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Deep Energy Retrofits of Existing Single Family Homes

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Building Science Corporation
www.buildingscience.com

National Building Museum
Washington, DC September 10, 2009



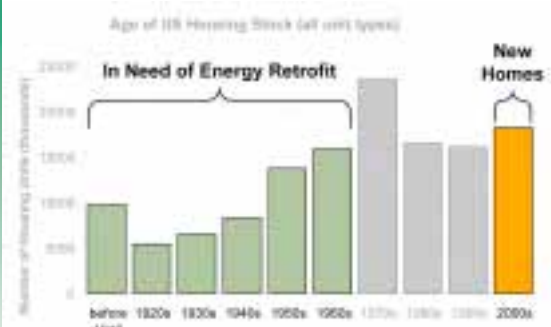
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Existing Housing Stock

60 million pre 1970 in need of upgrading

Age of US Housing Stock (all unit types)



Number of Housing Units (thousands)

2000+
15000
10000
5000
0

before 1820s 1820s 1830s 1940s 1950s 1960s 1970s 1980s 2000s 2000s

In Need of Energy Retrofit

New Homes

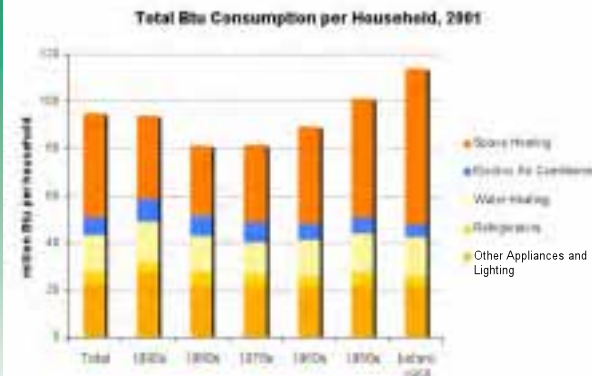
Source: US Census Bureau, Annual Housing Survey: <http://www.census.gov/hhes/www/housing/ahs/ahs.html>

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How Old and New Houses Use Energy

Total Btu Consumption per Household, 2001



million Btu per household

120
100
80
60
40
20
0

Total 1820s 1910s 1970s 1980s 1990s before 1960

- Space Heating
- Electric Air Conditioning
- Water Heating
- Refrigeration
- Other Appliances and Lighting

