Courtland Place-Seattle
Courtland Place-Seattle

- 2 ½ storey house w/ ADU
- 1895 SF TFA
- Designed 2008
Courtland Place - Seattle

Ventilation & Heat

- Continuous Balanced ventilation with energy recovery
- Ultimate Air RecoupAerator
- Fresh air supply to each living space
- Exhaust air from each bathroom, kitchen and mechanical
- Less than 6,000 BTUs/hour needed to maintain 68 Deg F throughout the Winter
- Water-to-Air heat exchanger
- Supplemental electric resistance (2)
• The Early Years: Garbage Bag Commissioning

• Indoor Air Distribution: Mixing and Uniformity (Do Not Ignore Stratification)

• Air-to-Water coil vs Slab Hydronic Heat

• The Balancer’s Dilemma: Heating Load vs Ventilation Load
Madrona PH-Seattle

6 kW Sauna?

ZONE 3
ZONE 2
ZONE 1
Madrona PH-Seattle

Sanden CO$_2$ Heat Pump

- Linear fit of EF to temperature
- Use TMY temperature bins to calculate an annual EF:

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<tr>
<th>Climate</th>
<th>Annual EF</th>
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Sanden CO₂ Heat Pump

Performance vs. Temperature

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<th>Outside Air Temperature (F)</th>
<th>Energy Factor (EF)</th>
<th>COP</th>
<th>Output Capacity (kW)</th>
<th>Input Power (kW)</th>
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Performance vs. Outside Temperature

\[ y = 0.0331x + 1.1958 \]

Output Capacity (BTU/hr)

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Madrona PH-Seattle

Sanden CO$_2$ Heat Pump

On-demand Electric Back-up

Heat exchanger to radiant heating system
Glasswood Building
Glasswood Building

- Heat Pump Water Heater
- Zehnder ComfoAir HRV
- Mitsubishi Ductless Mini-Split
- Exhaust
- Supply
Pumpkin Ridge PH– Hillsboro
Pumpkin Ridge PH– Hillsboro

- Summer Solstice
- October
- Winter Solstice
Pumpkin Ridge PH– Hillsboro

Overhang Annual Analysis (Direct Sunlight)

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67%
Pumpkin Ridge PH– Hillsboro

PHPP Peak Heating Load @ Design Temp

7,418 BTU/hr

Main Level South Glass = 172 SF
SHGC = 0.50
October Direct Sun: ≈ 70%

172 X 0.50 X 0.70 X 300 BTU/hr. =

18,060 BTU/hr

Result: 2.4 x Peak Heating Load
Pumpkin Ridge PH– Hillsboro

WeatherSpark Sept-Nov 2012

9/6 = 93°F
9/6 = 85°F
10/7 = 78°F
11/4 = 68°F
Pumpkin Ridge PH – Hillsboro
WeatherSpark Sept-Nov 2013

- 9/11 = 97°F
- 10/6 = 78°F
- 10/21 = 78°F
- 11/10 = 68°F
In perfect world upstairs and downstairs zone and Sanden for DHW.
**FARRIS/RESIDENCE**

