Orchards at Orenco Phase II

More Units…Less Cost…Still Passive

Ben Sturtz
REACH CDC

Michael Bonn
Ankrom Moisan Architects

Mike Steffen
Walsh Construction Co.

NAPHC
September 2016
Outline

• Orchards at Orenco – Background & Context

• Orchards Ph. I vs. Orchards Ph. II
  – Design
  – Passive House Process
  – Construction
  – Feedback / Monitoring / Measured Performance
  – Challenges and Lessons Learned
  – Costs

• Orchards at Orenco – Proof of Concept?
Learning Objectives

• Demonstrate how the Passive House standard has been applied successfully to affordable housing development, serving as a model for future developments in North America, and serving as a primary path to achieving net zero energy affordable housing

• Describe the key design measures incorporated in the overall building design, enclosure and mechanical systems to achieve Passive House certification

• Describe the integrated teamwork / process used by the project team in the design, construction and operation of high performance affordable housing

• Demonstrate how efficient design and cost optimization can be used to reduce the overall development and operating costs of affordable housing
The Orchards at Orenco

• Affordable housing community in Hillsboro, OR
  – Phase I: 57 units of workforce housing
    (completed 6/2015)
  – Phase II: 58 units of workforce housing
    (completed 7/2016)
  – Phase III: 52 units of family/workforce housing (2018?)

• Developer/Owner:
  REACH Community Development
REACH Community Development

• REACH’s goal is to provide Healthy, Safe and Affordable living

• Affordability not only includes low rents but also close proximity to work and schools, and low monthly utility bills

• REACH set a goal in their 2010 Strategic Plan to have a Passive House project in their portfolio by 2015
Why Passive House?

• Most rigorous building energy efficiency standard in world

• Achieve significant reductions of utility costs to residents, while improving comfort and durability

• The right path to net zero...
Orchards at Orenco - Background

- Site history
- Suburban location
- Growing community
- High-tech employer base
- Light rail
Location
Orchards at Orenco - Context

- Affordable living
- Amenity-rich
- Workforce
- Inclusive community
- Significant need
The Orchards at Orenco

PHASE 1
2015

PHASE 2
2016

PHASE 3
2017?
Project Team

Owner/Developer

Owner’s Representative

Architect of Record

General Contractor

Passive House Consultant

Design Architect

Mechanical Engineer

Structural Engineer

Civil Engineer

Landscape Architect

PHIUS+ Rater
Phase I Basics

- 57 units of affordable workforce housing
- 57,750 square feet
- 3-story, wood frame construction on concrete slab-on-grade foundation
Design Overview

Photo Credit: Casey Brauner

REACH COMMUNITY DEVELOPMENT       |        ANKROM MOISAN ARCHITECTS       |        WALSH CONSTRUCTION CO.
Aerial View from South
First Floor Plan
Passive House Doors (Interior)
Typical Roof Assembly: R-81
- 80 mil TPO roof membrane (fully adhered, white)
- 1/2” coverboard
- 12” polyisocyanurate insulation
- Self-adhered rubberized asphalt membrane vapor barrier (serves also as temp. roof)
- 3/4” plywood
- Prefabricated wood truss framing (trusses @ 24” o.c.)
- 5/8” gypsum wall board (2 layers)

Typical Exterior Wall Assembly: R-39
- Fiber cement siding w/ treated 1x wood furring @ 24” o.c.
- 1-1/2” rigid mineral wool insulation (8 lb. density)
- Spun-bonded polyolefin sheet water-resistant barrier
- 1/2” plywood with air sealing tape at all seams
- 2x10 wood framing (studs at 24” o.c.)
- 9 1/4” blown fiberglass insulation at all framing cavities
- Polyamide sheet vapor barrier
- 5/8” gypsum wall board

Typical Slab Assembly: R-19
- 4” concrete slab
- 15 mil polymer sheet vapor barrier
- 4” Type II expanded polystyrene insulation
- Gravel base with radon mitigation system piping

Enclosure Assemblies
Phase I Building Section
HVAC Design

- Highly iterative process
  - Design work → modeling work → costing analysis → constructability review
  - Repeat…
- Bidding / procurement
- Coordinating the work…

REACH COMMUNITY DEVELOPMENT       |        ANKROM MOISAN ARCHITECTS       |        WALSH CONSTRUCTION CO.
HVAC Design

Image courtesy of PAE Consulting Engineers
HVAC Design

- Highly iterative process
  - Design work → modeling work → costing analysis → constructability review
  - Repeat...

