PHIUS Climate Specific Criteria

PASSIVE STANDARDS IN VARYING CLIMATES

Seattle
- State: WA
- Location: Tacoma Intl AP
- Zone: 4C
- Annual Heating Demand: 5.4
- Annual Cooling Demand: 1
- Peak Heating Load Btu/ft²: 3.3
- Peak Cooling Load Btu/ft²: 3.4
- Manual J Peak Heating: 5.6
- Manual J Peak Cooling: 4.8
<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Demand (Site)</td>
<td>1 - 12 kBTU/Ft2-YR</td>
</tr>
<tr>
<td>Cooling Demand (Site)</td>
<td>1 - 21.4 kBTU/Ft2-YR</td>
</tr>
<tr>
<td>Peak Heat Load</td>
<td>0.8 - 5.4 BTU/Ft2-Hr</td>
</tr>
<tr>
<td>Peak Cooling Load</td>
<td>1.8 - 8.9 BTU/Ft2-Hr</td>
</tr>
<tr>
<td>Total Energy Demand (Source)</td>
<td>Beds+1 / 6200 kWh/PERSON-YR (Temporary)</td>
</tr>
<tr>
<td></td>
<td>Beds+1 / 4200 kWh/PERSON-YR (Future)</td>
</tr>
<tr>
<td>Air Tightness</td>
<td>0.05 cfm/gross sqft shell @ 50 pa</td>
</tr>
<tr>
<td></td>
<td>0.08 cfm/gross sqft shell @ 75 pa</td>
</tr>
</tbody>
</table>

Climate Specific: Warren VT
Heating Demand: **7.50 kBTU/ft2-yr**
Heating Load: **5.10 BTU/hr-ft2**
PH New Construction Projects in Vermont

Affordable Senior Housing
Elm Place - Milton VT

Habitat for Humanity
East Montpelier
PH New Multifamily Project in Vermont
Built in the early 70’s. Simple in construction.
Slab on grade floor without insulation.
Inexpensive widows.
Full size sliding door on patio.
Fiberglass insulation, Fireplace in great room and cathedral ceilings with no attic.
Fully shaded in the woods.
The 516 gallon of propane usage at 62-65 degrees in a 1440 sq ft home indicated the boiler was running often to keep up.

The 2 bathrooms have poor ventilation with potential to mold formation. One fan was pulling only 6-10 CFM, while a BR-fan should be pulling 50-80 CFM.
51 Upper Pines – Warren VT
Initial Condition

Thermal Bridges Everywhere
51 Upper Pines – Warren VT
Initial Condition

Thermal Bridges Everywhere
51 Upper Pines – Warren VT
Initial Condition

Air Leaks Everywhere

Initial BDT came to 1740 CFM
A lot of infiltration for a 1440 ft² house
- 1st Phase – Roof repair, insulation and new metal roof – Fall 2015

- 2nd Phase – Floor removal, slab and frost wall insulation, new floor – Summer 2016

- 3rd Phase – Air sealing, walls insulation, new windows and ventilation system – Spring 2017
51 Upper Pines – Warren VT
1st Phase Implementation

Energy Balance with PHPP – Climate Input

Climate Specific: Warren VT

Heating Demand: 7.50 kBTU/ft2-yr
Heating Load: 5.10 BTU/hr-ft2
ENERGY BALANCE
Finding the right R-value

Assemblies’ R-Value Calculation

<table>
<thead>
<tr>
<th>Assembly no.</th>
<th>Building assembly description</th>
<th>Interior insulation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Roof</td>
<td></td>
</tr>
</tbody>
</table>

Surface Film Resistance [hr.ft²°F/BTU]
- interior Rsi: 0.57
- exterior Rse: 0.23

<table>
<thead>
<tr>
<th>Area section 1</th>
<th>R per inch</th>
<th>Area section 2 (optional)</th>
<th>R per inch</th>
<th>Area section 3 (optional)</th>
<th>R per inch</th>
<th>Thickness [in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. T&amp;G board</td>
<td>1.280</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.500</td>
</tr>
<tr>
<td>2. Glass-Fiber Batts</td>
<td>3.330</td>
<td>sleepers 24&quot; OC</td>
<td>1.280</td>
<td></td>
<td></td>
<td>1.500</td>
</tr>
<tr>
<td>3. Plywood</td>
<td>1.470</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.500</td>
</tr>
<tr>
<td>4. Polyiso unfaced</td>
<td>6.200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.000</td>
</tr>
<tr>
<td>5. OSB</td>
<td>1.390</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.625</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
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</tr>
</tbody>
</table>

Percentage of sec. 1: 75%
Percentage of sec. 2: 25.0%
Percentage of sec. 3:                      Total: 16.13 in

U-value supplement: BTU/hr.ft²°F
R-Value: 82.6 hr.ft²°F/BTU
ENERGY BALANCE
COMPILING ENERGY LOSSES

Thermal Bridges’ input
Each one positive or negative is accounted for

Thermal Bridge Report
Project: 51 Pines - Waren VT - EnerPHit

U-value Floor U1 0.7999 Btu/hr*ft²*F
U-value Wall U2 0.0177 Btu/hr*ft²*F
Ufactor (2D) THERM 0.0666 Btu/hr*ft²*F

Ψe for PHPP -0.769 Btu/hr*ft²*F
Evaluating the insulated wall as was being prescribed along with the uninsulated slab, the results are a large negative thermal bridge that can mislead the energy balance.
Mechanicals for supplemental heating/cooling & ventilation

