

## Deep Energy Retrofit Measures Verification

Raynham and Springfield, MA



## Deep Energy Retrofit Measures

Pulling it all together:

- Plans (*Plan!*)
- Specification (*Specify!*)
- Verification (*Verify!*)

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## Deep Energy Retrofit Measures Verification

Why am I here?

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## Deep Energy Retrofit Measures Verification

Role of BSC in National Grid DER Pilot:

- Technical Support
- Verification

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## Deep Energy Retrofit Measures Verification

DER performance parameters:

- Performance Targets
- Performance Imperatives

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Performance Targets:

- R 5 Windows
- R 10 Slab
- R 20 Foundation Walls
- R 40 Above-Grade Walls
- R 60 Roof
- Air tightness 0.1 cfm 50 / s.f. enclosure

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### Performance Imperatives:

- Technically Sound
- Sufficiently Robust
  - Combustion safety
  - Durability: water management
  - Indoor air quality: water management
  - Hazard mitigation (soil gas, rot, other)
  - Ventilation
  - Comfort

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### Critical Enclosure Control Functions:

- Control (liquid) water
- Control air flow
- Vapor control
- Thermal control

“Technically Sound” = performs control functions

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### Foundation Walls:

- Performance Target – R 20
- Performance Imperatives –
  - Control (liquid) water
  - Control air flow
  - Thermal control
  - Vapor control

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### How do we do it? (Process)

- Review project plans
- Review project on site

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## DER Project Plans

- It's important to have a plan!  
(It's important to plan)

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## DER Project Plans



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## DER Project Plans



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## DER Project Plans

Component	Applicable to Building	Component treated in DER Project?	Note	Existing Conditions (Units)	Proposed	Performance Specifications			Equipment or Material
						Existing Conditions *	Proposed	DER Pilot Targets	
<b>Enclosure Measures</b>									
				Area of Enclosure Component (Sq Ft)		Effective R-value (R-value = 1 / U-value)			Indicate thickness and type of insulation added
Attic or Roof	Yes	Yes	None likely to change if thermal boundary moved	1340	2136	24.0	60.0	R 60+	8" MR-200 Icynene and 4" exterior polyisocyanurate
Above Grade Walls	Yes	Yes	grows area including windows and doors	2127	2481	2.0	40.0	R 40+	existing 2 x 4 cellulose cavity or icynene and 4" exterior polyisocyanurate
Insulated Foundation Wall - Above Grade	Yes	Yes	include if basement walls insulated or basement is intentionally heated, can start from one way existing to another in DER. do not include if basement walls insulated or basement is intentionally heated	216	216	2.0	30.0	R 40+	3" closed cell spray foam and 3.5" fiberglass batt
Insulated Foundation Wall - Below Grade	Yes	Yes		506	506	2.0	24.0	R 20+	2" closed cell spray foam and 3.5" fiberglass batt
Floor of Insulated/Conditioned Basement	Yes	Yes	708	708	2.0	10.0	R 10+	2" XPS with taped seams, embedded in 3" or 3PF insulation (wall insulation) at perimeter	
Basement Ceiling	No	No						R 30+	NA
Slab on Grade	No	No						R 10+ under and perimeter	NA
Floor over Unheated Garage or Overhang	Yes	Yes	280	696	3.0	40.0	R 40+	Enclosed cell spray foam and 3.5" fiberglass batt, 2" polyisocyanurate taped	
Windows	Yes	Yes	154	310	2.50	4.75	R 5 (U.2) **	New Paradigm Windows, Series 8312	
Doors	Yes	Yes	64	94	1.50	4.75	R 5 (U.2)	New Thermatr and Paradigm Doors	
Tight Storm or Modify Windows and Doors			area of affected windows or doors					R 5 (U.2)	
				Enclosure surface area		enter air leakage test measurement in cfm at 50 Pascals pressure difference		indicate basic strategy for airflow control	
<b>Air sealing</b>		Yes		5177	6743			674	Tyvek housewrap applied over exterior sheathing, all joints taped and sealed at back of window box extensions,
<b>HVAC</b>	exists ?			# units	# units	enter appropriate performance specification			indicate equipment type, RST, LTR, manufacturer and model number
Mechanical Ventilation	Yes	Yes	include CFM and, if applicable, recovery efficiency (%)	1	1	none	88%	Heat Recovery: Balanced, Distributed	Lifebreath HRV, M# 155ECM, 88% Max. Temp recovery
Heating equipment	Yes	Yes	enter AFUE of existing and proposed	1	1	94	94		Carrier Furnace Model # 58MVP, Direct Vent, 2 stage fed into new ductwork, integrate with HRV / stage #1 BTU output 60,000-75,000, stage #2 52,000.