- Bidding / procurement
- Coordinating the work...

---

Mechanical Penthouse
HVAC Design

- 3 HRV Zones
- Cook ERV serves each zone
HVAC Design

- Continuous 50cfm supply air per bedroom
- Continuous exhaust at kitchen and bath
- Electric cove heater in living room for user control & backup heat  
  - Estimated at 20% of building heating load
- No active cooling at apartments
Overheating?

- Exterior overhangs at all windows
- Solar blocking window screens for west facing units
- Residents need to open windows at night and close during the day...
Water Heating

- Ultra high efficiency boiler with supplemental storage
- Insulated trunk supply lines with electric trace tape reheat
Integrated Process

• Integrated team / collaborative approach
  – Owner + design team + construction team

• Design Charrette, leading to early concepts...
EXT. WALL OPTIONS

WALL A
- 11 7/8" TJI Wall Framing
- 11 7/8" Blown FG Insul.
  R-Value: R-39
  Moisture: FAIR

WALL B
- 2x6 Wall Framing
- 9 1/4" Blown FG Insul.
- 1 1/8" Mineral Wool Ext. Insul.
  R-Value = 6.8
  Moisture: GB

WALL C
- 2x8 Wall Framing
- 2 1/4" Blown FG Insul.
- 3" Mineral Wool Ext. Insul.
  R-Value = 4
  Moisture: BARGAIN

WALL D
- 2x6 Wall Framing
- 5 1/2" Blown FG Insul.
  R-Value = 7.5
  Moisture: BEST!

WALL E
- 2x6 Wall Framing
- 5 1/2" Blown FG Insul.
- 7 1/2" Blown FG Insul. w/ 7 1/2" TJI 7A.455
  R-Value =
  Moisture: ?
Integrated Process

• Integrated team / collaborative approach
  – Owner + design team + construction team

• Design Charrette, leading to early concepts...

• Highly iterative process
  – Design work → modeling work → cost analysis → constructability review
  – Repeat...
<table>
<thead>
<tr>
<th>Iteration</th>
<th>#12A</th>
<th>#12B</th>
<th>#12C</th>
<th>#12D</th>
</tr>
</thead>
<tbody>
<tr>
<td>R7 Thick Windows (New Window Schedule)</td>
<td>R7 Thick Window</td>
<td>R7 Thick Window</td>
<td>R7 Thick Window</td>
<td>R7 Thick Window</td>
</tr>
<tr>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td></td>
</tr>
<tr>
<td>R8 Wall</td>
<td>R8 Wall</td>
<td>R8 Wall</td>
<td>R8 Wall</td>
<td></td>
</tr>
<tr>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td>Wall C: 2x6 w/ 3&quot; Mineral Wool</td>
<td></td>
</tr>
<tr>
<td>Thermal Mass</td>
<td>Old Drywall Walls &amp; Ceilings</td>
<td>Old Drywall Walls &amp; Ceilings</td>
<td>Old Drywall Walls &amp; Ceilings</td>
<td>Old Drywall Walls &amp; Ceilings</td>
</tr>
<tr>
<td>Ventilation Rate (ACH)</td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td>Ventilation Rate (cfm per sq ft)</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>MVV recovery efficiency</td>
<td>89% (Under Air ERV)</td>
<td>89% (Under Air ERV)</td>
<td>89% (Under Air ERV)</td>
<td>89% (Under Air ERV)</td>
</tr>
<tr>
<td>MVV air change (Total Air ERV)</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Space Heating</td>
<td>Gas Boiler, 93% eff.</td>
<td>Gas Boiler, 93% eff.</td>
<td>Gas Boiler, 93% eff.</td>
<td>Gas Boiler, 93% eff.</td>
</tr>
<tr>
<td>Water Heating</td>
<td>Gas Boiler, 93% eff.</td>
<td>Gas Boiler, 93% eff.</td>
<td>Gas Boiler, 93% eff.</td>
<td>Gas Boiler, 93% eff.</td>
</tr>
<tr>
<td>Other</td>
<td>SPF in Plumbing Stack</td>
<td>SPF in Plumbing Stack</td>
<td>SPF in Plumbing Stack</td>
<td>SPF in Plumbing Stack</td>
</tr>
<tr>
<td>Heat Demand, Annual HRF (kWh/yr)</td>
<td>3.83</td>
<td>3.83</td>
<td>3.83</td>
<td>3.83</td>
</tr>
<tr>
<td>Water Demand, Annual HRW (kWh/yr)</td>
<td>10,306</td>
<td>10,306</td>
<td>10,306</td>
<td>10,306</td>
</tr>
<tr>
<td>Total Energy, Annual (kWh/yr)</td>
<td>5,531</td>
<td>5,531</td>
<td>5,531</td>
<td>5,531</td>
</tr>
</tbody>
</table>

