Achieving Passive House for Multi-Family Residential Projects

Orchards at Orenco Case Study

August 20, 2014

PRESENTED TO: BESF

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inspire interpret integrate

Presentation Outline

- Introduction to Passive House
- Case Study: Orchards at Orenco Housing
- Differences between PHPP and eQUEST
- Lessons Learned

Introduction to Passive House

Introduction to Passive House

Beginnings of Passivhaus

The Passivhaus standard

- Developed in Germany
- Founded in the early 1990s
- Professors Bo Adamson (Sweden) and Wolfgang Feist (Germany)
- The first Passivhaus Standard dwellings were in Darmstadt in 1991

Passive House Institute US (PHIUS)

- Founded in 2007
- Goal: bring the passive house strategy <u>back</u> to the US

“Passivhaus or 'Passive House' is the fastest growing energy performance standard in the world with 30,000 buildings realized to date” –
Passivhaus.org/uk

Introduction to Passive House

The Principles

Passive House is a performance based certification system – not a prescriptive path.

Based on:

- Superinsulation
- Airtightness
- Heat Recovery
- Ventilation
- Passive Solar Gain

Introduction to Passive House

Performance Criteria

Building Energy Demand:

- Heating = **4.75 BTU/hr-sf**
- Primary Energy Demand = **38 kBTU/sf-year**
- Airtightness = **0.6 ACH_{50}**

Introduction to Passive House

THE ANATOMY OF A PASSIVE HOUSE

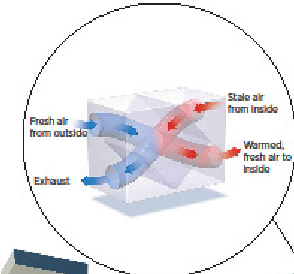
From the pages of Dwell to the New York Times, to various other architectural journals, chances are you've heard about Passive House. Often touted as "homes you can heat with a hair dryer," Passive House buildings boast energy loads low enough to make even the most environmentally-conscious homeowners drool. While the principles of the standard were born in North America in the 1970's, it was a German physicist, Dr. Wolgang Feist, who developed the standard and built the first prototype in 1990.

Since then, the standard has taken off in many European countries and began to make inroads in the United States. Today, Passive House US has 97 projects registered, mostly single-family houses, but also small schools, community centers, churches,& commercial buildings.

REACH Community Development is exploring the benefits and challenges of applying Passive House building strategies to a development in Hillsboro, Oregon's Orenco station district. The fully realized Orchards at Orenco development will provide 150 units of workforce housing built in 3 phases. During Phase One of the project, REACH will build a 57-unit Passive House-certified apartment building, thus demonstrating the applicability of Passive House concepts to affordable multifamily housing at a scale that is currently unprecedented in the United States. Here are just some of the components that make up a Passive House:

Roof

The roof at Orchards at Orenco will have 12" of insulation--about 4x the amount required by code. The light color of the roof reflects solar radiation, keeping temperatures on the roof surface and in the building at comfortable levels in warmer months.

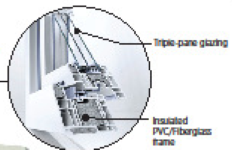


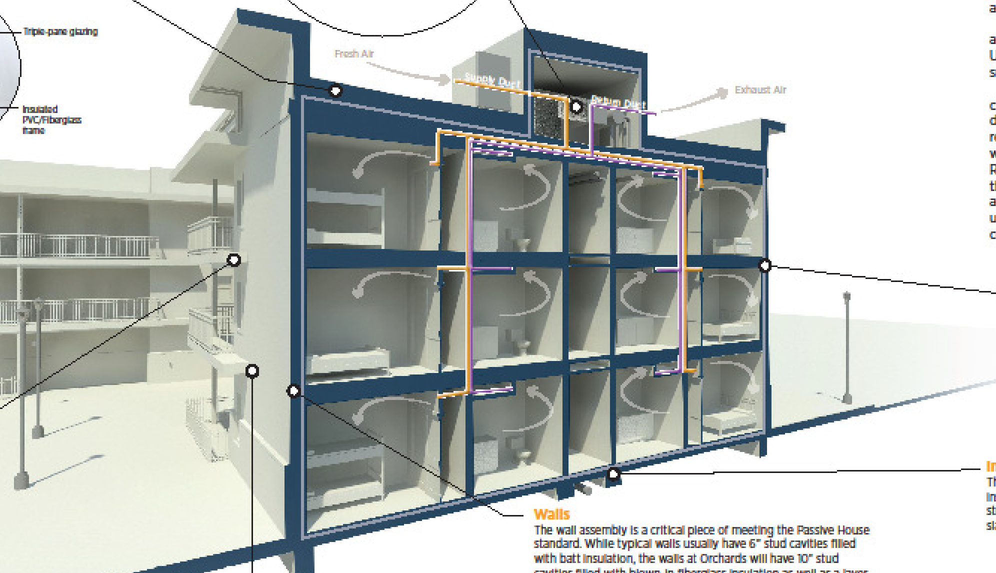
Heat Recovery Ventilator

The mechanical ventilation system and heat exchanger are critical to the building's energy efficiency and indoor air quality. The stale air exhausted from the kitchens and bathrooms warms fresh incoming air supplied to the unit bedrooms, making use of otherwise wasted energy.
— *Image from Broan*

Windows

Windows often present a weak point in a building envelope's thermal performance, so it is important to find windows that perform well. The Orchards at Orenco Passive House will use a PVC-Fiberglass hybrid window frame with argon-filled triple pane glazing. These windows will have European-style tilt-turn operation, allowing the windows to close tighter than the double-hung or slider styles that are more common in the United States.
— *Image from Euroline*





Continuous Air Barrier

The Passive House standard has rigorous requirements for building airtightness. In order to achieve this, Passive House buildings have continuous air barriers that cut down on heat losses due to infiltration. During the detailing and construction of a building, the design team and construction crew must be prudent in maintaining the continuity of the air barrier.

Solar Design

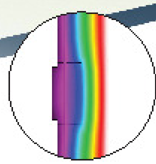
Smart design with regards to solar orientation is essential to keeping Passive House buildings comfortable, even in warmer months. Shading devices that allow the winter sun in but block the summer sun are an integral part of the building's solar design.

Insulated Slab

The ground floor slab sits on 4" of high-density foam insulation. The insulation continues underneath the structural footings and wraps around the vertical slab edge to meet the wall insulation.

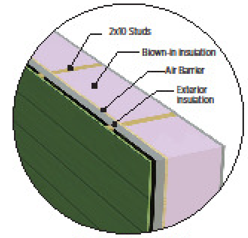
Walls

The wall assembly is a critical piece of meeting the Passive House standard. While typical walls usually have 6" stud cavities filled with batt insulation, the walls at Orchards will have 10" stud cavities filled with blown-in fiberglass insulation as well as a layer of exterior rigid insulation.

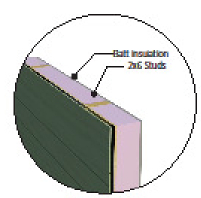


It's in the Details

In a superinsulated, airtight building, the design team and construction crew must work together to ensure every detail of the building is properly designed and constructed. Structural connections at balconies and other exterior elements, for instance, are often challenging areas that require copious amounts of coordination.
—*Thermographic analysis image, courtesy of Green Hammer*



Passive House Wall



Typical Wall

BENEFITS TO TENANTS

- *Up to 90% reduction in energy bills*
- *Superior indoor air quality*
- *Balanced thermal comfort througout the apartment*
- *Reduced outdoor noise inside apartments*
- *Innovative, forward-thinking living*

OTHER SUSTAINABLE FEATURES

- *Ample indoor bike parking*
- *Energy Star appliances*
- *Low-flow plumbing fixtures*

Ankrom Moisan

REACH Community Development

Introduction to Passive House

Compliance Tools & Verification

PHPP (Passive House Planning Package)

- Excel-format Spreadsheet
- Steady-State Heat Balance Calculations
- Monthly Climate Data Averages
- Simplified HVAC Efficiencies / Capacities
- Standard Schedules for Occupancy and Loads
- Validated Results in European Installations

Case Study

Orchards at Orenco

Orchards at Orenco

Project Team

REACH Community Development

williamwilsonarchitectspc

Ankrom Moisan

Housing Development Center

WALSH CONSTRUCTION

MGH ASSOCIATES

green hammer BUILDING CONTRACTORS

American HEATING & AIR CONDITIONING CO.

