Actionable, Cost-Effective
Passive Building Strategies

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Co-Founder and Consultant
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Objectives
Part 1:
  Conceptual Passive House Theory
  Climate Specific Standards
  Impacts on Cost

Part 2:
  Performance Criteria Analysis
  Characteristics of Cost-Effective Assemblies
  Examples
So, What About Cost?

Cost is a driver for every project

There is a cost to build ANYTHING – not just a passive house

Affordability is (still?) challenged

- Interest Rates
- Materials
- Labor Costs

Is there a PH Premium?

Climate Dependent, but typically added costs for:

- Mechanical Systems
- Incremental Insulation
- High Performance Windows and Door
- Air Sealing
How many construction methods can one person try?

14 years ago: I presented at my first PhiusCon
Since then, I have worked on projects that have used just about every possible type of assembly

Also, I was the Phius Certification Manager for approx. 3 years and still review projects for Phius
How many construction methods can one person try?
How many construction methods can one person try?

- Cast-in-place Concrete
- Exterior Foam Insulation
- Vented Attic

Wildwood, MO
How many construction methods can one person try?

CRETE House
Washington University in St. Louis, MO – 2017 US DOE Solar Decathlon
Precast Concrete: footings, floors, walls, roof, gutters, planters
How many construction methods can one person try?

Loughran Home
Goreville, IL – PHIUS+ 2015 Source Zero Certified
SIPS wall/roof on Timber Frame

Kala Forest Ave Passive House
Kansas City, MO – Phius Core 2021 Certified
SIPS w/ Interior Stud Wall, Vented attic
Builder: Kala Performance Homes
How many construction methods can one person try?

**The Full List of Walls:**
- Laminated Bamboo 1x10’s
- TJI Studs (no CI / CI)
- 2x4 with ext. Hanging TJI (Klingenberg Wall)
- 2x6 with Rigid Foam CI
- 2x6 with int. 2x4 w/ 2” Mineral Wool CI w/ stucco
- 2x6 with Zip R as Insulated Sheathing
- 2x6 with 4-6” EPS Nailbase w/ stucco
- Insulated Light Frame Steel w/ 4” Rigid Foam CI
- Structural Steel Frame with Fabric Enclosure
- Pre-Cast Concrete Sandwich Panels
- Cast-in-Place Concrete w/ ext. Foam
- Insulated Concrete Form (Basement Only)
- Insulated Concrete Form (Full Walls)
- Concrete block walls in Tropical Climate
- SIP panels as Structure
- SIP panels on a TimberFrame
- CLT and Timberframe w/ pre-fab wood walls
- Historic Masonry – Interior Retrofit

**Slabs:**
- Concrete with EPS
- Concrete with XPS
- Concrete with Foam Glass Aggregate

**Roofs:**
- Vented Attic with fibrous insulation
- Conditioned Roof with exterior foam
- Conditioned Roof mix of cavity and deck insulation
- Conditioned Roof with spray foam
A quick history lesson:

- Original PHI Criteria was developed by limiting the Peak Heating Load to the amount of heat that could be carried at the airflow required for fresh air ventilation by the building occupants
- This “removed” the traditional heating system resulting in cost savings

### Certification Criteria

<table>
<thead>
<tr>
<th>Demand Type</th>
<th>4.75 kBTU/ft²yr</th>
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<tbody>
<tr>
<td>Annual Heating Demand</td>
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<tr>
<td>Peak Heating Load</td>
<td>3.17 BTU/hr.ft²</td>
</tr>
<tr>
<td>Annual Cooling Demand</td>
<td></td>
</tr>
<tr>
<td>Peak Cooling Load</td>
<td></td>
</tr>
<tr>
<td>Primary Energy Demand</td>
<td>38.1 kBTU/ft²yr</td>
</tr>
<tr>
<td>Air Tightness: ACH₅₀</td>
<td>0.6 ACH₅₀</td>
</tr>
</tbody>
</table>
A CRITICAL ANALYSIS OF THE PASSIVE HOUSE STANDARD FOR THE CLIMATES OF THE UNITED STATES

Ryan Abendroth’s Thesis for Master of Architecture at University of Illinois in 2013

There is not a scientific reason to stop insulating in most climates. More Insulation = Less Heat Loss

Diminishing returns of insulation ARE in-effect and ARE significant, but still – more is more.
Climate-Specific Passive Building Standards

Graham S. Wright and Katrin Klingenberg
Passive House Institute US

July 2015
So how was the standard set?