* Data assumes PHIIP default values for lighting, appliance and plug loads. Actual anticipated loads are over twice these values and will not meet the Primary Energy standard.

Image courtesy of Green Hammer
<table>
<thead>
<tr>
<th>Item</th>
<th>Iteration</th>
<th>#7 Thick Windows (New Window Schedule)</th>
<th>#8 Thick Wall (New Window Schedule)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R-value</td>
<td>R-value</td>
</tr>
<tr>
<td>Walls</td>
<td>2x8 w/ Spray FG</td>
<td>28</td>
<td>2x8 w 5&quot; Mineral Wool</td>
</tr>
<tr>
<td>Window - typ size, apts</td>
<td>3x5 ft T/T &amp; Fixed</td>
<td>18%</td>
<td>3x5 ft T/T &amp; Fixed</td>
</tr>
<tr>
<td>Window - typ size, lobby</td>
<td>Ribbon of 3x5 ft T/T</td>
<td>6.0</td>
<td>Ribbon of 3x5 ft T/T</td>
</tr>
<tr>
<td>Window - typ size, corridor end</td>
<td>(2) 3x5 ft</td>
<td>18%</td>
<td>(2) 3x5 ft</td>
</tr>
<tr>
<td>Window:Wall Ratio, average</td>
<td>EU IGU 0.5/0.5</td>
<td>11.4</td>
<td>EU IGU 0.5/0.5</td>
</tr>
<tr>
<td>Window - frame, apts</td>
<td>uPVC T/T</td>
<td>5.9</td>
<td>Casco 300 T/T overinsulated</td>
</tr>
<tr>
<td>Window - frame, lobby</td>
<td>uPVC T/T</td>
<td>6.0</td>
<td>Casco 400+300 overinsulated</td>
</tr>
<tr>
<td>Window - glass south</td>
<td>EU IGU 0.5/0.5</td>
<td>11.4</td>
<td>LoE 180/180 Argon</td>
</tr>
<tr>
<td>Window - glass north</td>
<td>EU IGU 0.5/0.5</td>
<td>11.4</td>
<td>LoE 366/180 Argon</td>
</tr>
<tr>
<td>Window - glass east</td>
<td>EU IGU 0.5 solar control</td>
<td>11.4</td>
<td>LoE 366/180 Argon</td>
</tr>
<tr>
<td>Window - glass west</td>
<td>EU IGU 0.5 solar control</td>
<td>11.4</td>
<td>LoE 366/180 Argon</td>
</tr>
<tr>
<td>Doors - frame</td>
<td>uPVC T/T Door</td>
<td>5.9</td>
<td>Casco 301 T/T Door over insul</td>
</tr>
<tr>
<td>Roof</td>
<td>10&quot; EPS over Sheathing</td>
<td>49</td>
<td>10&quot; EPS over Sheathing</td>
</tr>
<tr>
<td>Slab-field</td>
<td>Slab w 4&quot; EPS</td>
<td>19</td>
<td>Slab w 4&quot; EPS</td>
</tr>
<tr>
<td>Slab-footer</td>
<td>Slab w 2&quot; EPS</td>
<td>10</td>
<td>Slab w 2&quot; EPS</td>
</tr>
<tr>
<td>Slab-edge</td>
<td>Slab w 6&quot; EPS</td>
<td>29</td>
<td>Slab w 6&quot; EPS</td>
</tr>
<tr>
<td>Thermal Mass</td>
<td>Dbl Drywall Walls &amp; Ceilings</td>
<td>Gypsum tile fr w/o carpet</td>
<td>Dbl Drywall Walls &amp; Ceilings</td>
</tr>
<tr>
<td>Ventilation Rate (ACH)</td>
<td>0.32</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Ventilation Rate (cfm per apt)</td>
<td>88% (Zehnder HRVs)</td>
<td>83% (Ultimate Air ERV)</td>
<td>83% (Ultimate Air ERV)</td>
</tr>
<tr>
<td>HRV recovery efficiency</td>
<td>0.75</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>HRV electrical efficiency (W/cfm)</td>
<td>0.75</td>
<td>0.75</td>
<td></td>
</tr>
</tbody>
</table>
# Passive House Energy Analysis Summary