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

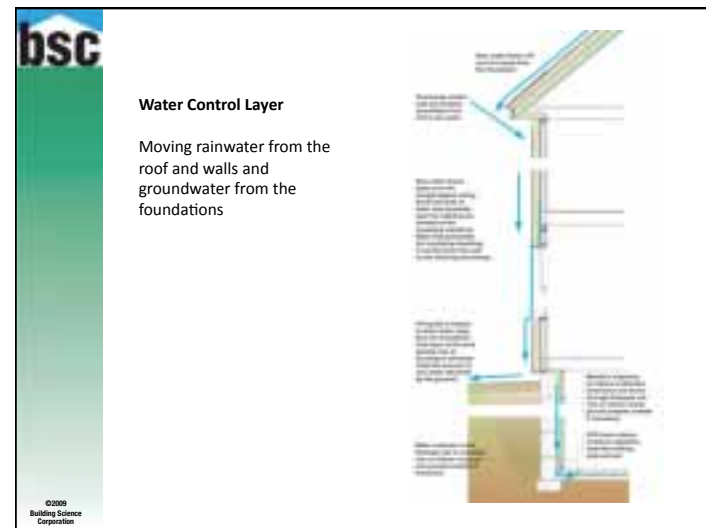
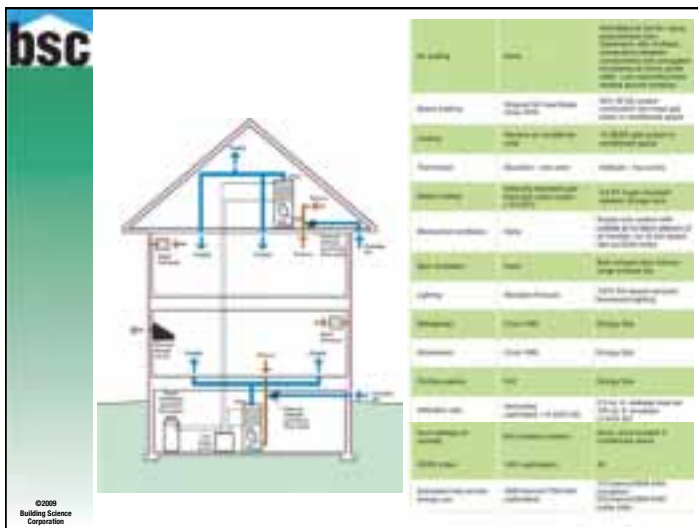
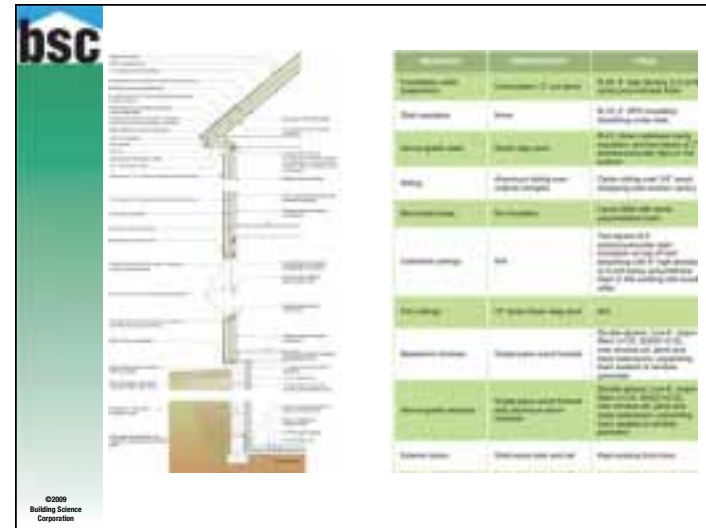
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A Deep Energy Retrofit Reduces the Energy Consumption of the home by a minimum of 70%



