Deep Energy Retrofits of Existing Single Family Homes

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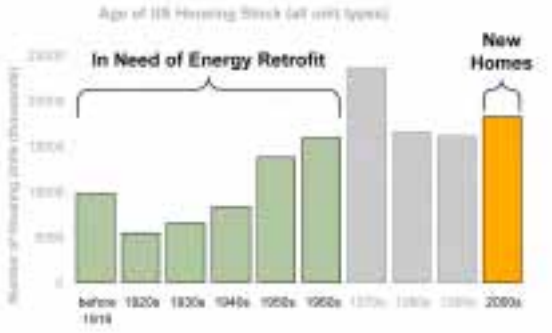
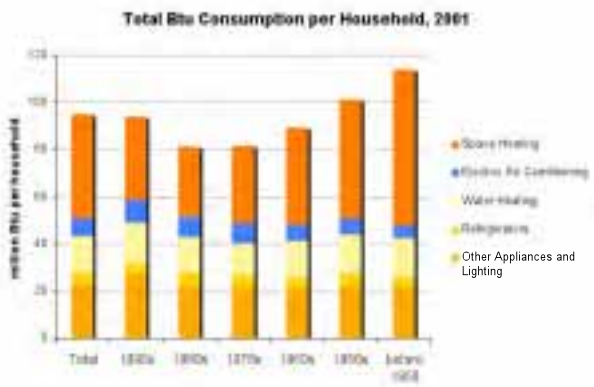
National Building Museum
Washington, DC September 10, 2009

Existing Housing Stock
60 million pre 1970 in need of upgrading



Source: US Census Bureau, Annual Housing Survey: http://www.census.gov/hhes/www/housing/ahs/ahs.html

How Old and New Houses Use Energy



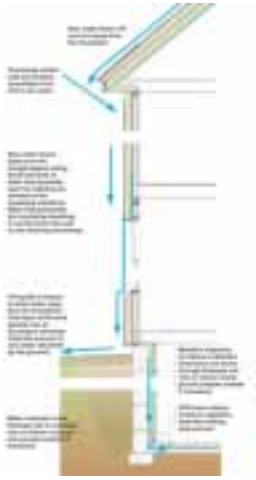
Source: US Census Bureau, Annual Housing Survey: http://www.census.gov/hhes/www/housing/ahs/ahs.html

A Deep Energy Retrofit Reduces the Energy Consumption of the home by a minimum of 70%

The house is now ready for the next 100 years

Water Control Layer

Moving rainwater from the roof and walls and groundwater from the foundations

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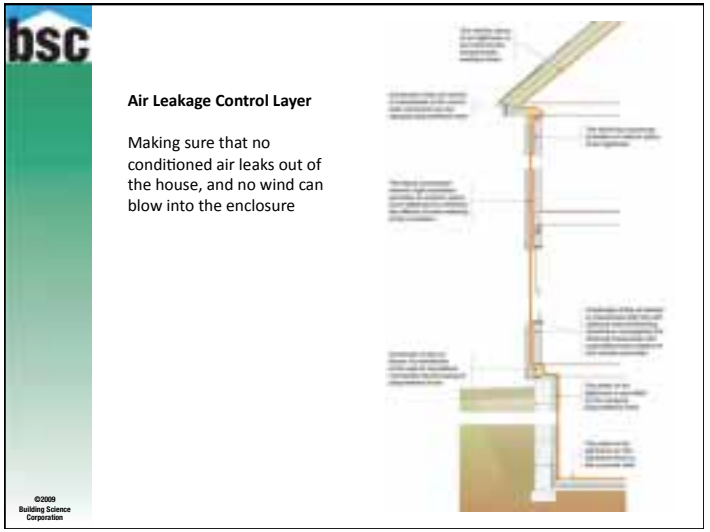
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Air Leakage Control Layer
Making sure that no conditioned air leaks out of the house, and no wind can blow into the enclosure
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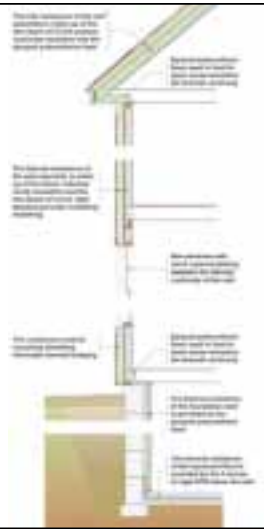
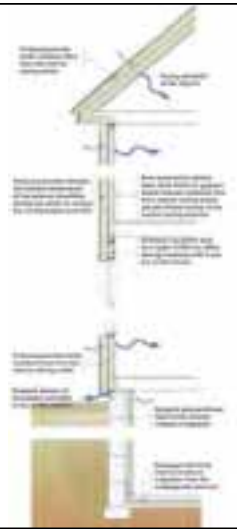
Thermal Control Layer

Must be consistent around all six sides of the cube



Vapor Control Layer

Make sure that no water in the vapor form gets trapped in assemblies, such that it gets cold enough to condense, turning to liquid water. When this happens things rot, corrode, and environments that are conducive to mold growth are created.



