Why Passive House? - Pecha Kucha

10 min - 30 slides x 20 sec.
High Performance Buildings

• Design / Build
• Performance Design / Build
• PH Design Consulting
• Construction

Passive House Projects
Why Passive House? - Pecha Kucha

• US Building Culture ...a low bar

• Why Passive House for NZE?

• Performance highlights - 2 PH projects

• CA coastal climate PH Do’s & Don’ts
Ireland circa. 800

1200 yrs of progress?

R2

U-factor 0.5 btu/hr/sf/F

(Building Science Corp.)

R1.5

U-factor 0.75 btu/hr/sf/F

50% less efficient!
Dumber buildings

“a thermodynamic obscenity”
Dr Joe Lstiburek, Building Science Corp.

• Award Winning
• LEED certified

Acqua Tower, Chicago
Building Science: Understanding?

Buildings rot
...even in CA

Standard Construction

High Performance Construction
Building Culture: Occupant Experience!

IAQ, Thermal & Acoustical Comfort

Rarely articulated as design criteria!

Low-Performance Building Culture
Out of BP wilderness with Passive House

• Rigorous energy standard (-90% HVAC)

• Simple design principles and methods

• Amazing Modeling tool: PHPP

• It works! (40 yr history)

Heat houses with just a hair dryer!
“Passive Solar” – ("mass & glass") had failed to deliver

1976 – Lo Cal House

1977 – Saskatchewan Conservation House

1978 – Leger House
Passive House: 40yr Intl. History

1977 - DOE
1978 - NEA
1979

1982 - DOE elim. proposed
1986 - Solar panels removed
MPG standards lowered

1992 - 1st Passive House, Darmstadt, Germany
1996 - PH Institute
2004 - 1st PH in US, Illinois
2012 - 1st PH/ZNE home, CA
Passive House - Energy Balance Equation

\[ (Q_S + Q_I) - (Q_T + Q_V) = Q_H \]
### PH Design Variables Matrix

<table>
<thead>
<tr>
<th>GAINS</th>
<th>LOSSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_S$ Solar Gains</td>
<td>$Q_V$ Ventilation Losses</td>
</tr>
<tr>
<td>$Q_I$ Internal Gains</td>
<td>• Insulation</td>
</tr>
<tr>
<td>Location</td>
<td>• Air Sealing</td>
</tr>
<tr>
<td>Shape</td>
<td>• Thermal Bridging</td>
</tr>
<tr>
<td>Orientation</td>
<td>• Windows/Doors</td>
</tr>
<tr>
<td>Glazing</td>
<td>• Glass U-val</td>
</tr>
<tr>
<td>SHGC</td>
<td>• Frames</td>
</tr>
<tr>
<td>Shading</td>
<td>• Install</td>
</tr>
</tbody>
</table>

$$
(Q_S + Q_I) - (Q_T + Q_V) = Q_H
$$
### PH Tools: PHPP Energy Modeling

#### Table:

<table>
<thead>
<tr>
<th>SHGC</th>
<th>Reduction Factor for Solar Radiation</th>
<th>Window Area</th>
<th>Window U-Value</th>
<th>Window R-Value</th>
<th>Glazing Area</th>
<th>Glazing Area as % of Gross Floor Area</th>
<th>Average Global Solar Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>0.54</td>
<td>80.2</td>
<td>0.21</td>
<td>4.7</td>
<td>64.9</td>
<td>3.7%</td>
<td>38</td>
</tr>
<tr>
<td>0.39</td>
<td>0.27</td>
<td>306.1</td>
<td>0.23</td>
<td>4.6</td>
<td>63.0</td>
<td>3.6%</td>
<td>66</td>
</tr>
<tr>
<td>0.50</td>
<td>0.42</td>
<td>97.5</td>
<td>0.25</td>
<td>4.0</td>
<td>70.5</td>
<td>4.1%</td>
<td>115</td>
</tr>
<tr>
<td>0.34</td>
<td>0.43</td>
<td>573.7</td>
<td>0.22</td>
<td>4.0</td>
<td>75.0</td>
<td>4.1%</td>
<td>115</td>
</tr>
<tr>
<td>0.42</td>
<td>0.41</td>
<td>0.0</td>
<td>0.0</td>
<td>4.0</td>
<td>75.0</td>
<td>4.1%</td>
<td>115</td>
</tr>
</tbody>
</table>

#### Verification Overview:

- **Climate**
- **U-Values**
- **Areas**
- **Ground**
- **Components**
- **Windows**
- **Shading**
- **Ventilation**
- **Additional vent.**
- **Annual heating**
- **Heating**
- **Heating load**

#### Provisions:

- **DHW+Distribution**
- **Solar DHW**
- **PV**
- **Electricity**
- **Electricity non-res**
- **Aux Electricity**
- **IHG**
- **IHG non-res**
- **Use non-res**
- **PE-Value**
- **Compact**
- **HP**
- **HP ground**
- **Boiler**
- **District heating**
- **Data**

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PH Tools: PHPP Energy Modeling