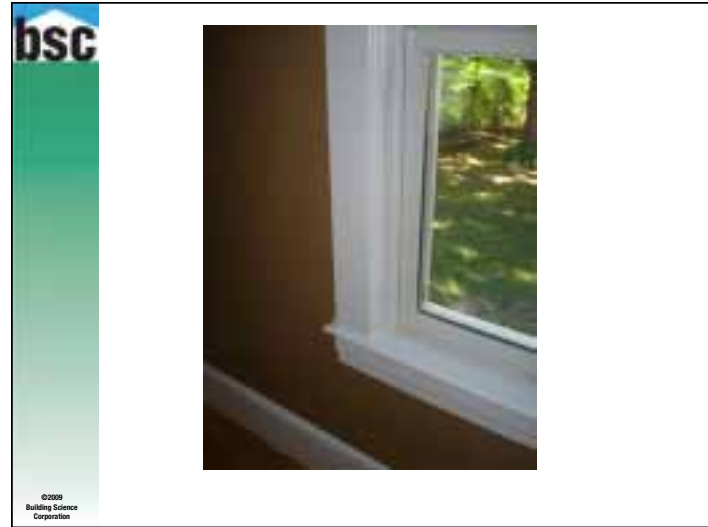
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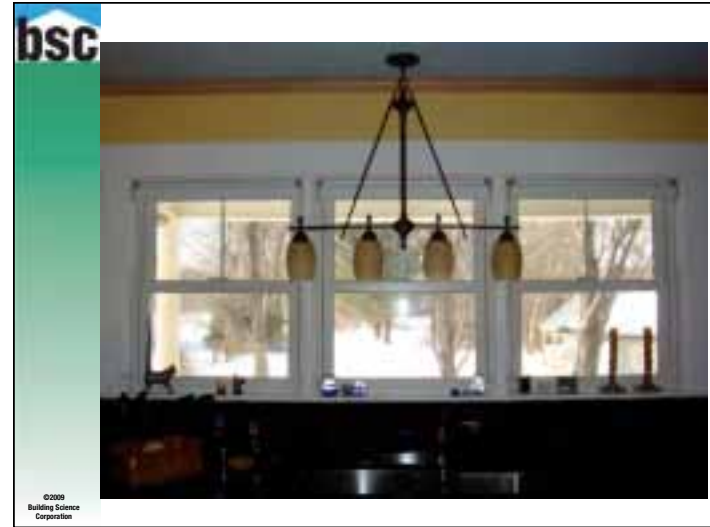
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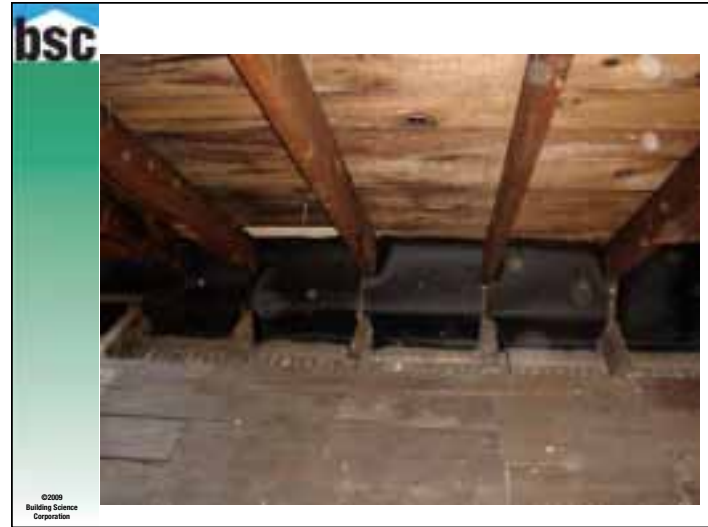
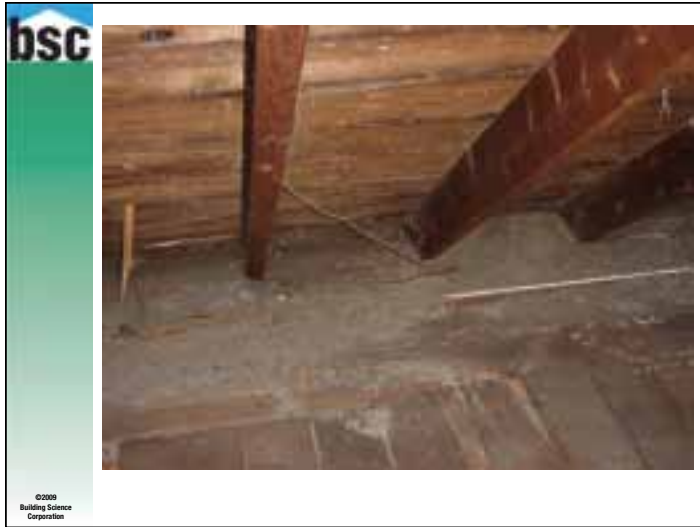
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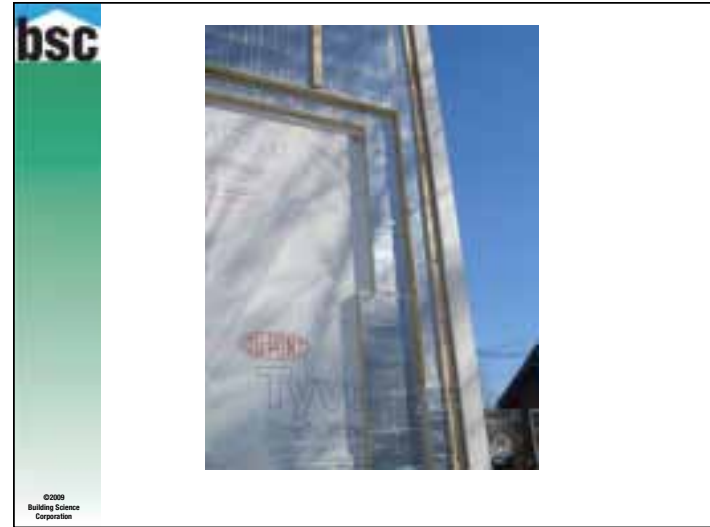
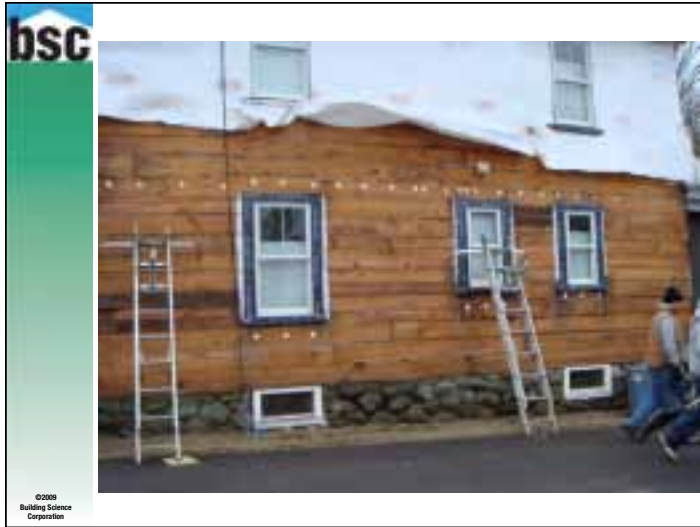
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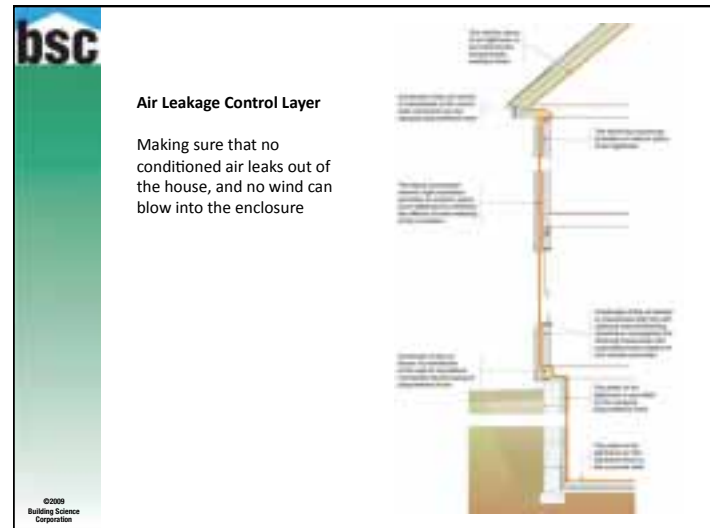


