Building Carbon Zero Marin with Passive House

Graham Irwin
Certified Passive House Consultant
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Marin County Symposium
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What is Passive House?

1. Passive Houses are so comfortable they don’t need standard heating & cooling.

2. Passive Houses are **SO COMFORTABLE** they don’t need standard heating and cooling.

3. Passive Houses provide superior air quality.

4. Passive Houses use **A LOT** less energy.

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**World’s 1st Passive House**
Kranichstein Passive House
Darmstadt, Germany (1990)

**1st Passive House in US**
Smith House

**1st Passive House in CA**
Tahan Residence
Berkeley, California (2007)

**1st Certified Passive House in CA**
O’Neill Residence
Sonoma, California (2010)
How Does Passive House Work?

- Ventilation System is Main System
- Size Building Loads to Fresh Air Supply
- Invest in the Shell, Save on the Equipment

Minimize Losses, Maximize Gains

1. Super-Insulation
2. Air-Tightness
3. Controlled Passive Solar
4. Heat Recovery Ventilation
5. Efficient Equipment, Appliances & Lighting

Image Source: Passivhaus Institut (PHI)
Heat Recovery Ventilation
for “Heat Recycling” & Superior IAQ

- Centralized Ventilation
- Air Extracted from “Wet” Rooms
- Air Supplied to Living & Sleeping Rooms
- Balanced & Continuous
- Use Windows in Nice Weather

Image Source: www.greenbuildingstore.co.uk/mvhr.php

Passive House HRVs Recover 8-15x Their Electrical Use (Passivhaus Institut study)
Passive House Ventilation (0.3 ACH) Exceeds ASHRAE 62.2 Levels
What About Cooling?

Source: Passive Houses in Mediterranean Climates, PHI
What About Cooling?

Peak Loads: Seville, Spain, Standard Construction

Source: Passive Houses in Mediterranean Climates, PHI
What About Cooling?

Peak Loads: Seville, Spain, Passive House

Source: Passive Houses in Mediterranean Climates, PHI
**Accurate Design**

(Passive House Planning Package)

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### Passive House Planning

**SPECIFIC ANNUAL HEAT REQUIREMENT**

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Temperature Zone</th>
<th>Area</th>
<th>U-Value</th>
<th>Temp. Factor</th>
<th>Q&lt;sub&gt;in&lt;/sub&gt;</th>
<th>Q&lt;sub&gt;out&lt;/sub&gt;</th>
<th>Net Q&lt;sub&gt;in&lt;/sub&gt;</th>
<th>Net Q&lt;sub&gt;out&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior Wall - Subtotal A</td>
<td>104.3</td>
<td>0.138</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>727</td>
<td>9.1</td>
<td>300.6</td>
</tr>
<tr>
<td>Exterior Wall - Ground B</td>
<td>83.4</td>
<td>0.108</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>490</td>
<td>9.1</td>
<td>324.5</td>
</tr>
<tr>
<td>Roof/Ceiling - Exterior D</td>
<td>69.6</td>
<td>0.133</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>278</td>
<td>9.1</td>
<td>243.8</td>
</tr>
<tr>
<td>Windows A</td>
<td>43.5</td>
<td>0.777</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>727</td>
<td>9.1</td>
<td>727.0</td>
</tr>
<tr>
<td>Exterior Door A</td>
<td>11.4</td>
<td>0.061</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>32</td>
<td>9.1</td>
<td>32.0</td>
</tr>
<tr>
<td>Exterior Thermal Bridge A</td>
<td>11.4</td>
<td>0.061</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>32</td>
<td>9.1</td>
<td>32.0</td>
</tr>
<tr>
<td>Perimeter Thermal Bridge B</td>
<td>11.4</td>
<td>0.061</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>32</td>
<td>9.1</td>
<td>32.0</td>
</tr>
<tr>
<td>Ground Thermal Bridge (B)</td>
<td>11.4</td>
<td>0.061</td>
<td>1.00</td>
<td>0.67</td>
<td>81.1</td>
<td>32</td>
<td>9.1</td>
<td>32.0</td>
</tr>
</tbody>
</table>

**Total net of building envelope area:** 392.1

**Transmission Heat Losses Q<sub>T</sub>**

<table>
<thead>
<tr>
<th>System</th>
<th>Effective Air Volume</th>
<th>V&lt;sub&gt;eff&lt;/sub&gt;</th>
<th>H&lt;sub&gt;A&lt;/sub&gt;</th>
<th>H&lt;sub&gt;E&lt;/sub&gt;</th>
<th>Q&lt;sub&gt;T&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation</td>
<td>33%</td>
<td>150.0</td>
<td>9.07</td>
<td>0.015</td>
<td>3.068</td>
</tr>
</tbody>
</table>