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## DER Project Plans

### E. Summary of Deep Energy Retrofit Plans

Briefly describe the conceptual plan for deep energy retrofit and remodeling/rehab/addition plan in context with each other. Describe specific approach planned for insulation of walls, foundation, attic and other aspects such as HVAC. (500 words max)

**BASEMENT:** The current basement is being renovated and well insulated with an R11 closed cell on the concrete foundation and a new GWB, R-13 perimeter wall. We are also planning on adding a 1.5" R layer of insulation over the existing concrete slab which will be completely sealed first ( overall existing head room is now 7'-0" and will go down to 6'-10" ) under a new floating floor.

**1st FLOOR ADDITION:** The first floor will remain mostly untouched, with the exception of the new windows, new entry and steps, back stairs entry to 3 season porch, and a new gas fully sealed gas fireplace. A new one story master suite addition is being planned with new full bath and dressing room is being added to the north and west of the existing house, reworking the existing corner bedroom of 158 sf and extending the existing crawl space with a new insulated r-40 floor, rather than going to the expense of a new full basement that is not desired by the owner. A new roof over the new addition will tie into a new roof over the rest of the existing back addition and sunroom of the house, replacing the low existing pitch with a new 4" pitched roof that will tie into the rest of the roofs on the house, providing a superior north drainage currently causing major problem.

**AG WALLS:** The existing 1st and 2nd floor walls will be blown in with cellulose and wrapped with 4" polyisocyanurate insulation to achieve the R-40 required.

**ROOFS:** All roofs will receive Icynene closed cell insulation on the underside with 4" polyisocyanurate insulation over the existing or new roof sheathing, above the rafters.

**WINDOWS:** All new windows in the addition and all existing windows in the house are being replaced with new Paradigm Vinyl Series 8312, R-5.

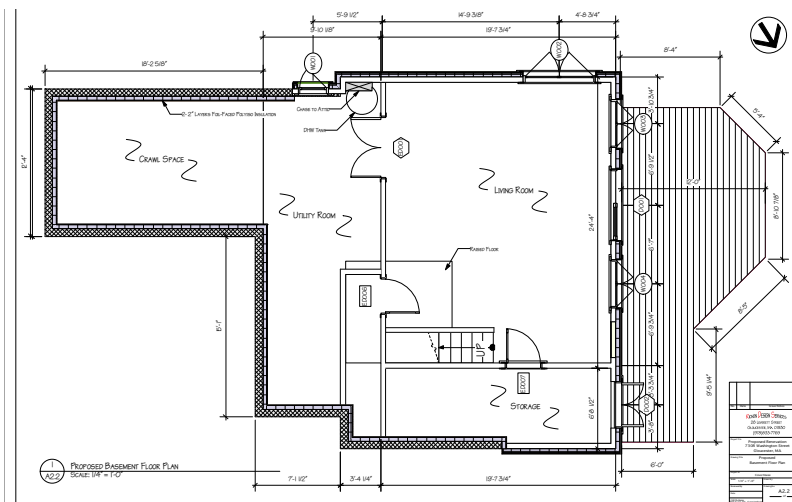
**HVAC:** The existing high efficiency forced air system will be maintained and added to with a new HRV located in the basement, and tied into the upgraded ductwork that will be extended into the new addition and existing house. The existing water heater will be replaced by a new on demand high efficiency direct vent water heater.

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## DER Project Plans



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## DER Project Plans

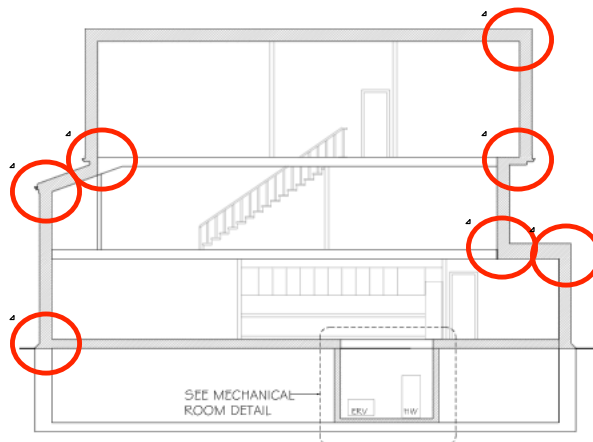
- BSC often asks for additional information in 1<sup>st</sup> round review
  - To allow evaluation of whether the plan is sound
  - Control functions → *transition of control functions*

