Buhs DER — Jamaica Plain, MA

- Project Overview
  - Builder: Byggmeister
  - Location: Jamaica Plain, MA
  - Climate: Cold Climate (5)
  - Type: 3 - Family
  - Stories: 3 plus full basement
  - Conditioned Floor Area*: 5,300 sq. ft.
  - 6-Sided Surface Area*: 7,456 sq. ft.
  - Conditioned Volume*: 42,120 cu. ft.
  - Final Airtightness: 2.4 ACH 50

* Information provided by Builder

Buhs DER — Jamaica Plain, MA

- Enclosure – Roof/Attic
  - *Thermal Control – At sloped ceiling and behind kneewall – polyiso board creates air gap below existing roof sheathing and then covered with closed cell spray foam; at flat ceiling, loose cellulose above*
  - *Air Control – closed cell spray foam connecting to plaster ceiling; "sealing" of exterior wall/roof connection.*
  - *Water Management – existing slate roof not addressed*
  - *Vapor Control – gable vents added to vent attic space*

Air gap created under roof sheathing

Buhs DER — Jamaica Plain, MA

- Enclosure -- Walls
  - Thermal Control: 4" foil-faced polyiso insulating sheathing (except at dormer which has slate shingled walls); cellulose blown into wall cavities.
  - Air Control: taped outer layer of polyiso; sealed around rafter tails to connect to roof. Sealed at base to foundation wall.
  - Water control: taped outer layer of insulating sheathing; flashing.
  - Vapor control: plaster walls/oil paint allow some drying to inside; sufficient exterior insulation to prevent condensation inside wall

Taped insulating sheathing w/ furring strips

Seal at base of wall

Buhs DER — Jamaica Plain, MA

- Enclosure – Basement Floor
  - Thermal Control: "Bathtub" of closed cell spray foam with thin concrete slab on top.
  - Air Control: closed cell spray foam under new concrete slab connecting to spray foam on foundation walls.
  - Water Control: closed cell spray foam under new slab
  - Vapor Control: R-10 closed cell spray foam under new slab

Floor not treated at existing FreeWatt System

Floor to wall spray foam connection

Buhs DER

Jamaica Plain, MA

- Enclosure – Basement Walls
  - Thermal Control: Closed cell spray foam directly against fieldstone walls; mineral wool added in above grade part.
  - Air Control: closed cell spray foam; extends over mud sill to connect with wall; continuous with closed cell spray foam on floor to connect with floor.
  - Water Control: closed cell spray foam (keeps water at foundation wall)
  - Vapor Control: closed cell spray foam over foundation walls

Metal stud wall over closed cell spray foam

Spray foam extends up over mud sill

National Grid DER Pilot Program
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Buhs DER

Jamaica Plain, MA

- Enclosure Design – Doors and Windows
  - New Serious Windows – 525 series
  - "Outie" windows – attached to 2x4 picture frame embedded in outer layer of insulating sheathing.
  - Storm doors provided for all existing exterior doors

Flanges attached to 2X frame surround

Existing interior trim retained

National Grid DER Pilot Program
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Buhs DER

Jamaica Plain, MA

- Mechanical
  - Existing FreeWatt system (combined heat & power/CHP) for space heating and DHW retained.
  - Ducted HRV for each unit (Venmar EKO 1.5 units).
  - Window ACs

FreeWatt System (feeding radiator distribution)

Measurable air leakage at window AC units

Basement HRV

National Grid DER Pilot Program
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25 Ellington Rd. Somerville, MA

- Project Overview
  - Builder: Synergy Construction
  - Location: Somerville, MA
  - Climate: Cold Climate (5)
  - Type: 3 - Family
  - Stories: 3 plus full basement
  - Conditioned Floor Area: 4,160 sq. ft.
  - 6-Sided Surface Area: 6,266 sq. ft.
  - Conditioned Volume: 23,487 cu. ft.
  - Final Airtightness*: 3.45 ACH 50
  - ***Note: Not part of National Grid DER program***