**The Ormonds at Orenco - Phase I**  
**Passive House Energy Analysis Summary**  
**Euroline Scenario**  
*(50% CD Set)*  
12/24/2013

## Results:

<table>
<thead>
<tr>
<th>Envelope</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>2x10 + 1.5” mineral wool</td>
</tr>
<tr>
<td></td>
<td>advanced framed, 15% framing factor</td>
</tr>
<tr>
<td></td>
<td>solid blocking @ exterior structural supports</td>
</tr>
<tr>
<td>Windows</td>
<td>EuroLine T/T uPVC overinsulated</td>
</tr>
<tr>
<td></td>
<td>R-frame</td>
</tr>
<tr>
<td>Glazing N/S</td>
<td>LoE 180/180 Ar, SHGC=0.34</td>
</tr>
<tr>
<td>Glazing E/W</td>
<td>LoE 366/180 Ar, SHGC=0.24</td>
</tr>
<tr>
<td>Residential Doors</td>
<td>EuroLine T/T Door uPVC overinsulated</td>
</tr>
<tr>
<td></td>
<td>ADA still (assumed 600 Series)</td>
</tr>
<tr>
<td>Glazing</td>
<td>same as above</td>
</tr>
<tr>
<td>Commercial Doors</td>
<td>TBD Wood Pre-Rated Door</td>
</tr>
<tr>
<td>Glazing</td>
<td>LoE 366/180 Ar, SHGC=0.24</td>
</tr>
<tr>
<td>Roof</td>
<td>12” Polyiso over Sheathing</td>
</tr>
<tr>
<td>Slab</td>
<td>4” EPS II</td>
</tr>
<tr>
<td></td>
<td>4” EPS IX</td>
</tr>
<tr>
<td></td>
<td>4” EPS1X</td>
</tr>
<tr>
<td></td>
<td>4” EPS II</td>
</tr>
</tbody>
</table>

## Assumptions:

- **Heating System**: 80% Heat Pump, COP = 4.15 (average all systems)
  - delivered via HRV supply & indoor heads
  - 20% Electric-Resistance (in apartments)
  - window washer shut-off
- **Ventilation System**: Ultimate Air ERV, 83% eff. 0.75 Wcfm
  - Apartment Ventilation: 50 cfm/pc
  - Comm. Res. Ventilation: 0.06 cfm/pc
  - CO2 sensor steps to code max req’d
- **DHW System**: Central Gas Heater w/ Trac-Hy on Lines
  - Water Heater efficiency = 94%
  - Hot Water Line Insulation: 1/2” hot water riser lines & min. 3/4” continuous
  - Low-flow fixtures throughout

## Assumptions:

- **Lighting**: Residential: 100% fluorescent/LED
  - Non-Residential: 0.8 Wfd occupied areas
  - 0.4 Wfd storage/circulation areas
  - Occupancy sensing in all non-residential areas

**Cooling Strategy**: Windows open right only, closed during day

- "Hold-open" recommended for windows. Turn position
  - HRV supply air tempered by heat pump, supply temp ~50F
  - HRV heat recovery bypass automated by thermostat

---

Image courtesy of Green Hammer
Integrated Process

• Integrated team / collaborative approach
  – Owner + design team + construction team

• Design Charrette, leading to early concepts...