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## Deep Energy Retrofit Measures Verification Plan Review - Enclosure



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- BSC often asks for additional information in 1<sup>st</sup> round review
  - To allow evaluation of whether the plan is sound
  - Control functions → *transition of control functions*
  - Give the project team the opportunity to resolve approach before construction

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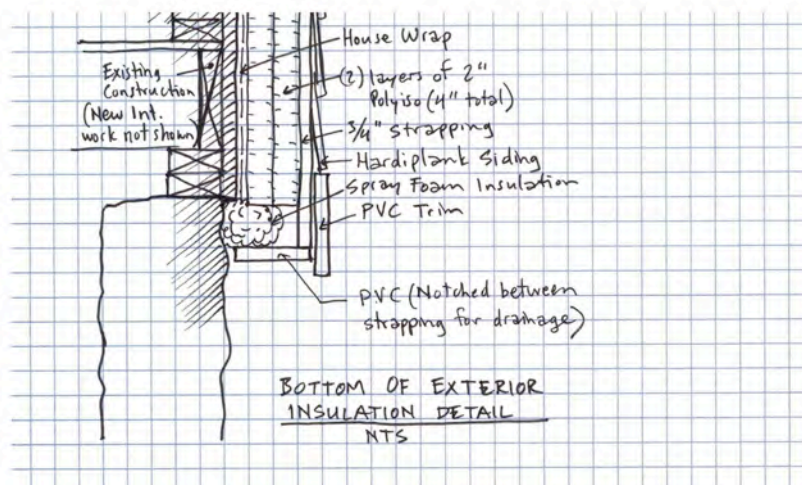


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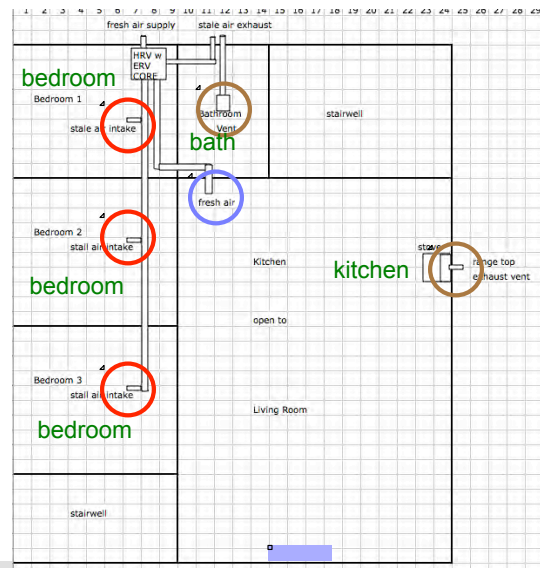


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## DER Project Plans

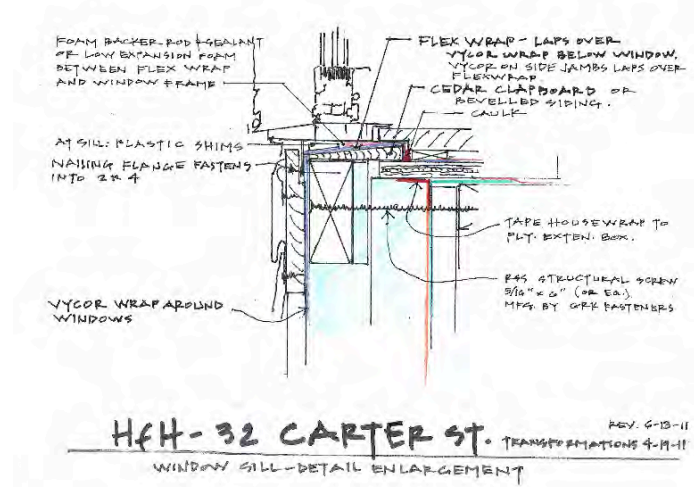
Example narrative description:

