

bsc The session investigated the questions:

1. how would you retrofit an older framed home to make it healthier, more durable and much more energy efficient.
- and
2. how would you build a new house if you could today?

The information presented draws on decades of research and experience from Building America and Canadian government-sponsored research projects, using several real building projects to demonstrate. Specifically, the process of selection of enclosure (roof, wall, basement, windows), heating, cooling, and ventilation will be presented, with straightforward explanations of each. The different decisions that might be made in a production builder setting versus a custom home will be presented. All solutions will focus on cold climates. Given time, some prognostications of future directions will be made.


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bsc Building AMERICA U.S. Department of Energy Research Toward Zero Energy Homes

What Would I do?

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 Building Science Corp & University of Waterloo

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bsc **Assessing the Impact of US Housing**

- **Total Housing Units in 2001 (millions):**

| | |
|----------------------------|------|
| Single-Family Homes | 73.7 |
| Apartments (all buildings) | 26.5 |
| Mobile Homes | 6.8 |
| Constructed since 2001 | 10 |

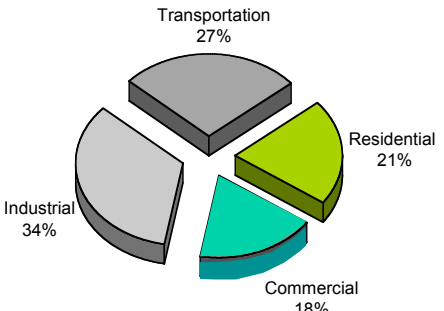
Approx Existing Units: 115 million units¹

1. Energy Information Administration, Residential Energy Consumption Survey, 2001 data: www.eia.doe.gov/emeu/recs
 2. EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/aer

