Building America U.S. Department of Energy Research Toward Zero Energy Homes

What Would I do?

www.buildingscience.com

John Straube, Ph.D., P.Eng
Building Science Corp & University of Waterloo

www.buildingscience.com

University of Waterloo

Better Buildings By Design 2010

Efficiency Vermont is a Registered Provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available on request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

www.BuildingScience.com 2

Learning Objectives

- **At the end of this program, participants will be able to:**
  - Understand process of decision making for energy efficiency.
  - Describe some new techniques for retrofit
  - Describe different mechanical systems
  - Proivde assemblies for super insulated homes

www.BuildingScience.com 3

The Whole Building Approach

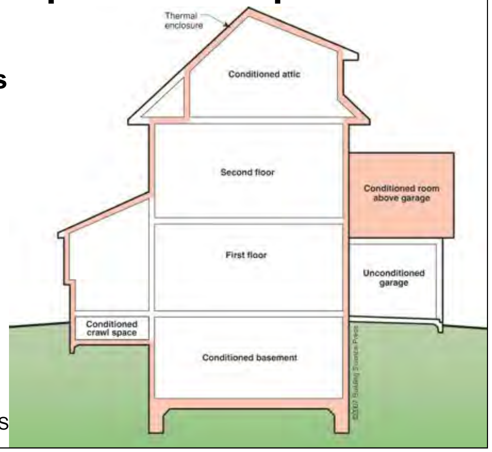
- **Performance Issues driving Retrofit:**
  - **Comfort**
  - **More use**
  - **Health**
  - **Durability**
  - **Operating Costs**
  - **Energy Efficiency**

www.BuildingScience.com

Building America U.S. Department of Energy Research Toward Zero Energy Homes

Expansion of space

- Points



www.BuildingS

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!**

www.BuildingScience.com

BSI-014

6

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 CO_2 controls**

www.BuildingScience.com

7

Enclosure Retrofit

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

www.BuildingScience.com

8

Deep Retrofit

Significant upgrades are incrementally less expensive

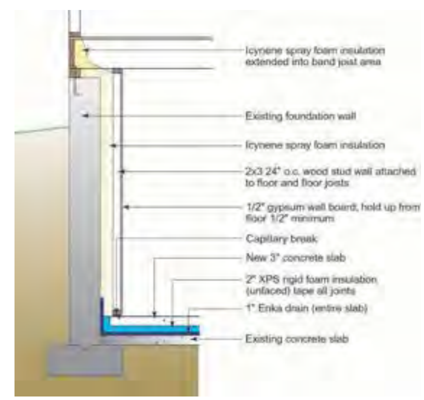
- Small upgrades very cost effective, but small (10-25% reductions)
- mid-range upgrades (15-50%) usually really expensive per energy saved

Deep retrofits (>50%) secure buildings future

- Allow for new styles, use, etc.
- Leap frog current housing

Basements

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



Building Science.com


Building Science Corporation
13


©2009
Building Science Corporation
www.BuildingScience.com
14


Building Science Corporation
15

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

www.BuildingScience.com

19

www.BuildingSci

20

bsc

www.B

21

bsc

www.BuildingScienc

22

bsc

www.BuildingScience.

23

bsc

www.B

24

Windows

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

www.BuildingScience.com

26

www.BuildingSc

28

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

www.BuildingScience.com

33

Airtightness

- **Tested when one wall not yet retrofit**
- **About 1 ACH@50 = 0.065 cfm/sf @50**
- **"Significant" leakage through basement slider windows**
- **No leakage at casement windows**

