

Kohta Ueno

Historic Preservation Meets Building Science: The Mallett Deep Energy Retrofit

# Overview

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## The Mallett Deep Energy Retrofit

- The design decision process for how the team chose assemblies and details
- Energy efficiency, durability, constructability

Image c/o Energy Circle

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## R-Value Targets

Climate Zone	Wall	Vented Attic	Compact Roof	Basement Wall	Exposed floor	Slab edge <sup>1</sup>	Windows (U/SHGC)	Sub-slab <sup>2</sup>
1	10	40	35	5	10	none	yes	none
2	15	50	40	10	20	5	0.35/<.25	none
3	20	50	45	10	20	7.5	0.30/<.3	5
4	25	60	45	15	30	7.5	0.30/<.35	7.5
5	30	65	50	15	30	10	0.24/<.50	7.5
6	35	75	60	20	40	10	0.18/--	10
7	40	90	65	25	45	15	0.15/--	15
8	50	100	75	35	50	20	0.15/--	20

**Table 2: Current Recommended "True" Minimum R-value (+/-)<sup>3</sup> including thermal bridging**  
Source: RR-1005: High R-Value Enclosures for High Performance Residential Buildings in All Climate Zones

- "True" R value: R-13 2x4 wall ≈ **R-8**  
R-19 2x6 wall ≈ **R-12**
- Estimated targets—will vary with local construction costs, energy costs, client targets

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# Enclosure Design

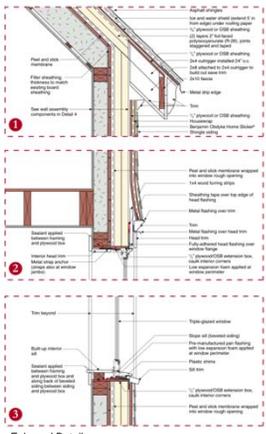


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## Enclosure Design (1 of 2)

- R-40 Walls (existing 2x4 framing filled with cellulose insulation and (2) foil-faced polyisocyanurate insulating sheathing on wall sheathing)
- R-50 Roof Insulation (existing 2x7 framing filled with cellulose insulation and (2) 2" layers foil-faced polyisocyanurate insulating sheathing on roof sheathing)
- Windows (Low-E triple pane krypton filled, U = 0.20 & SHGC = 0.44)



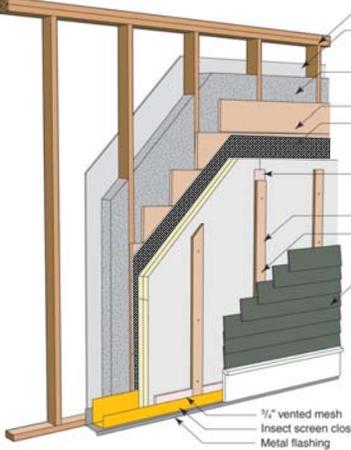
Enlarged Details



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## 4" Polyisocyanurate Foam



- Existing wood framing
- Interior finish as per project (existing horsehair plaster, replacement gypsum board)
- Retrofit cellulose or fiberglass insulation in wall cavity
- Existing board sheathing
- Draining polyolefin housewrap; used as a secondary air barrier/secondary drainage plane (some projects)
- 4" rigid foil-faced polyisocyanurate insulation (two layers of 2" insulation); tape horizontal and vertical joints
- 1x3 wood furring
- Furring attached with 6" heavy-duty flat head coated screws spaced vertically at 24" o.c.
- Lap siding (wood, vinyl, or rigid PVC) as per project
- 1/4" vented mesh
- Insect screen closure at base of wall
- Metal flashing

## Foam Sheathing Cladding Attachment



250 lbs/113 kg load (7.8 psf): <math><0.003''</math> deflection

Wood siding ~2 psf  
Fiber cement 2-3 psf  
Stucco 8-10 psf

Image c/o Petersen Engineering



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### Foam Sheathing Cladding Attachment

Rotational resistance provided by tension in fastener and compression of the insulation

See: Exterior Cladding Attachment Research, Peter Baker, EEBA 2012: <http://www.buildingscienceconsulting.com/presentations/documents/2012-09-26%20EEBA%20Baker%20Cladding%20Attachment.pdf>

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Enlarged Details

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### Vented and Unvented Roofs

- Vented roofs good solution for low cost, durable, high-R assembly, IF:
  - No mechanicals in vented roof AND
  - Good air barrier at attic floor

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### Unvented Roof: How?

- 2006 IRC: R806.4 Unvented attic assemblies
- Minimum R-value of "air impermeable insulation"
- Nail base needed with rigid foam on roof deck
- Air barrier on interior side of "roof sandwich"

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Enlarged Details

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### Water Control: Pan Flashings

- Deep energy retrofits (addition of insulation at existing wall) can make the wall more vulnerable to water leakage
- Previously "survivable" leaks may no longer be able to dry out.