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bsc **Building Energy Use**

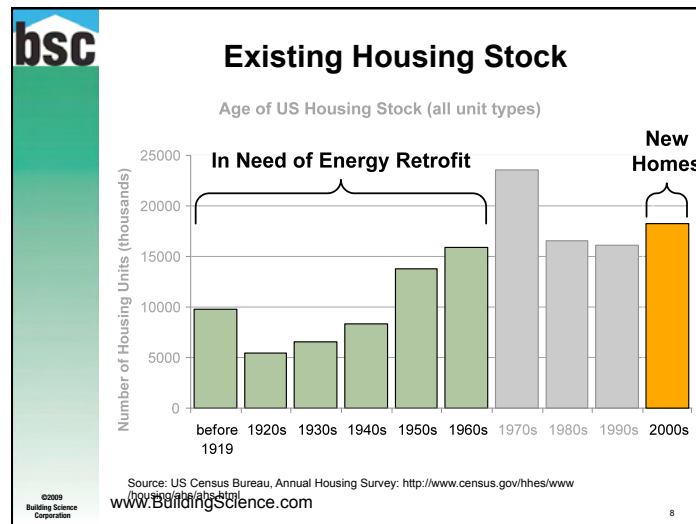
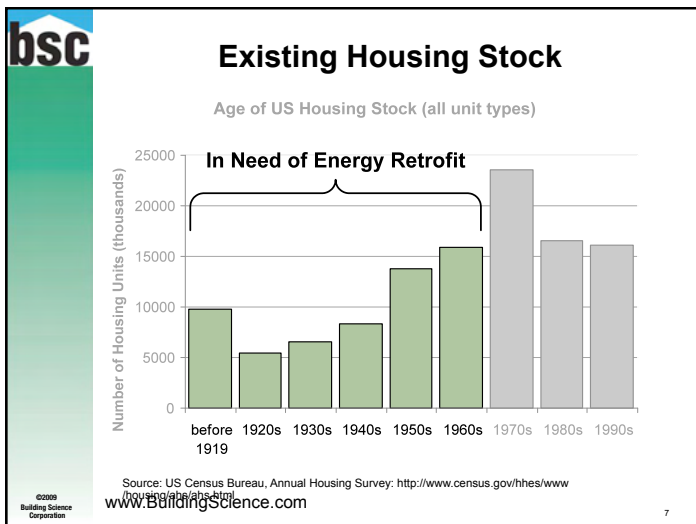
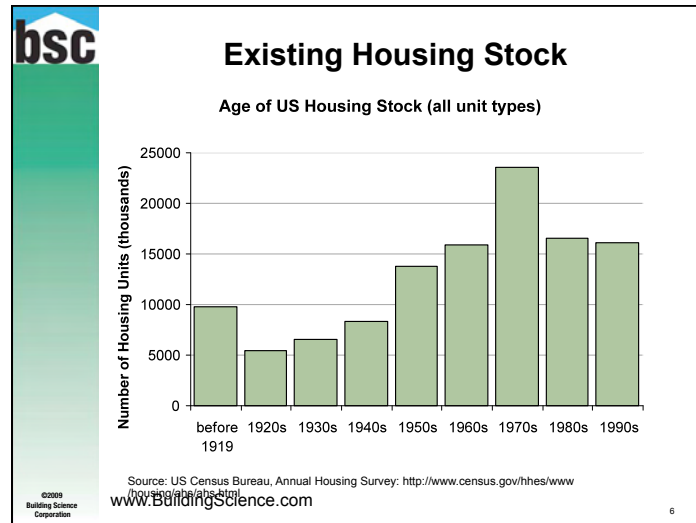
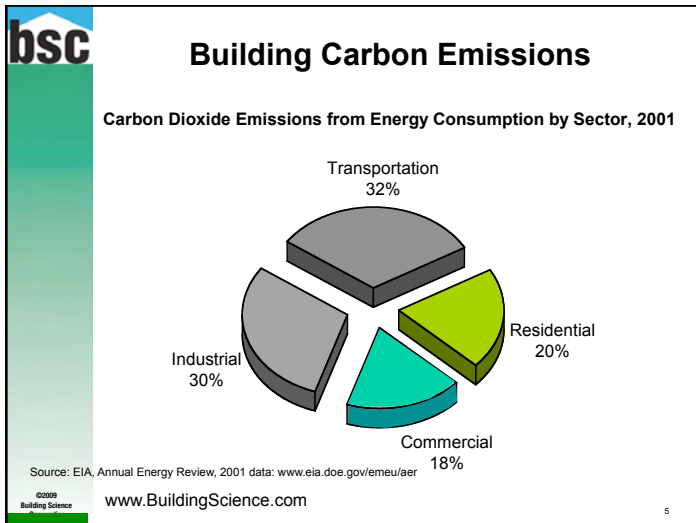
Primary Energy Consumption by Sector, 2001

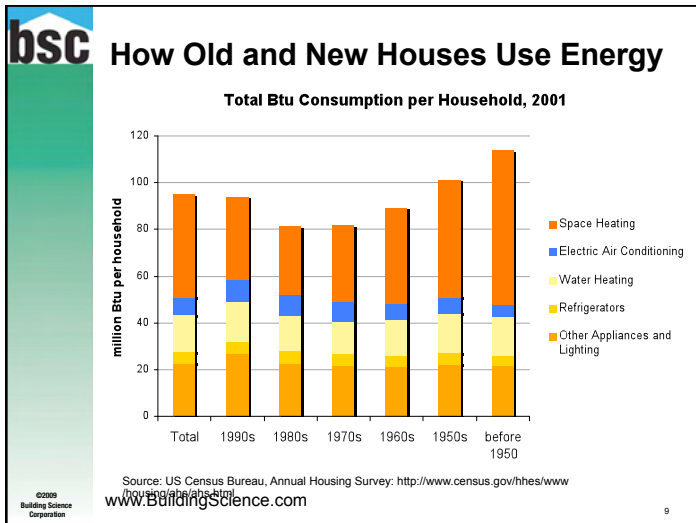


| | |
|----------------|-----|
| Industrial | 34% |
| Transportation | 27% |
| Residential | 21% |
| Commercial | 18% |