Old Boiler to New Boiler plus air handlers, outside air intake, filtration, and exhaust at baths and kitchen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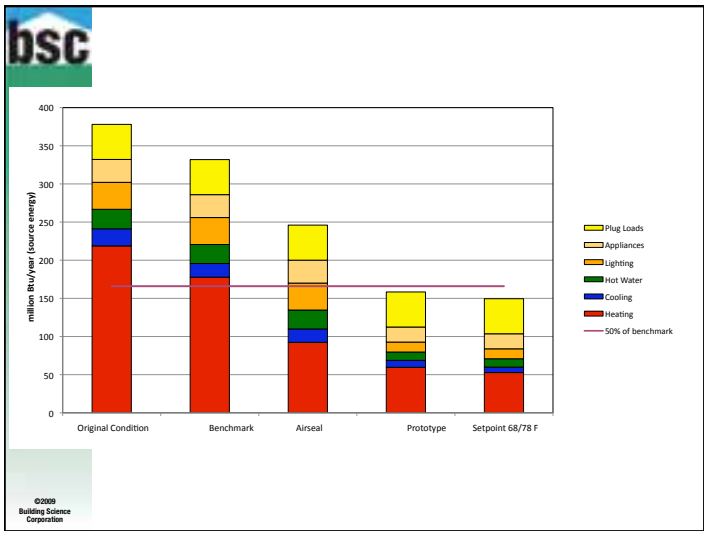
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400
350
300
250
200
150
100
50
0
million Btu/year (source energy)
Original Condition
Benchmark
Airseal
Prototype
Setpoint 68/78 F
Plug Loads
Appliances
Lighting
Hot Water
Cooling
Heating
50% of benchmark
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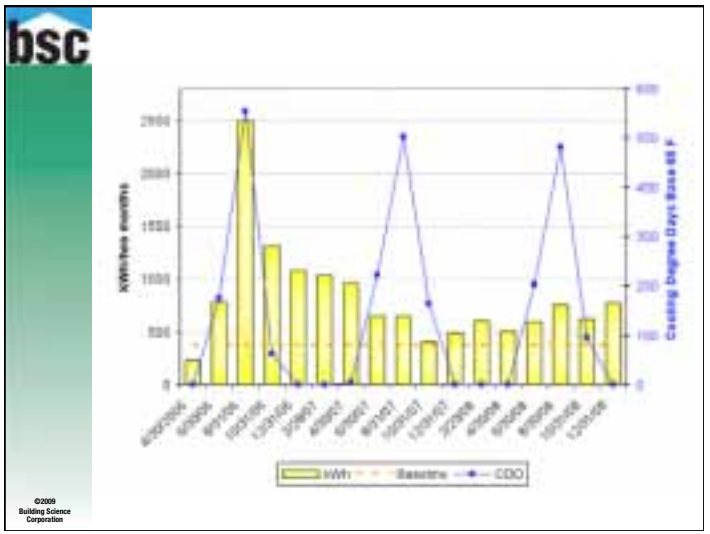
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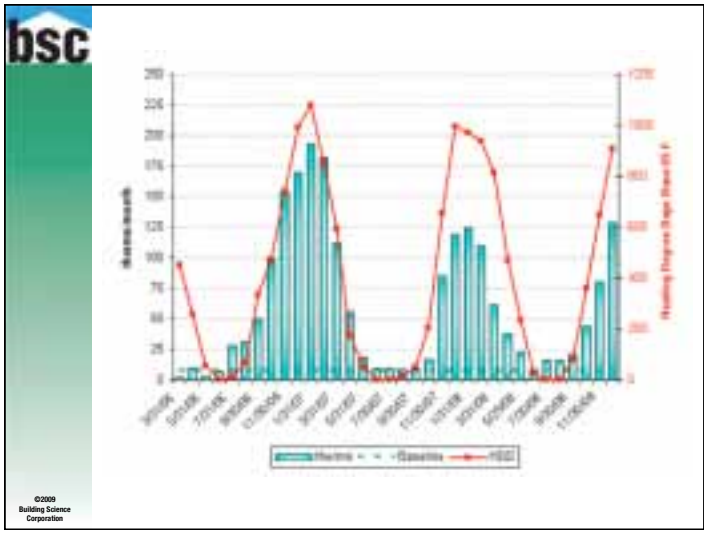
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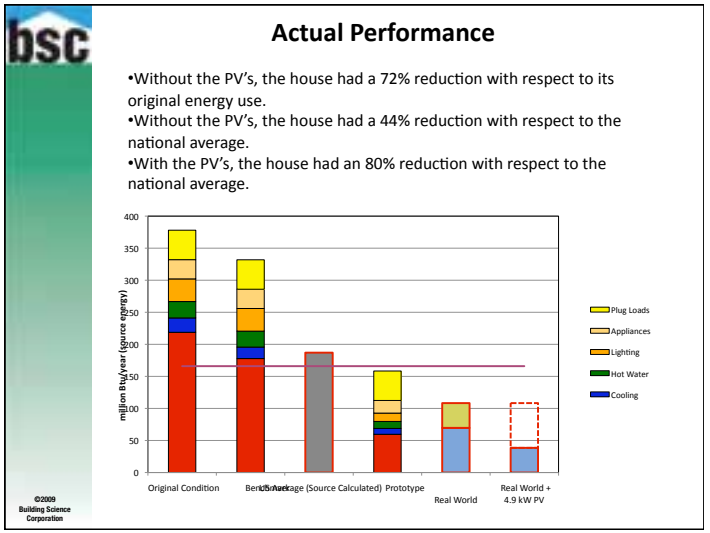
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Actual Performance
•Without the PV's, the house had a 72% reduction with respect to its original energy use.
•Without the PV's, the house had a 44% reduction with respect to the national average.
•With the PV's, the house had an 80% reduction with respect to the national average.
million Btu/Year (source energy)
400
350
300
250
200
150
100
50
0
Original Condition
Real World
Real World +
4.9 kW PV
Plug Loads
Appliances
Lighting
Hot Water
Cooling
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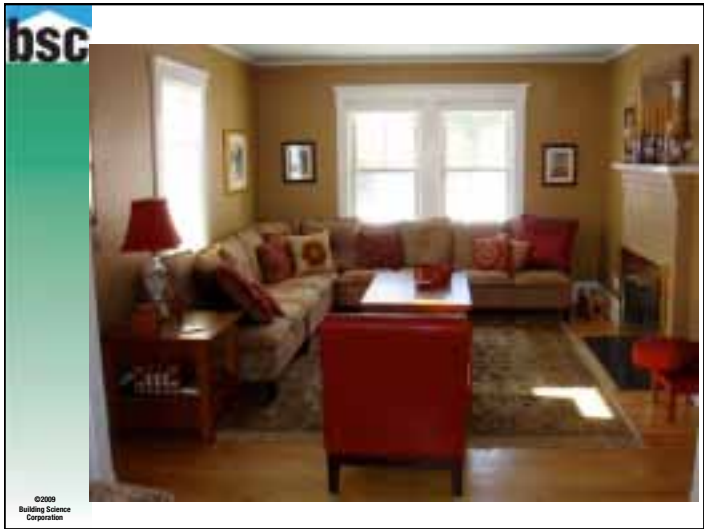
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Retrofit of Existing Farmhouse into a 2 Story Single Family Home with 3 Bedrooms and 2.5 Baths

