A Survey of High-Performance Building Retrofits in the North-East US

Andrew M. Shapiro, Energy Balance, In
Montpelier Vermont USA
andy@energybalance.us

With

Maclay Architects, Waitsfield, Vermont USA

Thomas Hartman, AIA, Coldham and Hartman
Amherst Massachusetts USA
tom@coldhamandhartman.com
North-East US vs Linz Austria Climate

Average Temperature, 2000-2008

- Boston
- Linz
- Montpelier VT

Bill Maclay, Principal
Maclay Architects
North-East US vs Linz Austria Climate

1% Cooling Conditions

Dry Bulb
Wet Bulb

Boston, Mass, US
Linz, Austria
Montpelier VT, US
BUILDING TYPE:
University Office and Classroom

SCOPE
Renovation of 1960’s era building & Addition

PROJECT SIZE  3,900 sq.m
PROJECT COST  $7,750,000 (562,000 Euro)
             $1,980 (1430 Euro)/sq.m

ENERGY INTENSITY (existing): 281 kWh/sq.m-a
ENERGY INTENSITY (modeled): 73 kWh/sq.m-a
MECHANICAL SYSTEMS:

- District heating and cooling from University system.
- Fan coils in offices, oversized so fan does not run for heating.
- Heat and moisture recovery ventilation.
- Occupancy control of temperature and ventilation
- Daylighting and occupancy control of lighting
Aiken Existing Detail at Floor Slab

\[ U = 1.4 \text{ W/sq.m-K} \]
U = 0.23 W/sq.m-K

Wall Section at Floor Slab - New Construction
MAXIMUM SHEAR BETWEEN MASONRY & WINDOW = \( \frac{1}{2} \) in. 
SPECIFY SEALANT WITH 100% EXTENSIBILITY IN \( \frac{1}{2} \) in. GAP 
(TREMCO SPECTRUM 1)
2: WINDOW HEAD- NEW CONSTRUCTION

- R-27 WALL
- BRICK MOVES UP MAX \( \frac{3}{4} \) in
- WALL & WINDOW DEFLECT DOWN UP TO \( \frac{1}{4} \) in MAX
- 1/2 in GAP FILLED WITH 100% EXTENSIBLE SEALANT (CAN EXTEND AND SHEAR 100% OF INSTALLED SIZE (ORIGINAL AT JAMB)

- AIR, MOISTURE & VAPOR BARRIER
- EXTERIOR FINISH
- INSULATION
- STRUCTURE
- INTERIOR FINISH
Bennington Downtown State Office Building
Bennington Downtown State Office Building

BUILDING TYPE: Historic Building, State Offices and Community College

SCOPE: Renovation & Addition

PROJECT SIZE: 2,200 sq.m, 45% new construction
PROJECT COST: $2,700,000 (1,957,000 Euro) in 2001
               $1280 (928 Euro) /sq.m.

ENERGY INTENSITY: 150 kWh/sq.m-a
MECHANICAL SYSTEMS:

• Earth coupled heat pump with gas backup; open loop due to very high water table, underground river only 8 m below surface
• Heat and moisture recovery ventilation
• Daylighting and occupancy control of lighting
Historic automotive showroom & garage

Contributing building to downtown historic district
• Historic industrial windows
• Retrofit with high-performance windows
• Masonry & parapet restoration
• Energy conservation
FIBERGLASS TRIPLE GLAZED LOW E ARGON FILLED WINDOWS

