

## Deep Energy Retrofit Measures Verification

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Worcester, MA





Energy Efficiency & Renewable Energy

## Deep Energy Retrofit Measures

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Pulling it all together:

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

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## DER Measures Specification – Be Specific!

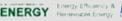
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### Control Functions Guide Specification

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

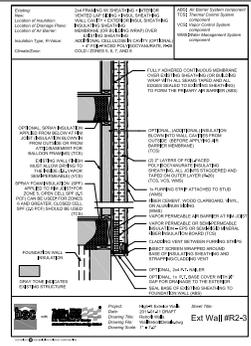
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## DER Measures Specification



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### DER Measures Specification

Existing:	2x4 FRAMING W/ SHEATHING + INTERIOR	ABS: Air Barrier System component
New:	VENTED LAP SIDING + INSUL SHEATHING	TCS: Thermal Control System component
Location of Insulation:	WALL CAVITY + EXTERIOR INSUL SHEATHING	VCS: Vapor Control System component
Location of Drainage Plane:	INSULATING SHEATHING	WMS: Water Management System component
Location of Air Barrier:	MEMBRANE (OR BUILDING WRAP) OVER EXISTING SHEATHING	
Insulation Type, R-Value:	ADDITIONAL CELLULOSE IN CAVITY (OPTIONAL) + 4" FOIL-FACED POLYISOCYANURATE, R-26	
Climate/Zone:	COLD / ZONES 5, 6, 7, AND 8	

FULLY ADHERED CONTINUOUS MEMBRANE OVER EXISTING SHEATHING (OR BUILDING WRAP WITH ALL SEAMS TAPED AND ALL EDGES SEALED TO EXISTING SHEATHING) TO FORM THE PRIMARY AIR BARRIER (ABS)

OPTIONAL SPRAY INSULATION APPLIED FROM BELOW AT RIM JOIST (INSULATION BLOWN IN FROM OUTSIDE OR FROM BALLOON FRAMING) (TCS)

EXISTING WALL FINISH MUST ALLOW DRYING TO THE INSIDE (I.E. FOR SEMI-PERMEABLE) (VCS)

OPTIONAL (ADDITIONAL) INSULATION BLOWN INTO WALL CAVITIES FROM OUTSIDE (BEFORE APPLYING AIR BARRIER MEMBRANE)

OPTIONAL (ADDITIONAL) INSULATION BLOWN INTO WALL CAVITIES FROM OUTSIDE (BEFORE APPLYING AIR BARRIER MEMBRANE)

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FULLY ADHERED CONTINUOUS MEMBRANE OVER EXISTING SHEATHING (OR BUILDING WRAP WITH ALL SEAMS TAPED AND ALL EDGES SEALED TO EXISTING SHEATHING) TO FORM THE PRIMARY AIR BARRIER (ABS)

OPTIONAL (ADDITIONAL) INSULATION BLOWN INTO WALL CAVITIES FROM OUTSIDE (BEFORE APPLYING AIR BARRIER MEMBRANE)

(2) 2" LAYERS OF FOIL-FACED POLYISOCYANURATE INSULATING SHEATHING, ALL JOINTS STAGGERED AND TAPED TO STUD

SPRAY FOAM INSULATION APPLIED TO RIM JOIST; FOR ZONE 5, OPEN CELL SPF (0.5 PCF) CAN BE USED; FOR ZONES 6 AND GREATER, CLOSED CELL SPF (2.0 PCF) SHOULD BE USED (TCS)

OPTIONAL SPRAY INSULATION APPLIED FROM BELOW AT RIM JOIST (INSULATION BLOWN IN FROM OUTSIDE OR FROM BALLOON FRAMING) (TCS)

EXISTING WALL FINISH MUST ALLOW DRYING TO THE INSIDE (I.E. FOR SEMI-PERMEABLE) (VCS)

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### DER Measures Specification – Being Specific

- 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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### DER Measures Specification

NOTE: AIR BARRIER AT ADDITION TO BE TAPED SHEATHING AND EXTERIOR FOAM INSULATION AT FOUNDATION WALL

BLOWER DOOR PRESSURE TEST TO BE CONDUCTED AT COMPLETION OF AIR BARRIER, BEFORE INSTALLATION OF INTERIOR WALL FINISHES. DIAGNOSTIC FOG TESTING WILL BE CONDUCTED TO FIND FLAWS IN AIR BARRIER SYSTEMS