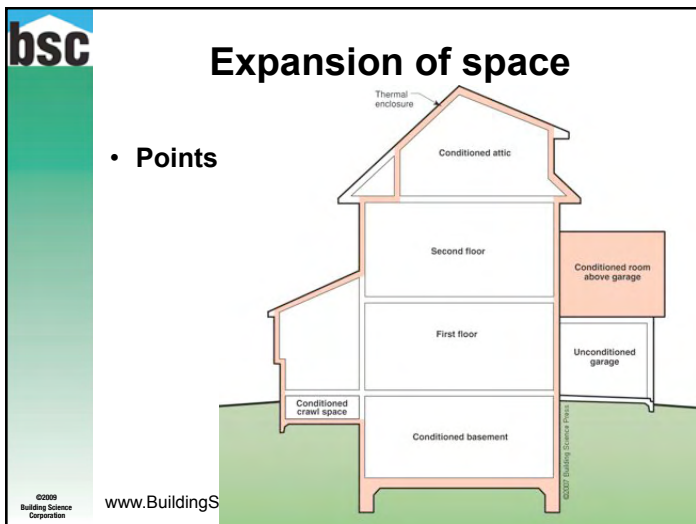
Source: EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/aer

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- ### bsc The Whole Building Approach
- Performance Issues driving Retrofit:
 - Comfort
 - More use
 - Health
 - Durability
 - Operating Costs
 - Energy Efficiency
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- ### bsc Choices
- Changing mechanical systems is least invasive
 - Lifespan is moderate, say (20 yrs)
 - 10% eff improvement = 10% operating savings = easy
 - Lighting and ventilation
 - Change is easy at any time
 - Lighting and controls payback quickly
 - Enclosures
 - Windows last 25-50 yrs
 - Insulation last 100+ yrs
 - Cladding lasts 35-200+ years
 - **MUST** have clear idea of enclosure upgrades **before** deciding on mechanical!
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Mechanical Retrofit

- **After enclosure upgrade**
 - Much smaller and quieter systems can be chosen
- **Air-based can be replaced with hydronic**
- **Steam-based can be replaced hotwater**
- **Low-temperature (more efficient) systems can be used**
- **For ventilations load add HRV**
- **Variable speed fans and CO₂ controls**

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Enclosure Retrofit

- **Important target for many buildings**
 - Airtightness
 - Windows
 - Insulation
 - Roof
 - Walls
 - Basement
 - Slabs
- **Prioritize by Ease and Impact**

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Deep Retrofit

Significant upgrades are incrementally less expensive

Small upgrades very cost effective, but small (10-25% reductions)

mid-range upgrades (15-50%) usually really expensive per energy saved

Deep retrofits (>50%) secure buildings future

Allow for new styles, use, etc.

Leap frog current housing

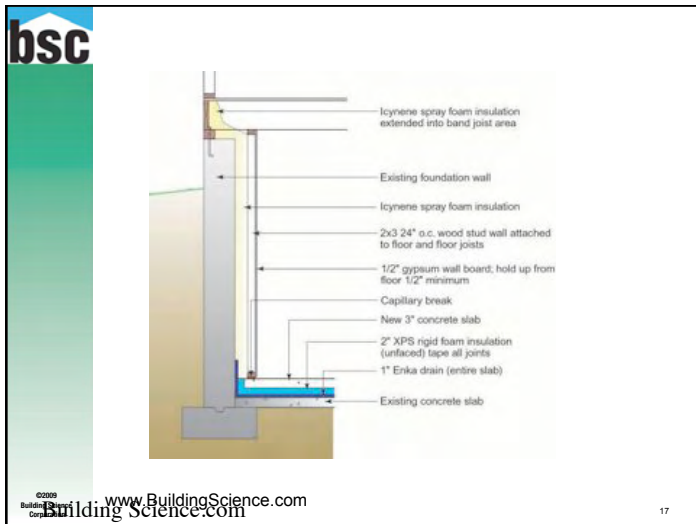
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Basements