* Information provided by Conservation Services Group

25 Ellington Rd. Somerville, MA

- Enclosure – Roof/Attic
  - *2 layers of foil-faced polyisocyanurate applied over existing roof sheathing, seams staggered and taped. Open cell spray foam applied in rafter bays from underneath the roof deck*

25 Ellington Rd. Somerville, MA

- Enclosure -- Walls
  - Thermal Control: 4” foil-faced polyiso insulating sheathing (except at dormer which has slate shingled walls); cellulose blown into wall cavities.
  - Air Control: Roof deck and framing extended beyond wall; no direct connection between roof membrane and house wrap. Spray foam acted as air barrier for roof/wall intersection.
  - Water control: Taped insulating sheathing behind lap siding
  - Vapor control: plaster walls allows drying to the inside; sufficient exterior insulation to prevent condensation inside wall

25 Ellington Rd. Somerville, MA

- Enclosure – Basement Floor
  - Client chose not to insulate basement floor
  - Perimeter sub-slab drainage and passive soil gas system added

Basement perimeter drain installation

25 Ellington Rd. Somerville, MA

- Enclosure – Basement Walls
  - R-21: 3.5”ccSPF applied to inside of wall over drainage mesh

Basement wall insulation before application of ignition barrier paint

September 2011 5

25 Ellington Rd. Somerville, MA

- Enclosure Design – Doors and Windows
  - Existing windows were vinyl replacement windows and older wood windows
  - All 32 windows replaced with U=0.19, SHGC=0.24, fiberglass, insulated glass units with suspended film

September 2011 6

25 Ellington Rd. Somerville, MA

- Mechanical
  - Heating and DHW: Gas fired furnace and hot water heaters replaced with Phoenix Versa Hydro, providing hydronic space heating and domestic hot water
  - HRV: 80% effective Fantech VH704 HRVs for each apartment
  - Cooling: Occasional use provide by window units; no central cooling system. No cooling upgrade with retrofit.

Fantech HRV. Photo provided by owner.

Phoenix Versa Hydro installation. Photo provided by owner.

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National Grid DER - Livermore — Marblehead, MA

- Project Overview
  - Project Type: Roof-only partial retrofit (includes window replacement and DHW & mechanical equipment replacement)
  - Builder: New England Green Build
  - Location: Marblehead, MA
  - Climate: Cold Climate (5)
  - Type: 2 - Family
  - Stories: 3 plus full basement
  - Floor Area: 2,000 sq. ft.
  - Surface Area: 4,514 sq. ft.
  - Volume: 24,000 cu. ft.
  - Pre-Retrofit Airtightness: 15.72 ACH 50

National Grid DER - Livermore — Marblehead, MA

- Enclosure – Roof
  - *Thermal Control – 5" closed cell (2.0 pcf) spray foam insulation between roof rafters and in 3rd floor gable walls, (2) 2" layers foil-faced polyisocyanurate insulating sheathing on top of existing roof sheathing*
  - *Air Control – closed cell spray foam*
  - *Water Management – new asphalt shingles on top of roofing paper with ice and water shield at roof perimeter*
  - *Vapor Control – closed cell spray foam*

Closed cell spray foam in roof and walls

National Grid DER - Livermore — Marblehead, MA

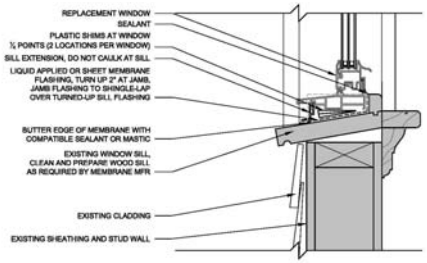
- Enclosure – Windows
  - New Harvey vinyl replacement window units – Tribute series R-5 windows
  - Existing sashes removed and new unit installed according to details