COST
Factors:

Construction Cost
Climate Data
Utility Cost
Occupancy
Envelope Area
Interior Conditioned Floor Area
What increases the cost to build Passive?

<table>
<thead>
<tr>
<th>Envelope</th>
<th>Systems</th>
<th>Service Fees</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Insulation</td>
<td>• Ventilation</td>
<td>• CPHC</td>
</tr>
<tr>
<td>• Air sealing</td>
<td>• Heating / Cooling</td>
<td>• Rater</td>
</tr>
<tr>
<td>• Membranes</td>
<td>• DHW</td>
<td>• Phius Certification Fee</td>
</tr>
<tr>
<td>• Specialty Envelope Products</td>
<td>• Appliances</td>
<td>• Extra Design Services</td>
</tr>
</tbody>
</table>
Quick Code Comparisons

Code requirements are trending towards greater energy efficiency every cycle.

Buildings built to current codes use ~50% less energy than the 1975 Baseline.

Image credit: U.S. Department of Energy
## TABLE 402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT\(^a\)

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR(^b)</th>
<th>SKYLIGHT U-FACTOR</th>
<th>GLAZED FENESTRATION SHGC(^b, e)</th>
<th>CEILING R-VALUE</th>
<th>WOOD FRAME WALL R-VALUE</th>
<th>MASS WALL R-VALUE(^i)</th>
<th>FLOOR R-VALUE</th>
<th>BASEMENT WALL R-VALUE</th>
<th>SLAB(^d) R-VALUE &amp; DEPTH</th>
<th>CRAWL SPACE WALL R-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>IECC 200</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.35</td>
<td>0.60</td>
<td>NR</td>
<td>38</td>
<td>13</td>
<td>5/10</td>
<td>19</td>
<td>10 /13</td>
<td>10, 2 ft</td>
<td>10/13</td>
</tr>
<tr>
<td>IECC 201</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.35</td>
<td>0.55</td>
<td>0.40</td>
<td>49</td>
<td>20 or 13+5(^h)</td>
<td>8/13</td>
<td>19</td>
<td>10/13</td>
<td>10, 2 ft</td>
<td>10/13</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.32</td>
<td>0.55</td>
<td>0.40</td>
<td>49</td>
<td>20 or 13+5(^h)</td>
<td>8/13</td>
<td>19</td>
<td>10/13</td>
<td>10, 2 ft</td>
<td>10/13</td>
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</tr>
<tr>
<td>4 except Marine</td>
<td>.30</td>
<td>.55</td>
<td>0.40</td>
<td>60</td>
<td>30 or 20(^{5h}) or 13(^{10c}) or 0(^{20c})</td>
<td>8/13</td>
<td>19</td>
<td>10ci or 13</td>
<td>10ci, 4 ft</td>
<td>10ci or 13</td>
</tr>
</tbody>
</table>
## Quick Code Comparison – CZ4: St. Louis

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR(^b,1)</th>
<th>SKYLIGHT(^b) U-FACTOR</th>
<th>GLAZED FENESTRATION (SHGC(\text{\textsuperscript{b, e}}))</th>
<th>CEILING (R)-VALUE</th>
<th>WOOD FRAME WALL (R)-VALUE(^g)</th>
<th>MASS WALL (R)-VALUE(^b)</th>
<th>FLOOR (R)-VALUE</th>
<th>BASEMENT(^c,9) WALL (R)-VALUE</th>
<th>SLAB(^d) (R)-VALUE &amp; DEPTH</th>
<th>CRAWL SPACE(^c,9) WALL (R)-VALUE</th>
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</thead>
<tbody>
<tr>
<td>4 except Marine</td>
<td>.30</td>
<td>0.55</td>
<td>0.40</td>
<td>60</td>
<td>30 or 20.85(\text{\textsuperscript{c}}) or 13(\text{\textsuperscript{d}}) or 08.20(\text{\textsuperscript{c}})</td>
<td>8/13</td>
<td>19</td>
<td>10ci or 13</td>
<td>10ci, 4 ft</td>
<td>10ci or 13</td>
</tr>
</tbody>
</table>

