16th & Nebraska
Salem, OR

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The Road to Passive House...

- Brief rundown of general systems and values leading to current PHPP Status (~10 slides)

- In depth look at systems, methods, challenges, and initial performance (~30 slides)
Salem, OR
• 4784 HDD
• 257 CDD
• 40” Avg. Annual Precipitation

16th and Nebraska Passive
• Designed and built by Bilyeu Homes
• Three Bedroom, 2.5 bath
• 1885 Total Square Feet (1567 TFA)
• Built Cost: $300,000 ($159 per sq. ft.)
• Add’l cost to reach P.H.:~6% ($18,000 or $9.55 per sq. ft.)

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General Design: the basic rundown...

• 10” Double stud wall system w/ 2” EPS insulation
• Suspended floor over crawl
• Truss roof with loose-fill
• Serious Windows
• Therma-Tru door panels with custom sills and 5-point lock system
• UltimateAir® RecoupAerator®
• Fujitsu® Mini-split heat pump
• Solar hot water
• Drain Water Heat Recovery

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Component Values

- Double Stud Walls: R-45
- Floor System: R-51
- Roof: R-96
- Therma-Tru Doors:
  - U-value: .13
- Serious 725 Low SHGC
  - SC-75 Card. 272
  - cog U-value: .105  SHGC: .298
- Serious 725 High SHGC
  - HM-88 Clear
  - cog U-value: .178  SHGC: .563

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Ventilation (and lack thereof)

- **UltimateAir® RecoupAerator®**
  Supplies in all bedrooms, office, and living room; Returns in all bathrooms, kitchen, and laundry room. Transfer grills above all doors.

- **Bosch Axxis condenser dryer**

- **Recirculating range hood with charcoal filter**
Fujitsu 9RLS single head “Hi-SEER” Mini-split Heat Pump

Smallest Most Efficient N. American Unit
12,000 BTU/hr (PHPP Heating Load=4583 BTU/hr)
26 SEER
12 HSPF
COP of 4.11 @ 41° F
~$1,500 (unit only)

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Solar Domestic Hot Water

40-tube Thermomax® Evacuated-Tube Solar Hot Water System

119 Gallon Storage Tank with electric backup element

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84” Power-Pipe® Drain Water Heat Recovery (DWHR) System

- Located in mech. room directly under upstairs bathrooms
- Minimize energy consumption from hot water heating

To be installed here...

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First hint at level of airtightness

- Initial blower door test (Dec. ‘09 pre-insulation/siding) failed to generate value—technician lacked small enough ring

- Diagnostics done at 100 Pa in conjunction with Thermal IR camera to insure “cover ready”.

- Blower door test March 11\textsuperscript{th} performed with “D” ring…….
Blower Door Results--“D” Ring

Net Air Volume for Pressure Test: 13,772.35 ft³
Resulting Value (avg. of three): .26 ACH 50

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# PHPP Verification

<table>
<thead>
<tr>
<th>Specific Demands with Reference to the Treated Floor Area</th>
<th>Monthly Method</th>
<th>PH Certificate</th>
<th>Fulfilled?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated Floor Area: 1567 ft²</td>
<td></td>
<td>4.75 kBTU/(ft²·yr)</td>
<td>Yes</td>
</tr>
<tr>
<td>Specific Space Heat Demand: 4.09 kBTU/(ft²·yr)</td>
<td></td>
<td>4.75 kBTU/(ft²·yr)</td>
<td>Yes</td>
</tr>
<tr>
<td>Pressurization Test Result: 0.3 ACH₅₀</td>
<td></td>
<td>0.6 ACH₅₀</td>
<td>Yes</td>
</tr>
<tr>
<td>Specific Primary Energy Demand (DHV, Heating, Cooling, Auxiliary and Household Electricity): 25.7 kBTU/(ft²·yr)</td>
<td></td>
<td>38.0 kBTU/(ft²·yr)</td>
<td>Yes</td>
</tr>
<tr>
<td>Specific Primary Energy Demand (DHV, Heating and Auxiliary Electricity): 10 kBTU/(ft²·yr)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Specific Primary Energy Demand Energy Conservation by Solar Electricity: 0 kBTU/(ft²·yr)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating Load: 2.9 BTU/(ft²·hr)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of Overheating: 0 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Useful Cooling Energy Demand: 4 kBTU/(ft²·yr)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling Load: 4 BTU/(ft²·hr)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

over 77.0°F
How it went together...
Foundation/Floor Framing

- Layout, preparations-
- Double Rim separated with 3”XPS
- 1.5” Type II EPS on underside of joists thermally decouples floor system from crawl space

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Wall Assembly

• Added cost of double wall system-
• Outer 2x4 wall load-
• Inner 2x4 wall load-
• Headers-
Second Floor System

- Open-web floor trusses

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• 8’ exterior wall studs and 92 5/8” partition wall studs accommodate ceiling furring
• Raised heel trusses (1’9”) for main roof

• Porch, garage, story break roofs all separated with EPS
Air Barrier Application

• All Sheathing sealed at seams with 3M™ All Weather Flashing Tape 8067

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Air Barrier Intersects

Wall/Ceiling Intersect

Wall/Window Intersect

Wall/Floor Intersect
Wall/Floor Air Barrier Intersect

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• Connecting the floor air barrier to the wall air barrier
Wall/Window Air Barrier Intersect

• Window flange tied back to A.B.

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Wall/Ceiling Air Barrier Intersect

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Ceiling Diaphragm and Furring

- 2x4 on edge, perpendicular to truss chords
- Wiring
- Thermal break

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Wall/Roof Intersect and Furring

(Animation)
Air Barrier Details

EPDM Rubber Gaskets at all A.B. Penetrations

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Air Barrier Challenges....

- Condensate and overflow lines (SDHW tank, mini-split etc.)—“straws” to the outside
- Attic access
- Dog door! (a customer necessity...)

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A.B. Challenges Cont’d

Condensate and overflow lines

“Drain-Plus” SUPCO DP34 condensate line seal

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A.B. Challenges Cont’d

Attic Access...

ORSC Section R807… “other readily accessible location”

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A.B. Challenges Cont’d

Dog Door

Access Magnetics “Freedom Pet Pass” dog door

Performance at 50 Pa…

(Video during blower door test)

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Ventilation Design/Installation

- Smooth Rigid throughout
- Utilizes Open Web Floor Truss for distribution and ovalized 6” for high-wall distribution on second floor
Insulation/Outsulation

GreenFiber® DensePack Cellulose (R-3.7/In.)

Insulfoam® Type II EPS (R-4.55/inch, Vapor Permeability 3.5 Perms)

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520 Bags of all-borate Cellulose
Application of 2” EPS

• Roof/Wall intersects and window perimeters first, then field infill after blower door test.

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Window Installation

Installed over EPS

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Siding Application

• .75” ventilated rainscreen, 12” o.c.

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The Current State

Expected Completion: April 2010
Initial Insights on Performance

Outside Upstairs Window Mullion
69° F

Inside Of Exterior Wall
70.5° F

Window Pane (taken at label to avoid reflected IR)
69.5° F

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Initial Performance cont’d

- Windows masked for painting (cutting down SHG)
- Three weeks in Feb. **without** heater operating (only tools, lights etc.)

Monday morning readings

**Outside Temp: 43.5° F**

**Inside Temp: 62.0° F**
Final Thoughts....

- Passive House design works....
- Point Source heating results in incredibly even temperatures throughout the house.
- Most challenges have solutions for P.H. compatibility
Thank you

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