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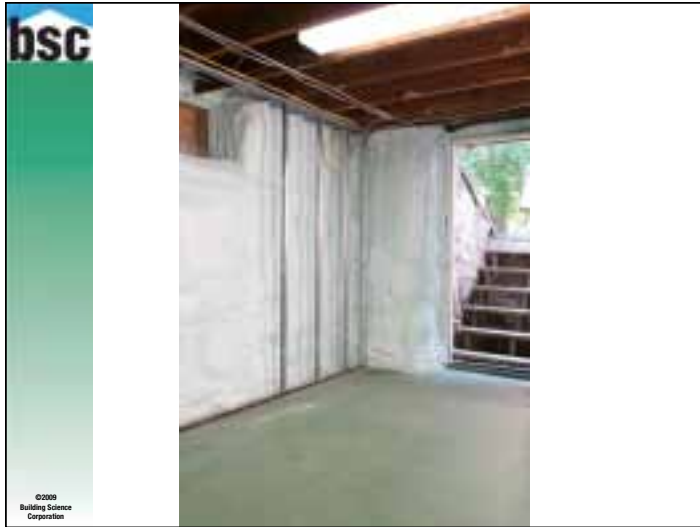


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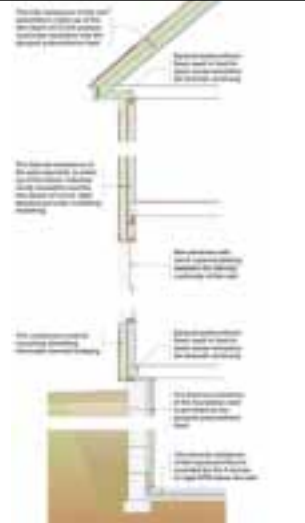
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Thermal Control Layer