- Synergy Construction will apply a secondary drainage wrap for during construction protection, but treated as a back up air barrier/ drainage plane. All seams are taped and sealed, top, bottom and around all windows and doors are sealed to existing wall sheathing to block out air infiltration.
- (4.25" total) of polyisocyanurate insulation board will be applied to all wall surfaces, sealed with liquid sealant to all temp air barrier at bottom of walls, top of walls, and around each window and door penetration for continuity in air barrier to the outside of the insulation face.
- Window openings are flashed with membrane to the face of the foam board, and back to the existing window opening. Membrane is sealed to the foamboard with construction tape adhesive.
- Windows are triple glazed R5 Paradigm units, installed and flashed to the foam board facing and tape flashed in place. Backer rod and caulking sealant to the inside of the window unit, connecting to the flashing membrane for a continuous air seal.
- The exterior foam board is sealed to the bottom of the wall, sill beam, and foundation top, which is sealed as an assembly by spray foam insulation to the interior of the mudsill.
- The foam board is also sealed to the top of the wall and rafter insulation (spray foam, existing) by spray foam sealant under existing roof deck.
- Furring strips hold the exterior assembly in place with exterior coated screws secured back to existing framing members.

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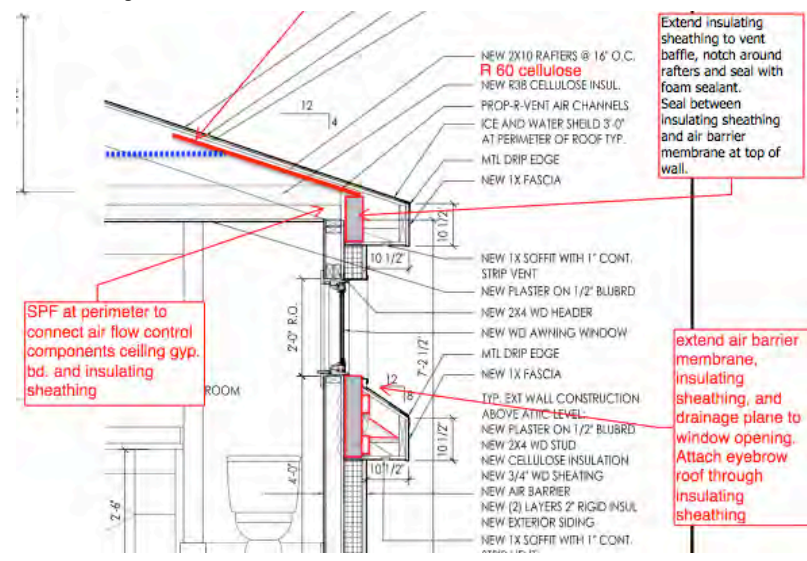
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# DER Project Plans



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# DER Project Plans



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## Deep Energy Retrofit Measures Verification

### Plan Review – Mechanicals

- Mechanical System Functions:
  - Space Heating
  - Space Cooling
  - Ventilation
  - Air Mixing
  - Water Heating

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## Deep Energy Retrofit Measures Verification

### Plan Review – Mechanicals

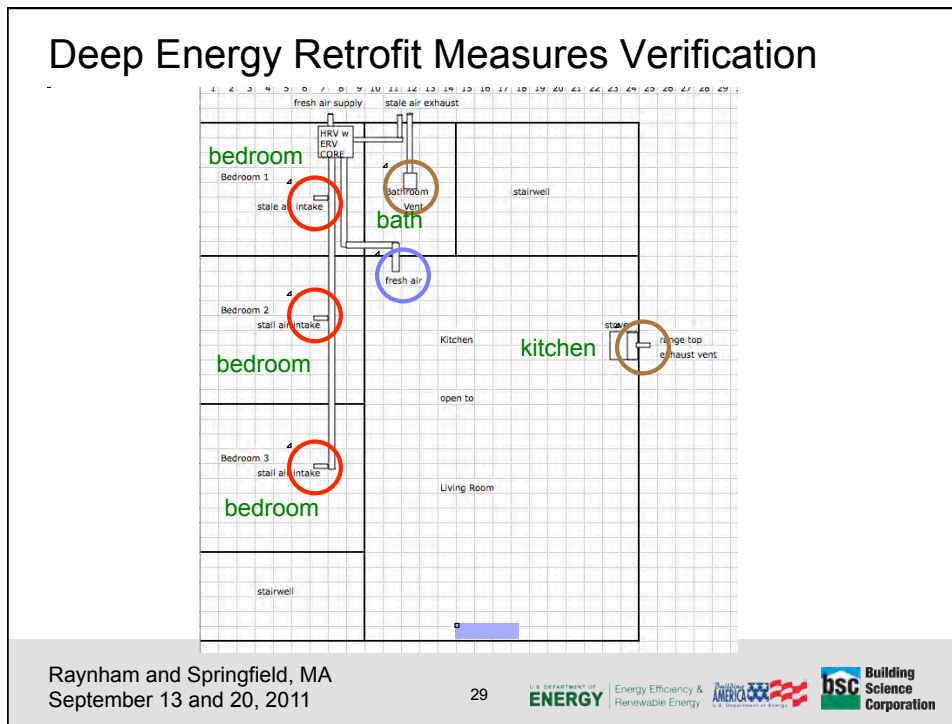
- Air Mixing:
  - Prevent stagnant air
  - Allow ventilation air distribution
  - Dilute contaminants
  - Comfort (space heating and cooling)
- Watch for
  - Non-ducted space conditioning and single point ventilation
  - Location of ventilation air supply and stale air pick-up