PRESSURE TESTING TARGET: 0.1CFM50 / SQUARE FOOT OF SHELL

TARGET CFM50 OF FINAL BLOWER DOOR: 580CFM50

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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

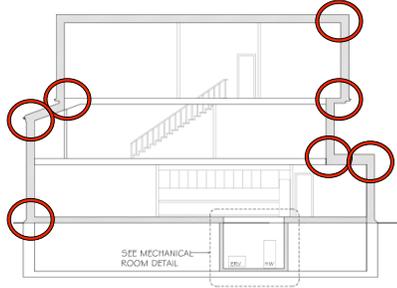


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#### Plan Review - Enclosure



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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*
  - Give the project team the opportunity to resolve approach before construction

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DER Project Plans

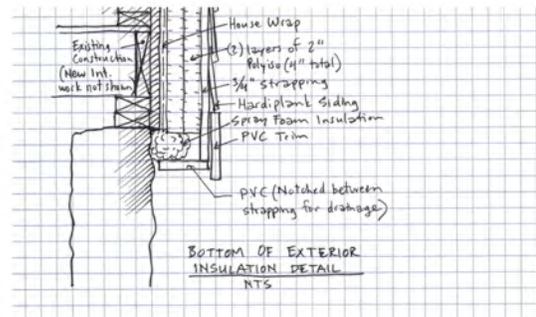


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DER Project Plans

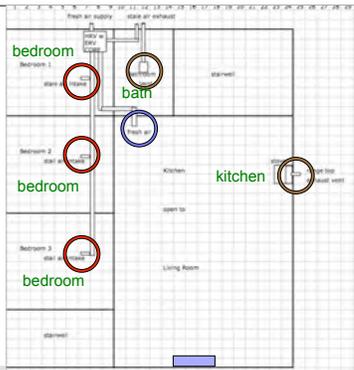


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DER Project Plans

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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### 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

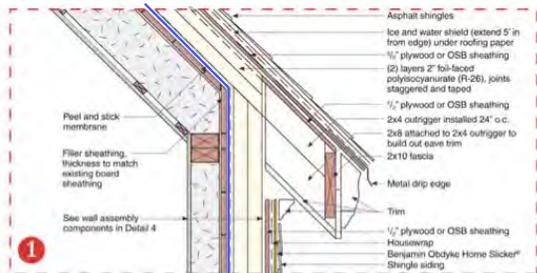
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### Staged DER

- Roof retrofit

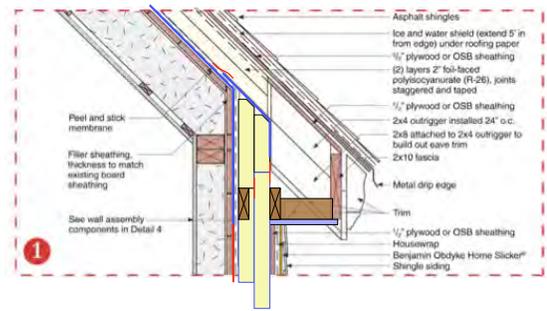


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### Staged DER – Roof First



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Staged DER



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### Staged DER



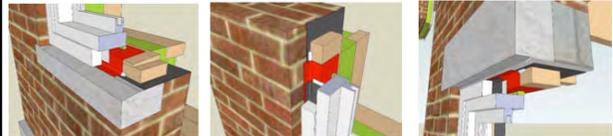
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### Staged DER

- Window Retrofit



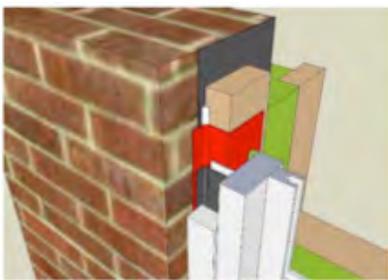
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### Staged DER

- Window Retrofit



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Time check

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Seen on site

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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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Are you sure you want to do that?



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### Deep Energy Retrofit Measures Verification

Are you sure you want to do that?



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### Deep Energy Retrofit Measures Verification

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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

You've got to see it to...