Must be consistent around all six sides of the cube



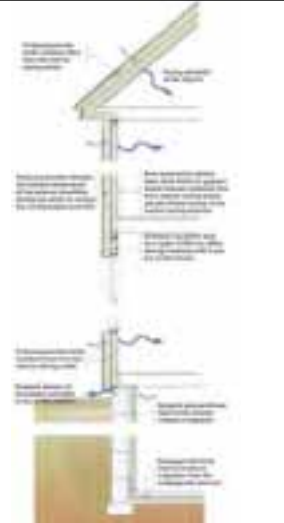
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This diagram illustrates a cross-section of a wall and roof assembly. It shows various layers including insulation, sheathing, and structural elements. Labels point to specific components, such as the exterior insulation, sheathing, and the thermal control layer. The diagram emphasizes the importance of maintaining a consistent thermal control layer around all six sides of the building's envelope.

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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.



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This diagram illustrates a cross-section of a wall and roof assembly, focusing on the vapor control layer. It shows the path of water vapor through the building envelope. Labels indicate the vapor control layer and the potential for condensation if it is not properly installed. The diagram explains that trapped water vapor can condense into liquid water, leading to rot, corrosion, and mold growth.

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Old Boiler to New Boiler plus air handlers, outside air intake, filtration, and exhaust at baths and kitchen



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This slide features a collage of four photographs. The top-left photo shows an old boiler in a basement. The top-right photo shows a new boiler and air handlers installed. The bottom-left photo shows the new boiler and air handlers with ductwork. The bottom-right photo shows the new boiler and air handlers with ductwork and an outside air intake.

