Whitchurch Passive House Cottage

Middlesex VT
Cellulose TJI Curtain Wall over Timber Frame

PH Buildings use 90% less energy than code built Building in the USA
That's almost 100% !!!!
Design Brainstorming

This is TinyURL.com/PHIUSCottage
The shorter album is TinyURL.com/PHIUSCottageDisplay
Design/Build Team Goals

- Sustainable, Robust and Resilient assemblies
Sustainable Locally milled Lumber
Timber Frame Raising
Hemlock air dried frame
Design/Build Team Goals

- Sustainable, Robust and Resilient assemblies
- Energy Modeling – PHPP- Therm - WUFI
Design/Build Team Goals

- Sustainable, Robust and Resilient assemblies
- Energy Modeling – PHPP- Therm – WUFI
- PHUIS+ Certification
The Five Principles

1. Superinsulated
2. Air Tight
3. Thermal Bridge Free
Thermal Envelope
## Thermal Envelope R-Values

<table>
<thead>
<tr>
<th>#</th>
<th>Assembly Description</th>
<th>Total Thickness</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>wall section</td>
<td>16.8 in</td>
<td>56.2</td>
</tr>
<tr>
<td>2</td>
<td>roof</td>
<td>25.0 in</td>
<td>77.4</td>
</tr>
<tr>
<td>3</td>
<td>basement wall</td>
<td>24.0 in</td>
<td>65.3</td>
</tr>
<tr>
<td>4</td>
<td>slab</td>
<td>12.0 in</td>
<td>33.3</td>
</tr>
<tr>
<td>5</td>
<td>footing</td>
<td>16.0 in</td>
<td>35.9</td>
</tr>
<tr>
<td>6</td>
<td>Basement wall</td>
<td>24.0 in</td>
<td>63.9</td>
</tr>
<tr>
<td>7</td>
<td>door</td>
<td>5.5 in</td>
<td>18.7</td>
</tr>
</tbody>
</table>
Wall to Foundation

- Vertical 1 x 2 hemlock battens on flanges
- Horizontal 1 1/2 x 4 hemlock battens control pilloing
- Vertical 3/4" cedar T&G sheathing
- DB+
- 3/4" T&VG cedar sheathing
- 2" hemlock spacer
- 6 x 8 joists on 3' ctrs.
- 2 x 8 T&G hemlock floor
- Capillary break
- Colphene (by Suprema)
- Solitex Mento 1000
- Cor-A-Vent
- Platon
- Grade
- 16" EPS
- 8" Concrete
- Backfill
- 22 psi EPS
- Radon/vapor barrier

Whitchurch Cottage Elevation of wall-to-foundation interface 130511
Wall section

- Hemlock timber frame
- DB+ air barrier
- Cedar interior finish
- Vertical TJI
- Dense pack cellulose
- Solitex mento WRB
- 2x3 hemlock perlins
- White cedar siding
Wall to Roof

- EPDM roof
- homosote
- hemlock roof deck
- 22" cellulose
- 2x6 rough sawn
- 16" TJI
- intello air barrier
- pine ceiling
- timber frame
- cedar cladding
- DB+ air barrier
- 16" TJI
- dense pack cellulose
- solitex mento WRB
# Heat Demand @ 0.6 ACH 50

## Energy Demands with Reference to the Treated Floor Area

<table>
<thead>
<tr>
<th>Treated Floor Area:</th>
<th>1436 ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Space Heat Demand:</strong></td>
<td>4.01 kBTU/(ft²yr)</td>
</tr>
<tr>
<td><strong>Pressurization Test Result:</strong></td>
<td>0.60 ACH₅₀</td>
</tr>
<tr>
<td><strong>Specific Primary Energy Demand</strong> (DHW, Heating, Cooling, Auxiliary and Household Electricity):</td>
<td>29.0 kBTU/(ft²yr)</td>
</tr>
<tr>
<td><strong>Specific Primary Energy Demand</strong> (DHW, Heating and Auxiliary Electricity):</td>
<td>14.4 kBTU/(ft²yr)</td>
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<tr>
<td><strong>Specific Primary Energy Demand</strong> Energy Conservation by Solar Electricity:</td>
<td>0.0 kBTU/(ft²yr)</td>
</tr>
<tr>
<td><strong>Heating Load:</strong></td>
<td>3.49 BTU/(ft²hr)</td>
</tr>
<tr>
<td><strong>Frequency of Overheating:</strong></td>
<td>over 77.0°F</td>
</tr>
<tr>
<td><strong>Specific Useful Cooling Energy Demand:</strong></td>
<td>0.77 kBTU/(ft²yr)</td>
</tr>
<tr>
<td><strong>Cooling Load:</strong></td>
<td>2.37 BTU/(ft²hr)</td>
</tr>
<tr>
<td><strong>PH Certificate:</strong></td>
<td>4.75 kBTU/(ft²yr)</td>
</tr>
<tr>
<td><strong>Fulfilled?</strong></td>
<td>Yes</td>
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<tr>
<td><strong>Monthly Method</strong></td>
<td>0.6 ACH₅₀</td>
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<tr>
<td><strong>Fulfilled?</strong></td>
<td>Yes</td>
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</tbody>
</table>
## Energy Demands with Reference to the Treated Floor Area