6.5” OF DENSE PACK CELLULOSE

GYPSUM BOARD WITH NO VAPOR BARRIER TO ALLOW FOR BRICK DRYING TO INTERIOR

1” PERMEABLE EPS INSULATION TO ISOLATE BRICK AND CELLULOSE

WOOD EXTERIOR (INSTEAD OF STEEL) WALL FRAMING TO MINIMIZE HEAT LOSS

NEW CONCRETE SLAB

VAPOR BARRIER

2” RIGID INSULATION WITH SLAB BREAK
REFLECTIVE WHITE TPO ROOFING
ZERO OZONE DEPLETING POLYISO INSULATION R-38
SPRAYED FOAM AT ROOF AND EXTERIOR WALL INTERSECTION FOR AIR SEALING
R-23 WALLS
HISTORIC BRICK EXTERIOR WALLS
RIGID INSULATION “RETURNS”
LIGHT GUIDING BLINDS FOR DAYLIGHTING
SOLAR CONTROLLED ROLLER SHADES
Measuring capillary uptake of brick – Building Science Corporation
www.buildingsscience.com
Photo 1: Measuring Brick Expansion Under Freeze/Thaw Cycling.
The graph shows the relationship between Strain ($\times 10^6$) and Degree of Saturation. The critical degree of saturation ($S_{crit}$) is 0.7.
Ross House:
Deep Energy Retrofit goes for Zero

Coldham & Hartman Architects
Location: Western Massachusetts
Ross House
BUILDING TYPE:
Older typical US Housing Stock
Wood frame, 1884

SCOPE: Deep Energy Retrofit + PV = Net Zero

PROJECT SIZE: 250 sq. m
PROJECT COST: $600,000 (435,000 Euro), including 12.4 kWp PV
$2400 (1740 Euro)/sq.m.

ENERGY INTENSITY: 33 kWh/sq.m-a
Existing House, built 1884
Retrofit Targets:

Walls: \( U = 0.17 \text{ W/m}^2\text{-K} \)
Roof: \( U = 0.11 \)
Windows: \( U = 1.0 \)
Earth: \( U = 0.28 \)

Air leakage rate: \( 0.3 \text{ m}^3/\text{sec} @ 50 \text{ Pa} \)
\hspace{1cm} 1.2 air changes @ 50 Pa

Energy use: \( 41 \text{ kWh/m}^2\text{-a} \)
ALL PENETRATIONS SEALED AND FLASHE TO DRAINAGE PLANE

SPRAY FOAM INSULATION CONTINUOUS TO UNDERSIDE OF EXISTING SUBFLOOR

5" SPRAY-APPLIED OPEN CELL FOAM

AIR SEALING KEY

ACTIVE AIR SEALING COMPONENTS (GREEN ELEMENTS)

- SPRAY SEALANT
- CONSTRUCTION ADHESIVE
- TAPED JOINT (AIR SEALING)
- BORDER OF AIR BARRIER SYSTEM

1 AIR BARRIER SYSTEM

1/2" = 1'-0"
FLASH TO EXTERIOR FACE OF RIGID FOAM

4" OPEN CELL POLYURETHANE SPRAY FOAM IN EXISTING STUD CAVITY (R-VALUE 3.6 / INCH TOTAL R-14 INSIDE) - PRIMARY AIR BARRIER
5/8" OSB WITH H-CLIPS - PRIME AND TAPE ALL SEAMS FOR PRIMARY AIR BARRIER AT ROOF PLANE - SEE 4/A5.2

(2) LAYERS 1.5" POLYISO, STAGGERED, TAPE AS DRAINAGE PLANE AND SECONDARY AIR BARRIER

CARRY INSIDE LAYER OF RIGID FOAM TO UNDERSIDE OF ROOF DECKING
HOLD BACK 1/8" FILL GAP WITH CONTINUOUS BEAD SPRAY FOAM

(2) LAYERS 1.5" FOIL-FACED POLYISOXYANURATE - R-6.5/INCH
STAGGERED AND TAPE TO PROVIDE SECONDARY AIR BARRIER

SPRAY FOAM UP INTO JOIST BAYS TO ENSURE CONTINUOUS PRIMARY AIR BARRIER FROM FLOOR TO FLOOR
Open cell urethane spray foam in stud wall cavities

First layer of foil-faced isocyanurate exterior foam
12.4 kW PV system
Daikin VRV heat Pump system
Steibel Eltron heat pump water heater
Venmar Eko EC Motor heat recovery ventilation
Other Vermont Projects

Pill House – net zero with wind power, First NESEA Net Zero Award

Putney School Field House – Net Zero with PV

State of Vermont Courthouse & Offices, Deep Energy Retrofit