- Flashing misses



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### Deep Energy Retrofit Measures Verification

Exterior insulation drainage plane is not where it used to be



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### Deep Energy Retrofit Measures Verification

Exterior insulation drainage planes sequencing:



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### Deep Energy Retrofit Measures Verification

- Roof-Wall flashing sequence



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### Deep Energy Retrofit Measures Verification

You've got to see it to...



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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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You've got to see it to...

- Window flashing whiffed



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You've got to see it to...

- Window flashing whiffed



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You've got to see it to...

- Window flashing whiffed



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You've got to see it to...

- Window flashing whiffed



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Mock-up makes perfect

- Window flashing mock up



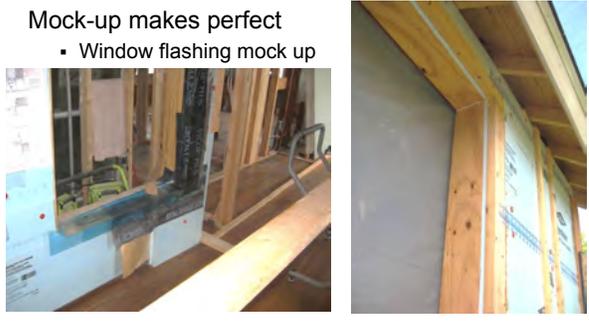
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Mock-up makes perfect

- 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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### 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...

- Control function recovery



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### Deep Energy Retrofit Measures Verification

You've got to see it to...

- Continuity of control functions



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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...

- 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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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...

- Control function transition at base of wall



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You've got to see it to...

- Control function transition at base of wall



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- 4.6 ACH50; 2129 CFM 50 total; 1100 CFM 50 through floor over basement
- 7.3 ACH50; 3590 CFM 50 total; 1740 CFM 50 through floor over basement

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### Retrofitting Air Barriers



Photo credit: Henry MacLean

Millbury, MA	Quincy, MA	Belmont, MA
1.4 ACH 50 0.09 cfm/sf enclosure	1.26 ACH 50 0.11 cfm/sf enclosure	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	Multiple air barriers exterior plus cavity spray foam interior, "chainsaw" transitions at new and existing roofs	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

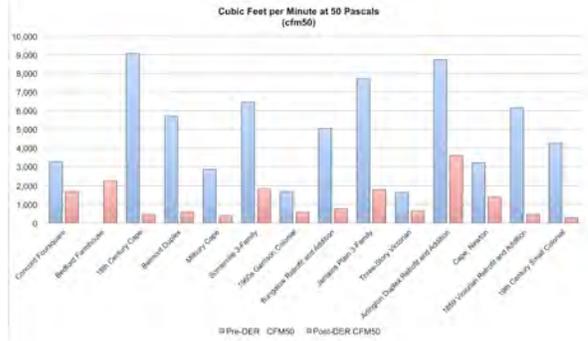
Closed-cell spray foam to interior roof, walls, and foundation walls.

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### DER Air Leakage Assessment

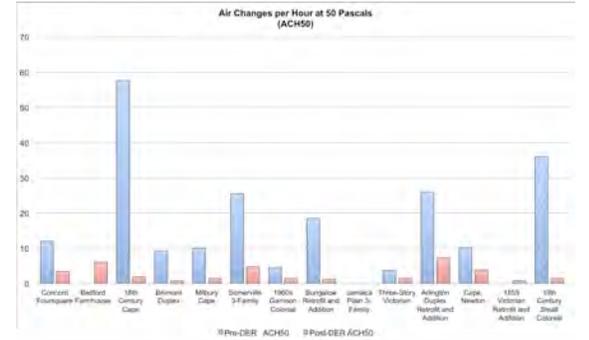


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### DER Air Leakage Assessment

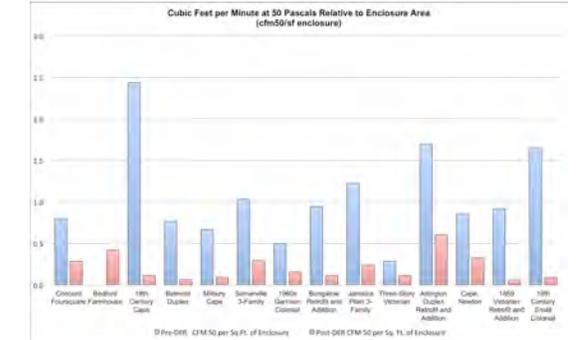


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### DER Air Leakage Assessment



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