Before – existing windows and storm windows

After – existing exterior trim retained

National Grid DER - Livermore — Marblehead, MA

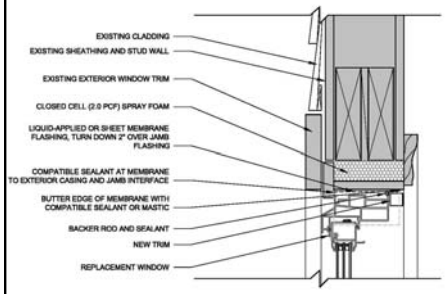
- Enclosure – Window Sill Detail



National Grid DER - Livermore

Marblehead, MA

- Enclosure – Window Head Detail



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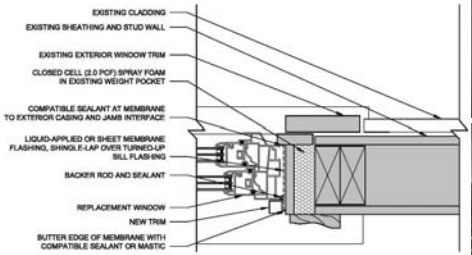
National Grid DER - Livermore

Marblehead, MA

- Enclosure – Window Jamb Detail



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National Grid DER - Livermore

Marblehead, MA

- DHW & Mechanical
  - Eternal GU195S 98% efficient tankless wall hung 20 gpm water heater to provide hot water to both units in the house
  - Crown BWC151 96% efficient natural gas direct-vent wall hung boiler to provide heating for both units in the house
  - HRV to be installed

Wall hung water heater and boiler

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Venable-Hwang DER — Arlington, MA

- Project Overview
  - DER Lead/Builder: Boston Green Building
  - Location: Arlington, MA
  - Climate: Cold Climate (5)
  - Type: Two-Family Duplex and Upward Addition
  - Stories: 3 stories, basement excluded
  - Conditioned Floor Area*: 3,168 sq. ft.
  - 6-Sided Surface Area*: 6,646 sq. ft.
  - Conditioned Volume*: 42,120 cu. ft.
  - Final Airtightness: 5.1 ACH 50

  Approx ½ of leakage through basement ceiling

* Information provided by Builder

Venable-Hwang DER — Arlington, MA

- Enclosure – Roof/Attic
  - ***Water Management*** – New asphalt shingle roof and building paper with ice and water membrane at perimeter
  - ***Air Control*** – Closed-cell spray foam at underside of roof deck
  - ***Vapor Control*** – Closed-cell spray foam at underside of roof deck
  - ***Thermal Control*** – ~10" Closed-cell spray foam at roof deck

Closed-cell spray foam at roof deck

Venable-Hwang DER — Arlington, MA

- Enclosure – Walls
  - ***Water control*** – Taped outer layer of insulating sheathing
  - ***Air Control*** – Taped outer layer of polyiso; exterior insulation extends between rafter tails to connect with roof spray foam
  - ***Vapor control*** – Sufficient exterior insulation to prevent condensation inside wall
  - ***Thermal Control*** – 4" foil-faced polyiso insulating sheathing; existing 1st floor wall cavities filled with closed-cell spray foam; existing 2nd floor wall cavities and apartment addition wall cavities filled with fiberglass

Taped and furred exterior sheathing

Spray foam insulation at first floor

Venable-Hwang DER — Arlington, MA

- Enclosure – Porch Floor and basement stair sidewalls
  - ***Air Control*** – Open-cell spray foam in framing cavities
  - ***Vapor Control*** – Vapor permeable assembly
  - ***Thermal Control*** – Open-cell spray foam in framing cavities

Basement access stair sidewall

Underside of porch floor

Venable-Hwang DER — Arlington, MA

- Enclosure – Basement Ceiling
  - ***Air Control*** – Taped foil-faced insulation at underside of joists, foam sealant at penetrations
  - ***Vapor Control*** – Taped foil-faced insulation at underside of joists
  - ***Thermal Control*** – Taped foil-faced insulation at underside of joists, dense pack cellulose in floor framing cavities

