Quantum Builders
Positive Energy
Building Design
Optimizing your PRIUS
Optimizing your Windows
Optimizing your Windows

• Maximizing the amount of glass
• Location, location, location
• Insulating the window frame
• Flashing – how to do it discretely!
• A cautionary tale about thresholds
• Conclusions
Darwin’s theory
Darwin’s theory of windows

<table>
<thead>
<tr>
<th></th>
<th>U.S. U = 0.33</th>
<th>OLDER E.U. U = 0.15</th>
<th>NEW E.U. U = 0.11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface temp.</td>
<td>-6°F</td>
<td>-3°F</td>
<td>-2°F</td>
</tr>
<tr>
<td>depression.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat loss through 69'' 2' x 4' window</td>
<td>35 BTU/HR</td>
<td>26 BTU/HR</td>
<td></td>
</tr>
</tbody>
</table>

Outside = 35°F  Inside = 68°F

1. Aluminum  2. Fiberglass  3. EPS insulation

Source: ARCHnews Green Column, June 2009. Dan Johnson, danjoh99@gmail.com
Reducing the Heat Demand

Less frame, more glazing lowers your Heating Demand:

<table>
<thead>
<tr>
<th>$U_f$</th>
<th>$Q_{solar}$</th>
<th>$Q_{T Fenster}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.72</td>
<td>15.2</td>
<td>3750</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3170</td>
</tr>
<tr>
<td>0.97</td>
<td>15</td>
<td>4034</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3452</td>
</tr>
<tr>
<td>1.05</td>
<td>13.5</td>
<td>4171</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3489</td>
</tr>
</tbody>
</table>

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
Location, location, location…

POOR: \(U_w\text{(installed)} = 1.05 \text{ W/m}^2\text{K}\)
Psi-install = 0.039 W/m\(^2\)K

Placing the window in the best location within the wall cavity:
Horizontal direction

BETTER: \(U_w\text{(installed)} = 1.00 \text{ W/m}^2\text{K}\)
Psi-install = 0.023 W/m\(^2\)K

BEST: \(U_w\text{(installed)} = 0.99 \text{ W/m}^2\text{K}\)
Psi-install = 0.02 W/m\(^2\)K

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
What does this do to my PHPP?

My project:

<table>
<thead>
<tr>
<th>Treated Floor Area</th>
<th>1448.5</th>
<th>ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Heated Building Footprint Area</td>
<td>796</td>
<td>ft²</td>
</tr>
<tr>
<td>Gross Enclosed Volume</td>
<td>12312.25</td>
<td>ft³</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Win Loc'n</th>
<th>λ</th>
<th>Ψ_{Install}</th>
<th>SSHD</th>
<th>AHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(%)</td>
<td>(W/mK)</td>
<td>(BTU/hr. °F)</td>
<td>kBTU/(ft²yr)</td>
<td>kBTU/(ft²yr)</td>
</tr>
<tr>
<td>0</td>
<td>0.016</td>
<td>0.009</td>
<td>4.29</td>
<td>4.8</td>
</tr>
<tr>
<td>30</td>
<td>0.011</td>
<td>0.006</td>
<td>4.24</td>
<td>3.73</td>
</tr>
<tr>
<td>50</td>
<td>0.008</td>
<td>0.005</td>
<td>4.21</td>
<td>3.71</td>
</tr>
</tbody>
</table>

By moving the windows to the center of the wall we reduced the Annual Heat Demand by 22%.
Avoid interior cold spots!

Images: Stefan Carpentier, Q+ Performance Testing, CA
Over-insulating

Simply adding insulation over your frame improves performance!

BEFORE: $U_w\text{(installed)} = 1.19 \text{ W/m}^2\text{K}$
Psi-install = 0.15 W/m$^2$K

AFTER: $U_w\text{(installed)} = 0.78 \text{ W/m}^2\text{K}$
Psi-install = 0.005 W/m$^2$K

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
Options for out-swing windows

Example of Danish project over-insulating out-swing windows:

![Diagram showing different construction solutions for out-swing windows.]