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## DER Measures Specification

### Control Functions Guide Specification

- Enclosure:
  - Water control
  - Air flow control
  - Vapor Control
  - Thermal Control
- Mechanical:
  - Space heating
  - Space cooling
  - Ventilation
  - Air mixing
  - Water heating

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Energy Efficiency & Renewable Energy

AMERICAN RECOVERY AND REINVESTMENT ACT OF 2009

DSC Building Science Corporation

# DER Measures Specification

Existing: New: Location of Insulation: Location of Drainage Plane: Location of Air Barrier: Insulation Type, R-Value: Climate/Zone:	2x4 FRAMING W/ SHEATHING + INTERIOR VENTED LAP SIDING + INSUL SHEATHING WALL CAVITY + EXTERIOR INSUL SHEATHING INSULATING SHEATHING MEMBRANE (OR BUILDING WRAP) OVER EXISTING SHEATHING ADDITIONAL CELLULOSE IN CAVITY (OPTIONAL) + 4" FOIL-FACED POLYISOCYANURATE, R-26 COLD / ZONES 5, 6, 7, AND 8	ABS: Air Barrier System component TCS: Thermal Control System component VCS: Vapor Control System component WMS: Water Management System component
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Project: High-Rise Exterior Walls  
Date: 2011/01/11 DRAFT  
Drawing Title: RIM JOIST WALL  
Drawing File: WallRimJoist.dwg  
Drawing Scale: 1" = 8' 0"

Sheet Title: Ext Wall #R2-3

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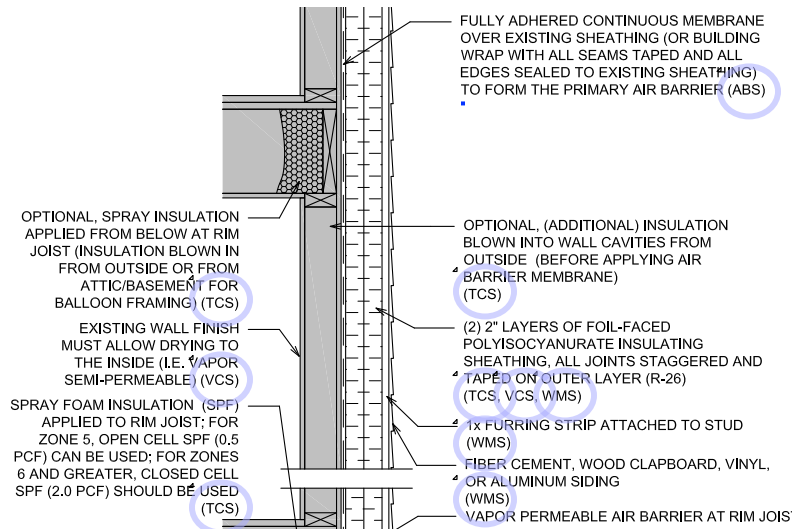
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## DER Measures Specification



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## DER Measures Verification – Plan Review

### 4. Enclosure Control Functions

#### Water Control Strategies

Liquid water control strategies described in the project plan include the following:

- **roof:** new asphalt shingles, ice and water membrane at perimeter, nailbase, 1-1/2" ventilation gap, insulating sheathing, new roof sheathing. The wall section drawing (A-11 in Morrison-DER-07-30-11-Plans-Architecturals 18 pp File 2.pdf) submitted with the application material indicates that roof overhangs will be attached over the insulating sheathing.
- **wall:** foil-faced outer layer of polyisocyanurate sheathing with seams of outer layer taped to form a continuous drainage plane, drainage and ventilation gap behind lapped wood cladding formed by vertical strapping, housewrap with taped and overlapped seams over existing and new sheathing as in-construction/back-up water protection.
- **windows:** new flanged windows flashed to outer layer of foam with self-adhered membrane flashing; backer rod and sealant joint at interior perimeter of window frame.
- **basement walls:** closed cell spray-applied polyurethane foam (cc SPF) applied to interior of foundation wall.
- **basement slab:** No interior perimeter drain or sump proposed. The application indicates sandy gravel below footing.