**Most Recent Project:**
St. Louis, MO

0.16 24-cont.  n/a  .386 cog  60  35  n/a  n/a  26

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**From Code to Passive House**

- Much better window performance
- A bit more wall insulation
- A bit more basement wall insulation
- Insulate full slab
- Airtightness about 5x tighter than code

Jessica Deem, Architect
Virescent Design
# Quick Code Comparison – CZ2: Austin

## Table 402.1.1

**Insulation and Fenestration Requirements by Component**

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Fenestration U-Factor (b)</th>
<th>Skylight U-Factor (b)</th>
<th>Glazed Fenestration SHGC (b, e)</th>
<th>Ceiling R-Value</th>
<th>Wood Frame Wall R-Value</th>
<th>Mass Wall R-Value (l)</th>
<th>Floor R-Value</th>
<th>Basement Wall R-Value</th>
<th>Slab R-Value &amp; Depth</th>
<th>Crawl Space Wall R-Value</th>
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</thead>
<tbody>
<tr>
<td><strong>IECC 200</strong></td>
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<tr>
<td>2</td>
<td>0.65</td>
<td>0.75</td>
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<td>13</td>
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<td>0</td>
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<td><strong>IECC 201</strong></td>
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<td>0.25</td>
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<td>13</td>
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<td>0</td>
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<td>0</td>
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<td><strong>IECC 202</strong></td>
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<td>0.65</td>
<td>0.25</td>
<td>38</td>
<td>13</td>
<td>4/6</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CLIMATE ZONE</td>
<td>FENESTRATION U-FACTOR&lt;sup&gt;b,1&lt;/sup&gt;</td>
<td>SKYLIGHT&lt;sup&gt;b&lt;/sup&gt; U-FACTOR</td>
<td>GLAZED FENESTRATION SHGC&lt;sup&gt;b, e&lt;/sup&gt;</td>
<td>CEILING R-VALUE</td>
<td>WOOD FRAME WALL R-VALUE&lt;sup&gt;g&lt;/sup&gt;</td>
<td>MASS WALL R-VALUE&lt;sup&gt;h&lt;/sup&gt;</td>
<td>FLOOR R-VALUE</td>
<td>BASEMENT&lt;sup&gt;c,g&lt;/sup&gt; WALL R-VALUE</td>
<td>SLAB&lt;sup&gt;d&lt;/sup&gt; R-VALUE &amp; DEPTH</td>
<td>CRAWL SPACE&lt;sup&gt;c,g&lt;/sup&gt; WALL R-VALUE</td>
</tr>
<tr>
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<tr>
<td>2</td>
<td>0.40</td>
<td>0.65</td>
<td>0.25</td>
<td>49</td>
<td>13 or 0 &amp; 10ci</td>
<td>4/6</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**IECC 2021**

**Austin TX Code Compliant (ish)**

- Heating demand: 5.63 kBtu/ft²/yr
- Cooling demand: 6.56 kBtu/ft²/yr
- Heating load: 8.52 Btu/hr ft²
- Cooling load: 3.19 Btu/hr ft²
- Source energy: 10,320 kWh/Person yr
- Site energy: 13 kBtu/ft²/yr

Air Infiltration Limit: 0.215 cfm<sub>50</sub>/ft<sup>2</sup> 3.00 ACH<sub>50</sub>

**Austin TX Optimum (ish)**

- Heating demand: 2.94 kBtu/ft²/yr
- Cooling demand: 9.91 kBtu/ft²/yr
- Heating load: 4.76 Btu/hr ft²
- Cooling load: 2.73 Btu/hr ft²
- Source energy: 7,525 kWh/Person yr
- Site energy: 9.38 kBtu/ft²/yr