Foil-faced rigid insulation at basement ceiling

Fire-rated Thermax® at basement ceiling

Venable-Hwang DER — Arlington, MA

- Enclosure – Basement Walls
  - Not applicable: Insulation at floor over basement; against BSC's recommendations the partially finished basement space was not included in the retrofit

Unimproved basement

Venable-Hwang DER — Arlington, MA

- Enclosure Design – Doors and Windows
  - New triple pane vinyl frame windows
  - "Outie" windows attached to strapping over drainage plane

Window installation from interior before air sealing with foam around window

"Outie" window attached to strapping over rigid insulation

Venable-Hwang DER — Arlington, MA

- Mechanical
  - Condensing furnace in for each unit
  - Condensing tankless water heater for each unit
  - HRV ducted to central heating distribution ductwork of each unit
  - DX coil for future provision of cooling

Tankless water heaters

Furnace for 2nd-3rd floor apartment

Venable-Hwang DER

Arlington, MA

- Challenges, Lessons
  - Installation of window over strapping complicates flashing and air control transitions
  - Intersection of porch roof and deck complicates (interrupts) continuity of air, vapor and thermal control
  - Basement ceiling did not provide a robust air flow control: accounts for ~1/2 of measured leakage for thermal enclosure

Porch roof connection

Post-DER diagnostic testing

National Grid DER Pilot Program
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Habitat for Humanity NCM DER — Lancaster, MA

- Project Overview
  - DER Lead: Transformations, Inc.
  - Builder: Habitat for Humanity
  - Location: Lancaster, MA
  - Climate: Cold Climate (5)
  - Type: Single-Family Colonial
  - Stories: 2 plus partial basement
  - Conditioned Floor Area: 1,440 sq. ft.
  - 6-Sided Surface Area: 3,028 sq. ft.
  - Conditioned Volume: 11,280 cu. ft.
  - Final Airtightness: 1.56 ACH 50

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Habitat for Humanity NCM DER — Lancaster, MA

- Enclosure – Roof/Attic
  - Water Management – New asphalt shingle roof
  - Air Control – Critical seal with spray foam at attic floor
  - Vapor Control – 1" closed-cell spray foam and vented roof
  - Thermal Control – 18" blown in cellulose over 1" closed-cell spray foam

Critical air seal at attic floor

House wrap sealed to wall top plate

National Grid DER Pilot Program
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Habitat for Humanity NCM DER — Lancaster, MA

- Enclosure – Walls
  - Water control: Taped outer layer of XPS; drainage mat between rigid foam and housewrap
  - Air Control: House wrap with taped seams, taped outer layer of XPS; sealed around rafter tails to connect to roof; sealed at base to foundation wall
  - Vapor control: Closed-cell spray foam in wall cavities, vapor diffusion gap behind XPS
  - Thermal Control: 4" XPS rigid foam insulation; existing wall cavities filled with closed-cell spray foam

Drainage mat behind insulating sheathing

Exterior sheathing sealed to baffles

National Grid DER Pilot Program
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Habitat for Humanity NCM DER — Lancaster, MA

- Enclosure – Basement Walls
  - Water Control: Dampproofing and 2" XPS rigid foam insulation at exterior concrete walls; perimeter drain; closed-cell spray foam (keeps water at foundation wall)
  - Air Control: Closed-cell spray foam extends over mud sill to connect with above-grade wall
  - Vapor Control: Closed-cell spray foam
  - Thermal Control: Closed-cell spray foam directly against existing fieldstone, brick and concrete block; intumescent paint thermal barrier

Spray foam with intumescent paint

Exterior insulating sheathing and perimeter drain

National Grid DER Pilot Program
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Habitat for Humanity NCM DER — Lancaster, MA

- Enclosure – Basement Floor
  - Water Control: 4-6" gravel layer
  - Air Control: New concrete slab
  - Vapor Control: Polyethylene under the slab with sand between polyethylene and concrete
  - Thermal Control: 2" XPS rigid insulation