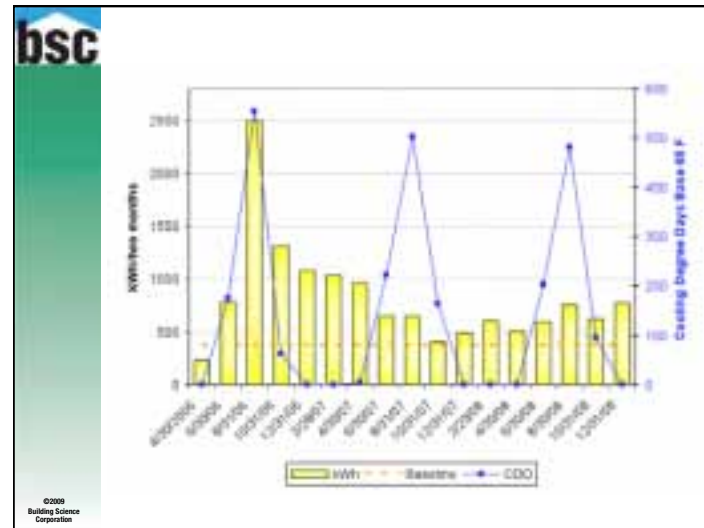
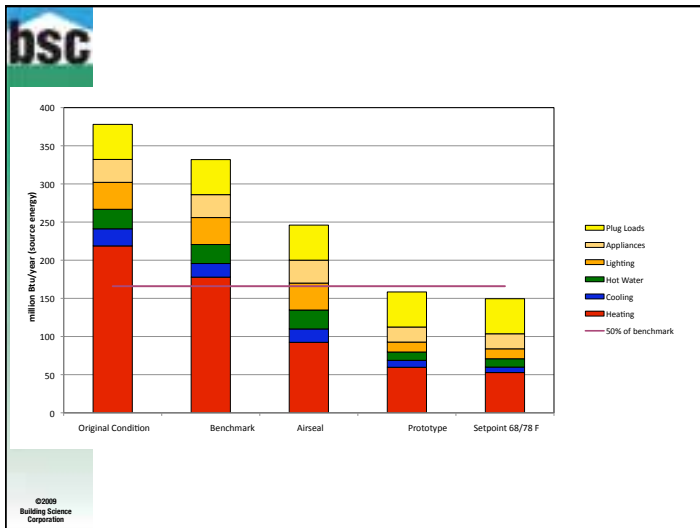
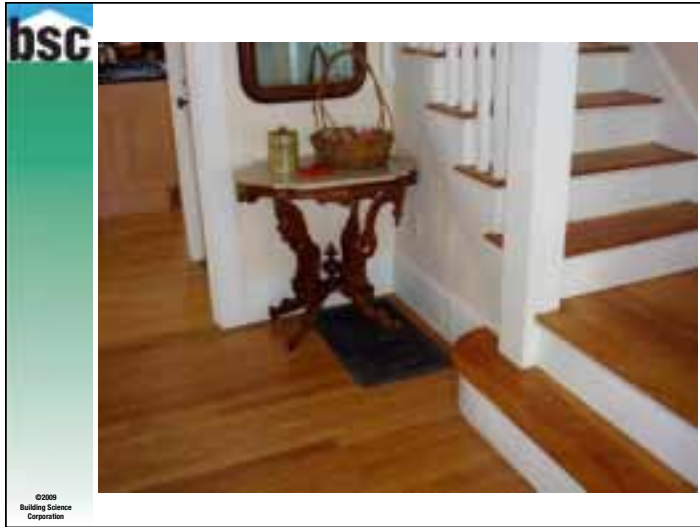
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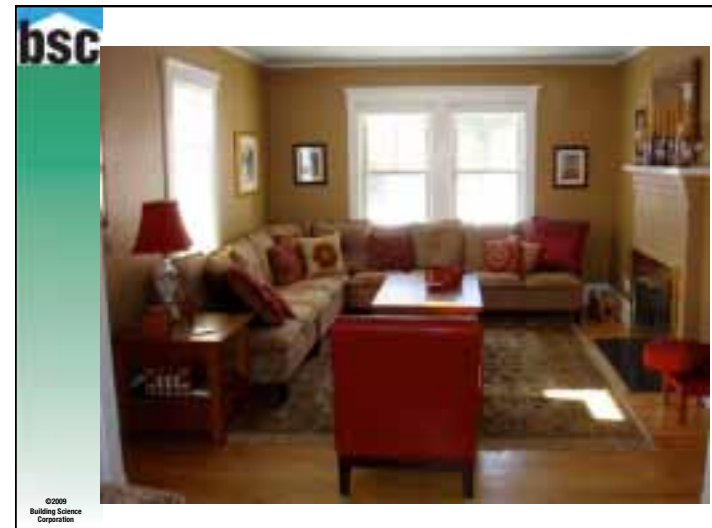
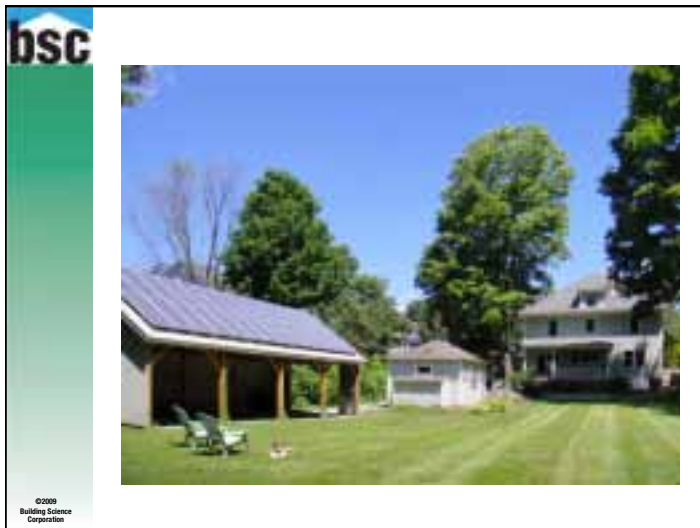
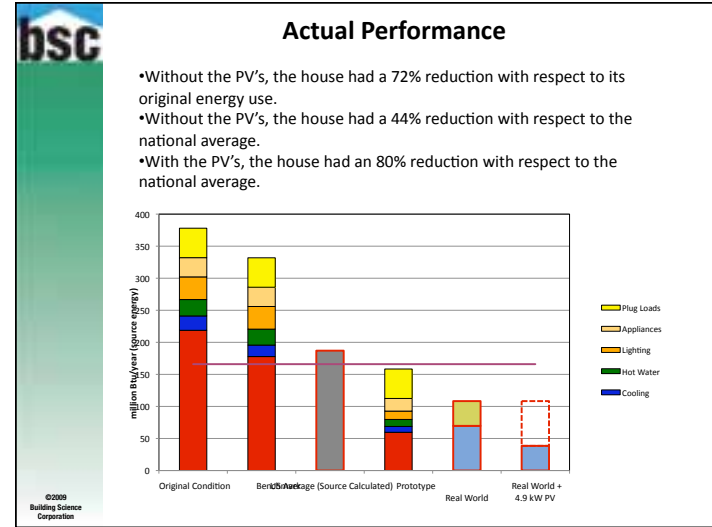
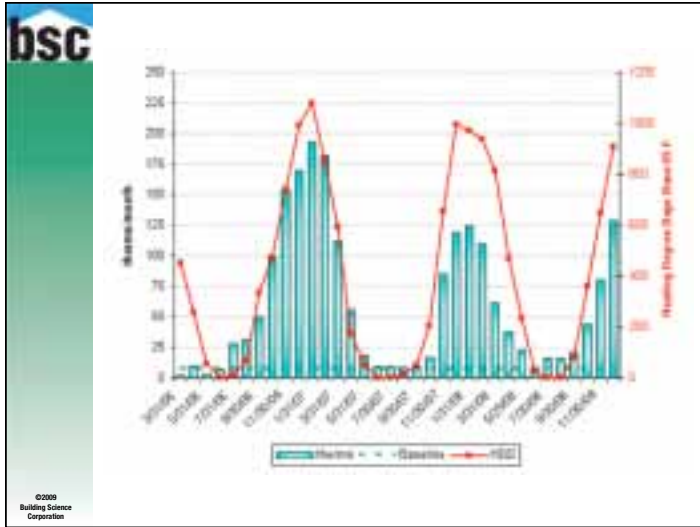
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This photograph shows a new boiler and air handling system installed in a basement. The boiler is a large white unit, and the air handlers are smaller units connected to the boiler. The system is surrounded by ductwork and piping. The floor is covered with green carpeting.