### Enclosure Design (2 of 2)

- R-24 Basement Walls (2" closed cell spray foam with 2x4 stud wall filled with cellulose)
- R-13 Rim Joist Area (2" closed cell spray foam with 2x4 stud wall filled with cellulose)
- R-10 Basement Slab (2" XPS below slab)

Enlarged Details

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### Basement Insulation Location

Building Enclosure Components:

1. Base Floor System(s)
2. Foundation Wall System(s)
3. Above Grade Wall System(s)
4. Windows and Doors
5. Roof System(s)

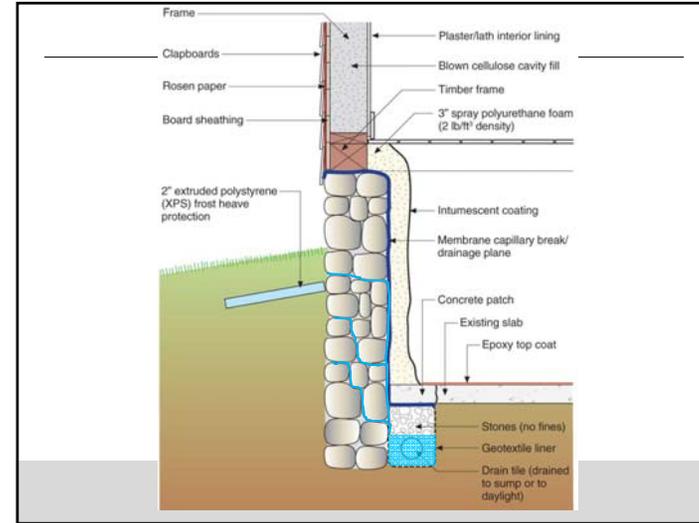
Building Enclosure Components:  
- Building Enclosure  
- Interior Spatial Separators

### Basement Insulation Location



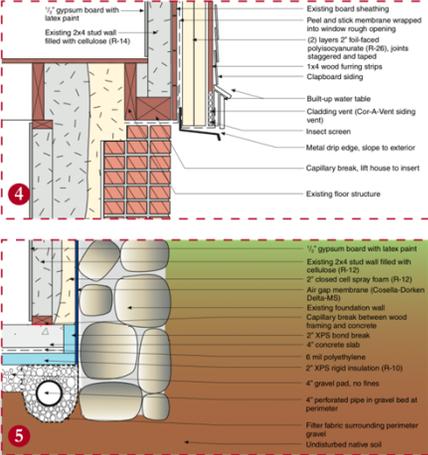
- 4.6 ACH50; 2129 CFM 50 total; 1100 CFM 50 through floor
- 8.5 ACH50; 3590 CFM 50 total; 1740 CFM 50 through floor

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### Foundation Insulation Details

- Stud wall and cellulose insulation for additional R-value
- 2" XPS sub-slab insulation



**4**

- Existing board sheathing
- Peel and stick membrane wrapped into window rough opening
- (2) layers 2" foil-faced polyisocyanurate (R-20), joints staggered and taped
- 1x4 wood furring strips
- Clapboard siding
- Built-up water table
- Cladding vent (Cov-A-Vent siding vent)
- Insect screen
- Metal drip edge, slope to exterior
- Capillary break, lift house to insert
- Existing floor structure

**5**

- 1/2" gypsum board with latex paint
- Existing 2x4 stud wall filled with cellulose (R-14)
- 2" closed cell spray foam (R-12)
- Air gas membrane (Coselle-Dorkest D400-M3)
- Existing foundation wall
- Capillary break between wood framing and concrete
- 2" XPS board break
- 4" concrete slab
- 6 mil polyethylene
- 2" XPS rigid insulation (R-10)
- 4" gravel pad, no fines
- 4" perforated pipe in gravel bed at perimeter
- Filter fabric surrounding perimeter gravel
- Undisturbed native soil

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# Air Barriers

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### Roof-to-Wall Air Barrier Connection

**INSULATE OVER AND UNDER THE ROOF DECK**

To get the most insulation into the shallow 7-in. rafters, we used closed-cell foam. On top of the foam, we added 1/2 in. of polystyrene foam board, which has the highest R-value per inch of the rigid foam boards. This yielded an R-60 roof without adding.

We didn't want to disrupt the interior plaster to spray foam into the wall cavities, so we filled the walls with cellulose and covered them with rigid foam.