• Highly iterative process
  – Design work → modeling work → cost analysis → constructability review
  – Repeat...

• Coordinating the work...
Phase I - Challenges & Lessons Learned

- Architectural design interface with PHPP
- Product availability
- Airtightness
- Managing subcontractors
- Resident engagement
Preliminary Airtightness Test Result: 0.0875 ACH\textsubscript{50}
Final Airtightness Test Result: 0.133 ACH$_{50}$
Phase I - Lessons Learned

• Owner vision - and commitment - is pivotal
Phase I - Lessons Learned

- Owner vision - and commitment - is pivotal

- It takes a team...working collaboratively, with everyone pulling in the same direction
Phase I - Lessons Learned

• Owner vision - and commitment - is pivotal

• It takes a team...working collaboratively, with everyone pulling in the same direction

• Early team integration pays off
Phase I - Lessons Learned

• Owner vision - and commitment - is pivotal

• It takes a team...working collaboratively, with everyone pulling in the same direction

• Early team integration pays off

• Proactive coordination and QC is essential
Phase I - Lessons Learned

• Owner vision - and commitment - is pivotal

• It takes a team...working collaboratively, with everyone pulling in the same direction

• Early team integration pays off

• Proactive coordination and QC is essential

• Keep it simple
The Building in Use

Photo Credit: Casey Brauner

REACH COMMUNITY DEVELOPMENT | ANKROM MOISAN ARCHITECTS | WALSH CONSTRUCTION CO.
Energy Monitoring

The Orchards

WEEKLY ENERGY BUDGET AT THE ORCHARDS

We’re tracking energy use as a community to collectively reduce our impact. An "Energy Budget" is set for each week, with different goals for 1 and 2-bedroom units. Your progress, in percentage used of your budget, is shown. It resets each week. As a community, we can see our combined progress. Congratulations to our Top Energy Savers!

DAY IN CYCLE

1  2  3  4  5  6  7

REACH COMMUNITY DEVELOPMENT | ANKROM MOISAN ARCHITECTS | WALSH CONSTRUCTION CO.
Education

• Building Owner
  • More upfront preparation/coordination required
  • Property management & maintenance staff
  • Owner’s training at turnover
  • Internal bucket meetings

• Building Tenants
  • Lease up
  • Move in
  • Ongoing
Benefits to Residents

• Utility savings estimated at $30-40/month
• Improved acoustics – can’t hear the MAX train...
• IEQ – continuous fresh air
• High degree of thermal comfort
Resident Satisfaction

“Every day I find a new reason to love it. It’s cool, it’s quiet, and I don’t even hear the train. During the heat wave, my girlfriend came over to sleep because it was so cool. Yay for German engineering!”

Georgye Hamlin quoted in POLITICO
Measured Performance

Orchards Phase I Energy Use: Measured vs Modeled (PHPP)

- Modeled EUI: 22.5 kBTU/sf yr (Plug loads per US norms).
- Measured (extrapolated): 21.6 kBTU/sf yr (4% under Model)
- Large Commons Elec Use

Graph courtesy of REACH Community Development / Housing Development Center
**Measured Performance**

- Apartments energy use lower than modeled
- Common area electricity use much higher than modeled
  - Causes have been investigated and troubleshooting is underway...
  - Fan at 3rd floor storage room that should be on timer is running continuously
  - Elevator usage higher than anticipated
  - Thermostats at freeze protection heaters in stairwells had been set at 70 degrees, have now been set to 45 degrees
  - DAS system added late during construction was not in original model (increasing site EUI slightly: approx. 0.2 kBTU/sf/yr)
Measured Performance

Energy Use Index (EUI) kBTu/sf/year

- Average Building: 72
- 2010 Oregon Energy Code: 52
- Architecture 2030 Goal: 22
- Phase I Design Model: 22.5
- Actual Energy Use (Extrapolated): 21.6