*BSC does not recommend using sand under the new slab

Vapor barrier over XPS with sand before slab is poured

New concrete slab

Habitat for Humanity NCM DER — Lancaster, MA

- Enclosure Design – Doors and Windows
  - New triple pane vinyl frame windows
  - "Outie" windows – picture frame 2x4 bucks let into outer layer of exterior insulation, opening flashed at drainage plane; window attached to strapping and flashed to exterior insulation
  - All new insulated doors

*BSC recommends installing windows in plane with the drainage plane to avoid complications in flashing and air control transition

Housewrap and flashing extends into the window box sealed with caulking

Flashing over strapping

Habitat for Humanity NCM DER — Lancaster, MA

- Mechanical
  - Ductless minisplit air source heat pumps to provide for both heating and cooling; one head on each floor
  - Ducted HRV in conditioned basement
  - Tankless water heater

Wall hung boiler

Mitsubishi minisplit outdoor units

HRV installed in basement

Inside mini-split unit with insulation behind

Garrison Colonial Comprehensive Retrofit

Milton, MA

Koh DER

Milton, MA

- Project Overview
  - Builder, DER lead: Boston Green Building
  - Location: Milton, MA
  - Climate: Cold Climate (5)
  - Type: Single-Family, Garrison Colonial
  - Stories: 2 plus full basement
  - Conditioned Floor Area*: 2,368 sq. ft.
  - 6-Sided Surface Area*: 4,676 sq. ft.
  - Conditioned Volume*: 22,458 cu. ft.
  - Final Airtightness*: 1.6 ACH 50

* Conditioned floor area includes basement, enclosure surface and conditioned volume include basement and attic

Exterior of completed retrofit

Koh DER

Milton, MA

- Enclosure – Roof/Attic
  - ***Water Management*** – New asphalt shingle roof cladding
  - ***Air Control*** – Closed-cell spray foam encapsulating rafters, gable end walls and exterior wall top plates
  - ***Vapor Control*** – 8" closed-cell spray foam at roof, ~4" at gable end walls
  - ***Thermal Control*** – Moved from attic floor to underside of roof deck; 8" closed-cell spray foam

Koh DER

Milton, MA

- Enclosure – Walls
  - ***Water control*** – Outer layer of insulating sheathing taped; house wrap over existing sheathing as secondary
  - ***Air Control*** – Taped outer layer of insulating sheathing, closed-cell spray foam at top of wall and rim-band joist areas
  - ***Vapor control*** – Sufficient exterior insulation to control condensation inside wall
  - ***Thermal Control*** – 4" polyiso insulating sheathing; existing 2x4 walls with cellulose or existing fiberglass

Taped polyiso exterior sheathing

Exterior wall control layers

Koh DER — Milton, MA

- Enclosure – Basement Walls
  - ***Water Control*** – Closed-cell spray foam over foundation wall and between wood studs (keeps water at foundation wall if continuous behind studs)
  - Air Control – Closed-cell spray foam and wood framing; spray foam extends over mud sill to connect with wall framing
  - Vapor Control – 3-4" closed-cell spray foam over foundation walls between studs, ?-1" behind wood framing
  - Thermal Control – 3-4" closed-cell spray foam

Foundation walls with spray foam (and HRV)

Koh DER — Milton, MA

- Enclosure – Basement Floor
  - ***Water Control*** – 2" XPS (non-water sensitive) over foundation slab, Owner determined basement remains dry through extreme weather event, sump pit added.
  - ***Air Control*** – all joints in 2" XPS taped, perimeter embedded in wall spray foam*
  - ***Vapor Control*** – Taped XPS under OSB floating floor**
  - ***Thermal Control*** – 2" XPS over foundation slab