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

Existing Farmhouse

55

56

Farmhouse Retrofit — Bedford, MA

Habitat for Humanity of Greater Lowell

Farmhouse Retrofit — Bedford, MA

Habitat for Humanity of Greater Lowell

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 (*Out*sulation!)
  - 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

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

Basement Wall Section

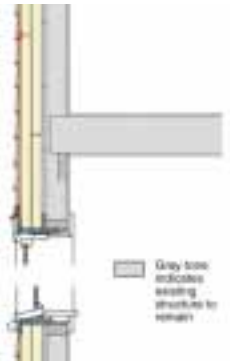
61

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



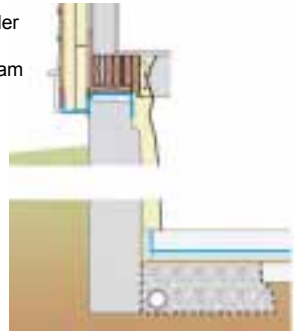
Typical Wall Section

62

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

Perimeter Drain



Basement Wall Section

- Window installation

- 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

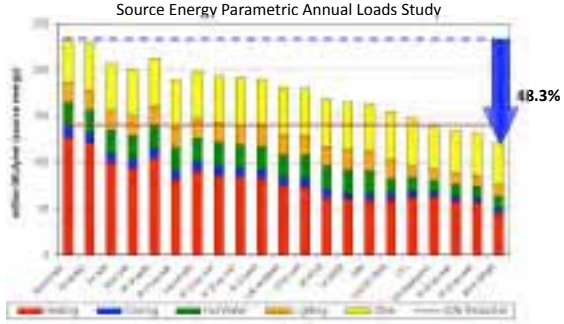
Farmhouse Retrofit

Bedford, MA

Habitat for Humanity of Greater Lowell

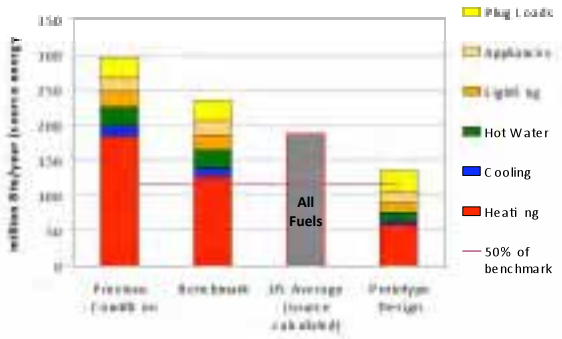
- Source Energy Savings

Source Energy Parametric Annual Loads Study



12 May 2009

Projected Energy Use

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