Air Infiltration Limit: 0.06 cfm<sub>50</sub>/ft<sup>2</sup> 0.83 ACH<sub>50</sub>
## Cost Analysis – CZ2: Austin

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Case 1 Minimum</th>
<th>Case 2 Base Case</th>
<th>Case 3 Optimized</th>
<th>Case 4 Optimized + R4.2 Slab Ins.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab</td>
<td>4” Concrete Slab = R 0.42</td>
<td>4” Concrete Slab = R 0.42</td>
<td>4” Concrete Slab + 1” XPS NGX Perimeter</td>
<td>4” Concrete Slab + 1” EPS Underslab</td>
</tr>
<tr>
<td>Walls</td>
<td>R13 (2x4 w/ Batt Insulation)</td>
<td>R21 (2x6 w/ Zip R3)</td>
<td>R24 (2x6 + Zip R6)</td>
<td>R24 (2x6 + Zip R6)</td>
</tr>
<tr>
<td>Roof</td>
<td>R38 (Not including framing)</td>
<td>R38 (Not including framing)</td>
<td>R49 (Not including framing)</td>
<td>R49 (Not including framing)</td>
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<tr>
<td>Windows</td>
<td>U-Value 0.4 BTU/ft² h F SHGC 0.25</td>
<td>U-Value 0.25 BTU/ft² h F SHGC 0.25</td>
<td>U-Value 0.2 BTU/ft² h F SHGC 0.25</td>
<td>U-Value 0.2 BTU/ft² h F SHGC 0.25</td>
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<tr>
<td>Airtightness</td>
<td>ACH50: 5 per hour CFM50: 0.36 per ft² (Envelope Area)</td>
<td>ACH50: 3 per hour CFM50: 0.215 per ft² (Envelope Area)</td>
<td>ACH50: .83 per hour CFM50: 0.06 per ft² (Envelope Area)</td>
<td>ACH50: .83 per hour CFM50: 0.06 per ft² (Envelope Area)</td>
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<tr>
<td>Energy Cost (Monthly in $)</td>
<td>38993.07 kWh</td>
<td>34764.64 kWh</td>
<td>28491.12 kWh</td>
<td>26076.03 kWh</td>
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<td>PV Required for Zero</td>
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<tr>
<td>Estimated DC System Size</td>
<td>26.4 kW</td>
<td>23.6 kW</td>
<td>19.3 kW</td>
<td>17.7 kW</td>
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<tr>
<td>Estimated Number of Panels</td>
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## Cost Analysis – CZ2: Austin

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION ( U )-FACTOR(^{b, i} )</th>
<th>SKYLIGHT(^b ) ( U )-FACTOR</th>
<th>GLAZED FENESTRATION SHGC(^{b, e} )</th>
<th>CEILING R-VALUE</th>
<th>WOOD FRAME WALL R-VALUE(^g )</th>
<th>MASS WALL R-VALUE(^h )</th>
<th>FLOOR R-VALUE</th>
<th>BASEMENT(^c, g ) WALL R-VALUE</th>
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<tr>
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<td>0.40</td>
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<td>0.25</td>
<td>49</td>
<td>13 or 0 &amp; 10ci</td>
<td>4/6</td>
<td>13</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### IECC 2021

Austin TX
Code Compliant (ish)

- **Air Infiltration Limit:**
  - 0.215 cfm\(_{50}\)/ft\(^2\)
  - 3.00 ACH\(_{50}\)

- **Energy savings due to Air Tightness:** 5376 kwh/year of site energy

- **Results in a 15.6% energy savings for the building and a cost savings of $806.40/year or $67.20/month @ $0.15/kwh**
Cost Analysis – CZ2: Austin

IECC 2021

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR</th>
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<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Baseline:
- Slab R = .42
Window U = 0.25
- Wall R = 18.1
- Window SHGC = 0.25
- Roof R = 38
- Airtightness = 0.06 cfm<sub>50</sub>/ft<sup>2</sup>
- Slab Per. = R5, 2'

Wall R-Value: 18.1

Energy savings due to increased R-value: 109.8 kwh/year of site energy

Results in a 0.38% energy savings for the building and a cost savings of $16.47/year or $1.3725/month @ $0.15/kwh
Cost Analysis – CZ2: Austin