PAE

MERIT ELECTRIC

Plumbing & Mechanical Contractors Group

STONEWOOD Design, Inc.

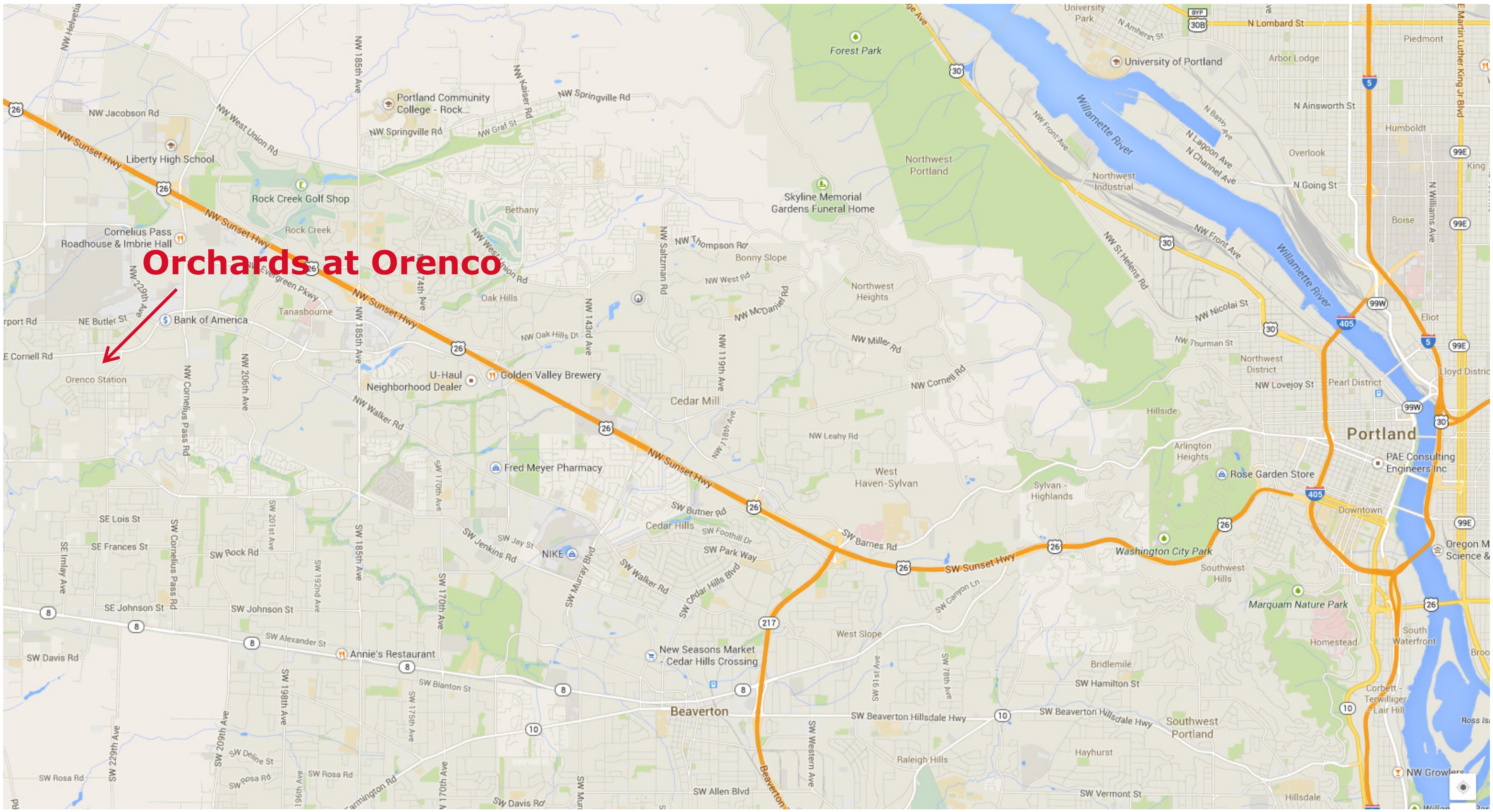
Orchards at Orenco

Why Passive House?

- Trends in Europe that show Passive House complexes offer better acoustics and air quality, see less turnover and lower maintenance costs
- Affordable living – not just affordable housing
- Reduced utility cost for building and tenants
- Assessing the Passive House strategy cost vs. benefits
- Allow development of the Passive House standard

Orchards at Orenco

Where is this project?



Orchards at Orenco

Project Statistics

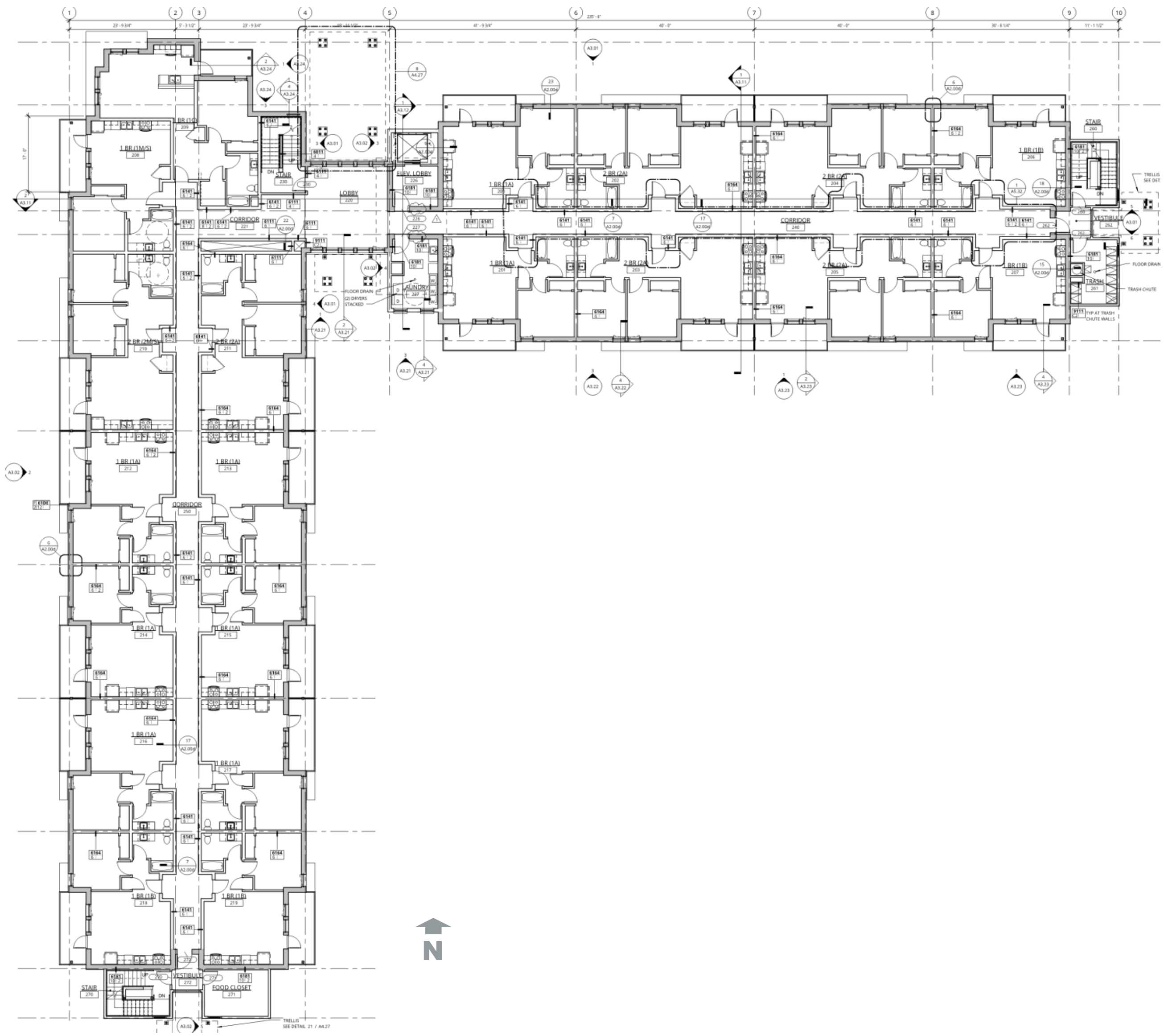
- Three stories
- 57,750 square feet
- 7,500,000 Budget - $130/sf
- 57 apartments
- < $25,000 annual income