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</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Space Heat Demand:</strong></td>
<td>3.56 kBTU/(ft²·yr)</td>
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<tr>
<td><strong>Pressurization Test Result:</strong></td>
<td>0.28 ACH₅₀</td>
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<td><strong>Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):</strong></td>
<td>29.0 kBTU/(ft²·yr)</td>
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<tr>
<td><strong>Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):</strong></td>
<td>14.5 kBTU/(ft²·yr)</td>
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<tr>
<td><strong>Specific Primary Energy Demand Energy Conservation by Solar Electricity:</strong></td>
<td>0.0 kBTU/(ft²·yr)</td>
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<tr>
<td><strong>Heating Load:</strong></td>
<td>3.14 BTU/(ft²·hr)</td>
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<tr>
<td><strong>Frequency of Overheating:</strong></td>
<td>%</td>
</tr>
<tr>
<td><strong>Specific Useful Cooling Energy Demand:</strong></td>
<td>0.77 kBTU/(ft²·yr)</td>
</tr>
<tr>
<td><strong>Cooling Load:</strong></td>
<td>2.37 BTU/(ft²·hr)</td>
</tr>
</tbody>
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Heat Demand at Different Levels of Airtightness

Heating Demand (in °C) vs. Air Change per Hour (ACH)

- 0.2 ACH: 2°C
- 0.4 ACH: 4°C
- 0.6 ACH: 6°C
- 0.8 ACH: 8°C
- 1 ACH: 10°C
- 1.2 ACH: 12°C
- 1.4 ACH: 14°C
- 1.6 ACH: 16°C
- 1.8 ACH: 18°C
- 2 ACH: 20°C
- 2.2 ACH: 22°C
- 2.4 ACH: 24°C
- 2.6 ACH: 26°C
- 2.8 ACH: 28°C
- 3 ACH: 30°C
- 4 ACH: 40°C
- 5 ACH: 50°C
- 6 ACH: 60°C
- 7 ACH: 70°C
- 8 ACH: 80°C
- 9 ACH: 90°C
- 10 ACH: 100°C

Legend: Heat Demand
## Results

Limit: Air Leakage @ 50 Pa $\leq 0.6 \text{ ACH}_{50}$
Goal: Air Leakage @ 50 Pa $\leq 0.4 \text{ ACH}_{50}$

For a 1500 ft$^2$ building with net volume 15,000 ft$^3$

<table>
<thead>
<tr>
<th>Level</th>
<th>Effective Leakage Area</th>
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<tbody>
<tr>
<td>10 ACH$_{50}$</td>
<td>125 in$^2$</td>
</tr>
<tr>
<td>3.0 ACH$_{50}$</td>
<td>40 in$^2$</td>
</tr>
<tr>
<td>0.6 ACH$_{50}$</td>
<td>8 in$^2$</td>
</tr>
<tr>
<td>0.3 ACH$_{50}$</td>
<td>4 in$^2$</td>
</tr>
</tbody>
</table>

For whole building integrity, know where your holes are!

Note: The Passive House Retrofit standard allows an Air Leakage @ 50 Pa $\leq 1.0 \text{ ACH}_{50}$ due to potential retrofit difficulties.
Footer Foam Insulation

8" EPS 44 psi R 4.3/in and concrete R.07/in total R -35.9
Air Barrier-Vapor/Radon Retarder --Ready for Pour

10 ml Stego Plastic sheeting  .0254 Perms
Foam Slab Insulation

8” EPS R4/in and concrete R.07/in Total R 34
Spray foam the foam !!
Taping the continues ATL-Radon/vapor retarder

Foundation air tightness layer ATL
Slab ATL installed

With reinforced center pad for center post
Foundation Wall ATL

Air seal taped to footer ATL and running up to Timber sill plate
Foundation foam

Walls R-65
Foundation foam
Interior Paneling
Wall Paneling

\[\frac{3}{4} \text{ " KD - T&G White Cedar}\]
Window Buck

¾" Fir plywood
Un-Vented 22” DP Cellulose Flat EDPM Roof Assembly
Conditions: Pre Certified PHIUS

• The science behind moisture migration and retention and ASHRAE Handbook
• information
• Published data and analysis using WUFI modeling software
• Field data from independent studies performed in similar climates on similar structures and assemblies
• The method and care of the installation
• The monitoring plan and implementation observed
Ceiling Paneling – Joint and Seam sealer
2 x 8 KD T&G Pine
Ceiling ATL-Air Barrier-Vapor Control Layer VCL

Highly Variable perm  0.17 Perm to 13.20 Perm
Pressure Activated taping
Done with a "P A D"
Predrill – Tape Air Seal Gasket
16 " TJL
Acrylic Air Sealing caulk

