Passive House Implementation: Regional Variations in Standards and Practice

Prudence Ferreira, CPHC
Passive House Practice Lead
pferreira@morrisonhershfield.com
www.MorrisonHershfield.com

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Learning Objectives

Discuss how codes, policy and standards impact passive house implementation on wood-frame projects.

Introduce hygrothermal considerations by climate region.

Survey passive house design and detailing approaches for multi-family wood construction.
“We owe it to the fields that our houses will not be the inferiors of the virgin land they have replaced. We owe it to the worms and the trees that the buildings we cover them with will stand as promises of the highest and most intelligent kinds of happiness.”

– Alain de Botton, The Architecture of Happiness
Code and Policy Context

All 25% better than code (blue bar)....

but EUI's all over the map.

Conclusion: % better modelling does not deliver consistent results.

Push for dynamic modelling that better reflects reality

And.....

Absolute targets
Passive House Principles
PHIUS+ 2018 METHODOLOGY

Climate Specific & Cost Competitive Space Conditioning Criteria

Developed by US Industry

NREL BEopt optimizes upgrade package by climate

Standards defined as cost optimal/competitive sweetspot between conservation and generation

on the path to zero
SPACE CONDITIONING
MUST MEET ALL 4 TARGETS!

Annual Heating Demand ≤ A (kBTU/ft².yr)
Annual Cooling Demand ≤ B (kBTU/ft².yr)
Peak Heating Load ≤ C (BTU/ft².hr)
Peak Cooling Load ≤ D (BTU/ft².hr)

Different advantages for each:
- Low *annual demand* saves energy
- Low *peak loads* ensure comfort, resilience, and reduce mechanical system size
## Net Zero Buildings

<table>
<thead>
<tr>
<th><strong>Class A</strong></th>
<th><strong>Definition</strong></th>
<th><strong>Site</strong></th>
<th><strong>Source</strong></th>
<th><strong>Cost</strong></th>
<th><strong>Carbon</strong></th>
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<tbody>
<tr>
<td>Within Building Footprint</td>
<td>A</td>
<td>NBI</td>
<td>ILFI</td>
<td>LEED</td>
<td>ILFI</td>
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<tr>
<td><strong>Class B</strong></td>
<td>On Site</td>
<td></td>
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<td><strong>Class C</strong></td>
<td>Off-Site, Combusted on Site</td>
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<td><strong>Class D</strong></td>
<td>Off-Site Purchased</td>
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<tr>
<td>D-1</td>
<td>Same Grid Region, Ownership Stake*</td>
<td></td>
<td>ILFI</td>
<td>LEED</td>
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<tr>
<td>D-2</td>
<td>Any Grid Region, Ownership Stake*</td>
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<tr>
<td>D-3</td>
<td>Same State, Class/Tier I RECs in Compliance Market</td>
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<tr>
<td>D-4</td>
<td>Any State, Class/Tier I RECs in Compliance Market</td>
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<td>D-5</td>
<td>Other RECs</td>
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<tr>
<td>D-6</td>
<td>Carbon Credits</td>
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*Owner's stake: outright ownership, power purchase agreement, virtual power purchase agreement, community solar, renewable energy investment fund.
Net Zero Ready Codes Canada
PH QAP Programs/Interest and Incentives

Incentive Programs
The list below includes known, current incentive programs for PHIUS+ programs, projects may qualify for.

PHIUS+ SPECIFIC INCENTIVE PROGRAMS
• California
• Connecticut
• Idaho
• Illinois
• Massachusetts
• New Hampshire
• New York
• Ohio
• Pennsylvania
• Rhode Island
• Virginia
• Washington

Image: Tim McDonald/Onion Flats
Hygrothermal Safety

BSD-106: Understanding Vapor Barriers
www.BuildingScienceCorp.com

! CAUTION!
Only a starting point:
NOT a prescription

Alaska in Zone 7/8

Zone 1 Includes:
Hawaii, Guam, PR, VI

Warm humid climate below white line
Minimize the use of materials that are prone to rot and mold.

Create assemblies that are vapor permeable to facilitate drying.

Waterproof and airseal to keep unwanted moisture and spores out of building assemblies.

Provide continuous balanced filtered mechanical ventilation to control indoor humidity and keep spores (and other allergens) out.

Prevent wetting and mold/fungus spore entry, promote drying.
WARM + HUMID

CLIMATE WALL ASSEMBLY HOUSTON

SEASONAL VAPOR DRIVE

is climate specific
FIBROUS INSULATION AIR | VCL | WRB WALL SECTION
MIXED HUMID CLIMATE

Rain Screen Facade:
3/4” - 1 1/2” vented cavity,
25-50 ACH

Wind-tight layer | WRB
Diffusion RETARDING in mixed humid climates ±10 perm,
over diffusion open fiberboard or gypsum sheathing

Vapor Control Layers:
1/2” OSB or Plywood: 0.7 Perm
Latex Paint: 5 Perm

OSB PERM:
0.7 to 1.2

Image: PHIUS
FIBROUS INSULATION AIR | VCL | WRB WALL SECTION
COLD CLIMATE

Rain Screen Facade:
3/8” - 1 1/2” vented cavity,
25-50 ACH

Wind-tight layer | WRB
Diffusion OPEN in cold
climates ≥35 perm, over
diffusion open fiberboard
or gypsum sheathing