*BSC recommends urethane caulk for air sealing cracks in existing slab

**BSC recommends epoxy paint on slab for vapor control in this situation

XPS under OSB

Thermal break under existing wood stud wall

Koh DER — Milton, MA

- Enclosure Design – Doors and Windows
  - New triple pane vinyl frame windows
  - "Outie" windows attached to strapping over drainage plane

Koh DER — Milton, MA

- Mechanical
  - Advanced combo space/water heating
  - Hydro-air distribution
  - HRV ducted to central heating/ cooling distribution
  - Photovoltaic system

Combo system and air handling unit

PV panels on rear roof

High efficiency HRV

Koh DER

Milton, MA

- Challenges, Lessons
  - Decision not to overclad the roof resulted in smaller windows at 2nd floor, less water protection from overhangs, and difficult air control and thermal control continuity at roof-wall transition
  - Installation of window over strapping complicates flashing and air control transitions
  - Perimeter of over-slab insulation placed before rest of floor allowed embedding perimeter in wall spray foam and prevented damage to slab insulation during construction.
  - HRV system connected to central ductwork requires back-draft dampers to control ventilation

Lavine DER — Newton, MA

- Project Overview
  - DER Lead/Builder: VO Design Build
  - Location: Newton, MA
  - Climate: Cold Climate (5)
  - Type: Single-Family Cape
  - Stories: 1.5 plus full basement
  - Conditioned Floor Area*: 2,044 sq. ft.
  - 6-Sided Surface Area*: 5,535 sq. ft.
  - Conditioned Volume*: 17,150 cu. ft.
  - Final Airtightness: 4.54 ACH 50

* Information provided by Builder

Lavine DER — Newton, MA

- Enclosure – Roof/Attic
  - Water Management: New asphalt shingle roof and taped polyiso
  - Air Control: Taped housewrap continuous from roof to wall
  - Vapor Control: Sufficient exterior insulation to control condensation inside wall
  - Thermal Control: 4” polyiso on exterior with open-cell spray foam in framing cavities and encapsulating existing fiberglass; new cellulose at cathedral sections

Polyiso with sleepers and roof sheathing

Open-cell spray foam in cathedral ceiling

Lavine DER — Newton, MA

- Enclosure – Walls
  - Water control: Taped outer layer of insulating sheathing; “perforated” closure piece
  - Air Control: Taped house wrap connected to roof house wrap
  - Vapor control: Sufficient exterior insulation to control condensation inside wall
  - Thermal Control: 4” foil-faced polyiso insulating sheathing; wall cavities filled with existing fiberglass and voids filled with cellulose where needed

Perforating the water table

Attached porch; spray foamed at connections

Lavine DER — Newton, MA

- Enclosure – Basement Walls
  - Water Control: Closed-cell spray foam (keeps water at foundation wall)
  - Air Control: Closed-cell spray foam; extends over mud sill to connect with above-grade wall framing
  - Vapor Control: Closed-cell spray foam on foundation wall with open-cell foam over framing sill
  - Thermal Control: spray foam directly against existing fieldstone wall and framing sill

Spray foam in basement and at rim joist

Lavine DER

Newton, MA

- Enclosure – Basement Floor
  - Water Control: Granular fill and perimeter drain with sump pump
  - Air Control: New concrete slab
  - Vapor Control: Polyethylene in contract with concrete slab
  - Thermal Control: "Bathtub" of 2" XPS rigid insulation

XPS "bathtub" with radiant heating

Basement slab system with radon vent

National Grid DER Pilot Program
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Lavine DER

Newton, MA

- Enclosure Design – Doors and Windows
  - A mix of new triple pane vinyl frame windows and double pane wood fame windows
  - Infill basement windows
  - "Outie" windows – Attached to window strapping in outer layer of insulating sheathing
  - Existing doors remained, new basement bulkhead door

Flanges attached to window strapping

National Grid DER Pilot Program
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Lavine DER