**Labels in diagram:**  
Existing roof sheathing  
Two layers of 2-in. rigid polyiso foam (R-24)  
6-in. closed-cell spray foam (R-36)  
Blown-in cellulose  
Existing sheathing  
Draining housewrap  
Two layers of 2-in. rigid polyiso foam (R-24)  
1/2-in. furring strip  
Wood siding

### "Chainsaw" Retrofits (Roof-to-Wall)

**Labels in diagram:**  
Asphalt shingles  
Top and water shield (sealed 6" from edge) under roofing paper  
1/2" plywood or OSB sheathing  
(2) layers of 2" foil-faced polystyrene (R-24), gables staggered and lapped  
1/2" plywood or OSB sheathing  
2x4 outrigger (spaced 24" o.c. 2x4 attached to 2x4 outrigger to build out same line)  
Metal drip edge  
Tim  
1/2" plywood or OSB sheathing  
Housewrap  
Benjamin Obdyke Home Slicker® single siding

See wall assembly components in Detail 4

See "The History of the Chainsaw Retrofit" (Green Building Advisor)  
<http://www.greenbuildingadvisor.com/blogs/dept/musings/history-chainsaw-retrofit>

### Wall Retrofit Air Barrier Options

Photos showing various wall retrofit air barrier options, including Tyvek and other membrane applications on exterior walls.

### Self-adhered Membrane as Air Barrier

Photos showing a building exterior with a self-adhered membrane applied as an air barrier. The membrane is dark and covers the entire exterior surface.

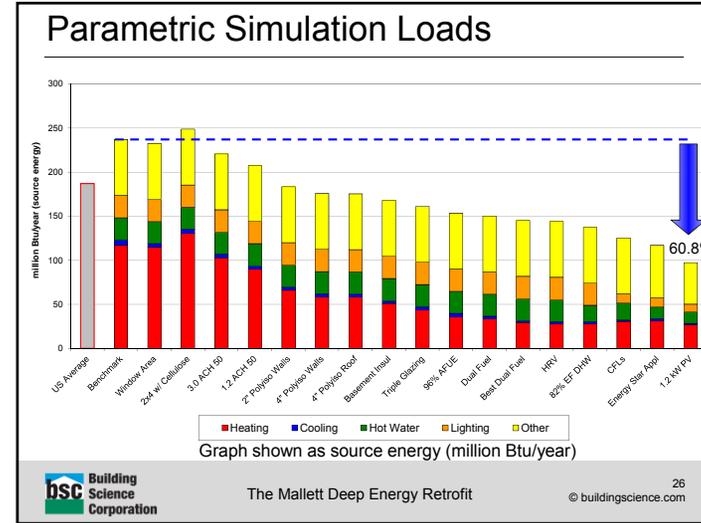
- 69 CFM 50 (0.09 ACH 50) w. blanked off openings
- 337 CFM 50 (0.4 ACH 50) pre-drywall

# Energy Performance



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# Simplified Mechanicals



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## Mini-Splits (DHPs)




Mini-split non-ducted head

Mini-split short ducted system

- Both heating & cooling
- Multi-splits (single outdoor unit)
- Systems with SEER=26 and HSPF=11 available



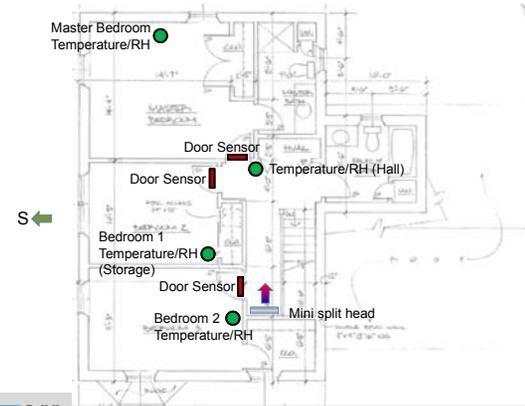
Mini-split outdoor unit



**Mini-Splits Heating/Cooling in Cold Climate**

- 1818 sf house, solar-oriented, superinsulated (12" spray foam walls, R-80 roof), triple glazed windows, very airtight
- Central Massachusetts location
- Net zero performance

**Mini-Split Heat Pumps**



**Mini Split Heating Research Conclusions**

- Single point heating per floor can keep rooms close to setpoint (~5-7° F)
- Deep heating setbacks cause greater differences
- Leaving doors closed increases temperature differences
- Deep setbacks result in long runtimes for mini split heat pumps
- “Acceptable sizing” data inconclusive, but other practitioners in colder climates have hard data
- Effective trade-off for superinsulated enclosure

**Infrared Images**

### Infrared Images

- December 26, 2012 (27 F outside)

19.9°F  $\epsilon=0.90$  FLIR

18.5°F  $\epsilon=0.90$  FLIR

18 33

### Infrared Images

- December 26, 2012 (27 F outside)

18.5°F  $\epsilon=0.90$  FLIR

19.9°F  $\epsilon=0.90$  FLIR

18 33

### Infrared Images

23.4°F  $\epsilon=0.90$  FLIR

21.2°F  $\epsilon=0.90$  FLIR

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### Snow Melt Patterns

- One of these things is not like the other...

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# Questions?

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