**BSC Comments:** The information provided on the application form as well as the drawings submitted describe a reasonably robust liquid water management system for the above grade walls. To remove possibility of misinterpretation, the plans should be clear that lapping of house wrap is to be shingle style. The project plan indicates that the existing deck will be removed but does not indicate how a rebuilt deck at the rear door will be (or whether it will be) connected to the exterior wall system. The plan does not provide details of how the portions of the chimney to remain will be integrated into the water control system of the wall. The concrete front stoop may require special detailing to avoid excessing risk of bulk water intrusion and a lapse in the thermal control system at this location.

The plan does not indicate a water control layer at the structural roof deck. Also, the system does not provide back-up water control to manage the contingency of liquid water entering through the ridge vent. If a foil-faced polyisocyanurate insulation is used for the outer layer of the exterior roof insulation, this layer could be taped at the outer face to provide a secondary or tertiary water control layer.

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## DER Measures Specification

- Communicate the *functional intent*
  - Very difficult to anticipate every condition
  - Empowers person in the field:
    - Water control → down and out
    - Air flow control → make connections air tight
    - Thermal control → avoid putting bridges through it
    - Vapor control → where is moisture sensitive material?  
which direction is the vapor drive?  
do we need to allow diffusion or control it?

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## Staged DER

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## DER Project Plans – Staged DER

- Staged DER = Long range planning
  - High performance retrofit measures
    - Connect to existing components
      - Transfer control functions to existing components
    - Anticipate connection to future components
      - Transfer control functions to new components
  - Make the next guys job easier

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## Staged DER



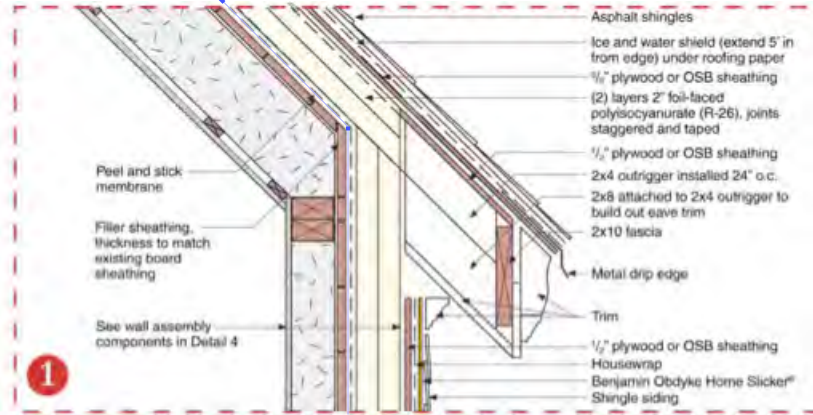
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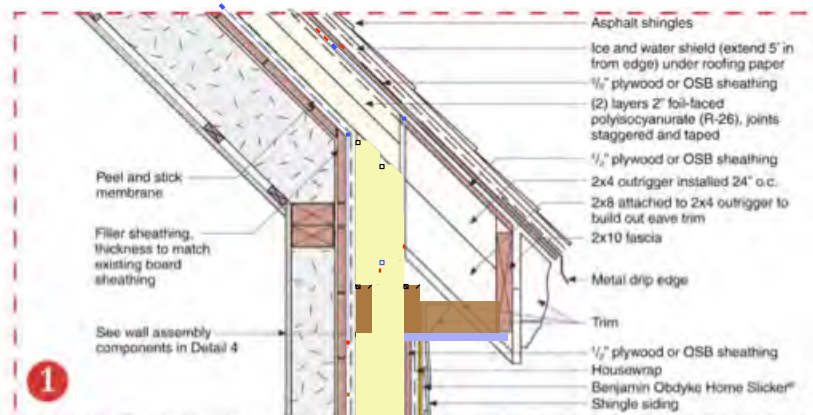
## Staged DER

- Roof retrofit



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## Staged DER – Roof First



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## Staged DER



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## Staged DER

- Window Retrofit



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## Staged DER

- Window Retrofit



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## Staged DER



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Time check

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Seen on site

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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Significant components not on plans



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Significant components not on plans



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Are you sure you want to do that?