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bsc Farmhouse Retrofit Bedford, MA

Habitat for Humanity of Greater Lowell



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12 May 2009 57

This slide shows a two-story farmhouse in Bedford, MA, during its deep energy retrofit. The exterior siding has been removed, revealing the wooden framing. A dark pickup truck is parked in the driveway. The date is 12 May 2009, and the slide number is 57.

bsc Farmhouse Retrofit Bedford, MA

Habitat for Humanity of Greater Lowell



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12 May 2009 58

This slide shows the same two-story farmhouse in Bedford, MA, after its deep energy retrofit. The exterior is now finished with white siding and dark shutters. A dark pickup truck is parked in the driveway. The date is 12 May 2009, and the slide number is 58.

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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

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This slide lists the design highlights for the farmhouse retrofit project. The highlights include a high-performance building enclosure retrofit, high efficiency heating and hot water systems, central-fan-integrated ventilation, a new bedroom and barrier-free full bath on the first floor, an affordable housing developer, and the use of volunteer and student labor. The slide number is 59.

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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

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60

This slide lists the retrofit challenges to high performance for the farmhouse. The challenges include water management and air barrier continuity with thick insulating sheathing (outsulation!), structural attachment through insulating sheathing, windows and doors, room for mechanical distribution, and structural remediation. The slide number is 60.

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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

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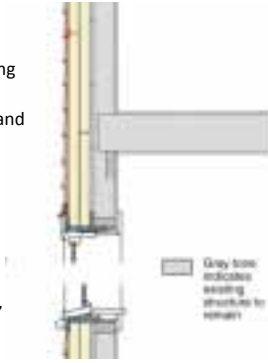
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Wall Details

- 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



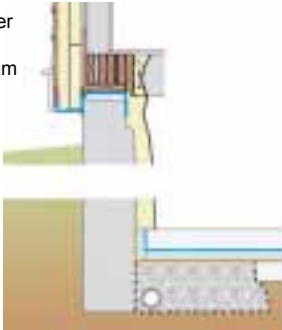

Typical Wall Section

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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