Energy Balance Graphs

Monthly Heating Demand

Verification Metrics
Net Zero Energy Goals

Average 3000 sf Home (280 m²)
Annual Energy Usage = 40,000 kWh

- LIGHTS/PLUGS: 10,000
- HOT WATER/COOKING: 10,000
- HVAC: 20,000

Cottle 3200 sf Zero Energy Home (280 m²)
Estimated Annual Energy Usage: 10,000 kWh

- HVAC: 2,000
- HOT WATER: 3,000
- SOLAR HOT WATER: 6,000
- LIGHTS/PLUGS: 5,000

CONSERVED ENERGY: 60%

≈ 65% GAS (CA)

PG&E
### ZNE Loads Analysis, Budgeting, Renewable Energy

#### Energy Design & Engineering Required!

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**Passive House Planning**

<table>
<thead>
<tr>
<th>Building</th>
<th>Cottage Home</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Electricity Demand**

<table>
<thead>
<tr>
<th># Households</th>
<th>Persons</th>
<th>Energy Use</th>
<th>EnerGuide Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### APPLIANCES

<table>
<thead>
<tr>
<th>Item</th>
<th>Energy Use</th>
<th>EnerGuide Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator/Freezer</td>
<td>21.4</td>
<td></td>
</tr>
<tr>
<td>Undercounter Freezers</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Extra Freezer</td>
<td>13.6</td>
<td>Energy Star</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>21.7</td>
<td></td>
</tr>
<tr>
<td>Coffee Maker</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>Electric Tea Pot</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>Garbage Disposal</td>
<td>10.2</td>
<td></td>
</tr>
<tr>
<td>Clothes Dryer</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Clothes Washer</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Electric Clothes Dryer</td>
<td>23.8</td>
<td></td>
</tr>
<tr>
<td>Hair Dryer</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Clothes Iron</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Water Pump</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>Solar Thermal pump</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Demand HW pump</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>Hot Water (Gas) Heater</td>
<td>25.8</td>
<td></td>
</tr>
<tr>
<td>Garage Door Opener</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

#### Electronics

<table>
<thead>
<tr>
<th>Item</th>
<th>Energy Use</th>
<th>EnerGuide Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV - LCD Flat Panel</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>Cable TV Box/DVD Recorder 1</td>
<td>14.7</td>
<td></td>
</tr>
<tr>
<td>Cable TV Box/DVD Recorder 2</td>
<td>17.7</td>
<td></td>
</tr>
</tbody>
</table>

#### Other

<table>
<thead>
<tr>
<th>Component</th>
<th>Energy Use</th>
<th>EnerGuide Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td>21%, 2030</td>
<td></td>
</tr>
<tr>
<td>HEATING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIGHTING</td>
<td>8%, 800</td>
<td></td>
</tr>
<tr>
<td>ELECTRONICS</td>
<td>19%, 1870</td>
<td></td>
</tr>
<tr>
<td>HW</td>
<td>15%, 1465</td>
<td></td>
</tr>
</tbody>
</table>

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First Certified NZE new home in CA

- Avg. variation <0.5°
- $0.85 /day (HVAC)
- +Energy – EV charging
- IAQ, comfort!

YouTube: “The Hair Dryer Home...”
Sunnyvale Passive House Retrofit

Before – (12.76 ACH$_{50}$)
- 1957 ranch
- No insulation
- Extreme discomfort
- Condensation, mold
- Poor air quality

After - (1.47 ACH$_{50}$)
- Passive House
- Extreme comfort
- Sublime IAQ
- Heat w Hair Dryer
Sunnyvale PH Retrofit: Performance

HVAC Loads

MSHP: $127
Mini-Split HP: $124
Ovens: $94
Refrigerator: $81
Din&LR Lt/Rcp: $64
Dishwasher: $61
Bath Heaters: $54
Kit&Din Lights: $46
Mstr&So BR Lt/Rcp: $29
Exhaust Hood: $26
HRV: $26
Air Circ Fan: $19
Kitchen Recep: $12
LR Lt/Rcp: $9
Micro&Island Rcp: $8
Bath Recep: $6
No BR&Bath Lt/Rcp: $6

Bath heaters: $0
Washer/dryer > MSHP
72° set point
Total HVAC = $0.65 /day
A break ... enjoy
Provence
Super-insulated buildings are different!

Do’s and don’t for CA coastal climate zones ...
Do: Integrated Project Delivery (Design-Build)

Collaboration from the get go
Do: Apply Building Science & Engineering

Design building assemblies that will endure:

- Engr’d vapor profiles
- High drying potential
Do: Design for Water, Air, Thermal Control

Design to KISS
Don’t: Solar ignorance or greed
South - overhangs

Shading!
Shading!
Shading!

West - vertical

SUN ANGLES - SAN JOSE, CA

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Do: Heed overheating warnings

Frequency of Overheating \( h_0 \geq h_{\max} \):

- 18.7% at the overheating limit \( h_{\max} = 75 \, ^\circ F \)

Condensing dryers

Solar HW storage

External Heat Gains Matter!
Passive Houses need ventilation, heating and cooling!
Do: External kitchen exhaust

- IAQ matters most
- Recirculating hoods diminish air quality; (research data)
- Building code; ASHRAE
Thanks for listening!

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• Design/Build
• Performance Design/Build
• PH Design Consulting
• Construction

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