLC, FHB*, Green Building Advisor)

Next Steps and Future Plans

CZ 5A Test Hut

- Three winters of test roof data
  - Normal, humidified, air leakage
- Decommissioning/disassembly
  - Actual test roof conditions after exposure
- Formulating building code language
  - Mass implementation only possible as a code-compliant option
  - Restrictions on use, standards to be met, application to various CZs
  - May require future hygrothermal modeling task

Manufactured Housing Project

- Stakeholder meeting and statement of needs
- Possible implementation of monitored test site

REFERENCE SLIDES

Project Budget

Project Budget: Three-year project, covering monitoring of climate zone 5A test hut and manufactured housing needs assessment & field work
Variances: n/a
Cost to Date: Roughly 20% of total budget spent to date
Additional Funding: Cost share provided by funding partners (Nu-Wool and NAIMA)

Budget History					
October 2016 – FY 2016 (past)		FY 2017 (current)		FY 2018 – September 2019 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$156,671	$41,646	$134,334	$35,710	$139,297	$37,029

Project Plan and Schedule

- Start date: October 2016
- Planned end date: September 2019
- Westford Test Facility Results
  - 9/2017: Winter 1 (“Normal”)
  - 9/2018: Winter 2 (“Humidified”)
  - 9/2019: Winter 3 (“Air Leak)
- Manufactured Housing Roofs
  - 7/2017: Needs Assessment
- Go/no-go decision points
  - Westford Test Facility: are there viable assemblies based on moisture conditions in roof? (BP1, BP2)
- Westford Test Facility (CZ 5A Hut):
  - Currently collecting Winter 1 data
  - Data analysis
  - Commissioning testing (air leak)

ID	Task Blue = Design/Implementation Green = Reporting	Start	Finish
1	Roof Assembly Selection	10/20/2016	11/17/2016
2	Vetting Test House, Site Visit	11/3/2016	12/1/2016
3	Roof Instrumentation Package Design	12/5/2016	1/2/2017
4	Instrumentation Setup & Testing	1/3/2017	1/20/2017
5	Test Plan to Industry Partners	1/3/2017	2/2/2017
6	Pre-Insulation Instrumentation (“Rough”)	1/23/2017	2/6/2017
7	Insulation/Installation Documentation	2/7/2017	2/22/2017
8	Post-Insulation Instrumentation (“Final”)	2/7/2017	2/21/2017
9	Field Testing/Commissioning	2/8/2016	2/22/2016
10	Reporting: Instrumentation & Testing	3/22/2017	4/6/2017
11	Reporting: Initial Data (Sensor Function)	5/8/2017	5/22/2017
12	Reporting: Winter 1 Results	8/22/2017	9/18/2017
13	Develop and Test Humidification System	10/23/2017	11/21/2017
14	Install Humidification System	12/21/2017	1/4/2018
15	Reporting: Winter 2 Results, Humidifier	8/22/2018	9/17/2018
16	Develop and Test Air Leak System	9/20/2018	10/18/2018
17	Install Air Leak System	12/24/2018	1/8/2019
18	Decommissioning and Disassmbly	8/21/2019	9/3/2019
19	Reporting: Winter 3 Results, Air Leakage	8/21/2019	9/16/2019
20	Reporting: Final and Summary	9/18/2019	10/16/2019