**Heating / Cooling**
- Fujitsu 12000 BTU – Single Source located in the living room

**Ventilation**
- Lunos e² – Two pairs located in the bedrooms and living room
- Lunos eGO – One unit in each bathroom
The Passive House Retrofit has a heating demand of only 7655 kBTU/yr for 1440 sqft floor home and a Peak Heat Load of 5139 BTU/hr.
First Phase of the Project
The Roof Overhaul
First of 7 lifts
ISO sealed to insulation box

All Joints Carefully Taped
First Phase of the Project
The Roof Overhaul

12” PolyIso for R-83 Finished Roof
First Phase of the Project
Finished Roof

12” Polyliso for R-83 Finished Roof
Execution of Second Phase
Inside Slab Insulation

Remove Old Floor and cover Slab with 5” of PolyIso
Execution of Second Phase
Inside Slab Insulation

Interior floor plywood over ISO board
Execution of Second Phase
Inside Slab Insulation

Joints and perimeter air sealed
Execution of Second Phase
Finished Floor
Execution of Second Phase
Outside Frost-Wall Insulation

**Dig Trench and cover Frost Wall with 6” of XPS**
Execution of Second Phase
Foundation Insulation Complete
Foundation/floor insulated & Heat pump installed
End Phase II
Begin Phase III
Sheathing Removed At South Wall
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rear at chimney, actual insulation
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rear and West wall sill repair
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

East wall cantilevered beam fixed
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Naked with air sealing at joints
Third Phase
Air-Sealing/Insulation of Walls
and Replacement of Windows

stud with tape
Third Phase
Air-Sealing/Insulation of Walls
and Replacement of Windows

stud with tape
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

All joints sealed with tape
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

All joints/studs sealed with tape
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Insulation
Dam Rear
Wall Chimney
Cavity
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

East Side air sealed
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Taped joints overlapped corners
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rear wall SPF complete
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

East wall foam complete
Third Phase
Air-Sealing/Insulation of Walls
and Replacement of Windows

Rough opening prep
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Sill, membrane, window
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Air and water sealed
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

South Wall Partially Foamed
Third Phase
Insulation of Walls and Replacement of Windows

West Wall Foam Complete
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rear wall
1st Layer
3” ISO
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

West Wall
ISO Complete
Third Phase
Air-Sealing/Insulation of Walls
and Replacement of Windows

First layer of 3” ISO board with window box
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

1st layer ISO sealed, second layer installed
Third Phase
Air-Sealing/Insulation of Walls
and Replacement of Windows

Typical 1st layer sealing
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

1st ISO taped to XPS found insulation
Third Phase
Air-Sealing/Insulation of Walls
and Replacement of Windows

Rear 2nd Layer ISO w/strapping
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Air seal penetrations
Third Phase
Siding Finishing
End
Third Phase
End Results
Third Phase

Living Room East

Before - After
Mechanicals

Ductless Mini-Split Heat Pump
Outdoor unit -- Indoor unit

Lunos e²

Lunos eGO
Ventilation ERV's Locations 1st Floor

- LUNOS e2 Pair 1, Fan A
- Possible LUNOS eGO in joined tubes
- LUNOS e2 Pair 1, Fan B
- BR
- Mech Rm
- Kitchen
- 8' x 6'8" Slider
- Open to Above
Ventilation ERV’s Locations 2nd Floor
The final Blower Door Test was

48cfm@50Pa

a reduction of 97% air infiltration from the **1740 CFM** (0.48 cfm/sf of shell area @ 50Pa) in the initial condition.
Final Results
Blower Door Test

48 cfm@50 Pa

Is equivalent to

0.013 cfm/sf of shell area @ 50 Pa
(0.27 ACH50)
Estimated BEFORE Renovation

<table>
<thead>
<tr>
<th></th>
<th>Before Renovation</th>
<th>After Renovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space heating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating demand</td>
<td>65.25 kBTU/(ft^2 yr)</td>
<td>7.50 kBTU/(ft^2 yr)</td>
</tr>
<tr>
<td>Heating load</td>
<td>36.58 BTU/(hr ft^2)</td>
<td>5.10</td>
</tr>
<tr>
<td>Primary energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating, cooling, dehumidification, DHw, auxiliary electricity, lighting, electrical appliances</td>
<td>118.0 kBTU/(ft^2 yr)</td>
<td>70.6 kBTU/(ft^2 yr)</td>
</tr>
</tbody>
</table>
Passive House Planning Package – PHPP modeling comparison

Forecasted with Renovation

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Heating Demand</th>
<th>Primary Energy</th>
<th>Heating, Cooling, Dehumidification, DHW, Lighting, Electrical Appliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating demand</td>
<td>6.39 kBTU/(ft² yr)</td>
<td>54.5 kBTU/(ft² yr)</td>
<td>85% of 7.50 kBTU/(ft² yr), 84% of 5.10, 77% of 70.6 kBTU/(ft² yr)</td>
</tr>
<tr>
<td>Heating load</td>
<td>4.29 BTU/(hr ft²)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

90% Reduction in Heating Demand
Actual kW usage metered for 12 months 8-2017 through 8-2018 = 7121 kW on site compared to 7750 kW allowed per PHIUS+ 2015 (6200 kW/person PE for 4 occupants)
THE TAKE-AWAY

If we want to make renewable energy sustainable we must start by eliminating the energy waste to the last kWatt possible.
Thank you

Because we care about you saving money and living healthy, and care about the environment, our legacy and our future, we make energy efficient buildings.

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Paul Sipple – necco@gmavt.net