- **Easy to retrofit and improve from the interior**
- **Ceiling height is the big restriction for slab solutions**

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Above grade walls

- Interior retrofit limits improvements to airtightness, rain control, thermal bridge
- Exterior allows excellent improvements and increased durability
- Windows should be done at the same time
- Installation cost \$200+/- so get good windows, eg vinyl triple glazed for \$30/sf

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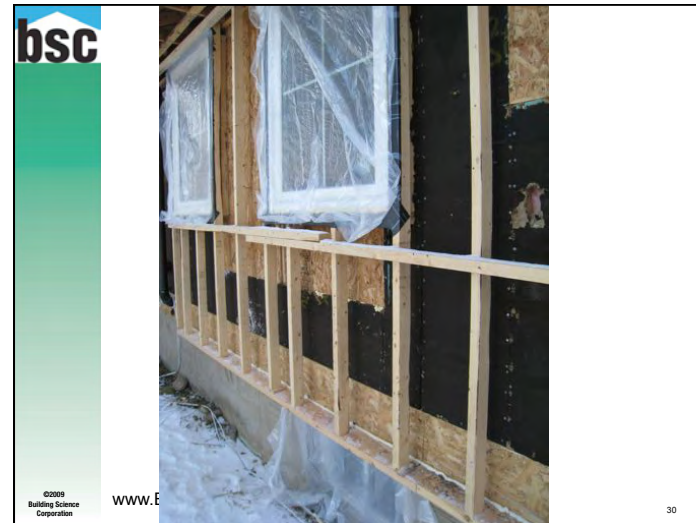
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Windows

- Important choice!
- Need better rain control
- Improved R-value of course

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A photograph of a man in a red shirt working on a window frame. He is using a tool to work on the frame, which is partially covered with a blue protective material. The interior of the house is visible through the opening, showing a staircase and some furniture.

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Fully Ventilated Attics

- **Can re-roof whenever, with whatever**
- **Deal with moisture, then add insulation**
 - Rain leaks, air leaks
- **If possible, keep ventilated attic**
 - Inspect ceiling plane, plug all holes with caulking and foam
 - Consider 1" of spray foam air barrier
 - Blow in minimum R60 cellulose, R75-R100 sensible