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR&lt;sup&gt;b,i&lt;/sup&gt;</th>
<th>SKYLIGHT&lt;sup&gt;b&lt;/sup&gt; U-FACTOR</th>
<th>GLAZED FENESTRATION SHGC&lt;sup&gt;b,e&lt;/sup&gt;</th>
<th>CEILING R-VALUE</th>
<th>WOOD FRAME WALL R-VALUE&lt;sup&gt;g&lt;/sup&gt;</th>
<th>MASS WALL R-VALUE&lt;sup&gt;h&lt;/sup&gt;</th>
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<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Baseline:
- Slab R = .42
- Wall R = 18.1
- Roof R = 38
- Slab Per. = R5, 2'

Window U = 0.25
Window SHGC= 0.25
Airtightness = 0.06 cfm<sub>50</sub>/ft<sup>2</sup>

Energy savings due to increased R-value: 106.3 kwh/year of site energy

Results in a 0.37% energy savings for the building and a cost savings of $15.95/year or $1.33/month @ $0.15/kwh
Cost Analysis – CZ2: Austin

IECC 2021

Baseline:
- Slab R = .42
- Wall R = 18.1
- Roof R = 38
- Slab Per. = R5, 2'

Window U = 0.25
Window SHGC= 0.25
Airtightness = 0.06 cfm₅₀/ft²

Energy cost due to increased U-value: 713.2 kwh/year of site energy
Results in a 2.46% energy increase for the building and a cost increase of $106.98/year or $8.92/month @ $0.15/kwh

Energy savings due to decreased U-value: 230.9 kwh/year of site energy
Results in a 0.80% energy savings for the building and a cost savings of $34.64/year or $2.89/month @ $0.15/kwh
Saving $$$ on Windows and Doors - Tips

• Work with the manufacturer!
  • Unilux Example
  • Alpen Example
  • Zola Example
  • These things are not unique but exist for all manufacturers and small tweaks can make a huge difference in price with minimal design impact

• Window Types
  • Fixed vs Operable
  • Material Dependent

• Doors
  • Should have multipoint locks.
  • Lift slide if sliding
  • Solid doors do not need to be from the window manufacturer
Cost Analysis – CZ2: Austin

I find this upgrade generally makes sense!
I find this upgrade generally doesn’t make sense (CZ4 and below)!

---

### TR6 PH+ Balanced

**Product name:** Alpen Tyrol TR-6 Thin Glass Triple Tilt-Turn

<table>
<thead>
<tr>
<th>Climate specific recommendations</th>
<th>WH/m²K</th>
<th>BTU/hr ft²</th>
<th>W/m²K</th>
<th>BTU/hr ft²</th>
<th>W/m²K</th>
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</thead>
<tbody>
<tr>
<td>8</td>
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### TR9 PH+ Balanced