Orchards at Orenco

Rendering

Orchards at Orenco

Typical Floor Plan



Orchards at Orenco

Passive House Strategies

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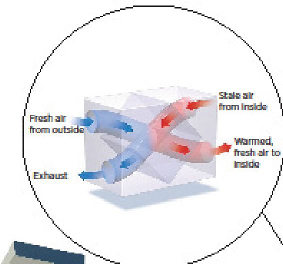

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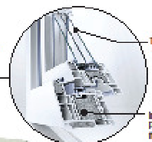

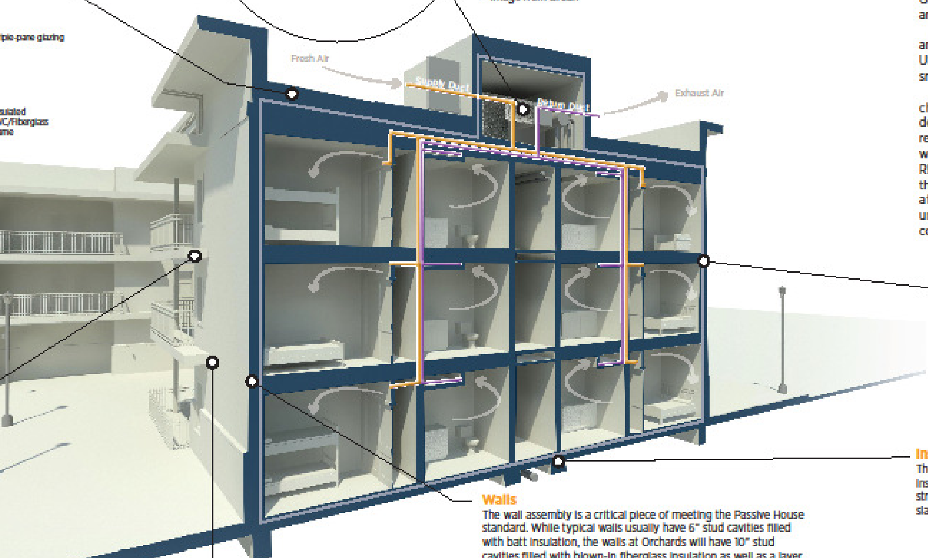

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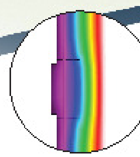

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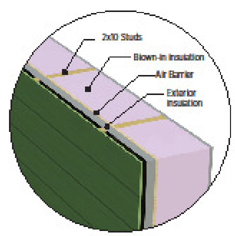

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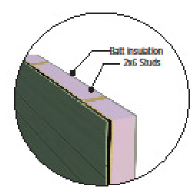

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REACH Community Development

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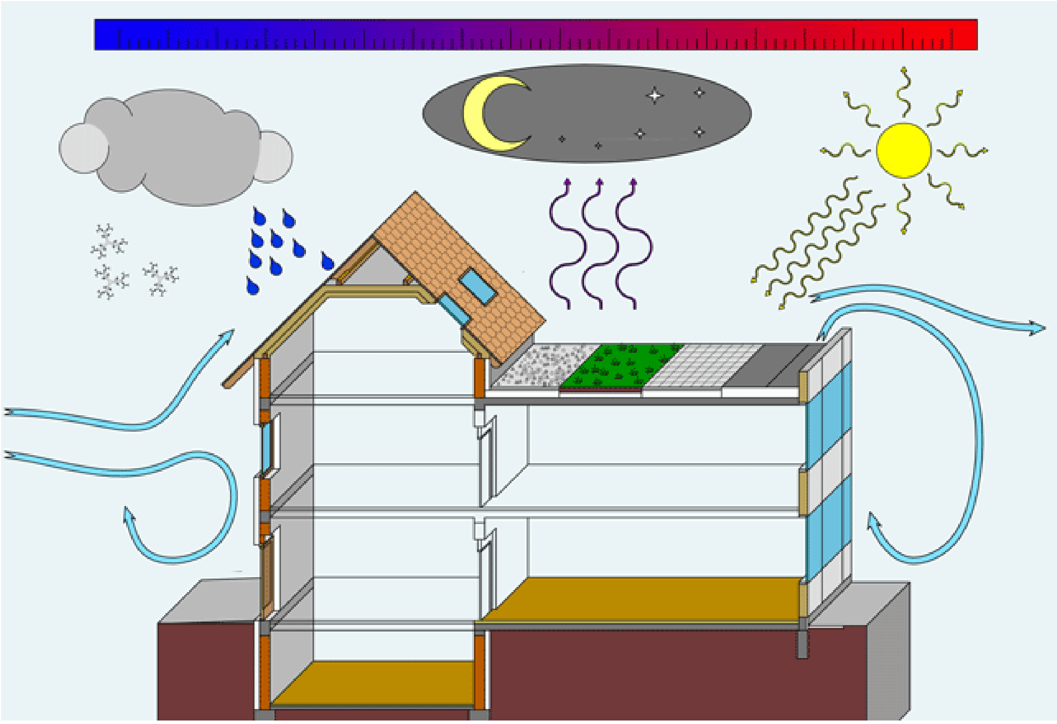
Envelope Performance