Graph courtesy of PAE Consulting Engineers
Enclosure Monitoring

- Monitoring performance of exterior wall assembly
- Study designed by RDH Building Science Laboratories
- Funded by ROXUL
- Will collect data for 2 years at least
Monitoring Locations
Enclosure Monitoring – Interior Temp

Image used with permission from ROXUL Inc. and RDH Building Science Inc.
Enclosure Monitoring – Interior RH

Image used with permission from ROXUL Inc. and RDH Building Science Inc.
Enclosure Monitoring – Sheathing MC

Image used with permission from ROXUL Inc. and RDH Building Science Inc.
Enclosure Monitoring – Sheathing RH

Image used with permission from ROXUL Inc. and RDH Building Science Inc.
Enclosure Monitoring – Sheathing RH

Image used with permission from ROXUL Inc. and RDH Building Science Inc.
Cost?
### Soft Costs - Premium

#### Incremental Soft Costs

<table>
<thead>
<tr>
<th>Design</th>
<th>Amount</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>37,260</td>
<td>Additional coordination/research</td>
</tr>
<tr>
<td>Mechanical</td>
<td>19,600</td>
<td>PAE - Full Design for mechanical system</td>
</tr>
<tr>
<td>Energy Modeling</td>
<td>24,000</td>
<td>PAE - Energy Modeling &amp; Incentives</td>
</tr>
<tr>
<td>PH consultant</td>
<td>38,720</td>
<td>Green Hammer</td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td>8,000</td>
<td>PHIUS</td>
</tr>
<tr>
<td></td>
<td>21,000</td>
<td>Earth Advantage PHIUS on site review</td>
</tr>
<tr>
<td><strong>Total soft costs</strong></td>
<td><strong>$148,580</strong></td>
<td></td>
</tr>
</tbody>
</table>

Analysis courtesy of Housing Development Center
# Hard Costs - Premium

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional construction duration</td>
<td>$31,500</td>
</tr>
<tr>
<td>Additional supervision/QC</td>
<td>$25,000</td>
</tr>
<tr>
<td>Overexcavation for underslab insulation</td>
<td>$10,000</td>
</tr>
<tr>
<td>2x10 stud wall - additional material cost</td>
<td>$60,000</td>
</tr>
<tr>
<td>Fero clips/brick detailing</td>
<td>$20,000</td>
</tr>
<tr>
<td>Detailing/material for separating interior PH spaces</td>
<td>$10,000</td>
</tr>
<tr>
<td>Siding return detail for overinsulation</td>
<td>$20,000</td>
</tr>
<tr>
<td>Additional flashing details</td>
<td>$20,000</td>
</tr>
<tr>
<td>Roofing insulation</td>
<td>$50,000</td>
</tr>
<tr>
<td>Wall insulation</td>
<td>$53,907</td>
</tr>
<tr>
<td>Slab on grade insulation</td>
<td>$55,711</td>
</tr>
<tr>
<td>Windows and Deck Doors</td>
<td>$176,217</td>
</tr>
<tr>
<td>Commercial doors, including interior PH doors</td>
<td>$38,443</td>
</tr>
<tr>
<td>HVAC</td>
<td>$83,886</td>
</tr>
<tr>
<td>Infiltration costs</td>
<td>-</td>
</tr>
<tr>
<td>Hot water heater</td>
<td>$2,000</td>
</tr>
<tr>
<td>Low flow fixtures</td>
<td>$3,480</td>
</tr>
<tr>
<td>Temp maintenance system</td>
<td>$15,000</td>
</tr>
<tr>
<td>Lighting</td>
<td>-</td>
</tr>
<tr>
<td>Appliances</td>
<td>$6,256</td>
</tr>
<tr>
<td>Energy monitoring system</td>
<td>$87,000</td>
</tr>
<tr>
<td>Elevator</td>
<td>-</td>
</tr>
<tr>
<td>Siding/rain screen</td>
<td>$20,000</td>
</tr>
<tr>
<td>Blocking, Hold offs, SAM</td>
<td>$25,000</td>
</tr>
<tr>
<td>Air Testing</td>
<td>$10,000</td>
</tr>
<tr>
<td>Other misc. costs</td>
<td>$50,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$873,400</strong></td>
</tr>
<tr>
<td><strong>Markup</strong></td>
<td><strong>$37,120</strong></td>
</tr>
<tr>
<td><strong>Total hard costs</strong></td>
<td><strong>$910,520</strong></td>
</tr>
</tbody>
</table>