©2009 Building Science Corporation

www.BuildingScience.com

38

Mechanicals

- **Definitely need 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

©2009 Building Science Corporation

www.BuildingScience.com

39

- **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

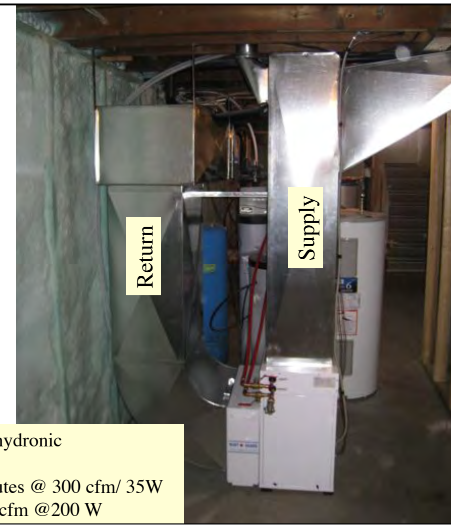
©2009 Building Science Corporation

www.BuildingScience.com

40

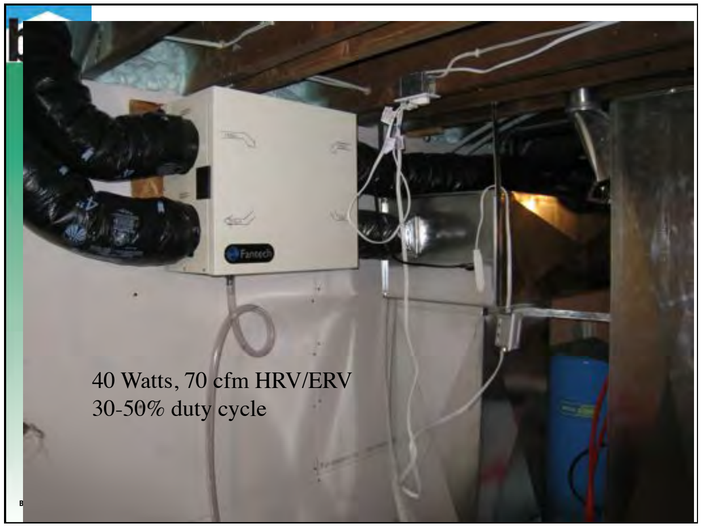
www.Build

41



Air handler with hydronic
coil and pump
Slow start: 8 minutes @ 300 cfm/ 35W
Htg Speed @650 cfm @200 W

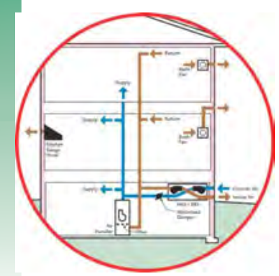
42



40 Watts, 70 cfm HRV/ERV
30-50% duty cycle

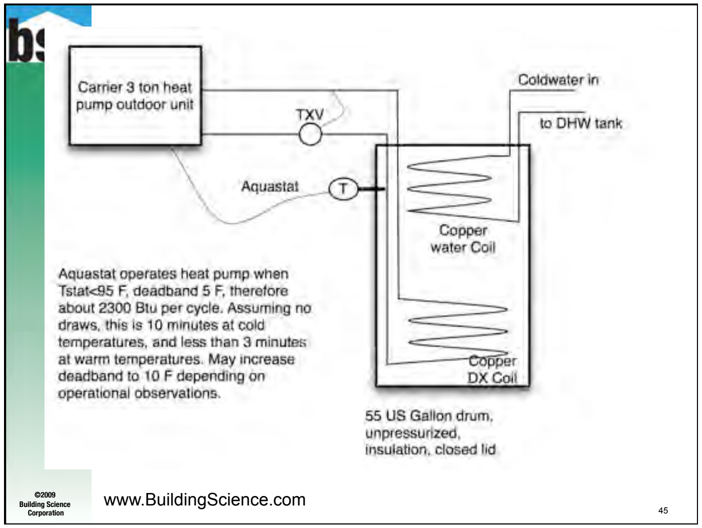
Ventilation

- Intermittent operation of HRV – 40W
- Couple with low speed ECM air handler - 35W
- Hourly average use under 30W



