Greening Affordable Housing

Building Science Corporation
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ACI, Kansas City, MS
April 30, 2009

Westford House

Westford House Lowell HFH
Lowell, MA

Project Overview

- Builder: Habitat for Humanity of Greater Lowell
- Location: Westford, MA
- Climate: Cold (5A)
- Type: Single Family, Affordable
- Stories: 1 ½
- Bedrooms: 3
- Baths: 2 Full
- Floor Area: 1340 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
- Framers’ cost to enclose building including windows and foam $12,500
- Electrical, Plumbing, Mechanical equipment and installation $30,000
- Interior finishes, cabinets, appliances, GIMB and installation $30,000
- Septic systems and site work $12,000
- 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 kW PV system after tax credits $24,000
TOTAL WITH SITE GENERATE ENERGY $224,000

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) = $30/month @ $0.15/kWh
= $3.30 per day

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

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Source Energy Savings

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- Source Energy Savings

Gas (400 therms) = $50/month @ $1.50 /therm
Electric (4200 kWh) = $50/month @ $.15/kWh
= $3.30 per day

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Gas Consumption

Electricity Usage

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Gas (400 therms) = $50/month @ $1.50 /therm
Electric (4200 kWh) = $50/month @ $.15/kWh
= $3.30 per day
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, 0.33 & SHGC = 0.28)

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)

Construction Support
- Pre-Construction Workshops
- Demonstrations
- Field Visits with Follow-Up Memos and Sketches
Window Flashing Demonstration
Building the box for the window

Window Installation Demonstration

Construction Support Photos

Foundation Wall Insulation

ERV Intake and Exhaust Side Door

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Lowell, MA

Construction Support Photos

Roof Framing

Roof Insulation

Westford House On-Site Meeting

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Systems Testing
- Blower Door Test for Overall Air Infiltration
  - Target: 1127 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

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

Prescriptive-based Code Approval
- Exceeds IECC Section 404 Compliance by over 50%

Quality Assurance
- Energy Models
- Wall Mock-Up
- Durability Checklist
- Details in Drawing Set
- Homeowner’s Manual

Excerpt from Durability Checklist

Quality Assurance
- Advanced Framing & Air Sealing Details from Drawing Set
Quality Assurance
- LEED for Homes Third-Party Verification
- ENERGY STAR Third-Party Verification
- Builders Challenge Third-Party Verification
- Implementation of Durability Checklist
- Field Visits and Demonstrations

Quality Control – BSC Information Sheets
Details from BSC Information Sheet on Airtight Drywall Approach – Reviewed with Drywall Installers

Builders Challenge Certificate

Neutral Cost Analysis

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Installation Cost</th>
<th>Homeowner Savings</th>
<th>Annual Energy Savings</th>
<th>Homeowner’s Savings</th>
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<tr>
<td>Base</td>
<td>$15,000</td>
<td>$1,212</td>
<td>$110</td>
<td>$12,900</td>
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<tr>
<td>Test</td>
<td>$15,000</td>
<td>$1,212</td>
<td>$110</td>
<td>$12,900</td>
</tr>
</tbody>
</table>

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

- Equipment intakes and exhausts were relocated from original plan due to development of the site plan after the house was under construction.

Solution:

- Develop site plan with drawing set that identifies walkways, other proposed hardscapes and proposed utility locations.

Coordination of Intake and Exhaust Locations

- Draw 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

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

Solution:

- Position R-30 mineral wool insulation over spray foam and in between floor joists.
**Gaps Analysis & Lessons Learned**

**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 1st layer of foam.

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**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.

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**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 without these members already in place.

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

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**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.

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**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.

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**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.

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Community gathered before Westford House Dedication Ceremony

SINGLE FAMILY REHAB- BEDFORD, MA

Retrofit of Existing Farmhouse into a 2 Story Single Family Home with 3 Bedrooms and 2.5 Baths

The Farmhouse is located in a Cold Climate, Climate Zone 5A (5596 HDD, 5358 CDH)

Existing Farmhouse

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Design Highlights
- High-Performance Building Enclosure Retrofit
- High Efficiency Heating and Hot Water Systems
- Central-Fan-Integrated Ventilation
- New Bedroom and Barrier-Free Full Bath on First Floor
- Affordable Housing Developer
- Volunteer and Student Labor

Retrofit Challenges to High Performance
- Water Management and Air Barrier Continuity with Thick Insulating Sheathing (Outsulation!)
  - Transition air barrier down and in at foundation wall while maintaining water management (down and out!)
  - Roof-Wall interface
- Structural Attachment through Insulating Sheathing
- Windows and Doors
- Room for Mechanical Distribution
- Structural Remediation

Basement Details
- Capillary Break installed under new sill beam
- 2”-3” High Density Spray Foam (~R13 – R19.5) applied to Rubble Stone Foundation
- Intumescent Paint fire protection for spray foam
- R-10 XPS under New Slab

Wall Details
- 4” Cellulose in Walls (R-14)
- 2” – 4” Foil-Faced Polyiso Insulating Sheathing (R-13 to R-26)
  - Joints staggered horizontally and vertically
  - All joints taped and sealed
- Wood furring strips, vinyl siding

High Performance Windows
- U = 0.31, SHGC = 0.32
- Double pane, vinyl-framed, low-e, argon fill

Window Installation
Roof Details
- High Density Spray Foam Air Seal at Roof Perimeter
- Spray Foam Flash Coat 1”-2” (~R6-12) to underside of Roof Sheathing and at Gable Walls
- Cellulose Netted and Blown 2”-4” (~R7-14) between Roof Rafters and Gable Framing
- 4” (R26) Foil-Face Polyiso Insulating Sheathing, in (2) Layers
  - Joints staggered horizontally and vertically
  - All joints taped and sealed
- Nail base, Ice and Water Membrane, Asphalt Shingles

Mechanical Details
- 93% AFUE Furnace
- Ducts in Conditioned Space
- Ducts Sealed Exceptionally Tight
- Instantaneous Hot Water Heater EF = 0.82
- Energy Star Appliances
- Full CFL Package

Projected Energy Use

- Energy use breakdown for different categories such as heating, cooling, lighting, appliances, and others.