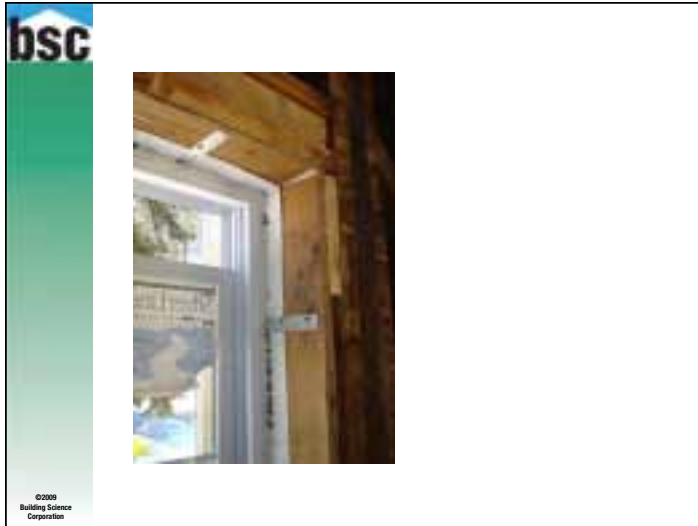
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- Window installation



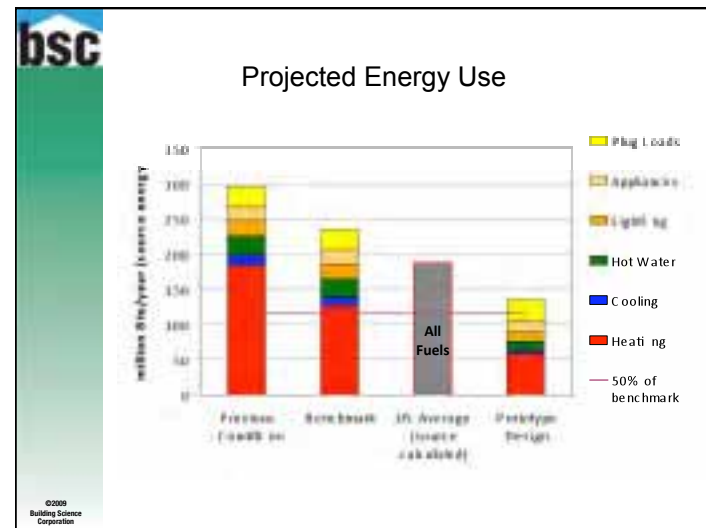
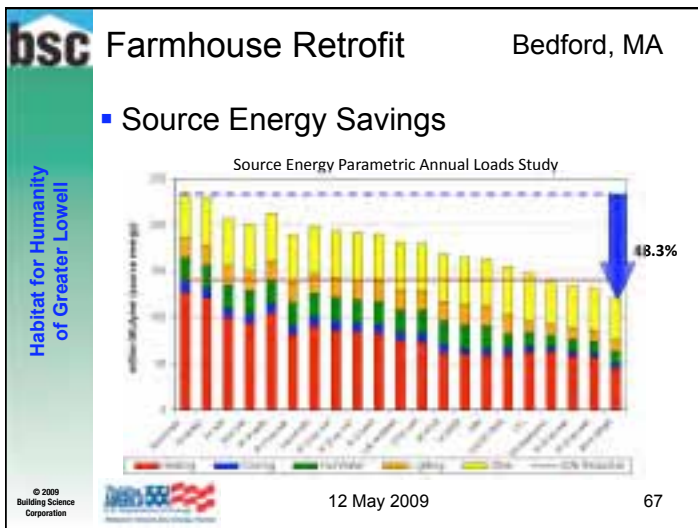
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- Mechanical Details
 - 93% AFUE Furnace
 - Ducts in Conditioned Space
 - Ducts Sealed Exceptionally Tight
 - Instantaneous Hot Water Heater EF = 0.82
 - Energy Star Appliances
 - Full CFL Package

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For more information go to :

www.affordablecomfort.org
see Thousand Home Challenge

www.buildingscience.com
search info and recent presentaions

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