**Product name:** Alpen Tyrol TR-9 PH+ Tilt Turn

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<th>Climate specific recommendations</th>
<th>WH/m²K</th>
<th>BTU/hr ft²</th>
<th>W/m²K</th>
<th>BTU/hr ft²</th>
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<td>0.13</td>
<td>0.333</td>
<td>0.388</td>
<td>0.068</td>
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**Window Comparison**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type (uPVC, Wood, Wood/Alu, Alu)</th>
<th>Glass Tempered or annealed</th>
<th>Color int</th>
<th>Color Ext</th>
<th>U Value</th>
<th>SHGC</th>
<th>Fixed</th>
<th>Operable</th>
<th>spacer</th>
<th>VT</th>
<th>Shipping</th>
<th>Total incl. Shipping</th>
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<td>Wood</td>
<td>$122,336.00</td>
<td>annealed</td>
<td>Timber</td>
<td>Timber</td>
<td>0.31</td>
<td>0.82</td>
<td>black, techniform</td>
<td>70-73</td>
<td>$12,000.00</td>
<td>$122,336.00</td>
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<td>uPVC</td>
<td>$85,116.74 double Approx. 597,884 triple</td>
<td>annealed</td>
<td>White</td>
<td>White</td>
<td>0.26</td>
<td>window quote: 0.28, data sheet 0.38</td>
<td>0.249-0.2655</td>
<td>white or black</td>
<td>69</td>
<td>$3,500.00</td>
<td>$85,116.74 double Approx. 597,884 triple</td>
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<tr>
<td>Aluminium</td>
<td>$123,422 double $ Triple (about $8 higher)</td>
<td>Tempered</td>
<td>White</td>
<td>White</td>
<td>0.09</td>
<td>0.34</td>
<td>0.89-0.96</td>
<td>1.1-1.4</td>
<td>black</td>
<td>61</td>
<td>$7,000.00</td>
<td>$123,422 double $ Triple (about $8 higher)</td>
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<td>uPVC</td>
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<td>Tempered</td>
<td>White 9016</td>
<td>White 9016</td>
<td>0.17</td>
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<td>Wood/Alu</td>
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<td>natural</td>
<td>black</td>
<td>0.09</td>
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<tr>
<td>uPVC</td>
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<td>White</td>
<td>White</td>
<td>White</td>
<td>0.37 operable, 0.44 fixed</td>
<td>0.25</td>
<td>0.26</td>
<td>grey</td>
<td>53-63</td>
<td>$5,800.00</td>
<td>$102,043.00</td>
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<tr>
<td>uPVC</td>
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<td>White</td>
<td>0.24-0.36</td>
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<td>0.25</td>
<td>grey</td>
<td>41-61</td>
<td>37-56</td>
<td>$60,594 (double)</td>
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</table>

**Takeaways:**

1. Price different manufacturers - it's all over the place
2. Triple Pane is more expensive – may not be worth it in some climates (see above)
   Some manufacturers have very small premium to upgrade to triple pane
   Acoustics and Comfort must be considered.
3. UPVC frames are cheaper than wood, aluminum clad wood, or aluminum
Cost Analysis – CZ2: Austin

IECC 2021

Baseline:
Slab $R = 0.42$
Wall $R = 18.1$
Roof $R = 38$
Slab Per. = R5, 2'
Window $U = 0.25$
Window SHGC = 0.25
Airtightness = 0.06 cfm$_{50}$/ft$^2$

Energy Cost due to removal of Slab Edge Insulation: 460.7 kwh/year of site energy
Results in a 1.59% energy increase for the building and a cost increase of $69.10/year or $5.76/month @ $0.15/kwh
Cost Analysis – CZ2: Austin

IECC 2021

Baseline:
- Slab R = .42
- Wall R = 18.1
- Roof R = 38
- Slab Per. = R5, 2'

Window U = 0.25
Window SHGC= 0.25
Airtightness = 0.06 cfm.<sub>50</sub>/ft<sup>2</sup>

Energy savings due to increased R-value: 2007.8 kwh/year of site energy
Results in a 6.92% energy savings for the building and a cost savings of $301.17/year or $25.10/month @ $0.15/kwh
Characteristics of a Cost-Effective Slab

- “Proper” amount of sub-slab insulation
- Drainage gravel and radon mitigation system (where required)
- Membrane between insulation and concrete slab.
- Mitigate/Eliminate Perimeter Thermal Bridge

Sub-slab insulation choices:
- EPS
- XPS
- Foam Glass Aggregates
• Defining the “Proper” amount of sub-slab insulation
  • Use energy modeling to increase or decrease the insulation
  • Look at the change between Heating and Cooling Demands
  • Also compare the Site/Source total energy – You may be surprised.

• Start with the assumption that there should always be some sub-slab insulation – even in Hot Climates CZ 1-3!

A little look under the hood:
Phius used BeOpt as part of the Phius Certification standard setting process in 2015, 2018, and 2021. Looking at a limited data sample of the BeOpt runs, the optimizer chose an uninsulated slab in only 2.22% of cases nationwide! (specific locations in HI, CA, FL, TX, LA, GA)
Characteristics of a Cost-Effective Slab

What happens when a slab is insulated?