**BRYAN/AND/STEPHANIE/FARRIS**

**30680/NW/REDHAWK/ROAD**

**NORTH/PLAINS,/OR/97133**

**H** 503.447.1123

**PROJECT DESCRIPTION**

**HVAC/SYSTEM/DESIGN**

**PROJECT ADDRESS**

**CONTACT INFORMATION**

**DRAWN BY**

**DRAWN ON**

**REVISION DATE**

**REASON**

**INITIALS**

**SCALESHEET NUMBER**

**TOTAL SHEETS**

**MECHANICAL/PLAN**

**4/29/13**

**N/A**

**1**

**1**

**HVAC DUCTING LAYOUT**

**VENTILATION + CONTROLS SCHEMATIC**

**BASEMENT SECTION A-A**

**Ventilation Return Trunk, 8" x 16" from each bath**

**Heat/Cooling/Ventilation Supply Trunk, 8" x 16" boots down for lower floor, up for main floor**

**HVAC Supply Air**

**Ventilation Return from bathrooms**

**Fresh air intake**

**Stale air exhaust**

**MHK wireless thermostat mounted in lower hall**

**Zehnder wired remote (mounted in kitchen)**

**Zehnder wireless remote (mounted in each bath)**

**Mitsubishi SUZ-KD15NA outdoor unit**

**Zehnder Comfo 350 HRV**

**240VAC 20A circuit with disconnect**

**240VAC 15A circuit**

**Zehnder wired remote (mounted in kitchen)**

**Zehnder wireless remote (mounted in each bath)**

**DESIGN NOTES:**

Target exhaust design flows based PHPP airflow rate of **165 cfm**:
- Kitchen 40cfm
- Bathrooms 28cfm x 4
- Laundry 14cfm

Zehnder ComfoAir 350: Max capacity **218 cfm**
- PHPP Design Air Flow Rate: **165 cfm**
- PHPP Standard Flow Rate (0.30 ACH): **127 cfm**

ASHRAE 62.2-2013 Ventilation Rate (w/ Infiltration Credit) **131 cfm**
- ASHRAE 62.2-2010 (Table 4.1)/ 2011 ORSC Ventilation Rate (Table TABLE 1101.1(3)) **90 cfm**

**Computer Generated by HAMMER & HAND**

**IMAGINE ENERGY**

**2409 N KERBY AVENUE**

**PORTLAND, OR 97227**

**P 503.477.9585 F 503.477.3340**

**INFO@IMAGINEENERGY.NET**

**CCB #: 167963**

**WA LIC #: IMAGIEL934PT**
Lower Level HVAC

**HVAC DUCTING LAYOUT**

- HVAC SUPPLY
- VENTILATION RETURN
- COLD AIR RETURN
- FRESH AIR SUPPLY

**DESIGN NOTES:**

Target exhaust design flows based PHPP airflow rate of 165 cfm:
- Kitchen 40cfm
- Bathrooms 28cfm x 4
- Laundry 14cfm

Zehnder ComfoAir 350: Max capacity 218 cfm

PHPP Design Air Flow Rate: 165 cfm

PHPP Standard Flow Rate (0.30 ACH): 127 cfm

ASHRAE 62.2-2013 Ventilation Rate (w/ Infiltration Credit) 131 cfm

ASHRAE 62.2-2010 (Table 4.1)/ 2011 ORSC Ventilation Rate (Table 1101.1(3)) 90 cfm
Main Floor HVAC

- **Ventilation Return Trunk, 8" x 16"**
  - from each bath

- **Main Floor HVAC Cold Air Return**
  - Mitsubishi SEZ-KD15NA Air Handler

- **Lower Floor HVAC Cold Air Return**
  - Zehnder Comfo 350 HRV

- **HVAC Supply Air**
  - Ventilation Return from bathrooms

- **Stale air exhaust**
- **Fresh air intake**

- **Mitsubishi SUZ-KD15NA outdoor unit**
- **Wireless receiver**
- **Refrigerant lineset**
- **240VAC 15A circuit**
- **240VAC 20A circuit with disconnect**

- **MHK wireless thermostat**
  - mounted in lower hall

- **Zehnder wired remote**
  - (mounted in kitchen)

- **Zehnder wireless remote**
  - (mounted in each bath)

- **240VAC 15A circuit**

- **Heating/Cooling/Ventilation Supply Trunk, 8" x 16"**
  - boots down for lower floor, up for main floor

- **DESIGN NOTES:**
  - Target exhaust design flows based PHPP airflow rate of 165 cfm:
    - Kitchen 40cfm
    - Bathrooms 28cfm x 4
    - Laundry 14cfm
  - Zehnder ComfoAir 350: Max capacity 218 cfm
  - PHPP Design Air Flow Rate: 165 cfm
  - PHPP Standard Flow Rate (0.30 ACH): 127 cfm
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  - ASHRAE 62.2-2010 (Table 4.1)/ 2011 ORSC Ventilation Rate (Table 1101.1(3)): 90 cfm
Pumpkin Ridge PH– Hillsboro

