Building Smaller, Building Better: Getting to Net Zero Ready by Design

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BETTER BUILDINGS BY DESIGN CONFERENCE
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Westford House
Westford, MA

Project Overview
- Builder: Habitat for Humanity of Greater Lowell
- Location: Westford, MA
- Climate: Cold (5A)
- Type: Single Family, Affordable
- Stories: 1½
- Bedrooms: 3
- Baths: 2 Full
- Floor Area: 1,340 sq. ft.
- Basement Area: 816 sq. ft.

Estimated Energy Reduction: 44.1%
Estimated Energy Savings: $1,259 / year
Cost: $200,000
Construction Start: March 2008
Construction Finish: October 2008
Construction Schedule: 8 Months

How the Costs Breakdown
- Foundations installed including concrete: $3,500
- Slab installed including concrete: $1,000
- Lumberyard pricing of entire package including foam sheathing: $70,000
- Framer’s cost to enclose building including windows and foam: $12,500
- Electrical, Plumbing, Mechanical equipment and installation: $30,000
- Interior finishes, cabinets, appliances, GWR and installation: $15,000
- Septic systems and site work: $15,000
- General labor and overhead: $40,000

TOTAL PRE SITE GENERATED ENERGY: $200,000
Lowell HFH donated labor: $40,000
Lowell HFH donated materials: $25,000
Total Cost to HFH: $125,000

3.5 kWp PV (350+ kWh/month)
Electric = $0

Lowell  Habitat for Humanity Westford, MA
2,156 sq. ft. @ $92/sq. ft.  HERS 49
Gas (400 therms) = $50/month @ $1.50/therm
Electric (4200 kWh) = $50/month @ $0.15/kWh
= $3.30 per day

With 3.5 kWp PV (350+ kWh/month)
Electric = $0

Energy Balance left: ~ 400 therms of gas at $1.50/therm
$600 per year

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Source Energy Parametric Annual Loads Study

Source Energy Savings

Enclosure Design
- R-66 Roof Insulation (unfaced fiberglass batt insulation with (2) 2” layers foil-faced polyisocyanurate insulating sheathing on roof sheathing)
- R-45 Walls (2x6 framing at 24” o.c. with unfaced fiberglass batt insulation and (2) 2” layers foil-faced polyisocyanurate insulating sheathing)
- Windows (Low-E double pane argon filled, U = 0.33 & SHGC = 0.28)

Enclosure Design
- R-26 Basement Walls (2) 2” layers foil-faced polyisocyanurate insulating sheathing)
- R-13 Rim Joist Area (2” high density spray foam at first floor rim joist area)
- R-10 Basement Slab (2” XPS below slab)

Mechanical Design
- 96% AFUE Gas Furnace
- 0.82 EF Instantaneous Water Heater
- Fantech Energy Recovery Ventilator (ERV)
### Pre-Construction Workshops
- Demonstrations
- Field Visits with Follow-Up Memos and Sketches

### Window Flashing Demonstration
Foundation Wall Insulation

### Roof Insulation
Foundation Wall Insulation

### Systems Testing
- Blower Door Test for Overall Air Infiltration
  - Target: 127 CFM / 3.6 ACH 50
  - Results: 964 CFM / 3.1 ACH 50
- Duct Blaster Test for Duct Leakage
  - No leakage to outside
  - 145 CFM total leakage at 25 Pa
- HVAC Register Flows
- Ventilation System Flows
- Room Pressurization
- HVAC System Static Pressure and Overall Flow

### Systems Testing Photos
- Installing Transfer Grille
- Testing Register Flows
- Identifying Duct Leakage
- Duct Blaster Testing

### Prescriptive-based Code Approval
- Exceeds IECC Section 404 Compliance by over 50%
Excerpt from Durability Checklist

Installing Siding on Wall Mock-Up

Excerpt from Homeowner's Manual

Verification of Complete Air Seal at Rim Joist

Verification of Incomplete Air Seal at Rim Joist to be Re-Sealed

Details from BSC Information Sheet on Airtight Drywall Approach – Reviewed with Drywall Installers
Assumptions: 30 year mortgage, 7% interest rate, $1.40/therm, $0.18/kWh
- $329 annual net positive cash flow
  ($1121 annual savings - $792 added mortgage cost)
- $273 annual net positive cash flow assuming testing/inspections ~$700
  ($1121 annual savings - $848 added mortgage cost)

Marketability & Market Coverage
- Low-Income Affordable Single-Family Home
- Home Built into Existing Neighborhood with Many Services within Walking Distance

Builder Commitment
- Plan to build new homes in 2009 that meet Building America performance specifications:
  1 in Wilmington, MA
  2 in Dracut, MA
  7 in Bedford, MA

Highlight high-performance features of their homes in marketing information such as:
101 Ways We are Building Green

Gaps Analysis & Lessons Learned
- Coordination of Ductwork and Plumbing
- Coordination of Intake and Exhaust Locations
- Door Installation Sequence and Details
- First Floor Rim Joist Spray Foam Thermal Barrier
- Attachment of Basement Wall Insulation
- Basement Wall Insulation Thermal Barrier
- Air-Barrier Above Second Floor Ceiling
- Electrical Service Entrance
- 12:12 Roof Pitch and Volunteers
- Volunteer Labor

Problem: Plumbing and ductwork competed for space at the end of the house between the rim joist and the floor joist. The 4" of foam on the basement wall constrained the space available for these services to run.
Solution: Show plumbing on plans with ductwork to identify potential conflicts.
Gaps Analysis & Lessons Learned

Door Installation Sequence and Details

Problem: Drawing set did not include a door installation sequence or door details to show how to install door, frame, trim and sill with 4" of foam on the walls.

Solution: Develop door installation sequence and details for drawing set.

First Floor Rim Joist Spray Foam Thermal Barrier

Problem: The high density spray foam installed in the rim joist area could not be left exposed without a thermal barrier.

Solution: Position 1/2" Roxul mineral wool insulation over spray foam and in between floor joists.

Attachment of Basement Wall Insulation

Problem: 4" of rigid foam insulation could not be attached back to the concrete foundation wall. Furring strips were attached to the concrete and roofing washers were fastened back to furring strips holding the foam in place.

Solution: Attach 1st layer of foam with furring and adhere 2nd layer to first layer of foam.

Basement Wall Insulation Thermal Barrier

Problem: The foil-faced polyiso installed in the basement could not be left exposed without a thermal barrier.

Solution: Use foil-faced polyiso that is rated as a thermal barrier or cover the foam with gypsum board.

Air-Barrier Above Second Floor Ceiling

Problem: Collar ties and strapping for the second floor ceiling were installed before the gypsum serving as the air barrier was installed. It would have been difficult to install the gypsum with these members already in place.

Solution: Move the air barrier from the interior gypsum to the roof sheathing.

Electrical Service Entrance

Problem: The main electrical box and wires are located in an undesired location on the front of the house.

Solution: Ask builder for proposed utility connections to identify preferred locations.
Gaps Analysis & Lessons Learned

12:12 Roof Pitch and Volunteers

Problem: The volunteers had a difficult time installing the siding and trim on the dormers while standing on the main roof which has a 12:12 pitch.
Solution: Design house to have a lower sloped roof or to not have any dormers.

Volunteer Labor

Problem: The volunteers had a difficult time with air sealing, particularly around the windows and along the ductwork.
Solution: Have brief meetings at the start of each day to demonstrate each task or assign one volunteer per task to oversee their group.

Conclusion

BSC looks forward to working with Habitat in 2009 to provide healthy, durable, energy-efficient and affordable homes to families in need throughout the Greater Lowell area.