Heat loss through the slab is reduced

- In the winter, this heat loss to the ground adds to the heating demand
- In the summer, this heat loss to the cool ground is beneficial
- The heat loss to the ground is sensible heat loss
- The latent heat demand stays the same, but sensible has been cut dramatically
- The demands are similar, but the efficiency of the mechanical system determines the annual source energy use!!
1. Use standard (commonly available) materials and techniques
2. Limit thicknesses (especially CI layers, but also the cavity)
3. Limit “trips around the building” by limiting the number of layers and/or number of steps involved in installation
4. Work with the contractor and material suppliers

Other Priority:
Reduce thermal bridging and increase airtightness by:
  Aligning the insulation and airtight layers from component to component
  Examples: between below grade wall and above grade wall, from wall to roof, slab to wall, wall to wall, etc.
Characteristics of a Cost-Effective Basement

1. Insulation amount dialed in with energy model
2. Continuous Insulation + thermal bridging reduction
3. Connecting insulation
   Slab to Basement Wall
   Basement Wall to Above Grade Wall
4. Air barrier on concrete wall
   1. Connect to above grade wall on exterior
5. Manage Moisture
   1. Exterior Surface Ideal
   2. Unfaced Cavity Insulation (or none)
   3. Footing drain and radon mitigation system
Characteristics of a Cost-Effective Wall

1. Insulation amount dialed in with energy model
2. Continuous Insulation + thermal bridging reduction
3. Insulation “in-plane” and contiguous with other assemblies (roof, rim joist, basement wall, slab, etc.)
4. Air barrier on sheathing
5. Moisture managed w/o use of specialty products
   1. Follows Phius’ Prescriptive Guidelines for Moisture Management.
6. Limits CI to 4” Maximum
   1. More CI creates potential window install issues
   2. Reveal shading can start to negatively effect energy balance
   3. At 4” and beyond Phius requires fastener correction
   4. 4” is often the limit for siding warranties
   5. 4” is also the typ max thickness of thermally broken brick ties
   6. Beyond 4”, fasteners get long/heavy, install is a problem and a facade system such as a fiberglass clip and rail is likely
Method 1: Vented Attic – not conditioned

- Use underside of attic structure as air and vapor barrier
- A solid material (sheathing) is best, but membranes can work
- Drop ceiling can be used for electrical and mechanical
  - Might need to be overly large for certain systems – cost increase
- Biggest advantage is using cheaper blown in fibrous insulation

Method 2: Conditioned Attic – non-vented

- Use top side of roof structure (sheathing location as the air and vapor barrier.
- Use a “nailbase” product to protect the air barrier and meet the Phius Prescriptive Requirements for moisture management
- Split Insulation above and below roof deck
  - This method works on flat roofs – replace nailbase with rigid
Ventilation

ERV with small homerun ducting (Zehnder / Brink)

1. Easy install, airtight ducts
2. Acoustical benefits – less sound transmission
3. Greater Static Pressure (UL Listing)
4. Equipment and duct material cost typically more than trunk + branch

ERV with Trunk + Branch ducting (Renewaire, Broan, Venmar, vane, Lifebreath, Fantech, Panasonic, etc.)

1. Duct system more difficult to fabricate and install
2. More acoustical concerns
3. More labor required
4. Equipment and duct material cost typically less than homeruns

Total cost depends on many factors but comes down to paying more in labor for the trunk + branch system or more in equipment for the homerun duct system and corresponding ERV.
Domestic Hot Water

• Heat Pump Water Heater (tank)
  • Located inside the thermal envelope
• Save Cost with Limited Distribution
  • Cluster plumbing fixture
    • Eliminates long runs and/or recirculation system
    • RARE!
  • “On-Demand” Re-circulation Loop
    • I see this on many projects
    • Not as cost effective, but limits wasted water
    • Does not save energy, but saves water
    • Practically required for most projects to meet ZERH standards.
Has anyone (besides me):

• Used the # of refrigeration appliances to determine the CPHC Fee?
• Compared Appliances versus the PH Premium

The Value of the CPHC and combining the Energy Model and Experience Optimization NO MORE and NO LESS than what is required to meet the project goals.
Thank You