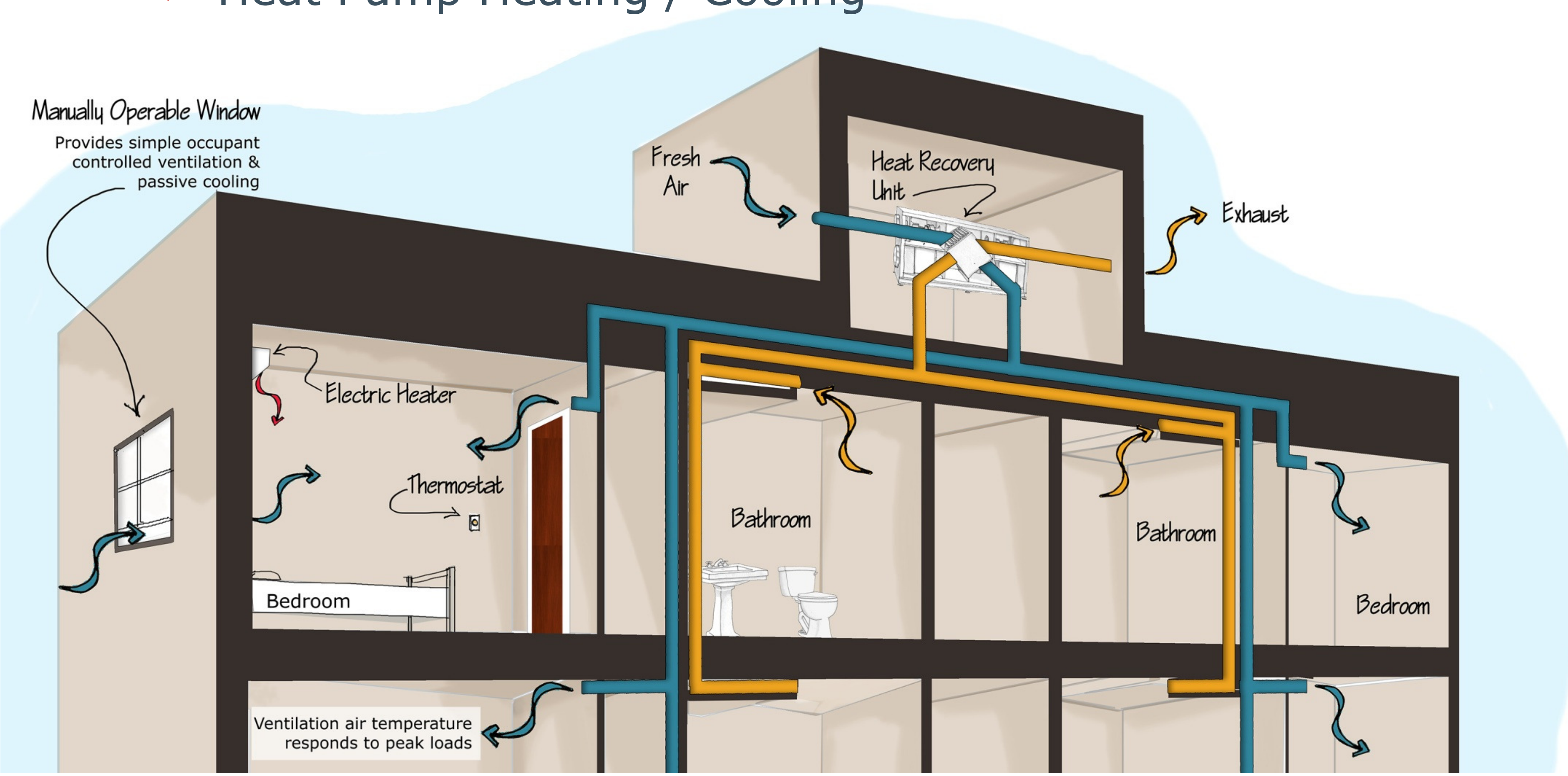
- R-39 Walls
- R-81 Roof
- R-18 Floors
- R-6.4 Windows
- 17% Glazing



Orchards at Orenco

HVAC Systems

- Electric Cove Heat
- Heat Recovery Units
- Heat Pump Heating / Cooling



Orchards at Orenco

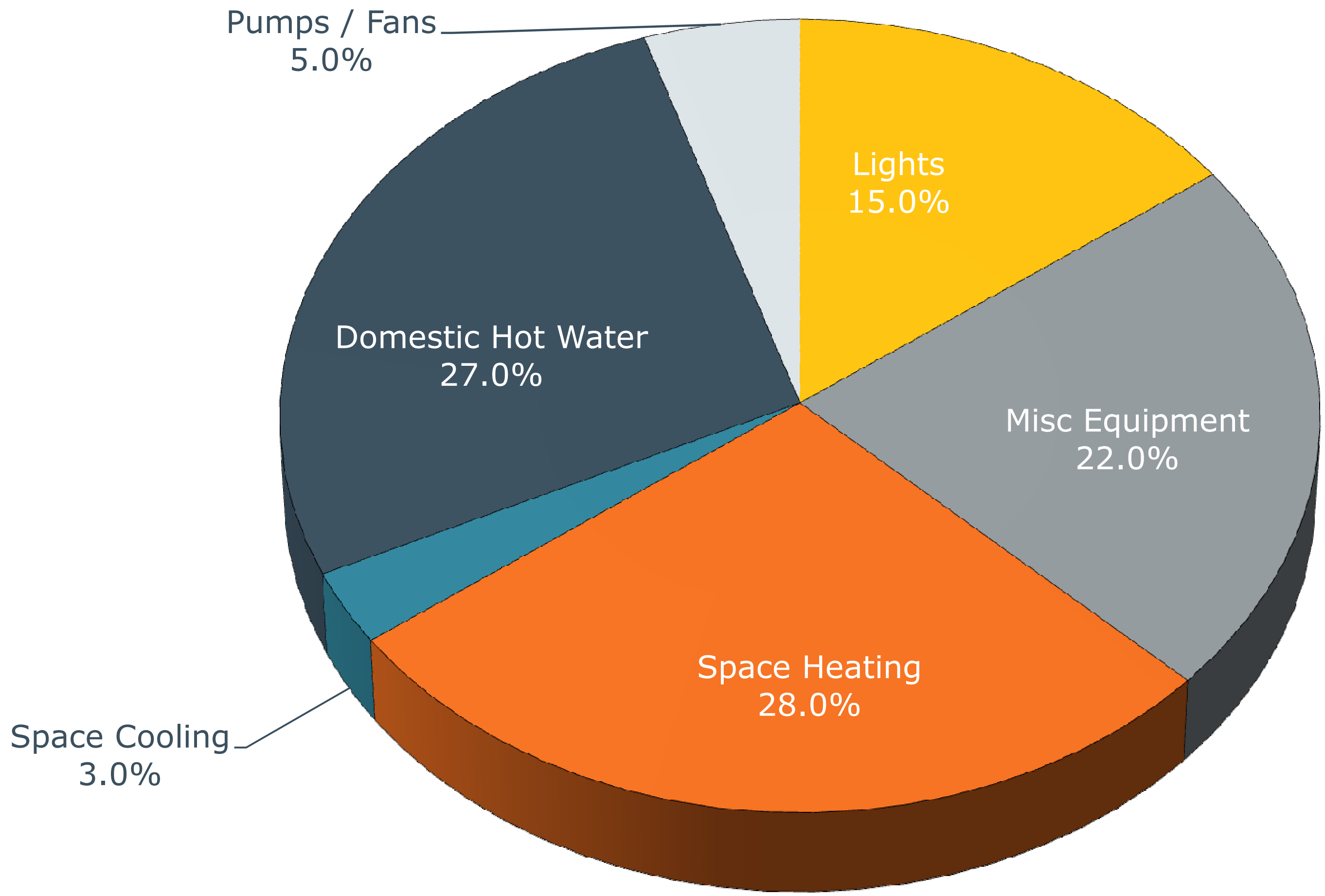
Modeling Methodology

Modeling for Energy Trust Incentives:

- eQUEST model – v3.64
- Baseline HVAC System: PTHP (all electric)
- Bundled Envelope Measures & HVAC System Efficiency
- Infiltration (0.82 ACH_{50} vs. 0.6 ACH_{50})
- Low-flow Plumbing Fixtures