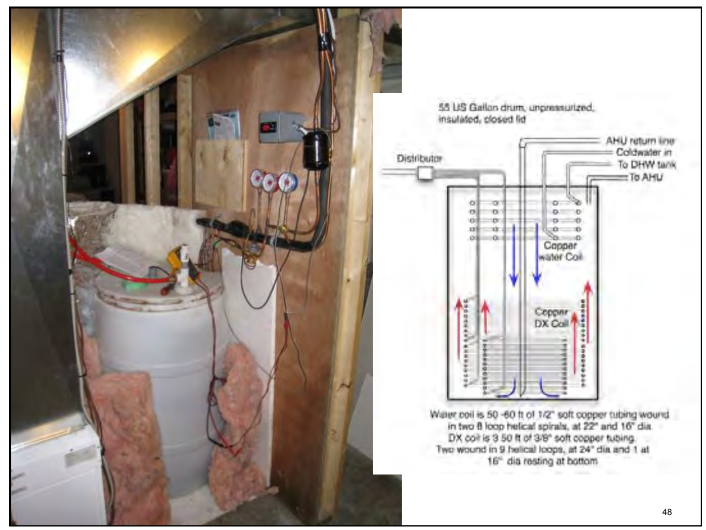
www.BuildingScience.com

44


Carrier 3 ton heat pump outdoor unit
TXV
Coldwater in
to DHW tank
Aquastat
T
Copper water Coil
Aquastat operates heat pump when Tstat<95 F, deadband 5 F, therefore about 2300 Btu per cycle. Assuming no draws, this is 10 minutes at cold temperatures, and less than 3 minutes at warm temperatures. May increase deadband to 10 F depending on operational observations.
Copper DX Coil
55 US Gallon drum, unpressurized, insulation, closed lid
©2009 Building Science Corporation
www.BuildingScience.com
45


©2009 Building Science Corporation
46


Building Science Corporation

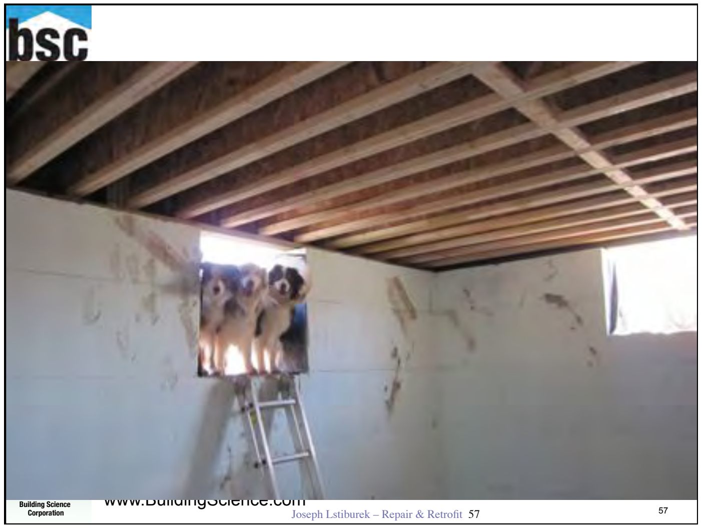

55 US Gallon drum, unpressurized, insulated, closed lid
Distributor
AHU return line
Coldwater in
To DHW tank
To AHU
Copper water Coil
Copper DX Coil
Water coil is 50 -60 ft of 1/2" soft copper tubing wound in two 8 loop helical spirals, at 22" and 16" dia
DX coil is 3 50 ft of 3/8" soft copper tubing.
Two wound in 9 helical loops, at 24" dia and 1 at 16" dia resting at bottom
48