Analysis courtesy of Housing Development Center
# Cost Premium & Financing

## Uses

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental Soft Costs</td>
<td>$148,580</td>
</tr>
<tr>
<td>Incremental Hard Costs</td>
<td>$910,520</td>
</tr>
<tr>
<td>Total incremental Cost</td>
<td>$1,059,100</td>
</tr>
<tr>
<td>Premium over &quot;typical Orenco&quot;</td>
<td>11.0%</td>
</tr>
</tbody>
</table>

## Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>REACH Equity</td>
<td>$300,000</td>
</tr>
<tr>
<td>Meyer Memorial Trust grant</td>
<td>$500,000</td>
</tr>
<tr>
<td>Neighborworks grant</td>
<td>$260,000</td>
</tr>
<tr>
<td>OHCS Weatherization</td>
<td>$100,000</td>
</tr>
<tr>
<td>Energy Trust of Oregon</td>
<td>$65,000</td>
</tr>
<tr>
<td>Enterprise charrette grant</td>
<td>$4,000</td>
</tr>
<tr>
<td><strong>Total additional Sources</strong></td>
<td><strong>$1,229,000</strong></td>
</tr>
</tbody>
</table>

Analysis courtesy of Housing Development Center
Would We Do It Again?
Innovation Towards Replication

- Best Overall Project and Best Affordable Project, 2015, PHIUS
- Sustainable Project of the Year, 2015, Portland Business Journal
- Golden Hammer Award for Best Project, 2015, Oregon Opportunity Network
- Energy Efficiency Project of the Year & People’s Choice Award, 2016, Daily Journal of Commerce
- Best Green Project, 2016, Affordable Housing Finance Magazine’s Reader’s Choice Award
- Featured in Dwell, Portland Monthly, Politico, Alaska Airlines’ in-flight magazine, and local newspapers
Orchards at Orenco Phase II - Context

- Rental Housing Crisis
- Cost Containment
- Market Demand
- Soft Cost Impacts
Orchards Phase I vs. Phase II

Phase I
(PHIUS+ Certified)

• Innovate to meet REACH strategic goal of building Passive House
• REACH brought significant private investment for this innovation

Phase II
(Passive House Inspired)

• Reduce costs to meet OHCS cost containment limits
• Additional private resources not available
• Take lessons learned & best practices from Phase I
Design Response to Cost Containment

Phase II (original design)
- L-shaped building with 46 parking stalls
- 57 units in 57,750 SF
- Shallow units to increase daylight
- Community room, office

Phase II (after design revisions)
- Bar building with 77 parking stalls
- 58 units in 49,900 SF
- Deeper, narrower units
- Reduced number of balconies
- Reduced amenity space
Wide and Shallow…

Narrow and Deep…

Phase I Typ. 1 BR

Phase II Typ. 1 BR
Orchards Phase I & II

**Phase I**
*(PHIUS+ Certified)*

- **Envelope**
  - Fully insulated slab & footings
  - 2x10 walls with 1 ½” exterior insulation
  - Triple-glazed windows
  - Low-slope roof with R-81 insulation

- **Whole building ERV with heat pump**

- **Spaces outside conditioned envelope = very expensive doors & detailing**

- **Ultra airtight: 0.13 ACH50**

- **Extended sequencing / duration**

**Phase II**
*(pursuing PHIUS+ Certification)*

- **Envelope**
  - Insulated slab. No insulation under footings
  - 2x8 walls with 1” exterior insulation
  - Triple-glazed windows
  - Steep-slope roof with R-60 insulation
  - Vented attic

- **Reduced vertical envelope area**
  - 35,000 SF → 27,700 SF

- **Same HVAC as Phase I, but with better zoning due to orientation of building**

- **All spaces inside conditioned envelope**

- **Airtight??????**
Phase I – Areas Outside PH Envelope

Phase II – All Areas Inside PH Envelope
Phase I Foundation  Phase II Foundation
1 ½” Exterior Insulation
2 x 10 Wall Framing