Orchards at Orenco

Typical Energy End Uses - Residential



Typical Residential Building: Baseline Energy Use

EUI = 72 kBTU/sf/year

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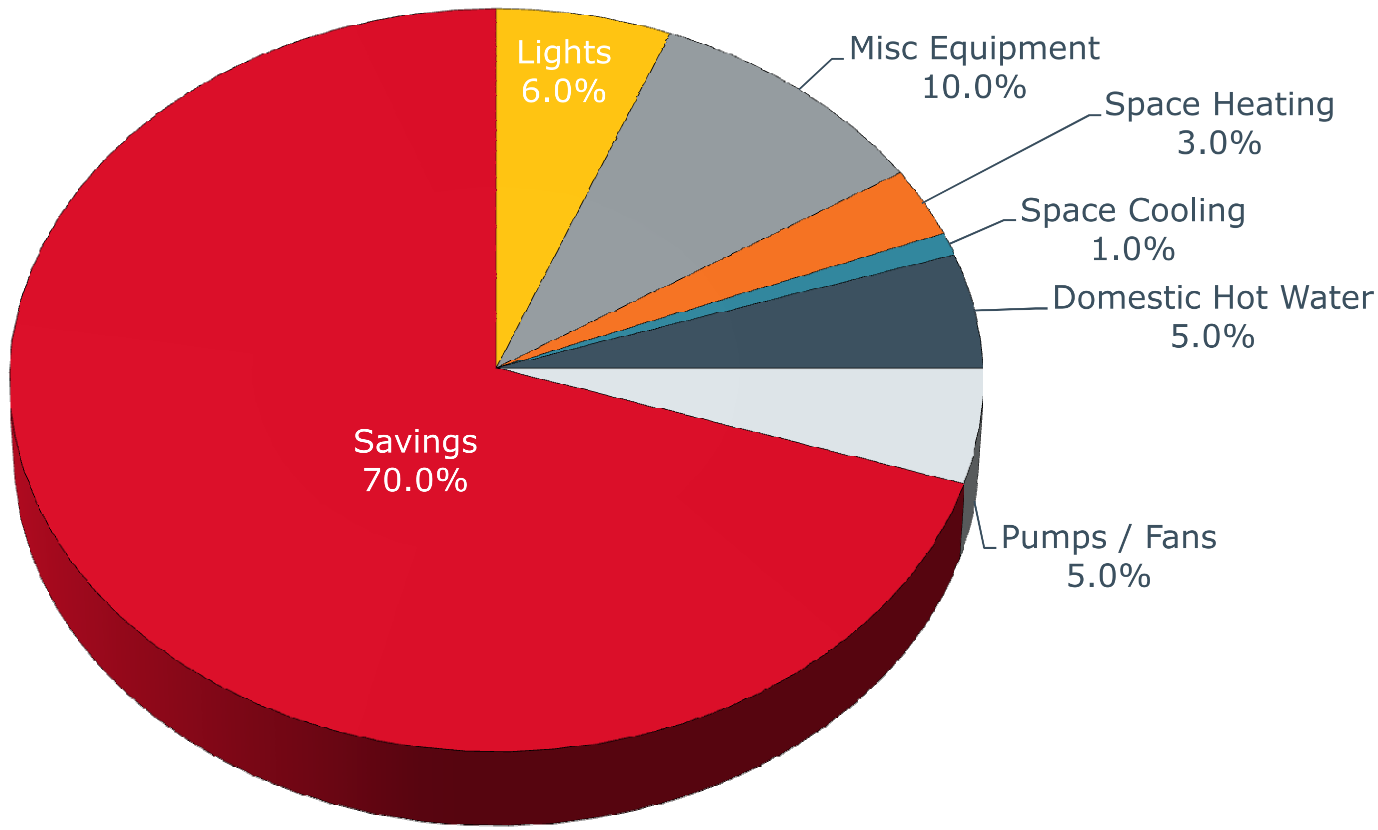
Predicted Energy End Use



Passive House Building

EUI = 20 - 24 kBTU/sf/year

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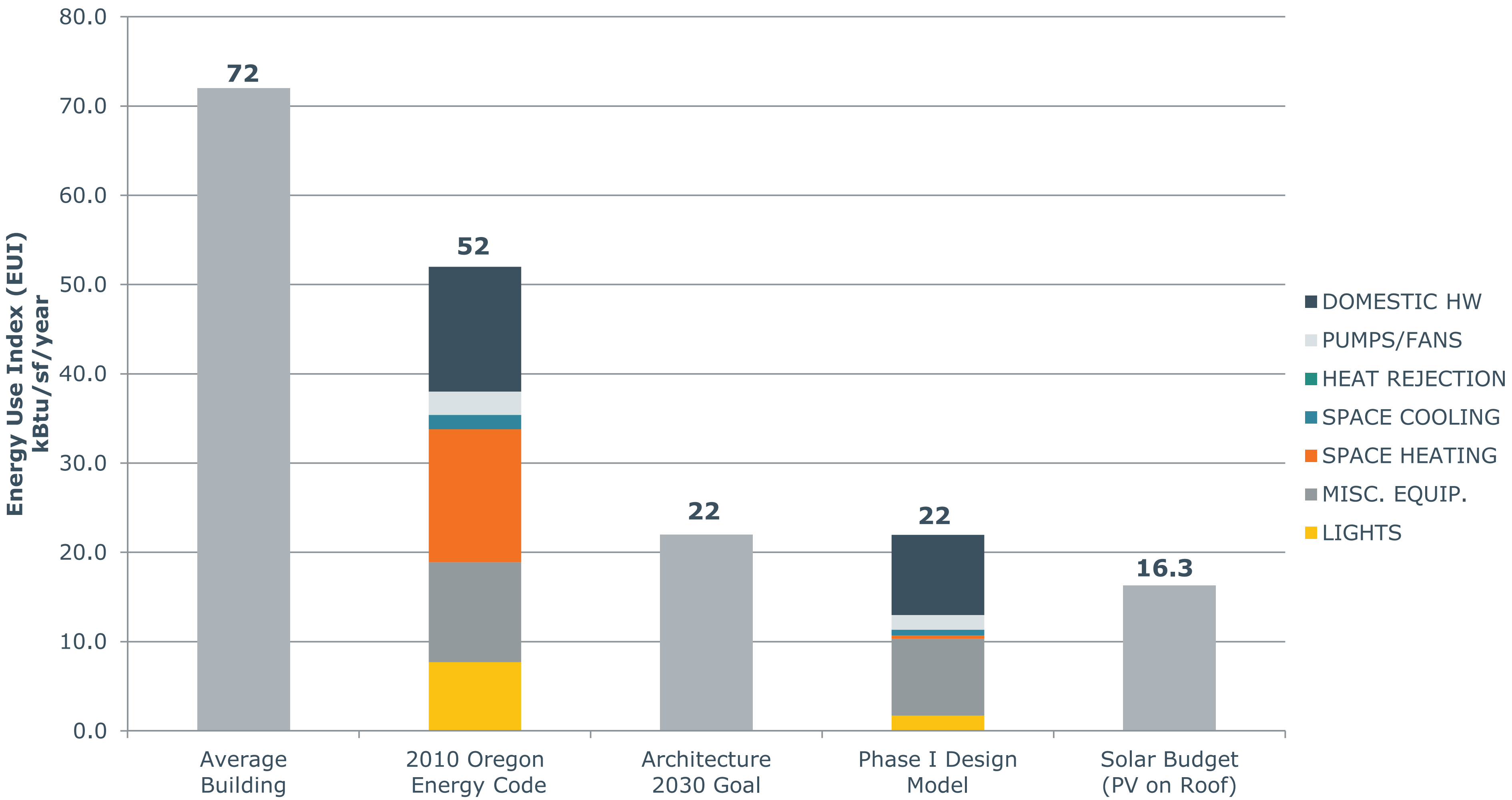
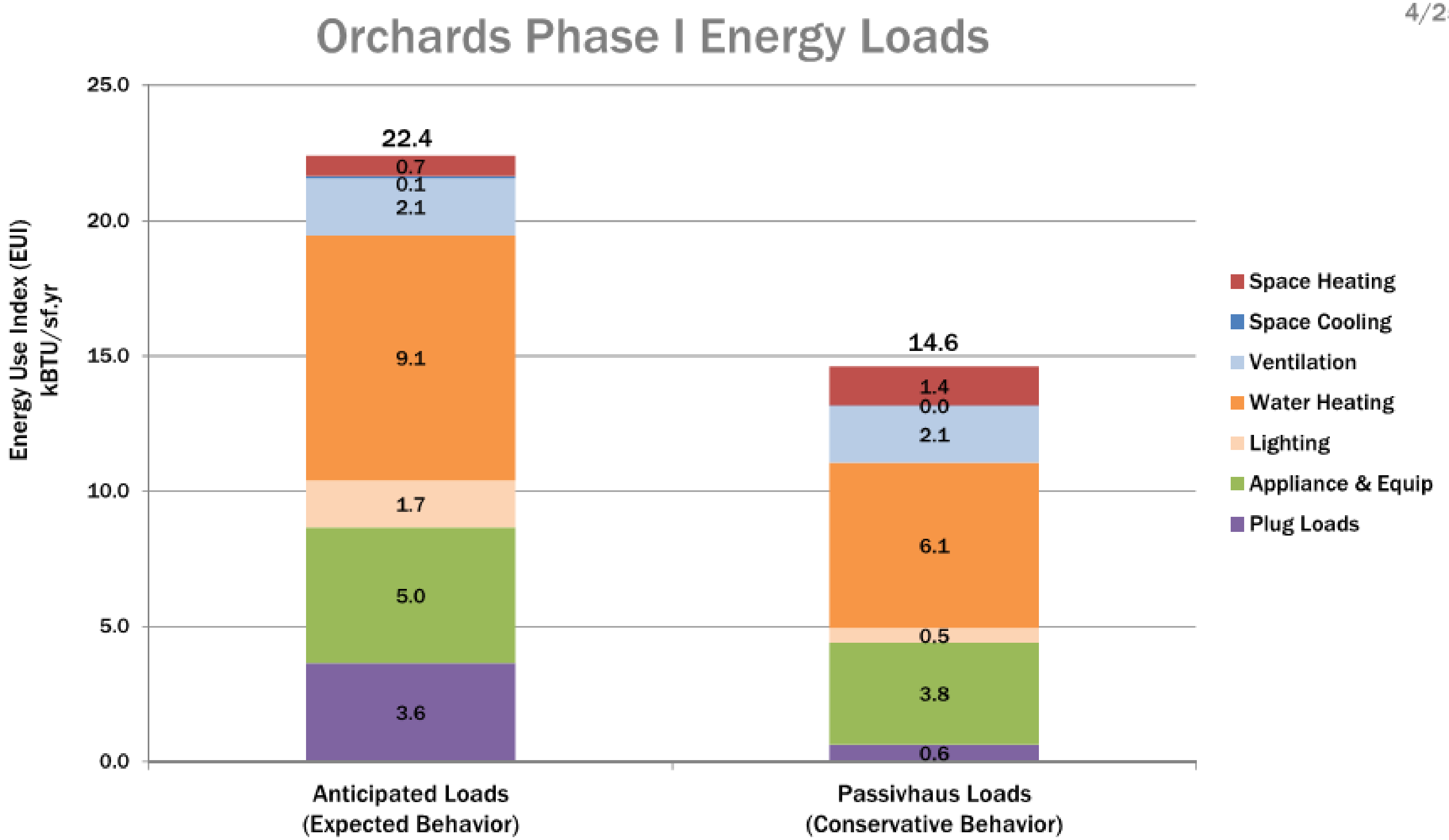
Energy Use Comparison