Vapor Control Layers:
1/2” OSB or Plywood: 0.7 Permi
Latex Paint: 5 Perm

OSB PERM:
0.7 to 1.2

DETAIL: FLOOR FRAMING CONNECTION
DETAIL COURTESY OF PHIUS

LATEX PAINT
AIR BARRIER
WIND/WRB LAYER

VAPOR DRIVE

Image: PHIUS
EXTERIOR FOAM AIR | VCL | WRB WALL SECTION
MIXED HUMID CLIMATE V1 & V2

20" CELLOULOSE
7/16" OSB SHEATHING WITH TAPE
1/2" GYP
2x2 BLOCKING AS REQ'D

[Latex Paint: 5 Perm]

[V1]

OSB PERM: 0.7 to 1.2

Windtight layer/vapor retarder: 1/2" OSB taped plus taped aluminum foil joints of staggered foam layers, siding

[V2]

Image: PHIUS, Detail Adam Cohen
EXTERIOR FOAM AIR | VCL | WRB WALL SECTION

VERY COLD CLIMATE: HIGHER % OF FOAM V1 & V2

20” CELLULOSE
7/16” OSB SHEATHING WITH TAPE
1/2” GYP
2x2 BLOCKING AS REQ’D

OSB PERM: 0.7 to 1.2

LATEX PAINT
AIR BARRIER
WIND/WRB LAYER

Latex Paint: 5 Perm

Vapor Control Layer: 1/2” OSB or Plywood

Windtight layer/vapor retarder: 1/2” OSB taped with WRB, siding

VAPOR DRIVE

Windtight layer/vapor retarder: 1/2” OSB taped plus taped aluminum foil joints of staggered foam layers, siding

Image: PHIUS, Detail Adam Cohen
Exterior Foam Above Grade
Exterior Foam – Soffit & Balcony
Exterior Foam – Punched Window
Exterior Foam – At Grade
Exterior Foam - Brick Clad
Alternative– Exterior Mineral Wool w/ Thermal Clips
Structural Considerations

Example thermal performance comparison for a steel stud wall with 4” of mineral wool insulation and different cladding attachment systems a) set spacing of clips 16”x 24”o.c. and b) with structural capacity factored in
Considerations for Cladding Attachment Spacing

**Wind Load:** Wind pressures on a building will change the required spacing of cladding attachments to handle the dynamic loading. This can depend on location and on the height and shape of the building. Tighter spacings of clips may be required at building edges or at higher locations on the building where there is greater pressures, compared to the center of the wall.

**Cladding Weight:** The dead load from the weight of the cladding itself will impact how far apart the cladding attachments can be spaced to distribute the load to prevent failure of the clip or fasteners. Lighter weight claddings like metal panel can be spaced further than heavy claddings like stone or terracotta.

**Deflection Limits:** While the pull-out strength and structural capacity of the clips are important, there may be strict deflection limits on the substructure for the cladding itself to prevent cracking or warping. Even if clips themselves can handle the wind and deal load, the spacing may still be limited by the deflection criteria.
Constructability and Panel Layouts

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Vertical Layout</th>
<th>Horizontal Layout</th>
<th>% Increase</th>
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</thead>
<tbody>
<tr>
<td>Total Rail Length</td>
<td>347 ft</td>
<td>223 ft</td>
<td>-36%</td>
</tr>
<tr>
<td>Number of Clips</td>
<td>105</td>
<td>111</td>
<td>7%</td>
</tr>
<tr>
<td>Clear Field Effective R-value</td>
<td>R-18.5</td>
<td>R-21.5</td>
<td>16%</td>
</tr>
</tbody>
</table>

Example rail layout impact on thermal performance
Wood-Based Approaches – Double Stud

Interior Insulated Double Framed Wall 2x6 and 2x4 Wood Stud (16” o.c.) Wall Assembly with 2” – 4” Gap – Clear Wall
Wood-Based Approaches – Double Stud
Wood-Based Approaches – Double Stud
Wood-Based Approaches – Mass Timber
Wood-Based Approaches – Mass Timber
Exterior Insulated Cross Laminated Timber (CLT) Wall
Interior Insulated CLT Facade

- Minimizes/eliminates thermal bridges:
  - No need for deflection header (CLT panel is the deflection header! ) means reduced length of linear thermal transmittance
  - Eyebrows (complete thermal break)
  - Corners (negative thermal bridge – credit back in PH model)
  - Shelf angle at brick transition to other cladding becomes intermittent point TB
  - No balcony attachment thermal bridge or need for thermally broken connectors, balcony is secured by same structural connection as CLT panel...2 birds with 1 stone
- Careful! Above is not true of exterior insulated “CLT curtain wall” systems
- Air barrier is on inside
- SAM (pre-stripped) is best most reliable method for CLT airsealing
- Panel to panel connections happen at sill heights. (When pre-fabbed, window gets carried on upper panel.)
Interior Insulated Cross Laminated Timber (CLT) Wall
Interior Insulated Cross Laminated Timber (CLT) Wall
Questions?

Prudence Ferreira, CPHC
Passive House Practice Lead
pferreira@morrisonhersfield.com
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