1” Exterior Insulation
2 x 8 Wall Framing

Phase I Ext. Wall

Phase II Ext. Wall
Phase I Building Section

REACH COMMUNITY DEVELOPMENT       |        ANKROM MOISAN ARCHITECTS       |        WALSH CONSTRUCTION CO.
Phase II Building Section

REACH COMMUNITY DEVELOPMENT | ANKROM MOISAN ARCHITECTS | WALSH CONSTRUCTION CO.
PHIUS+ Certification

• As design began, REACH called for Phase II to use lessons learned and best practices from Phase I while reducing costs to keep within cost containment limits set by state’s housing agency

• As construction began, building design was modeled in both PHPP and WUFI Passive

• Determined that design complied with requirements of PHIUS+ 2015 Passive Building Standard

• REACH decided to pursue certification for Phase II
Final Airtightness Test Results: $0.42 \text{ ACH}_{50} \text{ (taped)}$

$0.59 \text{ ACH}_{50} \text{ (untaped)}$
Phase II - Performance

• Modeled Performance: EUI = 22.2

• Measured Performance: Available Aug. 2017
Phase II - Lessons Learned

• Airtightness
  – A major challenge at steep slope roof with vented attic...
Phase II - Lessons Learned

• **Airtightness**
  – A major challenge at steep slope roof with vented attic...

• **Cost premium to achieve Passive House certification can be effectively reduced through more inherently efficient design**

• **Construction cost: $173/SF, $147k/unit**)
  – 8% cost/unit reduction from Phase I
  – 15%+ cost reduction if factoring in market escalation...
  – Negligible cost premium to achieve Passive House
Passive Measures - Incremental Costs

• Foundation insulation
• Wall framing
• Exterior insulation at cladding
• Triple-glazed windows (if required)
• Heat recovery at ventilation system
• Materials and labor to achieve airtightness
• Traction elevator
• Certification
• Quality assurance / verification
Orchards Phase I & II - Costs

**Phase I**
(PHIUS+ Certified)

- TDC of $14.5M
- $255K/unit
- Construction cost: $9,093,040
- $158/SF
- $159,527/unit
- Energy performance:
  - 5 energy models
  - 31-71% better than code
  - Actual data available now

**Phase II**
(pursuing PHIUS+ Certification)

- TDC of $13.6M
- $234K/unit
- Construction cost: $8,531,624
- $173/SF
- $147,097/unit
- Energy performance:
  - 3 energy models
  - 29-67% better than code
  - Actual data available in 2017
Orchards Phase I & II - Costs

**Phase I**  
(PHIUS+ Certified)
- TDC of $14.5M
- $255K/unit
- **Construction cost: $9,093,040**
- $158/SF
- $159,527/unit
- Energy performance:
  - 5 energy models
  - 31-71% better than code
  - Actual data available now

**Phase II**  
(pursuing PHIUS+ Certification)
- TDC of $13.6M
- $234K/unit
- **Construction cost: $8,531,624**
- $173/SF
- **$147,097/unit**
- Energy performance:
  - 3 energy models
  - 29-67% better than code
  - Actual data available in 2017
Orchards at Orenco - Proof of Concept

• When implemented with knowledge and skill, passive building measures are cost effective AND provide substantial benefits:
  – Enhanced comfort, health and durability
  – Energy use reduction, leading to operational cost savings

• Orchards at Orenco demonstrates that passive building measures can be implemented at multifamily housing for little additional first cost

• Life cycle cost & quality benefits likely to far exceed the additional investment at project inception
WHY?

• WHY are we not doing this on ALL affordable housing moving forward?

• WHY are we not doing this on ALL multifamily housing moving forward?

• “Split incentive” is potential issue for market-rate housing...shouldn’t be for affordable housing

• Construction market cost escalation IS an issue...
More Information & Insights

• REACH Community Development:

• Housing Development Center:

• Ankrom Moisan Architects:
  – https://www.youtube.com/watch?v=ewJUCWI6dqM

• PHIUS Case Study:

• BEST 4 Conference Paper:

• Guest Blog on Green Building Advisor:
Q & A