Orchards at Orenco

Passive House Energy Analysis

4/25/14



Orchards at Orenco

Passive House Energy Analysis

The Orchards at Orenco - Phase I

Passive House Energy Analysis Summary

Permit Set / PHIUS Pre-certification Submission

5/8/2014

green hammer
Designed for People. Built for Life.
1323 SE 6th Avenue, Portland, OR, 503-804-1746

RESULTS:

Space Heating Peak Load:	2.46	BTU/hr.sf	Total Source Energy EUI:	36.0	kBTU/sf.yr
Passive House Standard:	3.17	BTU/hr.sf	Passive House Standard:	38.0	kBTU/sf.yr
Percent of Limit:	78%		Percent of Limit:	95%	

ASSUMPTIONS:

Envelope:

		R-value	
Walls:	2x10 + 1.5" mineral wool	39	
	advanced framed, 15% framing factor		
	solid blocking @ exterior structural supports		
Windows:	EuroLine T/T uPVC overinsulated	6.4	R-frame
Glazing N/S:	LoE 180/180 Ar, SHGC=0.55	9.0	
Glazing E/W:	LoE 366/180 Ar, SHGC=0.25	7.5	
Residential Doors:	Euroline T/T Door uPVC overinsul.	4.3	R-frame
	ADA sill (assumed 4600 Series)		
Glazing:	same as above		
Lobby Doors (4):	Klearwall PH Door	6.7	R-frame
Glazing:	Saint Gobin 0.5/0.5 & Opaque Panel	11.4	
Corridor Doors (12):	Select Door Wood Fire-rated Door	3.1	R-frame
Glazing:	Ceramic glass (18"x24")	0.7	
Roof:	12" Polyiso over Sheathing	81	
Slab: Field:	4" EPS II	18	
Interior Footings:	1" EPS IX	6	
Perimeter Footings:	4" EPS IX	19	
Vertical Perimeter:	4" EPS II	18	
Airtightness:	0.60 ACH @ 50 Pa		

Other:

Thermal Mass:	Standard drywall
	1 inch gypcrete floor topping w/o carpet
Thermal Bridging:	Intermittent solid blocking at decks/awnings
	24 Plumbing vents, 10 roof drains, 3 radon vents
	(all vents/drains insulated through attic)

Heating System:

80% Heat Pump, COP = 4.31 (average all systems)
delivered via HRV supply & indoor heads
20% Electric-Resistance (in apartments)
window watcher shut-off

Ventilation System:

Cook ERVs 75% effectiveness 0.80 W/cfm
Apartment Ventilation: 50 cfm/apt, cont.
50 cfm add'l ventilation to second bedrooms in summer
Comm. Rm. Ventilation: 85 cfm, cont.
Office Ventilation: 15 cfm, cont.
Lobby Ventilation: 50 cfm, cont.
Whole-Building Ave: 0.58 ACH
Duct Insulation, HRV to Exterior: 4" FG w/ vapor barrier
No direct exhaust fans within PH envelope

DHW System:

Central Gas Heater w/ Trace Htg on Lines
Water Heater efficiency = 99% (nominal)
Bradford White EF-100T-199E-3N(A)
Hot Water Line Insulation: min. 3/4" continuous
(11) hot water riser lines assumed per floor
Low-flow fixtures throughout

Appliances:

Refrigerator/Freezers:	370 kWh/yr ES rating or better
Dishwashers:	275 kWh/yr ES rating or better
Clotheswashers:	184 kWh/yr ES rating or better
Clothesdryers:	gas
Range/Oven:	electric
Range Hood:	recirculating; charcoal filter
Elevator:	3000 kWh/yr
	i.e. Thyssen Krup, MRL Traction

Lighting:

Residential:	100% fluorescent/LED
Non-residential:	0.8 W/sf occupied areas
	0.4 W/sf storage/circulation areas
	occupancy sensing all non-residential areas

Cooling Strategy:

HRV supply air tempered by heat pump; supply temp ~50F
HRV airflow increased by 50cfm in each 2 bedroom unit during summer.
HRV heat recovery bypass automated by thermostat
Windows open night only if necessary, closed during day

NOTES:

1 **Floor area and window area inputs** based on 50% CD drawings (12/5/13) with following clarifications:
- where adjoining windows are not mulled together, the post between must receive same over-insulation as the wall condition,
- all doors are 3' x 8' nominal

2 **Envelope Configuration**: Laundry room, elevator enclosure, and end wing stair/storage areas are outside the Passivhaus envelope. No active heating is supplied to these spaces (aside from a 500W frost-prevention heater in the maintenance room). Specified wall insulation, airtightness layer, doors and windows segregate these spaces from the building proper. Access to mechanical pods is assumed to be from interior ceiling hatch (within the thermal envelope). All roof hatches occur at end-wing stairs, outside the thermal envelope.

3 **Lighting, equipment, plug loads and hot water usage** is based upon Passivhaus default values (used as the basis for PH certification). Actual loads are anticipated to be higher which may present periods of occupant discomfort due to overheating. Strategies to encourage occupant behavior toward energy efficiency are highly encouraged (i.e. lobby dashboard reporting each units' red/yellow/green status toward their energy usage target with more info on how to decrease energy usage such as reducing internal loads and night-flush ventilation).

4 This analysis includes a **thermal bridge analysis** of a typical solid blocking detail assumed at exterior structural connections. Intermittent blocking (not continuous) assumed at decks, awnings, unconditioned wall junctions, etc. Also included is a thermal bridge at all roof vents/drains, assuming they are insulated as they pass through the roof truss cavity. Vapor impermeable barrier should surround this insulation to avoid condensation.