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Are you sure you want to do that?



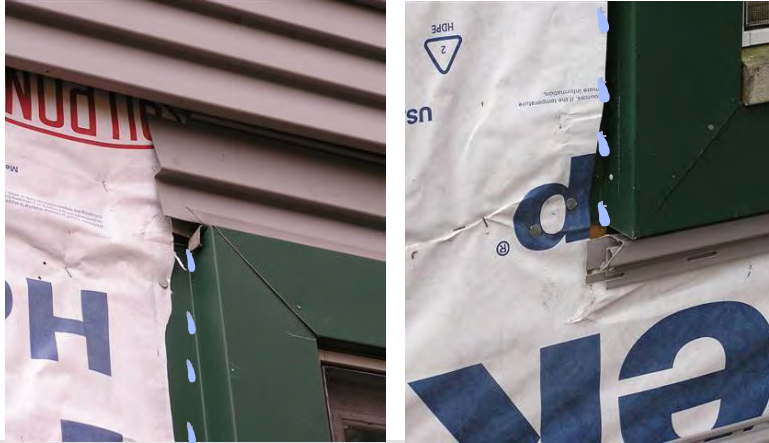
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## Deep Energy Retrofit Measures Verification

- Inspection of critical details revealed problems in existing conditions



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## Deep Energy Retrofit Measures Verification

- Inspection of critical details revealed problems in existing conditions



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## Deep Energy Retrofit Measures Verification

- Inspection of critical details revealed problems in existing conditions



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## Deep Energy Retrofit Measures Verification

- Drainage remediation



Siding removed to remediate flashing



Head flashing at new window



Drainage plane remediation at base of wall

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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Flashing misses



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Flashing misses



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing whiffed



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing whiffed



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing whiffed



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing whiffed



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing whiffed



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing mock up



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing mock up



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Window flashing saved



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Control function lapses



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Continuity of control function



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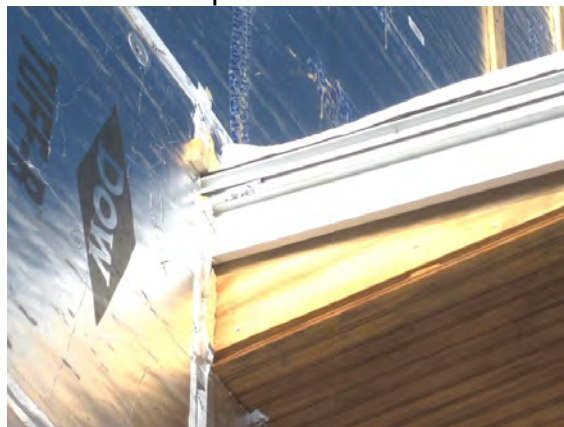
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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Control function lapses



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Continuity of control functions



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Continuity of control functions



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## Deep Energy Retrofit Measures Verification

You've got to see it to...



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You've got to see it to...



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Deck ledger over foam



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You've got to see it to...

- Deck ledger over everything



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Built up siding detail over foam



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Built up siding detail over foam



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You've got to see it to...



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Control function transition at base of wall



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Control function transition at base of wall



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## Deep Energy Retrofit Measures Verification

You've got to see it to...

- Flashing at base of wall: is it a gutter?



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- 4.6 ACH50;  
2129 CFM 50 total;  
1100 CFM 50 through  
floor over basement

- 8.5 ACH50;  
3590 CFM 50 total;  
1740 CFM 50 through  
floor over basement

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## Retrofitting Air Barriers



Millbury, MA

1.4 ACH 50  
0.09 cfm/sf enclosure

Rigid foam as air barrier, “chainsaw” retrofit of roof overhangs/eaves, blower door tests in progress



Photo credit: Henry MacLean

Quincy, MA

1.26 ACH 50  
0.11 cfm/sf enclosure

Multiple air barriers exterior plus cavity spray foam interior, “chainsaw” transitions at new and existing roofs



Belmont, MA

0.7 ACH 50  
0.06 cfm/sf enclosure

Rigid foam as air barrier, “chainsaw” retrofit of roof overhangs/eaves, blower door tests in progress

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## Retrofitting Interior Air Barriers



Photo credit: Dave C. Legg

Belchertown, MA

1.9 ACH 50  
0.12 cfm/sf enclosure

Closed-cell spray foam to interior roof, walls, and foundation walls.