**Table 2:** The table shows the linear thermal transmittance for different variations of the Brick 1 solution. Av. $\Psi$ is an average value of the linear thermal transmittance around the window and with the fittings (2%).

<table>
<thead>
<tr>
<th>Placement</th>
<th>Brick 1</th>
<th>Brick 2</th>
<th>Brick 3</th>
<th>Brick 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulated frame</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (inside, all around)</td>
</tr>
<tr>
<td>Av. $\Psi$ (W/mK)</td>
<td>0.020</td>
<td>0.009</td>
<td>0.008</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Source: Conference Proceedings, 12th International Conference on Passive Houses 2008, PHI. 'The Architectural and Technical Consequences of Different Window Details in a Danish Passive House' by Camilla Brunsgaard, Per Heiselberg and Rasmus L. Jensen, Aalborg University Department of Civil Engineering
Over-insulating

Sometimes too much of a good thing is not necessary!

30% COVERED:
\[ U_w(\text{installed}) = 0.96 \text{ W/m}^2\text{K} \]
\[ \text{Psi-install} = 0.008 \text{ W/m}^2\text{K} \]

50% COVERED:
\[ U_w(\text{installed}) = 0.94 \text{ W/m}^2\text{K} \]
\[ \text{Psi-install} = 0.003 \text{ W/m}^2\text{K} \]

100% COVERED:
\[ U_w(\text{installed}) = 0.89 \text{ W/m}^2\text{K} \]
\[ \text{Psi-install} = 0.013 \text{ W/m}^2\text{K} \]

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
Over-insulating

Optimizing psi-install with insulation

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
Not all over-insulating is good

Insulating over Alum-clad frames does not work as well…

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
Options for clad windows

Alum-clad on the sash only performs much better!

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
What, no more nailing fin?

Weaning ourselves off the old installation detail…

BEFORE

Source: BSC Info Sheet 302, Pan Flashing for Exterior Wall Coverings
Flash often, but flash carefully!

Please - NO thermal bridge pan flashing!

[Diagram: Sill pan under window to interior]
Sill install suggestions...

Sill pan behind nailing fin and in front of window

Bituthane membrane flashing

Air-tight taping to the interior

AFTER:

Post Presentation Note:
One audience member pointed out that the exterior wood sill had no way of being attached without penetrating the sill flashing. Two potential options:

1. Leave it off and use German-style exposed metal sills as flashing and finish
2. Use an A35-type clip to attach the wood sill to the jamb extensions and have it ‘float’ above the metal sill pan.
The Euro version...

Sill pan & flashing behind drip edge of window cladding

Bituthane membrane flashing

Air-tight taping to the interior

AFTER:
And a header install suggestion

- Over-insulation
- Nailing clips (Simpson LTP5’s)
- Air-tight taping at interior
- Window centered in wall

Euro Header:
Sills for Euro windows...
Now to the thresholds...
Step-over thresholds
Some investigation is needed!

STEP-OVERTHRESHOLD:
U (hdr + jmb) = 1.13 W/m²K
U (sill) = 1.27 W/m²K
U (frame) = 1.15 W/m²K

LOW THRESHOLD:
U (hdr + jmb) = 1.13 W/m²K
U (sill) = 3.329 W/m²K
U (frame) = 1.47 W/m²K

Overall Performance Delta: **0.32 W/M²K** (per door)
Conclusions

- Slimmer frames can perform better, despite lower U-values
- Moving the window into the wall center reduces Heat Demand
- Insulating over the frame improves the window performance
- Metal pan flashing details are tricky – proceed with caution!
- Look out for your door u-values: many low thresholds do not perform well! Account for this in your PHPP calculations.
Thank you!

Presentation & Data:
Bronwyn Barry

Review & assistance:
Stefan Carpentier