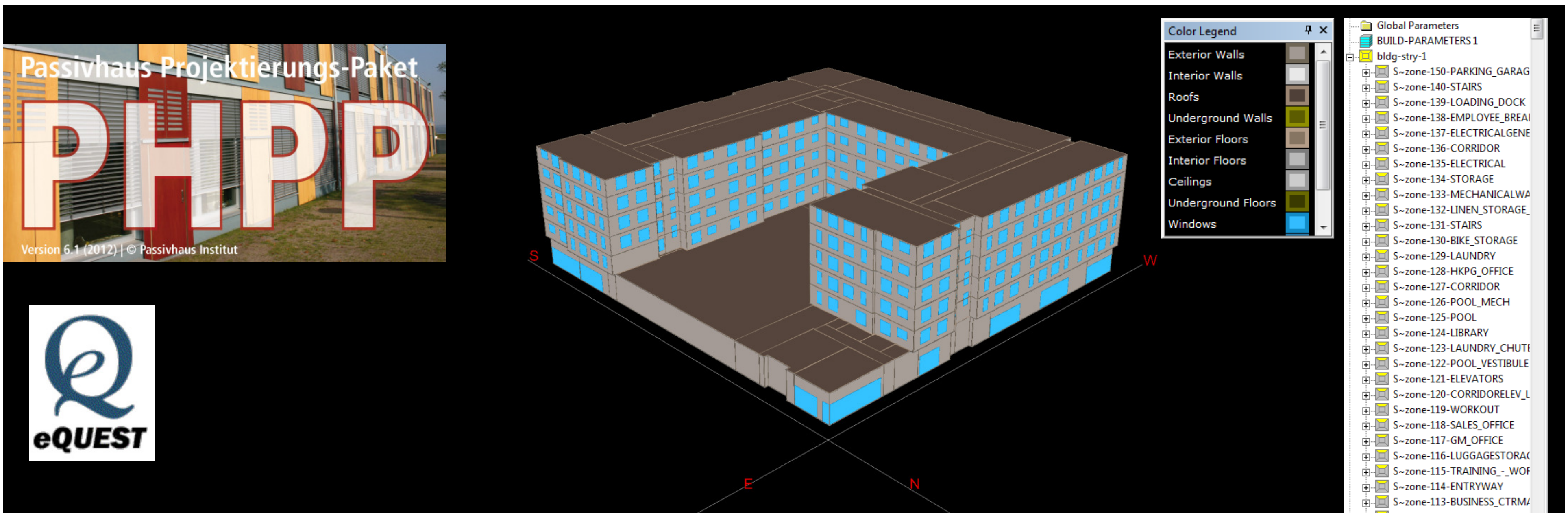
Orchards at Orenco

Where do we stand?

Building Energy Demand	Target	Design
Heating (BTU/hr-sf)	3.17	2.46
Primary Energy Demand (kBTU/sf-year)	38	36
Airtightness (ACH50)	0.6	TBD

Comparing Design Tools

PHPP & eQUEST



Comparing Design Tools

PHPP & eQUEST

Category	eQUEST	PHPP
Cost	None	$$
Training	On line Forums & User Groups	Training through PHIUS & User Groups
Model Format	DOE-2 engine	Excel
Initial Set Up	Wizard	Drawing Take-offs
HVAC Systems	Complex / Modifiable	Simple – efficiency based
Parametric Analysis	Yes	No
Accepted by ETO	Yes	No
Hourly Simulation	Yes	No

Comparing Design Tools

PHPP & eQUEST

- Who can use it?
- When each is most effective?
- What are the uses for each program?
- What do they not do?

Project Lessons Learned

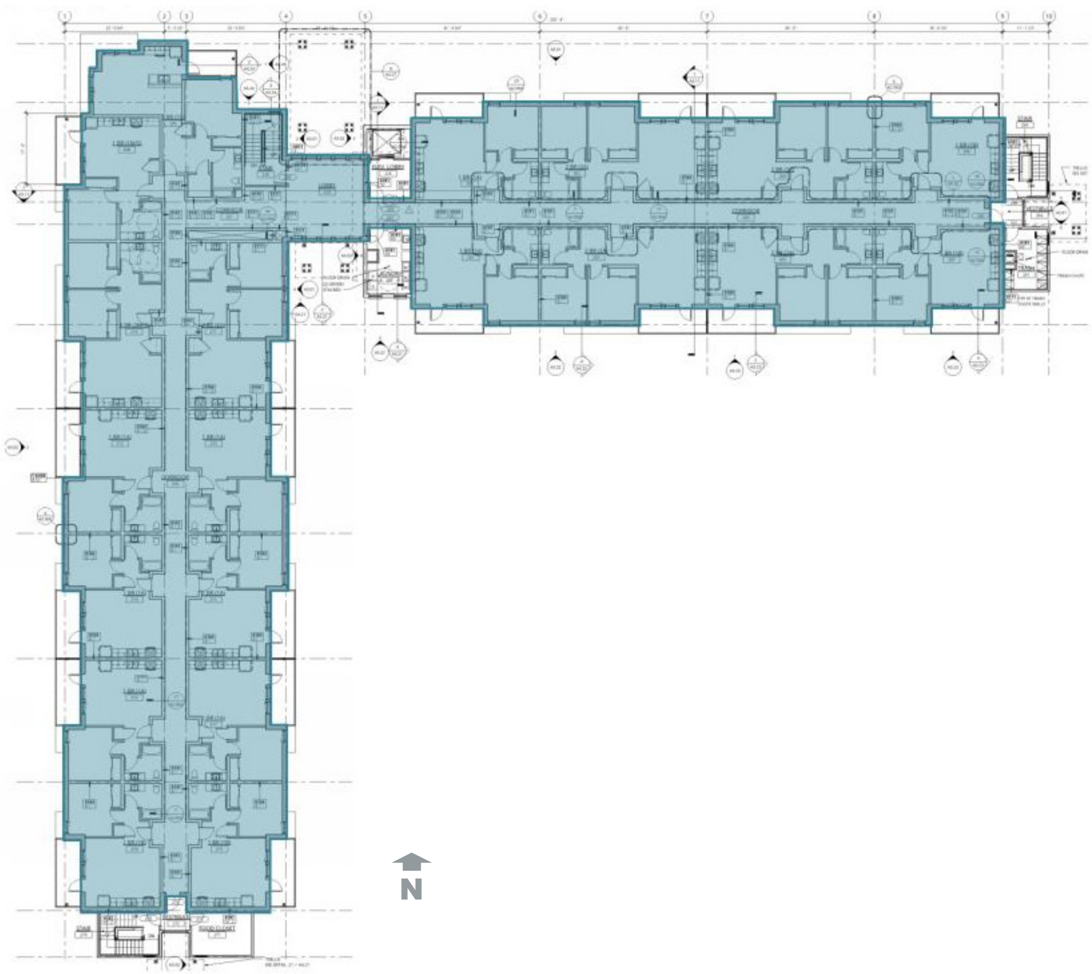
Lessons Learned

Topics

- Importance of Passive House Boundary for Commercial Buildings
- Optimizing Ventilation
- Kitchen Hood Exhaust
- Balance Point & Overheating
- Material & Equipment Availability
- Passive House US & Passivhaus Differences

Project Lessons Learned

Importance of Passive House Boundary



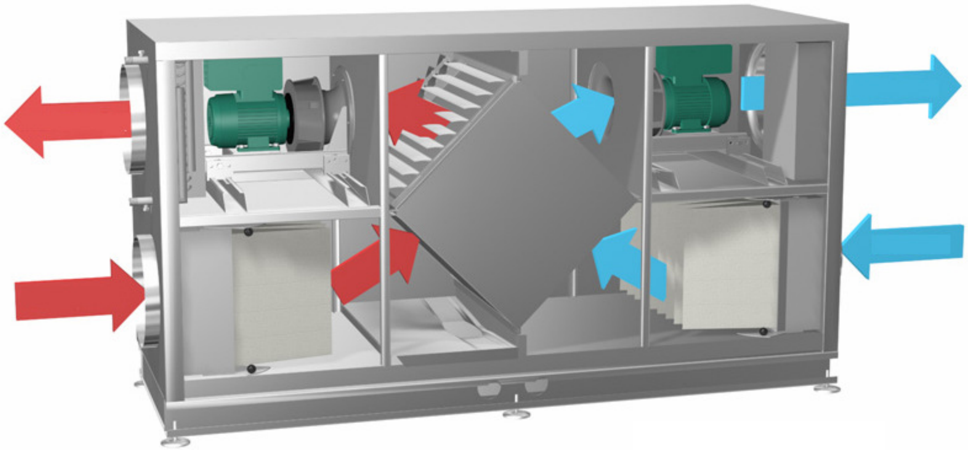
Infiltration Testing:

- Stairs - Stack Effect
- Elevators & lobby – stack effect
- Laundry – exhaust & make-up air
- Garbage Rooms – exhaust & make-up air

Project Lessons Learned

Optimizing Ventilation

- Tightly sealed building requires complete ventilation system
- Heat recovery is necessary
- Higher airflow = more energy
- Balance IAQ with energy efficiency
- Providing sufficient exhaust



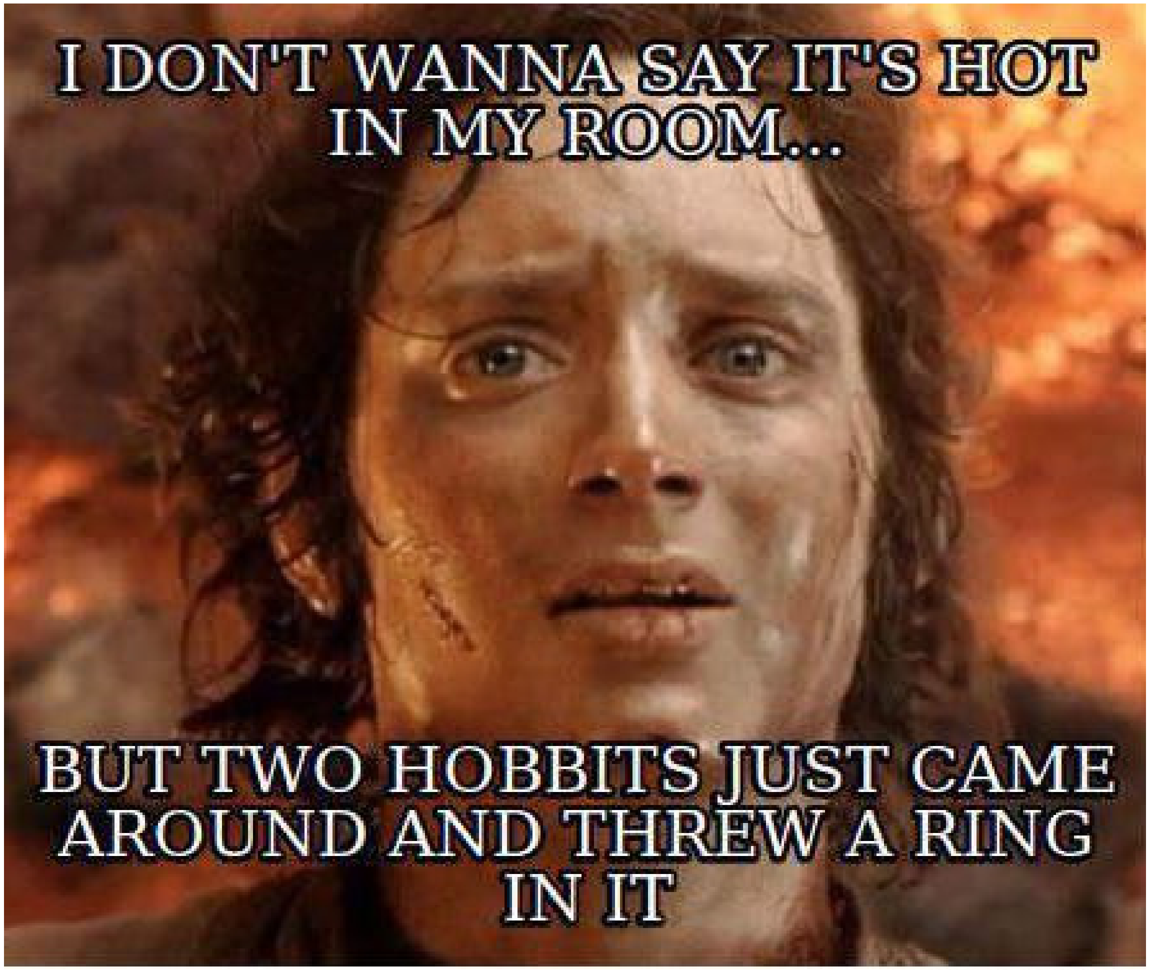
Project Lessons Learned

Kitchen Hood Exhaust

- Ducting kitchen hood exhaust duct outdoors is problematic
- Re-circulating hoods meet Passive House goals but are an IAQ concern
- Review kitchen hood ducting requirements with AHJ

Project Lessons Learned

Balance Point & Overheating



Project Lessons Learned

Balance Point & Overheating

Solutions:

- Reduce Internal Loads
- Shading
- Operable windows
- Cooling of ventilation air to take the edge off

Project Lessons Learned

Material & Equipment Availability / Selection

PHI ratings for HRV's differ from ratings by AHRI.

PHIUS will now accept AHRI rated efficiencies.

AHRI CERTIFIED®
www.ahridirectory.org

Certificate of Product Ratings

AHRI Certified Reference Number: 3816253 Date: 3/20/2014 †Status: Active

Product: Packaged Air-to-Air Energy Recovery Ventilator
Model Number: EV450J
Manufacturer: RENEWAIRE, LLC
Trade/Brand name: RENEWAIRE

Rated as follows in accordance with AHRI Standard 1060-2012 for Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment and subject to verification of rating accuracy by AHRI-sponsored, independent, third party testing:

Product Type: Plate
Pressure Drop (inches): 0.60

Leaving Supply Air Flow (SCFM): 450
Additional Notes:
This package contains 1 certified components, each with AirFlow of 450cfm

Leakage Ratings	Pressure Differential	EATR(%)	OACF	Purge Angle/Setting
Test 1:	-1.00	1.00	1.00	N/A
Test 2:	0.00	0.00	1.02	N/A
Test 3:	1.00	0.00	1.05	N/A

Thermal Effectiveness Ratings at 0" Pressure Differential

	Sensible(%)	*Latent(%)*	*Total(%)*
100% Air Flow Heating	73	53	66
75% Air Flow Heating	77	60	71
100% Air Flow Cooling	73	46	56
75% Air Flow Cooling	77	52	61

	Net Sensible(%)	*Net Latent(%)*	*Net Total(%)*
100% Air Flow Heating	73	53	66
75% Air Flow Heating	77	60	71
100% Air Flow Cooling	73	46	56
75% Air Flow Cooling	77	52	61

† Models with an 'Active' status are those that are currently in production. Models with a 'Discontinued' status are those that the manufacturer has elected to stop producing, yet stock is still available. Models with an 'Obsolete' status are those that the manufacturer is required to stop manufacturing due to an AHRI certification program test failure.

* Ratings followed by an asterisk (*) indicate a voluntary rerate of previously published data, unless accompanied with a WAS, which indicates an involuntary rerate.

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Project Lessons Learned

Material & Equipment Availability / Selection

Project Lessons Learned

PH

vs.

Passivhaus Institut

Summary

Next Steps

- Complete Construction
- Verify Performance
- Final Passive House Verification

Summary

Conclusions

- We need more examples of Passive House being applied to different application.
- Push the “envelope”.
- The Passive House process is becoming more refined to reflect US conditions.
- More widespread adoption will reduce costs – just like what we saw happen with LEED.


Questions?
THE ORCHARDS