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## Hall DER

Quincy, MA

### Project Overview

- DER Lead: Timeless Architecture
- Builder: Grifcon Contracting
- Location: Quincy, MA
- Climate: Cold Climate (5)
- Type: Single-Family Bungalow
- Stories: 3 plus full basement
- Conditioned Floor Area: 4,576 sq. ft.
- 6-Sided Surface Area: 6,806 sq. ft.
- Conditioned Volume: 36,346 cu. ft.
- Final Airtightness: 1.26 ACH 50



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## Hall DER

Quincy, MA

- Enclosure – Roof/Attic
  - **Water Management** – New asphalt shingle roof, fully adhered ice and water membrane on roof deck below rigid insulation
  - **Air Control** – Fully adhered ice and water membrane on roof deck below rigid insulation, open cell spray foam encapsulating roof framing
  - **Vapor Control** – Fully adhered ice and water membrane on roof deck below rigid insulation
  - **Thermal Control** – 4” polyiso insulating sheathing on roof sheathing, 10” open cell spray foam in roof framing



Photo credit: Henry MacLean / Timeless Architecture

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## Hall DER

Quincy, MA

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## Hall DER

Quincy, MA

- Enclosure – Walls
  - **Water Control** – Taped foil-faced polyiso, housewrap over wood sheathing
  - **Air Control** – Taped outer layer of polyiso; joints in layers of insulating sheathing offset horizontally and vertically; house wrap with taped joints; open-cell spray foam cavity insulatio
  - **Vapor Control** – Sufficient exterior insulation to control condensation inside wall
  - **Thermal Control** – 4” foil-faced polyiso insulating sheathing; open-cell spray foam cavity insulation



Housewrap under polyiso



Photo credit: Henry MacLean / Timeless Architecture

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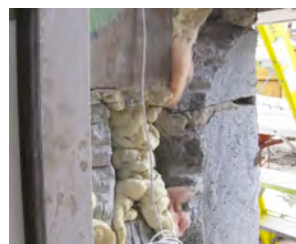
## Hall DER

Quincy, MA

- Enclosure – Basement Walls
  - **Water Control** – Closed-cell spray foam on foundation wall; rigid insulation at base of wall to create drainage gap
  - **Air Control** – Closed-cell spray foam
  - **Vapor Control** – Closed-cell spray foam
  - **Thermal Control** – Closed-cell spray foam; fiberglass batts in frame wall cavities



EPS under slab with polyethylene



Spray foam fills gaps in foundation wall

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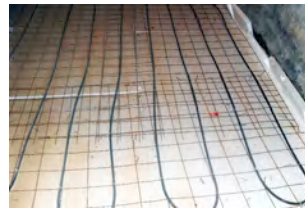
## Hall DER

Quincy, MA

- Enclosure – Basement Floor
  - **Water Control** – 4-6” Gravel layer beneath slab insulation
  - **Air Control** – 4” concrete slab over polyethylene sheet
  - **Vapor Control** – Polyethylene vapor retarder in contact with concrete slab over “bathtub” of EPS rigid insulation
  - **Thermal Control** – “Bathtub” of 2” EPS rigid insulation



EPS under slab with polyethylene



Radiant tubing  
photo credit: Henry MacLean / Timeless Architecture

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## Hall DER

Quincy, MA

- Enclosure Design – Doors and Windows
  - New R-5 double-hung windows
  - “Outie” windows – Installed in plywood extension box flashed to insulating sheathing, attached to rough opening framing with metal straps



Flashed window  
photo credit: Henry MacLean / Timeless Architecture

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## Hall DER

Quincy, MA

- Mechanical
  - Combined space/water heater
  - Air-source heat pump
  - Dual coil, 3 zone air handler
  - 5 panel solar water heating system
  - Photovoltaic system



High efficiency boiler



Air handler in conditioned attic

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## Hall DER

Quincy, MA

- Challenges, Lessons
  - Window and wall mock-ups -> excellent (and fast) installations
  - HRV system connected to central ductwork requires back-draft dampers to control ventilation



Window mock-up



Wall mock-up

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