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Mechanicals

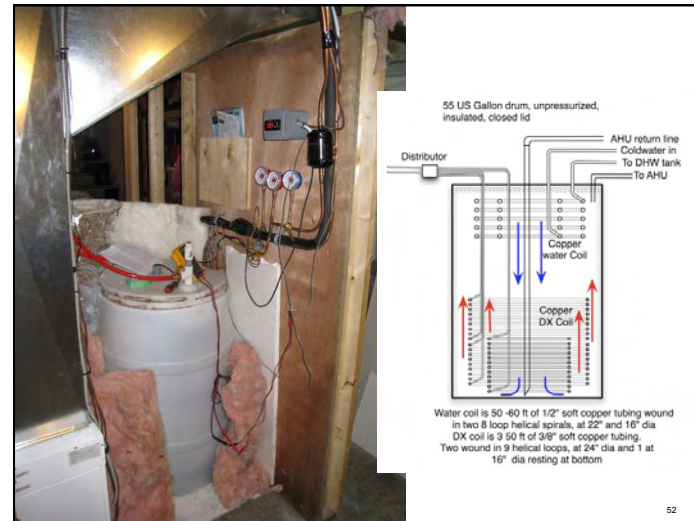
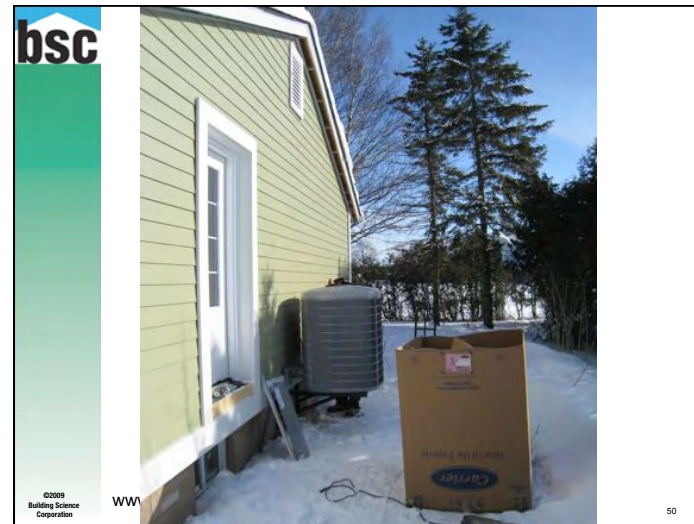
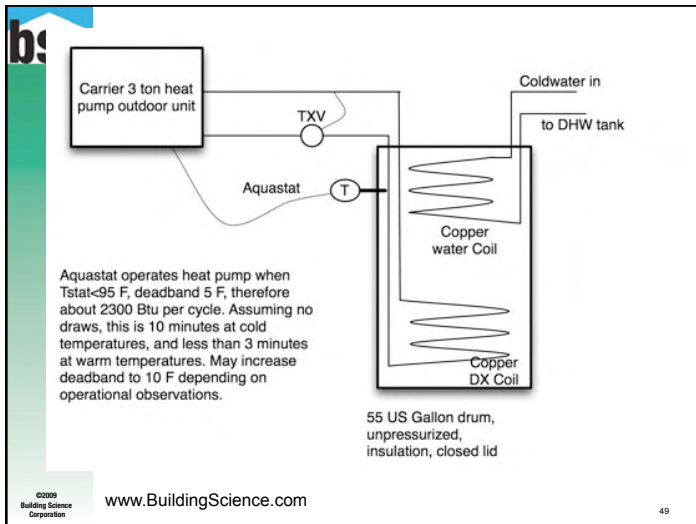
- **Definitely add mechanical ventilation**
- **Heat recovery now or later**
- **Remove and replace oil burners**
- **Natural gas is cheap and low carbon**
 - Even if it is only cheap for 10 yrs, NG pays
- **If you don't have natural gas**
 - Electricity via heat pumps
 - Heat via biomass boilers

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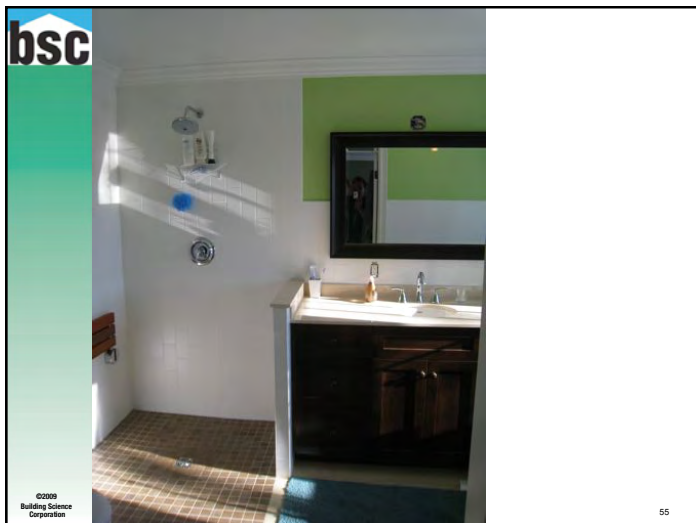
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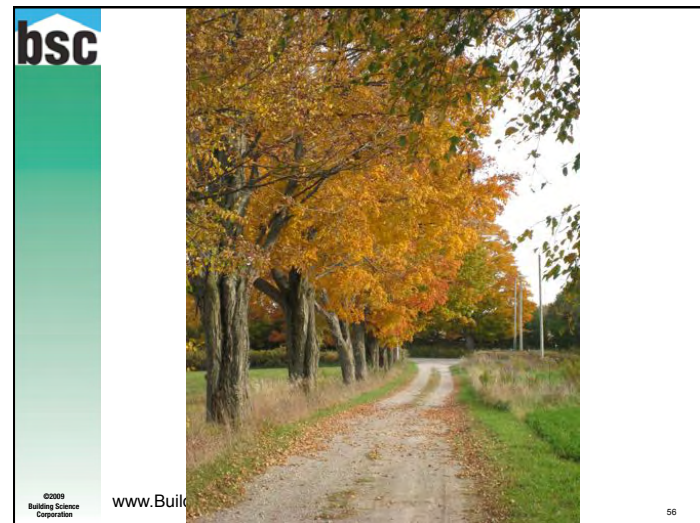


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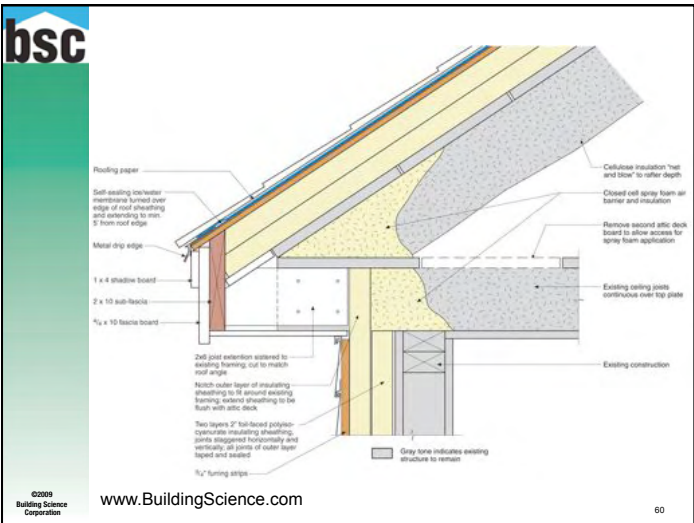
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Sloped Wood Roofs

- Usually require re-roofing and structural repair
- Deal with moisture, then add insulation
- If possible, keep ventilated attic
 - Inspect ceiling plane, plug all holes with caulking and foam
 - Consider 1" of spray foam air barrier
 - Blow in minimum R60 cellulose.
- If cathedral, insulate AND airtighten
 - Insulation on exterior is a benefit
 - airtighten

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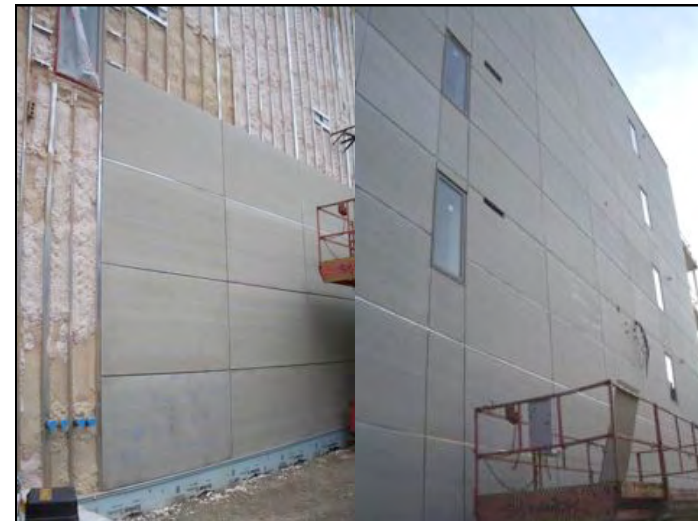


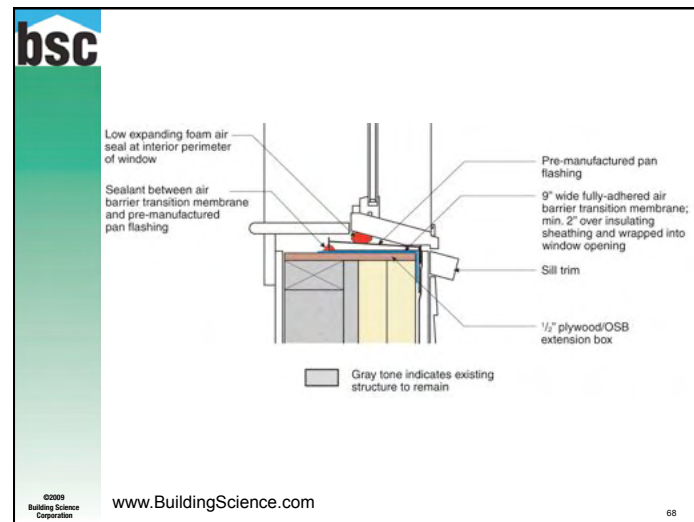
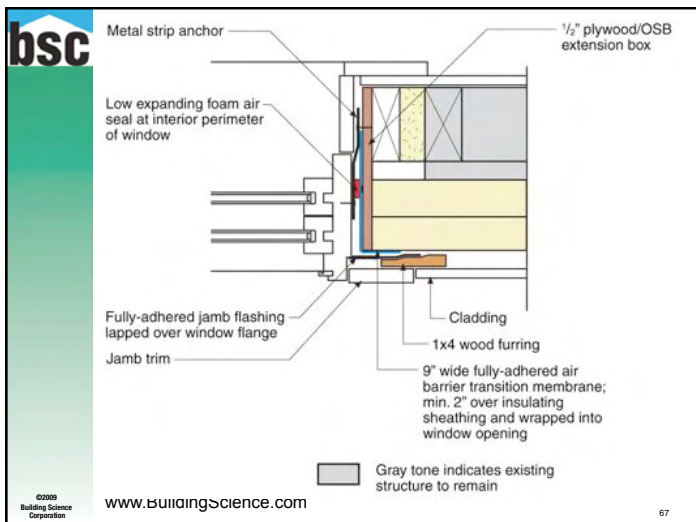
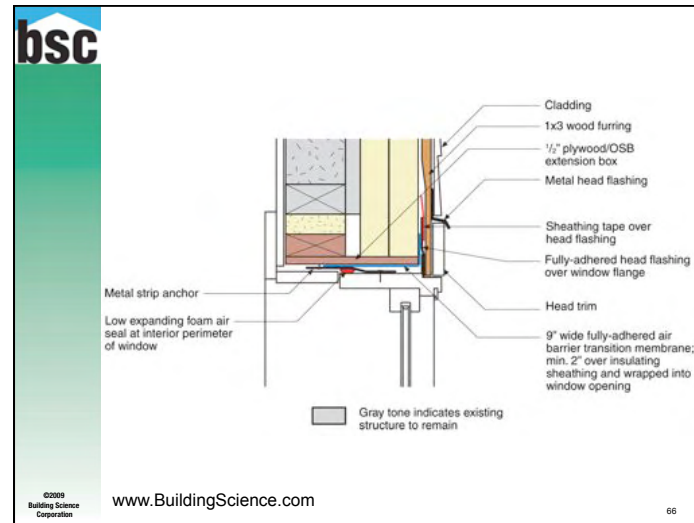
Other Exterior Retrofit

- Add board foam
- Needs extra care for airtightness
- More available in more places

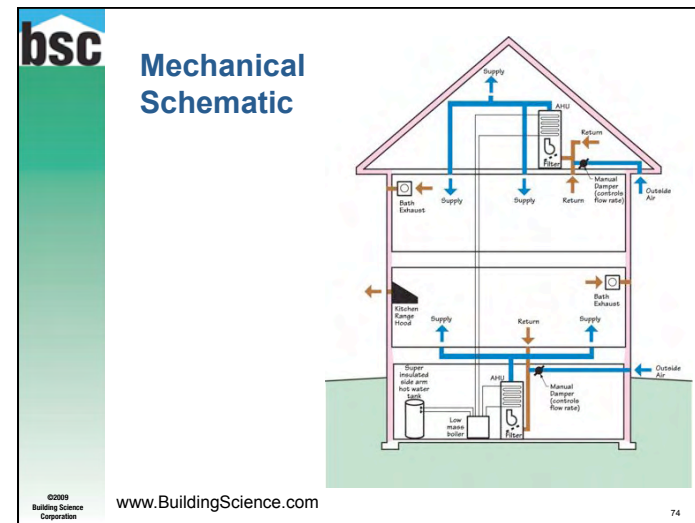
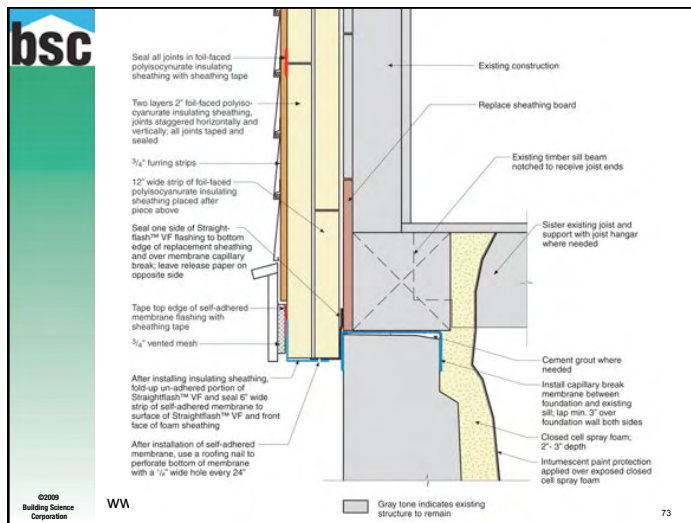
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New Build

- **Given normal construction**
- **Advanced framing**
- **Enclosure: 5/10/20/40/60 <math>< 2.0 @ 50</math>**
- **Mechanical ventilation**
- **Natural gas or electricity**

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Enclosure Design

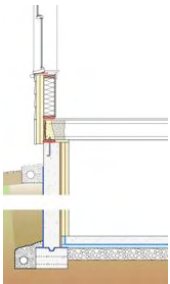
- R-60+ Cathedral Insulation (cellulose insulation with (2) 2" layers foil-faced polyisocyanurate insulating sheathing on roof sheathing)
- R75+ Ventilated attic
- R-40+ Walls (2x6 framing at 24" o.c. with cellulose insulation and (2) 2" layers foil-faced polyisocyanurate insulating sheathing)
- Windows R5+ (Low-E triple pane argon filled, $U = 0.18-0.21$ & $SHGC 0.25-0.40$)

Wall Section

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- **Enclosure Design**
 - R-20+ Basement Walls (R30+) R20 ICF + 2x4 R13 on interior or (3) 1.5" layers foil-faced polyisocyanurate insulating sheathing)
 - R-40+ Rim Joist Area (2"-3" spray foam air seal)
 - R-10 Basement Slab (2" XPS below slab)




Wall Section


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- **Mechanical Design**
 - 96%+ AFUE Gas Furnace -variable speed!!!
 - Condensing Water Heater -Microstorage
 - Energy Recovery Ventilator (ERV), low e, duty cycle



Fantech ERV




Goodman Furnace and Return Ductwork

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Conclusions



- **Low as practical energy use**
 - Air tighten
 - Insulate, externally if possible
 - Triple glazed windows
- **Increase durability, comfort and health**
- **Renewables, grid or site, can meet remainder**
 - Progress being made....
- **Avoid complex technology (unless pre-packaged)**
- **Allow for range of home owner involvement (most people don't want to twiddle their homes)**

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Other Overclad Options

- **Drained EIFS**
- **Drained & Ventilated metal sheets, panels, fiber cement**
- **Horizontal Lap Siding**

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