Newton, MA

- Mechanical
  - High efficiency boiler in basement for existing hot water baseboards and radiant heating in basement
  - Storage hot water heater supplied by boiler
  - Air-source heat pump with air handler in conditioned attic
  - Whole-house dehumidifier
  - ERV ducted to central air handler

Boiler and superstore tank in basement

National Grid DER Pilot Program
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Wick DER — Northampton, MA

- Project Overview
  - DER Lead: Coldham&Hartman Architects
  - Builder: Kent Hicks Construction
  - Location: Northampton, MA
  - Climate: Cold Climate (5)
  - Type: Single-Family
  - Stories: 2 plus full basement
  - Conditioned Floor Area*: 2,747 sq. ft.
  - 6-Sided Surface Area*: 6,711 sq. ft.
  - Conditioned Volume*: 34,624 cu. ft.
  - Final Airtightness: 0.75 ACH 50

* Information provided by Builder

Wick DER — Northampton, MA

- Enclosure – Roof/Attic
  - Water Management: New asphalt shingle roof and taped polyiso
  - Air Control: Taped Zip System Roof Sheathing
  - Vapor Control: Sufficient exterior insulation to prevent condensation inside assembly
  - Thermal Control: 4" polyiso on exterior with dense packed cellulose in framing cavities

Netted cellulose between the rafters

Wick DER — Northampton, MA

- Enclosure – Walls
  - Water control: Taped housewrap over taped polyiso, Zip wall system behind insulation
  - Air Control: Taped Zip system installed over board sheathing
  - Vapor control: Sufficient exterior insulation to prevent condensation inside wall
  - Thermal Control: 4" foil-faced polyiso insulating sheathing with cellulose insulation in wall cavities

Polyiso exterior insulating sheathing with housewrap drainage plane and furring

Wall system with ZipWall, polyiso and housewrap

Wick DER — Northampton, MA

- Enclosure – Basement Walls
  - Water Control: Closed-cell spray foam (keeps water at foundation wall)
  - Air Control: Closed-cell spray foam; extends over mud sill to connect with above-grade wall
  - Vapor Control: Closed-cell spray foam
  - Thermal Control: Closed-cell spray foam directly against existing fieldstone wall and extending over framing sill

Spray foam on existing foundation walls

Spray foam at rim joist

Wick DER

Northampton, MA

- Enclosure – Basement Floor
  - Water Control: Interior perimeter drain in gravel trench
  - Air Control: New concrete slab
  - Vapor Control: Polyethylene under the slab
  - Thermal Control: "Bathtub" of 2" EPS rigid insulation over existing slab

Interior sub-slab drainage

New concrete slab

National Grid DER Pilot Program
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Wick DER

Northampton, MA

- Enclosure Design – Doors and Windows
  - New triple pane vinyl frame windows
  - "Outie" windows – Attached to picture frame strapping over exterior insulation
  - Rigid foam inserts at basement windows
  - New insulated door at addition and two existing doors

Window with back dam and spray foam air seal

Window plan flashing extends over cladding

National Grid DER Pilot Program
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Wick DER

Northampton, MA

- Mechanical
  - Ground-source heat pump
  - High efficiency HRV in conditioned basement
  - 5 kW Photovoltaic array

High efficiency HRV

PV Inverter control panel

Air handler in conditioned basement

National Grid DER Pilot Program
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Bungalow Comprehensive Retrofit

Quincy, MA

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

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 insulation, open cell spray foam encapsulating roof framing
  - ***Vapor Control*** – Fully adhered ice and water membrane on roof deck below rigid insulation insulation
  - ***Thermal Control*** – 4" polyiso insulating sheathing on roof sheathing, 10" open cell spray foam in roof framing

Photo credit: Henry MacLean / Timeless Architecture

Hall DER

Quincy, MA

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

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

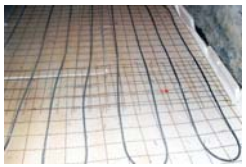
EPS under slab with polyethylene

Spray foam fills gaps in foundation wall

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 "bath tub" 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

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

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

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