**Ventilation Heat Losses Q<sub>V</sub>**

<table>
<thead>
<tr>
<th>Q&lt;sub&gt;V&lt;/sub&gt;</th>
<th>Q&lt;sub&gt;Q&lt;/sub&gt;</th>
<th>Q&lt;sub&gt;V&lt;/sub&gt;</th>
<th>Q&lt;sub&gt;Q&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.019</td>
<td>0.33</td>
<td>81.1</td>
<td>806</td>
</tr>
</tbody>
</table>

**Total Heat Losses Q<sub>T</sub>**

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Reduction Factor</th>
<th>Area</th>
<th>Global Radiation Heating Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>0.46</td>
<td>0.60</td>
<td>100</td>
</tr>
<tr>
<td>South</td>
<td>0.44</td>
<td>0.60</td>
<td>100</td>
</tr>
<tr>
<td>West</td>
<td>0.48</td>
<td>0.60</td>
<td>100</td>
</tr>
<tr>
<td>North</td>
<td>0.48</td>
<td>0.60</td>
<td>100</td>
</tr>
<tr>
<td>Horizontal</td>
<td>0.48</td>
<td>0.60</td>
<td>100</td>
</tr>
</tbody>
</table>

**Gross Solar Heat Gains Q<sub>S</sub>**

<table>
<thead>
<tr>
<th>Total</th>
<th>3200</th>
</tr>
</thead>
</table>

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- Climate Zone
- Building Form & Orientation
- Building Assembly R Values
- Thermal Mass
- Heat Losses to Ground
- Thermal Bridges
- Air Tightness
- Window U Values, SHGC & Installation
- Shading
- Solar Heat Gains
- Internal Heat Gains
- Internal Heat Recovery
- Heating & Cooling Loads
- Summer Conditions
- Mechanical & Natural Ventilation
- DHW & Solar Thermal
- District Heating
- Plug Loads, Appliances, Lighting
- Source Energy
- CO<sub>2</sub> Emissions
- Occupancy Patterns & Schedules
Accurate Design
(Passive House Planning Package)

Heating & Cooling Demand

- Roof Insulation
- Clerestory Wall Insulation
- Wall Cavity Insulation
- Wall Exterior Insulation
- Floor Insulation
- Exterior Doors U-Value
- Orientation
- Roof Overhang
- Roof Absorptivity
- Air Tightness (ACH50)
- Heat Recovery Efficiency
- Thermal Mass
- Front Windows
- Left Windows
- Back Windows
- Right Windows
- Glazed Doors
- Solid Door Glazing
- Glazing U-Value
- Glazing SHGC
- Roof Exterior Insulation

Design Value Adjustment
The Passive House Standard

1. Maximum Air Leakage: $0.6 \text{ ACH}_{50}$
2. Maximum Heating or Cooling
   $15 \text{ kWh/m}^2/\text{yr} (4.75 \text{ kBtu/ft}^2/\text{yr})$
3. Maximum Source Energy*
   $120 \text{ kWh/m}^2/\text{yr} (38.1 \text{ kBtu/ft}^2/\text{yr})$

*Before Solar Electricity

The Passive House Standard is a rigorous building performance standard. Consultants, projects or building components that have obtained the right to carry the logo have committed themselves to design excellence and the Passive House energy performance criteria.
Zero Carbon
Just Add Solar & Call It Done?
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Heating Demand
Solar + IHG
Internal Heat Gain
Marin’s Footprint
The Bad News

“Marin’s relative affluence and low amount of industry contribute to the residents being responsible 60-70% of the County’s carbon emissions.”

- Resilient Neighborhoods 2012 Pilot Program Results (www.resilientneighborhoods.org)
Marin: Where’s the Carbon?

- **Transportation**: 62%
- **Residential**: 19%
- **Commercial**: 12%
- **Agriculture**: 3%
- **Industrial**: 2%
- **Waste**: 2%

Source: Marin County Re-Inventory of Greenhouse Gas Emissions, Marin County Community Development Agency, September 2007
Extra Solar? Transportation!

Electric cars:
Your benefits may vary

The amount of greenhouse gas emissions associated with driving an electric car differs from one region to the next, depending on how each region generates electricity. Similarly, the amount of money an electric car driver saves on fuel each year varies, based on local utility rates. On this map, the first number represents the mileage of a gas-powered car that would have the same global warming emissions as an electric vehicle in that particular region. The second number represents the potential annual savings on fuel.

Source: Union of Concerned Scientists

Todd Trumbull / The Chronicle
Extra Solar? Clean the Grid!

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Thanks! Questions?

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Building Carbon Zero Marin
implementing energy efficiency in Marin’s building sector