High Sidewall Supply

Figure 4. High sidewall supply outlet example

Figure 5. Ceiling supply outlet example

Advanced Strategy Guideline: Air Distribution Basics and Duct Design
Arlan Burdick
IBACOS, Inc.
December 2011
Pumpkin Ridge PH

Main Level
Floor Distribution
HRV Imbalance?
Pumpkin Ridge PH– Hillsboro
Pumpkin Ridge PH– Hillsboro
Pumpkin Ridge PH– Hillsboro

Annual kWh Mini-Split

ACTUAL

PHPP BUDGET

1771

25%

1422
Pumpkin Ridge PH – Hillsboro

Ventilation Rate - So Many Flavors

Passive House
127 cfm (0.30 ACH)

ASHRAE 62.2-2013
142 cfm (0.34 ACH)

ASHRAE 62.2-2010
72 cfm (0.17 ACH)

BSC 01-2013
72 cfm (0.17 ACH)

Based on PHPP Room Ventilation Volume (a_{TFA}^8.2')
### Manometor

#### Cooling Degree-Days (CDD)

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<th>Month</th>
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<td>Dec</td>
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#### Heating Degree-Days (HDD)

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<td>Nov</td>
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<td>Dec</td>
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#### Humidification

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</table>
Humidification

AHRI Guideline F
(formerly ARI Guideline F)

2008 Guideline for
Selection, Installation
and Servicing of
Residential Humidifiers

Outdoor Design Conditions

Indoor Design Conditions
• Target Indoor RH?
• Moisture Generation Rate
Humidification

AHRI Guideline F
2 Gallons per Day (Family of 4)
8.33 lbs/gal
Humidification

Indoor Target: 70°F @ 30% RH
- DP=37°F
- HR=32 grains/lb

Outdoor: 20°F @ 70% RH
- DP=11°F
- HR= 11 grains/lb

130 CFM Removes 1.76 lbs/hr
5.1 Gallons Per Day
Humidification Energy Penalty?

HRV
-5.1 GPD dehumidification + 2 GPD Indoor Moist Load
3.1 GPD = 12.3 kWh per day

ERV @ 60% Moisture Recovery
-2 GPD dehumidification + 2 GPD Indoor Moist Load
0.00 GPD

1 gallon = 8.33 lbs
1 lb water to steam ≈1,000 BTU
**WUFI Indoor RH**

- **Outdoor Climate (Left Side)**
- **Indoor Climate (Right Side)**

**derived from** Portland, OR, ASHRAE Year 2

**Temperature / Relative Humidity**

**Air-conditioning system**
- **AC Type**: Heating only
- **Floating indoor temperature shift [°F]**: 5.04
- **Set point for heating [°F]**: 69.98

**Relative Humidity**
- **Moisture Generation Rate**
  - **Number of bedrooms**: 1
  - **Jetted tub without exhaust fan**
  - **User-defined Moisture Generation Rate**
    - **Moisture Generation Rate [lb/h]**: 0.64
- **Air Exchange Rate**
  - **User Defined**
  - **Air Exchange Rate [1/h]**: 0.3
  - **Building volume [ft³]**: 20000

**Graphs**
- Temperature [°F] vs. Date
- Relative Humidity [%] vs. Date
ERV Technology

Condensation vs Vapor Diffusion
ERV Technology

Vapor Diffusion: dPoint “Selective Membrane”

Blocks transfer of air, carbon dioxide, and other gases.

Cross-section of dPoint Selective Membrane

Heat and water vapour transfer through the membrane
Karuna House-Portland
Karuna House-Portland

Daikin Air to Water Heat Pump
Hydronic Floor Surface Area = 3,200 SF
Cooling Capacity: 12 BTU/hr/SF

38,400 BTU/hr

Result: 3.2 Tons of Cooling

Latent Load: **Ultra-Air 70H**