A caulk made of Natural latex, Tree resin, casein, talc, cellulose and water with Long term elasticity combined with high strength and resistance to tension
6” timber locs
16” OC
Insul-web netting

Separates 2 x 6 upper cavity from TJL cavity below
Roof Deck

KD Pine 5/4 x 10
South Eve
TJI overhang
East Eve

2 x 6 overhang
WRB Bulk Water

24’ x 24’ WRB Vapor open 38 perm, Class 111 and water closed over insulation envelope
Water Management – Gravel Stop Drip Edge

NW and NE corners
Wall Assembly
Window Bucks --Liquid Applied WRB
Acrylic and vapor open, Applied to outer 6” of Window bucks
Joint and Seam sealer
Acrylic and Vapor open, Applied to Window Buck seams and TJI attachment locations
Jumping Air barrier from foundation to wall

Used Pro Clima DA-S to jump air barrier from Stego along Sill plate to outside of wall paneling.
Pro Clima DB+
Variable perm ATL Air Barrier and Vapor Control Layer VCL
Taped and ready for TJI
TJI Attachment

7” Head Locs --
EDPM CUSTOM ROOFING GASKET
Completed Utility Chase Penetrations
CERV Duct Penetrations
Insulated Utility Chase and The Bridge/Skywalk
Utility Chase - Super Insulated-Air tight
WRB / Vented Rain Plane
Fly-Batten Detail
Pre DP Cellulose &
Window Air Leakage Test
1st Air Leakage Test    .123 ACH50

26 cfm@50 x 60 / Net Enclosed Volume 12,716 cuft
Cellulose DP Install -- 460 bales
3.8 lbs/cuft. = 5.75 tons @ 8 day install
Siding - Soffit Vent - Posts
Soffit Venting
Window Delivery
7 x 10  574 lbs.
Interior
Air seal Taping
Connecting Air Barrier
Foundation Air Barrier to Window
Buck/Bow to Window
Window sill Pans
2nd Air Leakage Test

45cfm@50 or .212 ACH50
Post Window Install, Plastic over 2nd Door opening
42% increase in air leakage from window install
19 cfm @ 50 or .089 ACH50
Site built PH
Viking doors
Multi point latching
4” recycled Poly ISO
North Wall
Center Roof Sensor Location
Perspective looking west along south facade
Final RESNET Testing Day !!!
### Optional preliminary blower door test (manual or automated test)

<p>| | | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td>8</td>
<td>Passive House Volume</td>
<td>12625</td>
</tr>
<tr>
<td>8.1</td>
<td>CFM50 test result - depressurization</td>
<td>26</td>
</tr>
<tr>
<td>8.2</td>
<td>ACH50 - depressurization</td>
<td>0.12</td>
</tr>
<tr>
<td>8.3</td>
<td>CFM50 test result - pressurization</td>
<td>0</td>
</tr>
<tr>
<td>8.4</td>
<td>ACH50 - pressurization</td>
<td>0.00</td>
</tr>
<tr>
<td>8.5</td>
<td>Average CFM50</td>
<td>13</td>
</tr>
<tr>
<td>8.6</td>
<td>Passive House ACH50</td>
<td>0.06</td>
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</table>

### Final blower door test

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>9</td>
<td>Passive House Volume</td>
<td>12625</td>
</tr>
<tr>
<td>9.1</td>
<td>CFM50 test result - depressurization</td>
<td>47</td>
</tr>
<tr>
<td>9.2</td>
<td>ACH50 - depressurization</td>
<td>0.22</td>
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<tr>
<td>9.3</td>
<td>CFM50 test result - pressurization</td>
<td>71</td>
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<tr>
<td>9.4</td>
<td>ACH50 - pressurization</td>
<td>0.34</td>
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<tr>
<td>9.5</td>
<td>Average CFM50</td>
<td>59</td>
</tr>
<tr>
<td>9.6</td>
<td>Passive House ACH50</td>
<td>0.3</td>
</tr>
</tbody>
</table>

9.8 Testing reports from automated testing software (typically, Tectite or Fantestic) included in documentation folder

Pass
Wall Sensors and Moisture Meter Extensions
North Wall
South Wall
Roof Sensors
Powerwise Board

RH, Temp and Moisture probe imbedded in fiber board layer
Homosote Fiber board

½” base layer for EDPM roof
Sensor locations

Looking north east
DP Cellulose Roof Envelope Sensors and Moisture Meter Extensions
36” x 16” Roof Cavity
NE Roof Sensor, 60” up rake from North wall
Chris in a 16" TJI DPC roof cavity to install sensors

2 x 8 T&G pine ceiling

1.125" x 8" kiln-dried pine deck

2 x 6 kiln-dried hemlock

==== insulweb

2013.10.18 15:09
Center Roof
Outer Powerwise sensor and Moisture Meter probe extensions
Center Roof Inner Powerwise and wire gasket in ceiling
Center Roof
Center Roof Sensor Location
NE Roof Sensor Location

Powerwise cables run to Center Roof and Showing are Moisture Meter Extensions