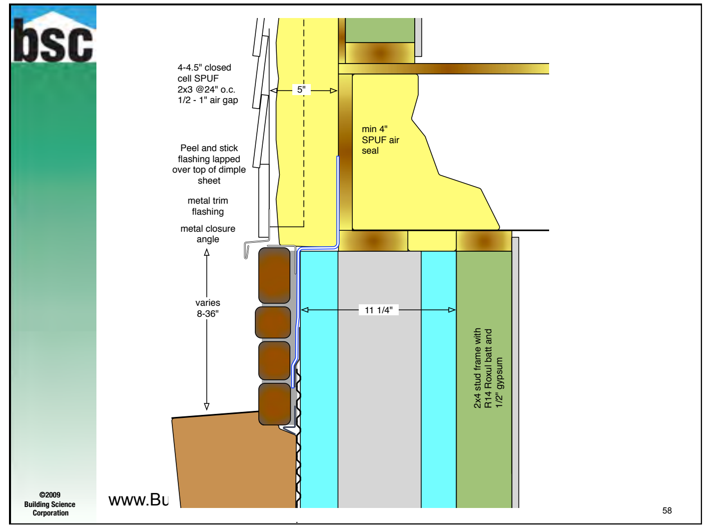
New Build

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

New Addition

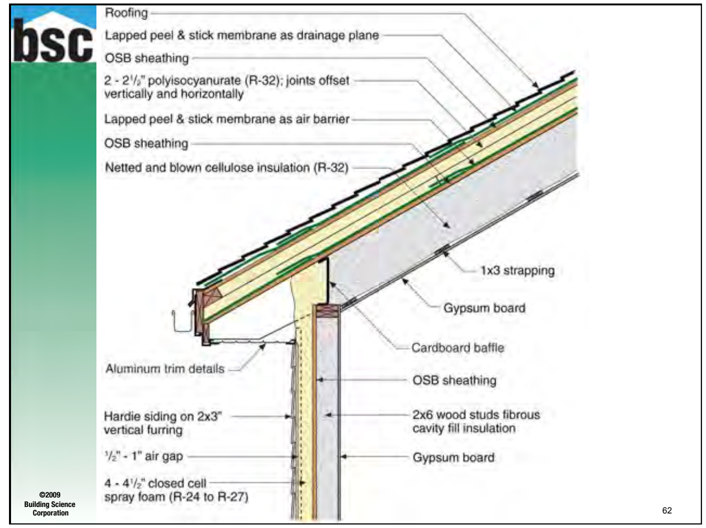
- Addition to provide new kitchen/living room and basement
- Same energy goals as retrofit
- ICF basement
- Wood frame above grade
- Unvented Cathedral


bsc
Building Science Corporation
www.BuildingScience.com
Joseph Lstiburek – Repair & Retrofit 57
57


bsc
4-4.5" closed cell SPUF 2x3 @24" o.c. 1/2 - 1" air gap
5"
min 4" SPUF air seal
Peel and stick flashing lapped over top of dimple sheet
metal trim flashing
metal closure angle
varies 8-36"
11 1/4"
2x4 stud frame with R14 Roxul batt and 1/2" gypsum
©2009 Building Science Corporation
www.Bu
58


bsc
©2009 Building Science Corporation
www.BuildingScience.com
59


Basement studded out, R14 Roxul


Roofing
Lapped peel & stick membrane as drainage plane
OSB sheathing
2 - 2½" polyisocyanurate (R-32); joints offset vertically and horizontally
Lapped peel & stick membrane as air barrier
OSB sheathing
Netted and blown cellulose insulation (R-32)
1x3 strapping
Gypsum board
Cardboard baffle
Aluminum trim details
OSB sheathing
Hardie siding on 2x3" vertical furring
2x6 wood studs fibrous cavity fill insulation
½" - 1" air gap
Gypsum board
4 - 4½" closed cell spray foam (R-24 to R-27)
©2009 Building Science Corporation
62


©2009 Building Science Corporation
www.BuildingScience.com


GRACE


©2009
71


bsc
©2009
Building Science
Corporation
www.BuildingScience.com
Joseph Lstiburek – Repair & Retrofit 75
75


bsc
Kitchen window


©2009
Building Science
Corporation
www.BuildingScience.com
Joseph Lstiburek – Repair & Retrofit 77
77


bsc
©2009
Building Science
Corporation
www.BuildingScience.com
Building
AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes