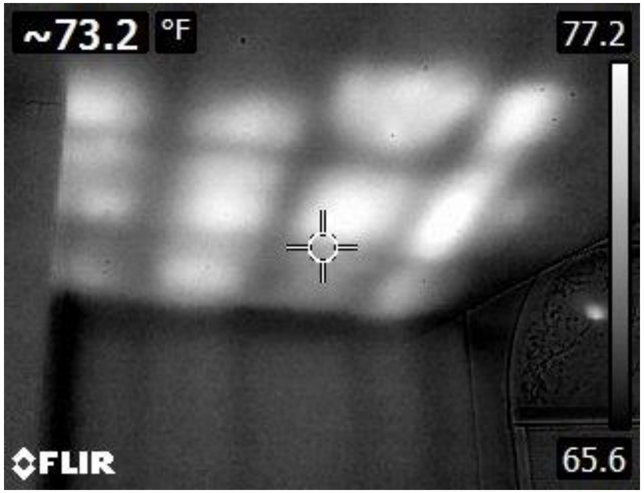
Validation Study of Experimental Insulating and Air-Sealing Technology for Enclosed Roof Cavities



Building Envelope Materials
Douglas Lamm, CEO
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Project Summary

Timeline:

Start date: 10/1/2017

Planned end date: 12/31/2019

Key Milestones

1. Lab Demonstration Completed; 9/30/2018
2. 2 Pilot Projects Completed; 11/15/2018

Budget:

Total Project $ to Date:

- DOE: $342,226
- Cost Share: $127,159

Total Project $:

- DOE: $600,362
- Cost Share: $228,931

Key Partners:

Mass Clean Energy Center
CertainTeed/Saint Gobain
Mass Technology Assessment Committee
Action For Boston Community Development

Project Outcome:

Goal:

To develop a minimally invasive retrofit insulation process for enclosed roof cavities. The process will stop air leaks and double the insulation value of the ERC.

Outcomes:

1. Process for un-insulated and under-insulated cavities developed and demonstrated in budget period 1
2. Optimization of processes to be completed in budget period 2

Team

	Name	Contribution
	Doug Lamm	Principal Investigator. Program management, experiments & pilots
	Alex Bell	Dispenser equipment development Experimental design & pilots
	Tom Pittsley	Test stand construction & pilots
	CertainTeed/Saint Gobain	Materials development Commercialization
	MassCEC	Matching funds Pilot project identification
	MassSave/Mass Tech Assessment Committee	Approval for MA weatherization programs
	Action for Boston Community Development	First commercial deployments

Challenge:

Improving Performance of Roofs In Existing Homes

Enclosed Roof Cavities (ERCs) Are Common:

Est. 80% Of Homes Have Dormer Roofs, Flat Roofs and/or Cathedral Ceilings

Problems Caused By Under-insulated Roof Cavities

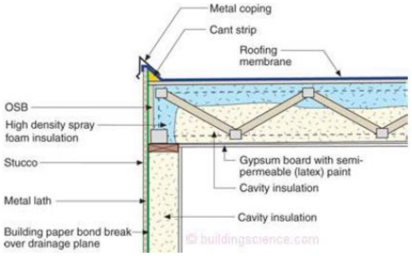
1. Ice dams lead to roof leaks

2. Heat loss from air leakage

Source:
- Weatherization in 2011 and Beyond, SPFA

Two Problematic Retrofit Solutions

1. Spray Foam: Invasive & Expensive



Source:
Don't Be Dense, Building Science Corp, 2010

2. Cellulose: Moisture Damage

Source:
Don't Be Dense, Building Science Corp, 2010

Approach

The Market Problem:

- How to retrofit enclosed roof cavities without tearing down the ceiling

What We're Doing:

- Injecting closed cell polyurethane insulating foam into ceiling surfaces through a tiny hole
- Using narrow diameter tubes to place the foam where needed in the cavity
- Developing a novel procedure for injecting the appropriate amount of material
- Developing novel dispense equipment to communicate to the injection technician and to validate foam quality
- Using an infrared camera to validate fill quality

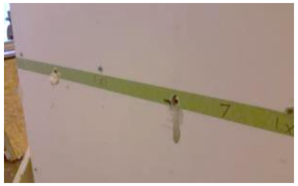
Critical Questions:

- Does the material overheat at 11.5" thickness?
- How to dispense without voids at wide rafter spacing (e.g. 24" on center)?
- How to dispense without voids at various roof angles or in flat roofs?
- How to minimize the number of holes in the cavity?
- How to dispense in fiberglass filled versus empty cavities?
- How to avoid having material drip through soffit vents?

Approach:

We're Modifying A Previously Developed System For Injecting Foam Into Wall Cavities

Step 1: Site-Prep



Find studs, measure, mark, drill

Insert tube or needle

Step 2: In Wall Metering

Inject known volume

Use IR camera to determine fill rate

Step 3: Injection

Inject pre-determined volume

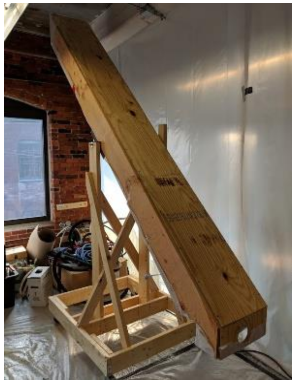
Repeat 1 to 3 times/cavity

Validate with IR

Approach:

We developed systems in the lab and then tested in pilot projects

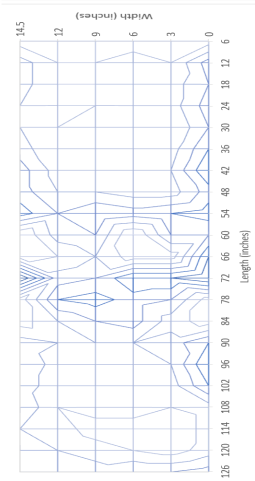
1. Build ERC test stands



2. Build “Talking Dispenser”

3 Test Injection Processes

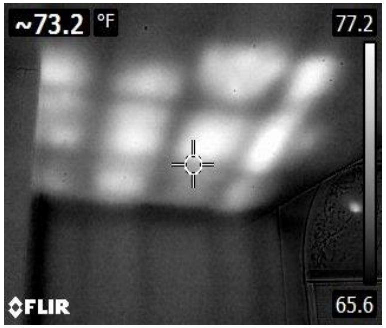
4. Measure results



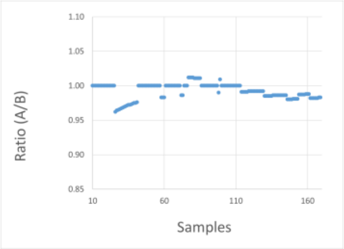
5. Inject Empty ERC Pilot

6. Inject Fiberglass Filled ERC Pilot

7. Validate Fill With IR Camera



8. Validate Foam Quality With Dispenser Data



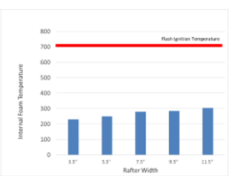
Impact

When fully deployed, we could insulate flat roofs in any triple decker from “Boston to Baltimore”

Feature	Advantage	Benefit
Closed cell polyurethane foam	Foam = R7/inch Cellulose/FG = R3.5/inch	Greater energy savings
	Foam = semi-impermeable Cellulose/FG = permeable	No roof rot
	Foam = air barrier Cellulose/FG = air permeable	Reduced heat loss
Injection	Injection = ½” hole per 8 feet Spray/Cellulose = tear off ceiling	Minimize ceiling repair time and cost
In wall metering	Calculates injection volume	Avoid blowout risk & voids
IR camera	View inside cavity	Validate fill quality
Talking dispenser	Real time ratio monitoring	Validate foam quality

Progress

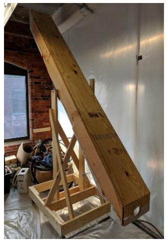
Max Safe Thickness



Cross Cavity Dispense

Talking Dispenser

Angle Dispense



Fiberglass Filled Pilot

Empty Cavity Pilot

Soffit Fill Process

Rafter Vent Process

Rafter Vent Pilot

Flat Roof Pilot

Final Report

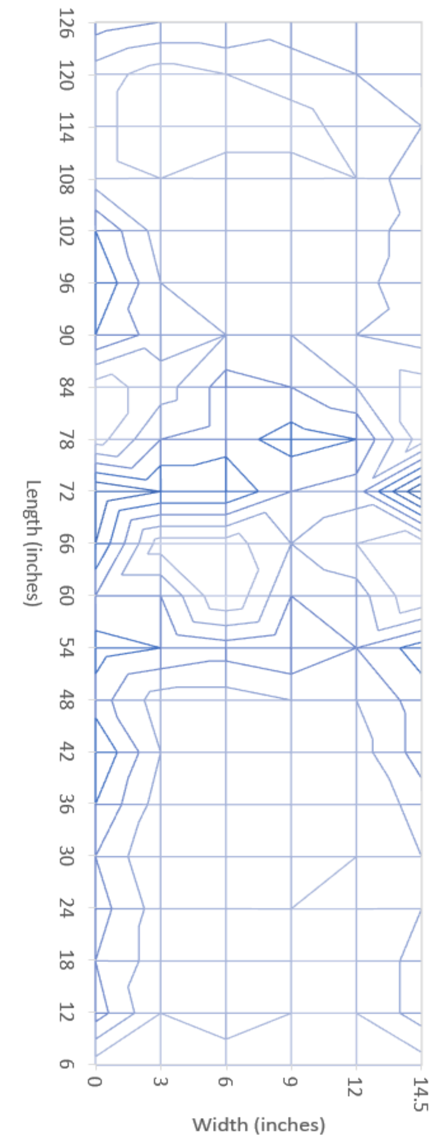
Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9

BP1

BP2

Progress

Measurement	BP 1 Target	BP 1 Achieved
Average foam thickness	2"	3.9"
R value of injected foam	13	30
Perm rating	<1	<1
Significant delaminations	None	None
Observable gaps in air barrier	None	None. Min thickness = 2.5”
Observable gaps in air barrier	None	Consistent thickness. Stdev = 0.7"



Stakeholder Engagement

CertainTeed SAINT-GOBAIN
- Developing low GWP materials
- Providing sales channel and marketing support

MASSACHUSETTS CLEAN ENERGY CENTER
- Providing funding to scale up talking dispenser
- Providing initial deployment reimbursement to building owners

mass save
- Approving the technology for residential and commercial reimbursement

abcd
- Providing funding for affordable housing projects

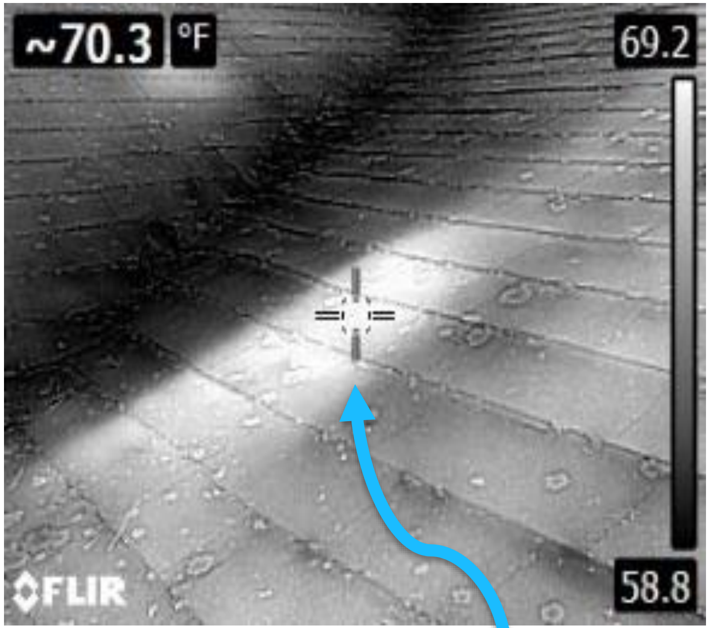
BEM Contractor Council
- Providing guidance on process and equipment design from contractor perspective

Boston Housing Authority
- Providing pilot projects and guidance on benefits from building owner perspective

MA Dept Housing & Community Development
- Providing pilot projects and guidance on benefits from building owner perspective

Remaining Project Work

More Consistent Fill Around Rafter Vent



Punctured Rafter Vent

Prevent foam spillage into soffit without need for soffit liner

Paper liner

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: $829,293
Variances: No variances from project budget
Cost to Date: 66% of project budget has been expended
Additional Funding: Approximately $100,000 additional funding secured through the MassCEC.

Budget History					
10/1/2017 – FY 2018 (past)		FY 2019 (current)		FY 2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$342,226	$127,159	$64,000	$16,000	$0	$0

Project Plan and Schedule

Project Schedule												
Project Start: 10/1/2017	Completed Work											
Projected End: 12/31/2018	Active Task (in progress work)											
	Milestone/Deliverable (Originally Planned)											
	Milestone/Deliverable (Actual)											
	FY2017				FY2018				FY2019			
Task	Q1 (Jan-Mar)	Q2 (Apr-Jun)	Q3 (Jul-Sep)	Q4 (Oct-Dec)	Q1 (Jan-Mar)	Q2 (Apr-Jun)	Q3 (Jul-Sep)	Q4 (Oct-Dec)	Q1 (Jan-Mar)	Q2 (Apr-Jun)	Q3 (Jul-Sep)	Q4 (Oct-Dec)
Past Work												
Q4 Milestone: Max Safe Temperature												
Q1 Milestone: Cross Cavity Dispense												
Q2 Milestone: Angle Dispense												
Q3 Milestone: Talking Dispenser												
Q4 Milestone: Pilot Projects												
Q1 Milestone: Soffit Fill Process												
Current/Future Work												
Q2 Milestone: Rafter Vent Process												
Q3 Milestone: Pilot Projects												
Q4 Milestone: Final Report												